

DOCTORAL THESIS

Doctoral Program in Psychology

Anosognosia in Patients with Acquired Brain Injury: New Assessment and Intervention Tools Based on Everyday Tasks

"Anosognosia en pacientes con daño cerebral adquirido: nuevas herramientas
de evaluación e intervención basadas en tareas cotidianas"

PhD Candidate

Daniel Alberto Salazar Frías

Supervisors

Ma Jesús Funes Molina

María Rodríguez Bailón

Department of Experimental Psychology
Mind, Brain and Behavior Research Center (CIMCYC)



**UNIVERSIDAD
DE GRANADA**

January 2025

Editor: Universidad de Granada. Tesis Doctorales
Autor: Daniel Alberto Salazar Frías
ISBN: 978-84-1195-740-3
URI: <https://hdl.handle.net/10481/102893>

La presente Tesis Doctoral se presenta bajo la modalidad de compendio de publicaciones. Las publicaciones incluidas son:

Salazar-Frías, D., Rodríguez-Bailón, M., Ricchetti, G., Navarro-Egido, A., & Funes, M. J. (2023). The Cognitive Awareness Scale for Basic and Instrumental activities of daily living to measure self-awareness after acquired brain injury: preliminary evidence of its validity. *The Clinical Neuropsychologist*, 38(5), 1133-1155.

<https://doi.org/10.1080/13854046.2023.2278822>

ISSN: 1385-4046 (Print) - 1744-4144 (Electronic)

Journal Citation Reports 2023: Q1 (19/92) Psychology

Salazar-Frías, D., Funes, M. J., Merchán-Baeza, J. A., Ricchetti, G., Torralba-Muñoz, J. M., & Rodríguez-Bailón, M. (2023). Translation, cross-cultural adaptation and validation of the 10-item Weekly Calendar Planning Activity in Spanish-speaking ABI patients: a multicenter study. *Frontiers in Psychology*, 14, 1-17.

<https://doi.org/10.3389/fpsyg.2023.1018055>

ISSN: 1664-4144 (Electronic)

Journal Citation Reports 2023: Q2 (56/218) Psychology, Multidisciplinary

Salazar-Frías, D., Rodríguez-Bailón, M., Ricchetti, G., Navarro-Egido, A., de los Santos, M., & Funes, M. J. (2024). Training to deal with distractions and conflicting situations in activities of daily living after traumatic brain injury (TBI): preliminary evidence from a single-case experimental design study. *Neuropsychological Rehabilitation*, 1-36.

<https://doi.org/10.1080/09602011.2024.2375495>

ISSN: 0960-2011 (Print) - 1464-0694 (Electronic)

Journal Citation Reports 2023: Q3 (55/92) Psychology

Table of contents

LIST OF ABBREVIATIONS.....	6
ABSTRACTS	8
<i>Abstract</i>	9
<i>Resumen</i>	15
PART I: INTRODUCTION	22
CHAPTER 1. COGNITION AND EVERYDAY FUNCTIONING.....	23
1.1 THE ROLE OF PARTICIPATION, OCCUPATION AND COGNITION IN ACHIEVING FUNCTIONAL INDEPENDENCE.....	23
1.2 THE RELEVANCE OF FUNCTIONAL COGNITION TO NEUROPSYCHOLOGICAL PRACTICE	25
1.3 TRADITIONAL VERSUS ECOLOGICALLY VALID NEUROPSYCHOLOGICAL ASSESSMENT: WHICH TESTS ARE MORE EFFECTIVE IN PREDICTING FUNCTIONAL PERFORMANCE?.....	27
CHAPTER 2. UNDERSTANDING SELF-AWARENESS AND ITS DEFICITS AFTER ACQUIRED BRAIN INJURY.....	34
2.1 SELF-AWARENESS: DEFINITION AND IMPLICATION FOR FUNCTIONAL OUTCOMES	34
2.2 THEORETICAL FRAMEWORKS AND COMPONENTS OF SELF-AWARENESS.....	36
2.3 COGNITIVE PROCESSES INVOLVED IN SELF-AWARENESS: MEMORY, EXECUTIVE FUNCTIONS AND COGNITIVE STRATEGIES	40
2.4 VARIATIONS IN SELF-AWARENESS ACROSS DOMAINS.....	45
2.4.1 <i>Self-awareness of different cognitive abilities</i>	46
2.4.2 <i>Self-awareness across tasks of varying difficulty</i>	47
CHAPTER 3. ASSESSING IMPAIRED SELF-AWARENESS AFTER ACQUIRED BRAIN INJURY: HOW TO BEST MEASURE EACH OF ITS COMPONENTS?.....	49
3.1 METHODS FOR THE ASSESSMENT OF THE METACOGNITIVE KNOWLEDGE COMPONENT OF SELF-AWARENESS.....	49
3.2 METHODS FOR THE ASSESSMENT OF ONLINE COMPONENT OF SELF-AWARENESS	54
CHAPTER 4. COGNITIVE REHABILITATION OF IMPAIRED SELF-AWARENESS AFTER ACQUIRED BRAIN INJURY: WHAT METHODS WORK BEST?	65
4.1 A GENERAL OVERVIEW OF TRADITIONAL COGNITIVE REHABILITATION APPROACHES.....	65
4.2 COGNITIVE REHABILITATION APPROACHES BASED ON ACTIVITIES OF DAILY LIVING TO ENHANCE FUNCTIONALITY AND GENERALIZATION	70
4.3 TREATMENT APPROACHES FOR IMPAIRED SELF-AWARENESS: THE IMPORTANCE OF ACTIVELY TARGET FUNCTIONAL AND COGNITIVE IMPAIRMENTS AND GENERALIZATION.....	71

PART II: AIMS OF THE RESEARCH.....	77
CHAPTER 5. MOTIVATION AN AIMS	78
PART III: EMPIRICAL STUDIES.....	84
CHAPTER 6. THE COGNITIVE AWARENESS SCALE FOR BASIC AND INSTRUMENTAL ACTIVITIES OF DAILY LIVING TO MEASURE SELF-AWARENESS AFTER ACQUIRED BRAIN INJURY: PRELIMINARY EVIDENCE OF ITS VALIDITY	85
6.1 ABSTRACT	86
6.2 INTRODUCTION	87
6.3 METHODS	93
6.4 RESULTS	100
6.5 DISCUSSION	108
6.6 LIMITATIONS AND FUTURE DIRECTIONS	113
CHAPTER 7. TRANSLATION, CROSS-CULTURAL ADAPTATION AND VALIDATION OF THE 10-ITEM WEEKLY CALENDAR PLANNING ACTIVITY IN SPANISH- SPEAKING ABI PATIENTS: A MULTICENTER STUDY	115
7.1 ABSTRACT	116
7.2 INTRODUCTION	117
7.3 METHODS	121
7.4 RESULTS	132
7.5 DISCUSSION	144
7.6 LIMITATIONS AND FUTURE DIRECTIONS	153
7.7 CONCLUSIONS	154
CHAPTER 8. THE MODERATING ROLE OF ONLINE AWARENESS IN THE ASSOCIATION BETWEEN STRATEGY USE AND PERFORMANCE ACCURACY ON A TEST OF FUNCTIONAL COGNITION IN INDIVIDUALS WITH ACQUIRED BRAIN INJURY	156
8.1 ABSTRACT	157
8.2 INTRODUCTION	158
8.3 METHODS	165
8.4 RESULTS	172
8.5 DISCUSSION	181
8.6 LIMITATIONS AND FUTURE DIRECTIONS	189
CHAPTER 9. TRAINING TO DEAL WITH DISTRACTIONS AND CONFLICTING SITUATIONS IN ACTIVITIES OF DAILY LIVING AFTER TRAUMATIC BRAIN INJURY (TBI): PRELIMINARY EVIDENCE FROM A SINGLE-CASE EXPERIMENTAL DESIGN STUDY	191
9.1 ABSTRACT	192

9.2 INTRODUCTION	193
9.3 METHODS	199
9.4 RESULTS	213
9.5 DISCUSSION	223
9.6 LIMITATIONS AND FUTURE DIRECTIONS	227
PART IV: GENERAL DISCUSSION	229
CHAPTER 10. GENERAL DISCUSSION.....	230
10.1 IMPROVING THE ASSESSMENT OF THE METACOGNITIVE KNOWLEDGE COMPONENT OF SELF-AWARENESS: ACCOUNTING FOR VARIATIONS IN COGNITIVE DOMAINS AND TASK COMPLEXITY	231
10.2 IMPROVING THE ASSESSMENT OF THE ONLINE COMPONENT OF SELF-AWARENESS: THE IMPORTANCE OF EVALUATING ITS DIFFERENT SUB-COMPONENTS SIMULTANEOUSLY IN THE CONTEXT OF PERFORMANCE-BASED C-IADL TASKS	233
10.3 RELATIONSHIP BETWEEN ONLINE SELF-AWARENESS, STRATEGY USE AND FUNCTIONALITY	237
10.4 DEFINING THE TREATMENT OUTCOMES AND ACTIVE INTERVENTION ELEMENTS FOR ADDRESSING IMPAIRED SELF-AWARENESS.....	238
10.5 LIMITATIONS AND FUTURE DIRECTIONS	241
REFERENCES	245

List of Abbreviations

ABI	Acquired Brain Injury
ADL	Activities of Daily Living
AQ	Awareness Questionnaire
BADL	Basic Activities of Daily Living
C-IADL	Cognitive Instrumental Activities of Daily Living
COWAT	Controlled Oral Word Association Test
DCMA	Dynamic Comprehensive Model of Awareness
EFPT	Executive Function Performance Tests
EF	Executive Functions
EComp	Everyday Compensation Scale
IADL	Instrumental Activities of Daily Living
IADL-C	Instrumental Activities of Daily Living Compensation Scale
ISA	Impaired Self-Awareness
MC	Multi-Context approach
MET	Multiple Errands Test;
MMSE	Mini Mental State Examination
MLAT	Multi-Level Action Test
MoCA	Montreal Cognitive Assessment
MST	Metacognitive Strategy Training
MT	Menu Task
NAT	Naturalistic Action Test
OTAAT	Occupational Therapy Anticipatory Awareness Test
PCRS	Patient Competency Rating Scale
RAVLT	Rey Auditory Verbal Learning Test
RCT	Randomized Controlled Trials

ROC	Receiver Operator Characteristic
SA	Self-Awareness
SADI	Self-Awareness of Deficits Interview
SCED	Single-Case Experimental Design
TBI	Traumatic Brain Injury
TMT	Trail Making Test
WCST	Wisconsin Card Sorting Test
WCPA-10	10-item Weekly Calendar Planning Activity

Abstracts

Abstract

Acquired Brain Injury is a leading cause of disability worldwide, often resulting in cognitive deficits that impair an individual's ability to perform daily activities essential for independent living. These deficits typically require cognitive rehabilitation, but progress is often hindered by the individual's lack of awareness of their own deficits. While some improvement in awareness may occur within the first few months post-injury, some individuals remain unaware of their deficits even years later. To address these clinical challenges, models such as the Dynamic Comprehensive Model of Awareness (Toglia & Kirk, 2000) have been proposed. This model conceptualizes self-awareness as a dynamic process with two main components: metacognitive knowledge, which includes beliefs and perceptions about one's abilities and limitations; and online self-awareness, a task-specific process activated immediately before, during, and after task performance, and including components such as task appraisal, self-monitoring, self-regulation, and the ability to accurately assess one's performance and recognize discrepancies between expected and actual outcomes. The model also emphasizes a dynamic rather than hierarchical relationship between knowledge, task demands, the context of the situation, and various metacognitive skills. The multifaceted, task-specific nature of self-awareness highlights the need for comprehensive evaluation tools that assess both metacognitive knowledge and online self-awareness within the same functional domain. Such tools would allow clinicians to identify specific self-awareness components that may be

impaired in individuals with brain injury. This is also crucial to deepen our understanding of the cognitive processes involved in self-awareness, which will inform the development of evidence-based cognitive rehabilitation interventions to remediate them. Despite widespread acknowledgment of the importance of addressing these deficits, there remains no consensus on the most effective methods for their assessment and treatment. This thesis seeks to advance knowledge, assessment, and intervention techniques for the distinct components of self-awareness and the cognitive processes supporting them in individuals with brain injury. To achieve this goal, emphasis is placed on integrating laboratory research with practical applications through innovative strategies targeting self-awareness deficits in real-world tasks. Accordingly, four studies were conducted to address three specific aims:

The first aim was to validate the Cognitive Awareness Scale for Basic and Instrumental Activities of Daily Living, a novel self-proxy discrepancy instrument developed in our laboratory to assess the metacognitive component of self-awareness across various cognitive domains and everyday contexts in Spanish-speaking individuals with brain injury. In the first study (Salazar-Frías, Rodríguez-Bailón, et al., 2023), we established convergent validity by comparing our scale with the well-established Patient Competency Rating Scale (Prigatano et al., 1998), revealing strong correlations with both the total scale and its subscales. To further assess agreement between the two scales, we conducted a Bland-Altman plot, which demonstrated excellent agreement, confirming our scale's reliability and reproducibility for clinical use. The scale's external validity was supported by its ability to distinguish between healthy controls and individuals with brain injury with and without impaired self-awareness. Additionally, we assessed the diagnostic accuracy of the scale using receiver operating characteristic curve analysis, which revealed optimal sensitivity and specificity. Notably, individuals with impaired self-awareness demonstrated significantly reduced accuracy in predicting their cognitive performance on complex instrumental activities of daily living compared to basic activities

of daily living, offering valuable insights into how impaired self-awareness may vary according to task complexity. Preliminary data support the Cognitive Awareness Scale for Basic and Instrumental Activities of Daily Living as feasible, valid, and clinically relevant tool for assessing impaired self-awareness across multiple cognitive-functional domains in Spanish-speaking individuals with acquired brain injury.

The second aim was to translate, culturally adapt, and validate the 10-item Weekly Calendar Planning Activity (Toglia, 2015), a novel tool for assessing multiple components of *online SA*, as well as other aspects of functional cognition like executive functions and strategy use for Spanish-speaking individuals with ABI. This instrument requires individuals to schedule a list of appointments into a weekly calendar, all while managing conflicting situations and adhering to multiple rules. It was specifically designed to simultaneously assess multiple sub-components of online self-awareness –both during, and after task performance– as well as broader functional cognitive skills like executive function and strategy use. To ensure semantic and conceptual equivalence between the translated and the original versions of the instrument, the second study (Salazar-Frías, Funes, et al., 2023) describes a rigorous cross-cultural adaptation process, adhering to guidelines from the International Society for Pharmacoeconomics and Outcomes (Wild et al., 2005) and the International Test Commission (2017).

Next, for the validation process, we established the construct validity (i.e., convergent and discriminant) of the Spanish 10-item Weekly Calendar Planning Activity by examining key outcomes –such as total strategy use, total accuracy and number of rules followed. These outcomes showed expected correlations, confirming the instrument’s convergent and discriminant validity with traditional neuropsychological tests of memory, executive function and relevant sociodemographic and clinical variables in individuals with brain injury. Regression analyses provided further insights into the cognitive processes underlying these outcomes, with total strategy used emerging as the most sensitive indicator of executive deficits. We also examined the instrument’s

incremental validity to determine its ability to predict functional outcomes beyond traditional neuropsychological measures. Hierarchical regression analysis confirmed the instrument's clinical utility, demonstrating its capacity to predict global functionality above traditional test of memory and executive function. External validity was also supported by the instrument's ability to differentiate cognitive-functional deficits in individuals with brain injury, including those with subtle impairments, and healthy controls, even after controlling for variables like age and education. This underscores its potential as a valuable diagnostic tool for assessing the functional impact of cognitive impairments on daily life.

In the third study (Salazar-Frías et al., under review), we further examined the online self-awareness measures derived from the Spanish 10-item Weekly Calendar Planning Activity, to strengthen its use as a functional cognitive assessment for individuals with brain injury. We began by exploring potential relationships between specific sub-components of online self-awareness, like self-monitoring strategies, self-recognized errors, and estimation discrepancy with traditional cognitive tests of memory and executive function. The observed correlation patterns supported a link between online self-awareness and higher-order cognitive processes such as executive functions. Next, we assessed the instrument's ability to detect online self-awareness deficits in individuals with brain injury compared to healthy controls. The findings confirmed the instrument's external validity, with individuals with brain injury performing significantly worse than healthy controls on all measures of self-awareness. This study also provides key insights into the relationship between cognitive strategies, online self-awareness, and functional performance—a topic of significant relevance that has received relatively little attention in current clinical research. A moderation analysis revealed that better performance was significantly associated with greater strategy use among individuals with brain injury who were aware of their performance, compared to those who were not aware and to healthy controls. This finding suggests that online self-awareness significantly enhances the use

of cognitive strategies during functional cognitive performance within this clinical population.

Together, the second and third studies highlight a critical need in neuropsychology and related fields for assessment tools that capture diverse sub-components of online self-awareness, as well as other essential aspects of functional cognition, such as executive function and strategy use. By doing so, these instruments go beyond traditional cognitive tests to provide a more comprehensive picture of an individual's functional capacity. This approach is of high relevance to rehabilitation professionals as it enables the development of targeted interventions that address both cognitive and functional needs, ultimately improving patient outcomes in everyday life. Moreover, these studies address a critical gap in culturally relevant tools by advancing ecologically valid, Spanish-adapted assessments tailored for Spanish-speaking individuals with brain injury.

The third aim was to develop and evaluate the efficacy of a novel, occupation-based cognitive intervention designed to improve online self-awareness and related cognitive processes –such as executive function and strategy use– in order to enhance functional outcomes for individuals with brain injury. Building on our findings and previous research highlighting the importance of executive function and strategy use for self-awareness, the intervention presented in the fourth study (Salazar-Frías et al., 2024) was specifically designed to target these processes. To maximize effectiveness, we combined evidence-based approaches, selecting methods known to be effective while accounting for their strengths and limitations. The study used a single-case changing-criterion design, with a baseline, three-level intervention, and post-intervention phases. In intervention sessions, an individual with traumatic brain injury was trained to perform two activities –making a sandwich and setting the table– while receiving structured feedback (i.e., verbal and video-feedback). Task demands were gradually increased to foster the individual's executive functioning and online self-awareness, including

anticipatory awareness, self-monitoring, self-regulation, and self-evaluation skills. Learning was systematically supported through targeted prompts and reflective questions during and after each task. This approach enabled the individual to develop strategies and self-monitoring skills through experiential learning from errors, ultimately fostering the ability to transfer these skills to new contexts involving novel stimuli and untrained tasks.

The results demonstrated a significant decrease in errors during post-intervention performance compared to baseline levels. Most errors identified in the early intervention sessions were successfully corrected in subsequent sessions and generalized to tasks that involve novel distractions and conflicting situations, as well as to untrained tasks. Notably, several improvements were maintained one month after the intervention, indicating that this approach is a promising strategy for addressing executive and metacognitive deficits following brain injury. These findings provide new empirical evidence for the effectiveness of an occupation-based intervention aimed at enhancing executive and metacognitive skills to improve functional performance. While the clinical implications are preliminary and further validation through single-case experimental designs or randomized controlled trials is warranted, the results suggest that integrating these intervention strategies into functionally relevant activities and contexts may enhance executive function and online self-awareness skills, effectively addressing functional limitations.

Overall, the findings of this thesis enhance our understanding of the complex nature of self-awareness and the factors contributing to its deficits after acquired brain injury. Addressing self-awareness effectively begins with the use of appropriate assessment tools for both of its components: metacognitive knowledge and online self-awareness. This research focused on identifying and addressing these components by adapting, validating, and developing novel, theory-driven assessment and intervention strategies within the context of everyday tasks. The instruments presented in the first three

studies facilitate the recording, observation, and analysis of performance, which is crucial for identifying functional and cognitive deficits. They also shed light on how different components of self-awareness interact with contextual, cognitive, and task-related factors, influencing both the expression of deficits and performance in activities of daily living. The data gathered from these instruments provide a solid foundation for effective intervention planning. This thesis emphasizes the importance of tailored intervention protocols that adjust activities and environmental demands to maximize functional outcomes. By fostering self-awareness and strategic use, these interventions promote the generalization of skills across various tasks and contexts, ultimately enhancing daily functioning and quality of life.

Resumen

El daño cerebral adquirido es una de las principales causas de discapacidad en todo el mundo y, a menudo provoca déficits cognitivos que afectan a la capacidad de una persona para realizar las actividades de la vida diaria. Estos déficits suelen requerir rehabilitación cognitiva, sin embargo, su progreso a menudo se ve obstaculizado por la falta de conciencia del individuo sobre sus propios déficits. Si bien puede haber cierta mejora en la conciencia durante los primeros meses posteriores de la lesión, algunas personas permanecen ajenas a sus déficits incluso años después. Para abordar estas dificultades, se han propuesto modelos como el Modelo Dinámico de Conciencia (Toglia y Kirk, 2000). Este modelo concibe la autoconciencia como un proceso dinámico con dos componentes principales: el conocimiento metacognitivo, que incluye las creencias y percepciones sobre las propias habilidades y limitaciones; y la autoconciencia en línea, un proceso específico de la tarea activado inmediatamente antes, durante y después de la ejecución de la tarea, que incluye componentes como la evaluación de la tarea, el auto-monitoreo, la auto-regulación y la capacidad para evaluar con precisión el rendimiento propio y reconocer las discrepancias entre los resultados esperados y los reales. El

modelo también enfatiza una relación dinámica entre el propio conocimiento, las demandas de la tarea, el contexto de la situación y diversas habilidades metacognitivas.

La naturaleza multifacética de la autoconciencia resalta la necesidad de contar con herramientas de evaluación que evalúen tanto el conocimiento metacognitivo como la autoconciencia en línea dentro del mismo dominio funcional. Este tipo de herramientas permitiría a los clínicos identificar componentes específicos de la autoconciencia que pueden verse afectados en personas con daño cerebral adquirido. Esto también es crucial para profundizar en la comprensión de los procesos cognitivos involucrados en la autoconciencia y facilitar el desarrollo de intervenciones de rehabilitación cognitiva basadas en evidencia para remediarlos. Aunque se reconoce ampliamente la importancia de abordar estos déficits, aún no existe consenso sobre los métodos más efectivos para su evaluación y tratamiento. Esta tesis tiene como objetivo ampliar el conocimiento, la evaluación y las técnicas de intervención dirigidas a los diferentes componentes de la autoconciencia y los procesos cognitivos que la sustentan en personas con daño cerebral adquirido. Para lograr este objetivo, se enfatiza la integración de la investigación de laboratorio con aplicaciones prácticas a través de estrategias innovadoras que abordan los déficits de autoconciencia en tareas de la vida cotidiana. Con esta finalidad, se realizaron cuatro estudios orientados a abordar tres objetivos específicos:

El primer objetivo fue validar la *Escala de Conciencia Cognitiva para Actividades Básicas e Instrumentales de la Vida Diaria*, un nuevo instrumento de discrepancia auto-proxy desarrollado en nuestro laboratorio para evaluar el componente metacognitivo de la autoconciencia en diversos dominios cognitivos y contextos cotidianos, específicamente en personas españolas con daño cerebral adquirido. En el primer estudio (Salazar-Frías, Rodríguez-Bailón, et al., 2023), se estableció la validez convergente al comparar nuestra escala con el reconocido *Índice de Competencia del Paciente* (Prigatano et al., 1998), lo cual mostró una correlación alta tanto con la escala

total como con sus subescalas. Para profundizar en el acuerdo entre ambas escalas, realizamos un análisis de Bland-Altman, que evidenció un excelente nivel de acuerdo y confirmó la fiabilidad y reproducibilidad de nuestra escala para su uso clínico. La validez externa se corroboró mediante la capacidad de la escala para diferenciar entre controles sanos y personas con daño cerebral, con y sin déficits de autoconciencia. Además, se evaluó la precisión diagnóstica de la escala mediante un análisis de curva ROC, revelando sensibilidad y especificidad óptimas. Un hallazgo relevante fue que las personas con déficits de autoconciencia mostraron una precisión significativamente menor al predecir su rendimiento en actividades instrumentales complejas, en comparación con las actividades básicas de la vida diaria, lo que aporta información valiosa sobre cómo los déficits de autoconciencia pueden variar según la complejidad de la tarea. Estos datos preliminares respaldan la *Escala de Conciencia Cognitiva para Actividades Básicas e Instrumentales de la Vida Diaria* como una herramienta viable, válida y clínicamente relevante para evaluar los déficits de autoconciencia en diversos dominios cognitivo-funcionales en personas españolas con daño cerebral adquirido.

El segundo objetivo fue traducir, adaptar culturalmente y validar la prueba Weekly Calendar Planning Activity de 10 ítems (Toglia, 2015) para personas españolas con daño cerebral adquirido. Esta prueba requiere que los participantes organicen una lista de citas en un calendario semanal, mientras gestionan situaciones conflictivas y se adhieren a múltiples reglas. Su diseño permite evaluar simultáneamente múltiples subcomponentes de la autoconciencia en línea durante y después de la tarea, además de otras habilidades cognitivas, como las funciones ejecutivas y el uso de estrategias. Para garantizar la equivalencia semántica y conceptual entre la versión traducida y el instrumento original, el segundo estudio (Salazar-Frías, Funes, et al., 2023) describe un riguroso proceso de adaptación transcultural, siguiendo las guías de la International Society for Pharmacoeconomics and Outcomes (Wild et al., 2005) y la International Test Commission (2017). Para validar la versión española, establecimos la validez de constructo (convergente y discriminante) de la prueba examinando medidas clave como el uso total

de estrategias, precisión y número de reglas seguidas. Los resultados mostraron correlaciones acordes con lo esperado, confirmando la validez convergente y discriminante del instrumento en relación con pruebas cognitivas tradicionales de memoria, funciones ejecutivas y variables sociodemográficas y clínicas relevantes. Los análisis de regresión profundizaron en los procesos cognitivos subyacentes, destacando el uso de estrategias como el indicador más sensible de déficits ejecutivos. También evaluamos la validez incremental de la prueba para determinar su capacidad de predecir el desempeño funcional más allá de las pruebas cognitivas tradicionales, con análisis de regresión jerárquica que confirmaron su utilidad clínica al predecir la funcionalidad global por encima de las pruebas de memoria y función ejecutiva. La validez externa también se respaldó, ya que el instrumento fue capaz de diferenciar los déficits cognitivo-funcionales entre personas con daño cerebral y controles sanos, incluso después de ajustar variables como la edad y el nivel educativo, subrayando su potencial como herramienta diagnóstica para evaluar el impacto funcional de los déficits cognitivos en la vida diaria.

En el tercer estudio (Salazar-Frías et al., en revisión), profundizamos en las medidas de autoconciencia en línea derivadas de la versión española de la prueba para fortalecer su uso como evaluación cognitiva funcional en personas con daño cerebral. Se exploraron las posibles relaciones entre subcomponentes específicos de autoconciencia en línea, como el auto-monitoreo, los errores auto-reconocidos y las discrepancias de estimación, en comparación con pruebas cognitivas tradicionales de memoria y función ejecutiva. Los patrones de correlación respaldaron un vínculo entre la autoconciencia en línea y los procesos ejecutivos. Después, evaluamos la capacidad del instrumento para detectar déficits de autoconciencia en línea en personas con daño cerebral frente a controles sanos, con hallazgos que confirmaron la validez externa del instrumento: las personas con daño cerebral mostraron un rendimiento significativamente inferior en todas las medidas de autoconciencia. Este estudio también arrojó información valiosa

sobre la relación entre estrategias cognitivas, autoconciencia en línea y desempeño funcional, un tema de gran relevancia que ha recibido poca atención en la investigación clínica actual. Un análisis de moderación reveló que un mayor uso de estrategias estaba asociado con un mejor rendimiento entre las personas con daño cerebral conscientes de su desempeño, en comparación con quienes no eran conscientes y los controles sanos. Este hallazgo sugiere que la autoconciencia en línea mejora significativamente el uso de estrategias cognitivas en el rendimiento cognitivo funcional de esta población clínica.

En conjunto, el segundo y tercer estudio subrayan la necesidad en neuropsicología y campos afines de contar con herramientas de evaluación que capturen diversos subcomponentes de la autoconciencia en línea y otros aspectos críticos de la cognición funcional, como las funciones ejecutivas y el uso de estrategias. Estos instrumentos van más allá de las pruebas cognitivas tradicionales, proporcionando una visión integral de la capacidad funcional del individuo, lo que es altamente relevante para los profesionales de la rehabilitación, al facilitar el desarrollo de intervenciones que aborden necesidades tanto cognitivas como funcionales y mejoren los resultados de los pacientes en la vida diaria. Además, estos estudios abordan una brecha importante al avanzar en herramientas culturalmente relevantes para el ámbito hispanohablante, ofreciendo evaluaciones ecológicamente válidas.

El tercer objetivo fue desarrollar y evaluar la eficacia de una intervención cognitiva diseñada para mejorar la autoconciencia en línea y los procesos cognitivos relacionados, como las funciones ejecutivas y el uso de estrategias, con el fin de optimizar el desempeño funcional en personas con daño cerebral. Basándonos en nuestros hallazgos y en investigaciones previas que destacan la importancia de las funciones ejecutivas y el uso de estrategias para la autoconciencia, la intervención presentada en el cuarto estudio (Salazar-Frías et al., 2024) fue diseñada específicamente para abordar estos procesos. Para maximizar la eficacia, combinamos enfoques basados en evidencia, seleccionando métodos que han demostrado ser efectivos, considerando sus fortalezas

y limitaciones. El estudio utilizó un diseño experimental de caso único con criterios cambiantes, que incluyó tres fases: línea base, intervención de tres niveles y post-intervención. Durante las sesiones de intervención, se entrenó a una persona con traumatismo craneoencefálico para que realizara dos actividades: hacer un sándwich y poner la mesa, mientras recibía retroalimentación estructurada. Las exigencias de las tareas se incrementaron gradualmente para trabajar las funciones ejecutivas y la autoconciencia en línea, incluyendo habilidades de conciencia anticipatoria, auto-monitoreo, auto-regulación y auto-evaluación. El aprendizaje fomentó de manera sistemática mediante indicaciones específicas y preguntas durante y después de cada tarea. Este enfoque permitió a la persona desarrollar estrategias y habilidades de auto-monitoreo a través del aprendizaje experiencial a partir de errores, fomentando su capacidad de transferir estas habilidades a nuevos contextos que involucraron estímulos novedosos y tareas no entrenadas.

Los resultados demostraron una disminución significativa de errores durante el rendimiento post-intervención en comparación con la línea base. La mayoría de los errores identificados en las primeras sesiones de intervención se corrigieron con éxito en sesiones posteriores y se generalizaron a tareas que implicaban distracciones y situaciones conflictivas nuevas, así como a tareas no entrenadas. Notablemente, varias mejoras se mantuvieron un mes después de la intervención, lo que indica que este enfoque es una estrategia prometedora para abordar los déficits ejecutivos y metacognitivos tras un daño cerebral. Estos hallazgos proporcionan nueva evidencia empírica sobre la efectividad de una intervención orientada a mejorar las habilidades ejecutivas y metacognitivas para optimizar el rendimiento funcional. Si bien las implicaciones clínicas son preliminares y se requiere una mayor validación a través de más estudios con diseños experimentales de caso único o ensayos controlados aleatorizados, los resultados sugieren que integrar estas estrategias de intervención en

actividades y contextos funcionalmente relevantes puede mejorar las habilidades de función ejecutiva y autoconciencia en línea, mejorando el desempeño funcional.

En general, los hallazgos de esta tesis enriquecen nuestra comprensión de la compleja naturaleza de la autoconciencia y de los factores que contribuyen a sus déficits después de un daño cerebral adquirido. Abordar la autoconciencia de manera efectiva comienza con el uso de herramientas de evaluación adecuadas para ambos componentes: el conocimiento metacognitivo y la autoconciencia en línea. Esta investigación se centró en abordar estos componentes mediante la adaptación, validación y desarrollo de estrategias de evaluación e intervención fundamentadas en teorías, en el contexto de las tareas cotidianas. Los instrumentos presentados en los primeros tres estudios facilitan el registro, la observación y el análisis del rendimiento, lo cual es crucial para identificar déficits funcionales y cognitivos. También arrojan luz sobre cómo diferentes componentes de la autoconciencia interactúan con factores contextuales, cognitivos y relacionados con la tarea, influyendo tanto en la expresión de los déficits como en el rendimiento en actividades de la vida diaria. Los datos recopilados a partir de estos instrumentos proporcionan una base sólida para la planificación de intervenciones efectivas. Esta tesis enfatiza la importancia de protocolos de intervención personalizados que ajusten las actividades y las demandas ambientales para maximizar los resultados funcionales. Al fomentar la autoconciencia y el uso de estrategias, estas intervenciones promueven la generalización de habilidades a través de diversas tareas y contextos, mejorando el funcionamiento diario y la calidad de vida.

Part I: Introduction

Chapter 1

Cognition and everyday functioning

1.1 The role of participation, occupation and cognition in achieving functional independence

The ability to perform everyday activities is a critical factor in determining an individual's level of independence, quality of life and participation. According to the International Classification of Functioning, Disability, and Health (World Health Organization, 2024) participation is defined as “*involvement in a life situation*” and includes the concepts of personal independence as well as social and community integration. When individuals engage in occupations they find meaningful and enjoyable, they are more likely to experience a sense of competence and independence and a desire to participate fully in society (Klepo et al., 2022). The term **activities of daily living** (ADL) collectively refers to those activities essential for daily functioning and independent living (Edemekong et al., 2019). These activities are classified as **basic activities of daily living** (BADL), which include tasks that individuals perform to maintain their health and well-being, such as eating, dressing, moving, and personal hygiene tasks like bathing, grooming, or brushing teeth (Legg et al., 2017). **Instrumental activities of daily living** (IADL) involve tasks that typically require interacting with one's environment to obtain goods and services, essential for functioning within the community. These tasks can be

more physically demanding than BADL, such as walking the dog or taking out the garbage. IADL also encompass cognitively demanding activities that involve sequencing steps, multitasking, and integrating various cognitive functions. These are often referred to as **cognitive IADL** (C-IADL, Toglia & Foster, 2022). Simple C-IADL, like making coffee or preparing a basic meal, are typically familiar and straightforward. In contrast, more complex C-IADL, such as shopping, organizing schedules, or managing finances, are less structured and require advanced multitasking, real-time problem-solving, and planning skills (Giles et al., 2019; Poncet et al., 2017; Toglia & Foster, 2022)

Many individuals with brain-related disorders experience cognitive impairments that interfere with their ability to perform ADL. In fact, research is converging to show that cognitive impairments may be a more significant predictor of rehabilitation outcomes and long-term functional impairment than physical disability after brain injury (Patel et al., 2002; Watson et al., 2020; Whyte et al., 2011). Additionally, evidence suggests a hierarchy of functional impairment in ADL during the recovery process. While most individuals regain independence in BADL, such as dressing, toileting, and transferring, during the early stages of recovery, many –particularly those with moderate to severe brain injury– continue to face challenges with more complex C-IADL, such as managing finances (Bottari et al., 2011; Dreer et al., 2012), driving (Bassingthwaight et al., 2024; Erler et al., 2018; Rapport et al., 2008), grocery shopping (Bottari et al., 2014; Giles et al., 2019), or meal preparation (Dubuc et al., 2019) even up to 10 years after ABI (Nelson et al., 2019; Ponsford et al., 2014; Tate et al., 2020; Wilson et al., 2017). Furthermore, research has shown that ABI and associated cognitive deficits contribute to reduced engagement in *leisure activities* (Trevorrow et al., 2024), *community participation* (Goverover et al., 2017; Kersey et al., 2020), and difficulties in returning to *work* (Scaratti et al., 2017).

1.2 The relevance of functional cognition to neuropsychological practice

Understanding how cognitive deficits impact daily functioning is crucial for selecting effective intervention protocols that enhance functional independence and psychological well-being in individuals with brain-related impairments. Apart from the multiple sensory, motor and social demands, performing ADL requires a broad range of cognitive processes. These processes enable individuals to interact with multiple objects simultaneously, process and prioritize information, sequence action steps, and adapt strategies to novel situations and challenges (Doig et al., 2017; Marcotte et al., 2022; Woods, 2021, see **Figure 1.1** for an example).

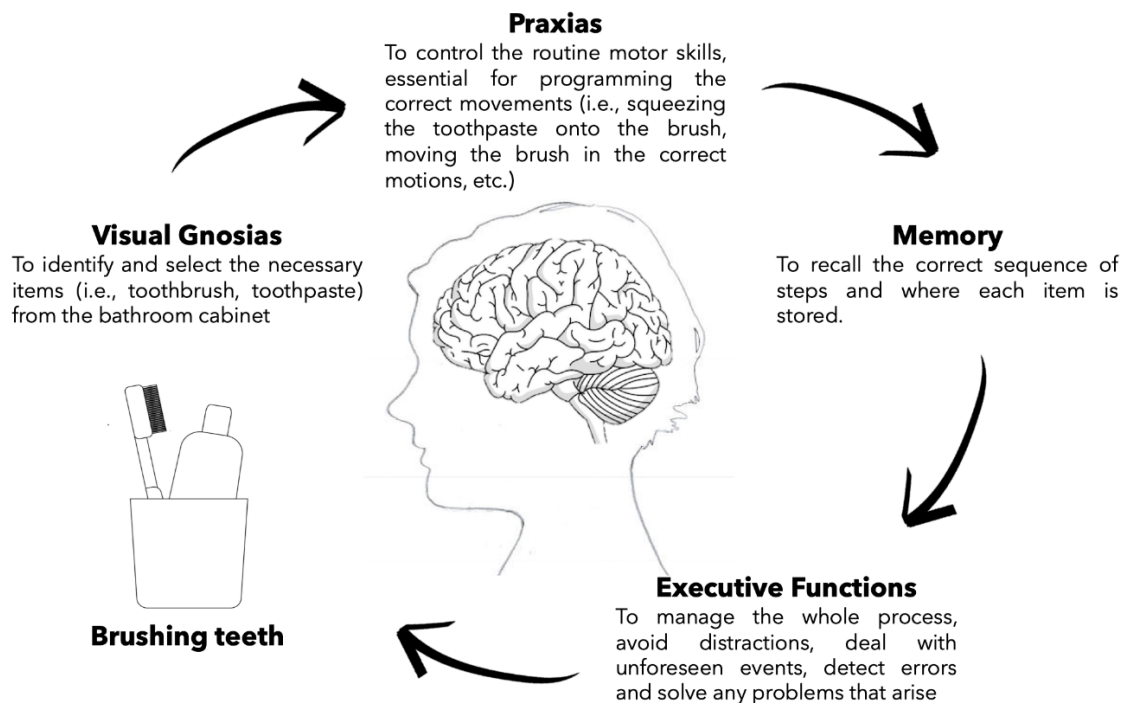


Figure 1.1 Example of the cognitive processes involved in brushing teeth

In recent years, a growing body of research has explored the complex dynamics between cognitive processes and ADL in individuals with different brain-related impairments (Baum et al., 2023; Chudoba & Schmitter-Edgecombe, 2020; Divers et al., 2021; Giovannetti et al., 2008; Lau et al., 2022; Schmitter-Edgecombe et al., 2021; Toggia,

2015). In this context, the term functional cognition has emerged as a “top-down” construct that integrates information from fields like occupational therapy and neuropsychology. Giles et al. (2020) define functional cognition as “*the cognitive ability to perform everyday tasks, conceptualized as incorporating metacognition, **executive function** (EF), other domains of cognitive functioning, and performance skills*”. As such, functional cognition can be considered as an implicit indicator of an individual’s ability to apply cognitive processes in real-life contexts.

From this perspective, even seemingly simple everyday tasks –such as brushing teeth or showering– demand the integration of multiple cognitive processes. For instance, memory deficits may disrupt the recall of the correct sequence of steps, initiation deficits may hinder moving from one step to the next, inhibition deficits may lead to easy distraction, and metacognitive deficits may impair the detection of errors and the evaluation of performance. The relevance and level of involvement of these cognitive functions can vary significantly between BADL and IADL, affecting performance differently. For example, many individuals with brain-related impairments may be fully independent in routine tasks like brushing their teeth or showering, yet face challenges with more complex activities–such as cooking, coordinating a series of errands, or managing finances–that demand higher-level skills in planning, monitoring, decision-making, and problem-solving (Toglia & Foster, 2022).

In line with this idea, another body of research has contributed valuable insights into developing theoretical frameworks that explain how different cognitive profiles contribute to functional difficulties in everyday life (Giovannetti et al., 2021). Notably, studies by Giovannetti et al. (2006, 2008, 2012) on individuals with different types of dementia have established a framework for distinguishing between two categories of everyday action errors –omission and commission– and examining their association with different cognitive processes. *Omission errors*, defined as the failure to perform necessary actions, are linked to deficits in general cognitive functioning and episodic memory. In

contrast, *commission errors* involve performing incorrect actions, such as violating the correct sequence of steps, substituting one object for another, or repeating a step. According to these authors, *commission errors* are more closely associated with deficits in EF. Similarly, Morady and Humphreys (2009) explored how the introduction of semantically related distractors affected error types during ADL in an individual with brain injury and action disorganization syndrome –a condition described by Schwartz et al. (1991) as involving difficulties in performing multi-step tasks unrelated to motor deficits. Their findings showed that the presence of these distractors increased the proportion of omission errors, while commission error rates remained stable. This suggests that an individual's ability to perform everyday activities depends not only on underlying cognitive processes but also on task-specific factors, such as the novelty of the activity's demands and the inclusion of distractions, as suggested by Skidmore (2017) and Curiel Cid et al. (2022). Thus, to enhance the prediction of functional performance and inform effective interventions, further research is needed to clarify the cognitive processes underlying performance deficits. Additionally, studies should explore how factors like task demands and contextual characteristics influence these outcomes.

1.3 Traditional versus ecologically valid neuropsychological assessment: which tests are more effective in predicting functional performance?

Clinicians and researchers in neuropsychology have traditionally relied on cognitive test results as key indicators of daily functioning in individuals with brain-related disorders. These tests are designed using artificial and unfamiliar materials to reduce the influence of prior experience, thereby enabling the precise identification of deficits in specific cognitive processes like attention, memory, and EF. While these measures are well-established predictors across various functional domains (Egeto et al., 2019; Hoskin et al., 2005; Krynicki et al., 2023) and have demonstrated correlations with measures of functional performance (Amanzio et al., 2018; Aretouli & Brandt, 2010; Bangen et al., 2010; Farley et al., 2011; Lipskaya-Velikovsky et al., 2018), they fail to account for all the

variance in behavior in real-world environments (Chaytor et al., 2006; Royall et al., 2007; Skidmore, 2017). In fact, recent findings by Baum et al. (2023) challenge the assumption that cognitive abilities measured by traditional cognitive tests can predict functional performance, offering compelling evidence for recognizing *functional cognition* as a distinct construct, separate from EF and both fluid and crystallized cognition.

In this regard, some authors are calling for a paradigm shift in how we measure cognitive abilities related to everyday tasks, advocating for a *function-based approach* that moves from focusing on abstract constructs to real-world functions (Burgess et al., 2006; Curiel Cid et al., 2022; Giovannetti et al., 2021; Marcotte et al., 2022; Robertson & Schmitter-Edgecombe, 2016; Ruff, 2003; Toglia & Foster, 2022). In response, neuropsychologists and occupational therapists have developed various *function-based tests* that attempt to more accurately assess functional cognition. Examples of these tests include the Multiple Errands Test (MET; Shallice & Burgess, 1991) and its variants (MET-home; Burns et al., 2020; MET-hospital; Knight et al., 2002), the Cooking Task (Chevignard et al., 2000), the Menu Task (MT; Marks et al., 2021), or the Executive Function Performance Tests (EFPT; Baum et al., 2008), among others (see Romero-Ayuso et al. 2021 for a recent review). These tests involve familiar IADL multitasking tasks that are comparable to those encountered in real-world, such as shopping at a mall or grocery store, making toast and coffee, wrapping a gift, packing a travel bag or making a cup tea. Performance on these tasks may be influenced by the individual's awareness, use of strategies, and previously acquired skills, offering a broader understanding of their capacity to engage in everyday activities (Marks et al., 2021). **Table 1.1** summarizes the key differences between the traditional and the function-based approaches.

According to Baum et al. (2023), function-based approaches to assessment originated from the concept of **ecological validity** proposed by Brunswik (1955) which refers to it as testing that is representative of real-world performance requiring multitasking that occurs in unrestricted environments. However, *ecological validity*

remains a controversial construct in current studies of naturalistic tests, largely due to the lack of consensus on its definition and its operationalization (see Pinto et al., 2023; Suchy, DesRuisseaux, et al., 2024; Suchy, Mora, et al., 2024, for recent reviews). Considering the above literature, it's important to define *ecological validity* as a multidimensional construct with two main dimensions: *veridicality* and *verisimilitude*¹.

Table 1.1 Summary of the differences between traditional and function-based approaches to assessment (Adapted from Gillen and Raphael-Greenfield, 2020)

Traditional assessments	Function-based assessments
• Use novel/artificial tasks to document the presence or absence of specific impairments in attention, memory, executive function, etc. • Examples of tools include: MMSE, MoCA, RAVLT, WCST, COWAT, and TMT. • Examples of included tasks are: trail making, clock drawing, naming animals, remembering lists of words, citing number strings, or spelling backward. • Performed in laboratory or clinical settings to control for distractions. • Requires single or dual tasking.	• Use familiar real-world to assess multiple functional cognitive processes that support or limit performance. • Examples of tools include: MET, MT, Cooking Task, EFPT • Examples of included tasks are: shopping at a mall, making toast and coffee, wrapping a gift, packing a travel bag, or making a cup tea. • Performed in simulated, or natural contexts such as kitchens, malls, etc. • Requires multitasking.

MMSE, Mini Mental State Examination; MoCA, Montreal Cognitive Assessment; RAVLT, Rey Auditory Verbal Learning Test; WCST, Wisconsin Card Sorting Test; COWAT, Controlled Oral Word Association Test; TMT, Trail Making Test; MET, Multiple Errands Test; MT, Menu Task; EFPT, Executive Function Performance Tests

¹ These concepts are also referred to as, *generalizability* and *representativeness*, respectively by Burgess et al. (2006).

Veridicality refers to a test's ability to predict or generalize to real-world functioning. *Verisimilitude*, includes both *content validity* –for example, when a test is developed considering the theoretical relationship between the demands of the test and the construct that is being assessed (e.g., a test of EF adequately covers the intended construct, such as the need to multitask, planning, and spontaneously initiate and terminate actions)– and *face validity*, which refers to the extent whether a test resembles real-world scenarios (e.g., the test is performed in a kitchen and requires the use of kitchen utensils) (Suchy, Mora, et al., 2024). *Verisimilitude* has become a popular approach in neuropsychology and occupational therapy, contributing to the development of instruments that closely resemble real-world tasks. It has been argued that because these instruments are administered in environments that mimic or reflect real-life situations, they enhance the ability to infer real-world performance from test results, thereby offering greater ecological validity compared to traditional cognitive measures (Spooner & Pachana, 2006).

However, despite their real-world resemblance, tests based on verisimilitude cannot automatically be assumed to predict daily functioning (i.e., have *veridicality*). Two recent critical reviews by Suchy, Mora, et al. (2024) and Suchy, DesRuisseaux, et al. (2024) highlight significant inconsistencies in the evidence supporting the *ecological validity* of tests designed to simulate real-world activities and predict everyday functioning. Many of the studies reviewed fail to meet essential criteria due to methodological limitations and insufficient statistical rigor. For example, several studies base their claims not on functional outcomes, but on correlations with other cognitive tests (i.e., demonstrating construct validity; Doherty et al., 2015; Raspelli et al., 2011) or on correlations between virtual and real version of the same tasks (Besnard et al., 2016; Nir-Hadad et al., 2017; Rand et al., 2009). Additionally, most studies fail to control for the potential impact of multiple comparisons or confounding variables such as age and education, which are known to affect both test performance (Cortés Pascual et al., 2019) and daily functioning

(Mlinac & Feng, 2016). Furthermore, a substantial portion of the studies rely on small sample sizes (30 or less participants) which leads to unstable and inflated correlation coefficients that are difficult to replicate. As detailed by Suchy, Mora, et al. (2024), only a small proportion of studies claiming to demonstrate the ecological validity have adequately addressed it by examining its association with *functional outcomes* and using sufficiently *large samples* (Kenworthy et al., 2020; Renison et al., 2012; Schmitter-Edgecombe et al., 2021; Siu & Zhou, 2014; Tiznado et al., 2021).

In this context, a *key challenge* is the need for greater scientific rigor in research aimed at establishing the ecological validity of cognitive tests designed to simulate real-world activities. Future studies should employ larger sample sizes and control for potential confounding variables, such as age and education, while also accounting for the effects of multiple comparisons. Additionally, more advanced statistical techniques, such as incremental validity analyses using regression models, are essential to assess whether new test scores improve the prediction of functional outcomes beyond traditional cognitive tests (Suchy, Mora, et al., 2024). To further strengthen clinical studies, methods such as receiver operating characteristic (**ROC**) curve analysis, logistic regression, and discriminant function analysis should be applied. These approaches provide estimates of sensitivity, specificity, and positive and negative predictive values, enabling clinicians to more accurately identify individuals with and without functional impairments through cognitive assessments (Marcotte et al., 2022).

More importantly, most tests designed to simulate real-world activities have been developed in English-speaking countries, and few have been translated, adapted, or validated for use in other cultural contexts. Consequently, a *second challenge* for clinical professionals in non-English-speaking countries is the translation and adaptation of ADL-based assessment instruments, using methodologies that account for psychological, linguistic, and cultural factors to be considered (Alves et al., 2021; Sireci et al., 2006; Wild et al., 2005). Given that ADL performance has been shown to be strongly influenced by

cultural factors (Alves et al., 2021; Jang & Kawachi, 2019), these instruments must be systematically adapted and validated to ensure a proper cultural fit, allowing for their effective use across different cultural contexts (Borsa et al., 2012; Sireci et al., 2006). Moreover, cultural adaptation studies facilitate the comparison of data within both national and international scientific communities (Alves et al., 2021).

While questions remain about which tests most effectively predict functional performance, a major advantage of the *function-based approach* is its ability to identify several specific cognitive functions that affect daily tasks. This approach helps clinicians to better assess an individual's ability for independent living and determine the level of assistance required for task completion, providing a more comprehensive understanding of overall functioning compared to the *traditional approach* (Giovannetti et al., 2021; Romero-Ayuso et al., 2021). This facilitates communication between clinicians, patients and their families, enabling more meaningful explanations and tailored recommendations that directly address relevant questions for them, such as: “*Can I live safely alone? How much help does my familiar need to run errands or go shopping? Why is my familiar struggling to manage his medication?*” (Giovannetti et al., 2021; Marcotte et al., 2022; Ruff, 2003). Indeed, a primary reason individuals with brain-related disorders undergo neuropsychological testing is to acknowledge how these disorders affect their ability to function independently in everyday life (Ruff, 2003).

However, to truly meet the needs of our patients, we must focus on providing individualized interventions that address their unique challenges. This paradigm shift benefits not only the assessment process, but also the development of targeted interventions. Traditional neuropsychological approaches often rely on repetitive practice to remediate specific cognitive skills (Ruff, 2003; Toglia & Foster, 2022), whereas functional cognitive interventions draw from influential research in educational and cognitive psychology and emphasize learning and generalization (Feuerstein et al., 2015; Vygotsky, 1978). These interventions offer more personalized interventions by engaging

individuals in meaningful, problem-solving activities through a top-down approach aimed at improving functional performance. Extending laboratory and clinical research findings to everyday functioning is a crucial step, as embracing evidence-based science and practice is essential in the clinical field. One main aim of this thesis, along with its studies, is to contribute to this body of knowledge by providing rehabilitation professionals, such as neuropsychologists and occupational therapists, with assessment tools that can predict real-world behavior and implement tailored intervention strategies that improve daily functioning and quality of life (Lau et al., 2022; Ownsworth et al., 2006; Toglia & Goverover, 2022).

Chapter 2

Understanding self-awareness and its deficits after acquired brain injury

2.1 Self-awareness: definition and implication for functional outcomes

Acquired brain injury (ABI) is a neurological condition, recognized as a leading cause of morbidity and mortality worldwide (Brazinova et al., 2021; Feigin et al., 2022). It refers to any physical damage to the brain not caused by congenital or degenerative diseases, and can result from a variety of causes, including stroke, traumatic brain injury (TBI), cerebral infection, and brain tumors (Wallis et al., 2022). A recent meta-analysis by Tsai et al., (2021) suggested that cognitive impairments –such as deficits in memory, attention, processing speed, and EF– are common from the acute to chronic phases after moderate-to-severe brain injury and require rehabilitation treatment.

Unfortunately, the rehabilitation process and functional recovery are hindered when individuals exhibit *reduced self-awareness* (SA) of their deficits (Bivona et al., 2019; S. K. W. Cheng & Man, 2006; Ciurli et al., 2010; Dromer et al., 2021b, 2021a; Mamman et al., 2022; Parker et al., 2018; Prigatano & Sherer, 2020; Schmidt & Ownsworth, 2022; Villalobos et al., 2019, 2021). Prigatano and Schacter (1991) defined SA as “*the capacity to perceive the self in relatively objective terms while maintaining a sense of subjectivity.*”

Initially, the term **anosognosia** was used to refer to the clinical condition of individuals with left hemiplegia that was accompanied by unawareness of their paralysis (anosognosia for hemiplegia). It has since been applied to describe a lack of SA of any possible symptoms derived from a neurological and/or neuropsychological condition including motor, cognitive, sensorial and psychological deficits (Dromer et al., 2021a; Prigatano, 2009). The term anosognosia is often used interchangeably throughout the literature with other terms such as *poor awareness*, *lack of awareness*, *unawareness of deficits* or **impaired self-awareness** (ISA)² (Sansonetti et al., 2021).

Research shows that ISA is a common problem in individuals with ABI, occurring in 54-73% of individuals in the first 6 months after severe TBI (Geytenbeek et al., 2017) and in 52% of individuals after stroke (Hartman-Maeir et al., 2003). While SA may improve in the first few months, some individuals remain unaware of their problems years after ABI (Kelley et al., 2014; Vanderploeg et al., 2007). Clinically, ISA can be understood as a deficit characterized by difficulty recognizing impairments that causes individuals to make behavioral choices and experience reactions that negatively affect daily functioning (Prigatano & Sherer, 2020; Toglia & Kirk, 2000). This includes ceasing active engagement in self-care activities, struggling to maintain interpersonal relationships, failing to achieve and sustain a productive life, or attempting activities beyond their capabilities (Toglia & Foster, 2022). Further, ISA has been associated with a wide range of negative clinical outcomes, and poor rehabilitation results (Amanzio et al., 2020; Dromer et al., 2021a, 2021b), including reduced goal setting behavior, decreased motivation, and lower commitment to treatment (Di Somma & Fleming, 2024). Families sometimes worry about their familiar with ABI attempting tasks without recognizing their limitations, such as leaving the oven on while cooking or getting lost while running an errand, which can significantly increase caregiver burden (Cheng et al., 2024). Not only do these conditions

² We will consistently refer to this condition as ISA throughout this thesis.

contribute to negative mental health outcomes, such as poor life satisfaction, social isolation, increased depressive symptoms, and identity issues (Bassingthwaight et al., 2024; Blömer et al., 2015; Liddle et al., 2012), but also results in a significant long-term economic burden. This includes costs associated with the need for caregiver assistance with everyday activities, loss of productivity, and loss of income (Kersey et al., 2020).

2.2 Theoretical frameworks and components of self-awareness

Different theoretical frameworks have been proposed in order to better explain and understand SA and its deficits in individuals with ABI. One of the most influential models is that proposed by Crosson et al. (1989), which uses a pyramid to illustrate three interdependent hierarchical levels of SA (see **Figure 2.1**):

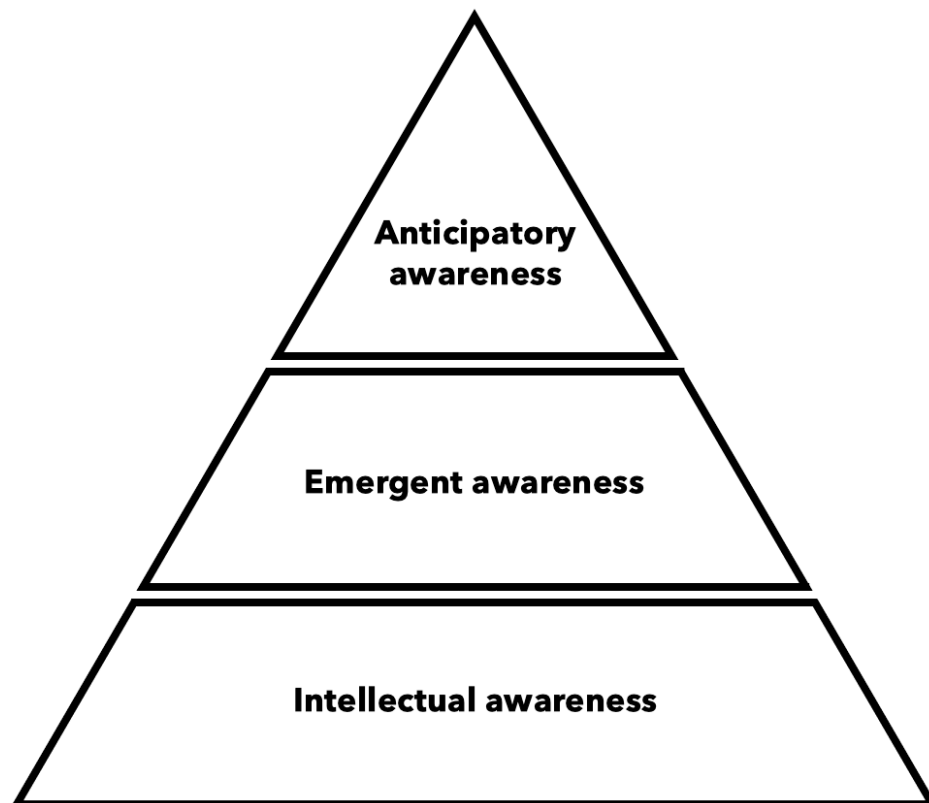


Figure 2.1 Pyramid Model of Awareness by Crosson et al. (1989).

1. *Intellectual awareness*: the base level, which involves an individual's ability to recognize that a particular deficit exists (e.g., impaired attention) and understand its consequences (e.g., difficulty to complete simple tasks and to follow instructions).
2. *Emergent awareness*: the second level, which involves an individual's ability to monitor ongoing performance, and thus be able to identify problems or errors as they occur.
3. *Anticipatory awareness*: the top level, which involves an individual's ability to predict that a difficulty or problem will occur because of the existing deficit.

The Pyramid Model suggests that SA is not an all-or-none condition, with each higher level relying on those below it (Crosson et al., 1989). Consequently, an individual must have intact intellectual and emergent awareness to understand the broader implications of their deficits and anticipate future problems related to their performance of functional tasks. Although the hierarchy between levels has been questioned (Abreu et al., 2001), the model's key contribution lies in its ability to guide the assessment, planning, and implementation of cognitive interventions, which can be targeted at the specific level affected.

A decade later, and also considering SA from a clinical perspective, Toglia and Kirk (2000) extended Crosson's pyramid model by proposing the ***Dynamic Comprehensive Model of Awareness***³ (DCMA), which emphasizes a dynamic rather than hierarchical relationship between knowledge, task demands, the context of the situation, and various metacognitive skills (Toglia & Foster, 2022; see **Figure 2.2**).

³ This model underpins the theoretical framework of this thesis

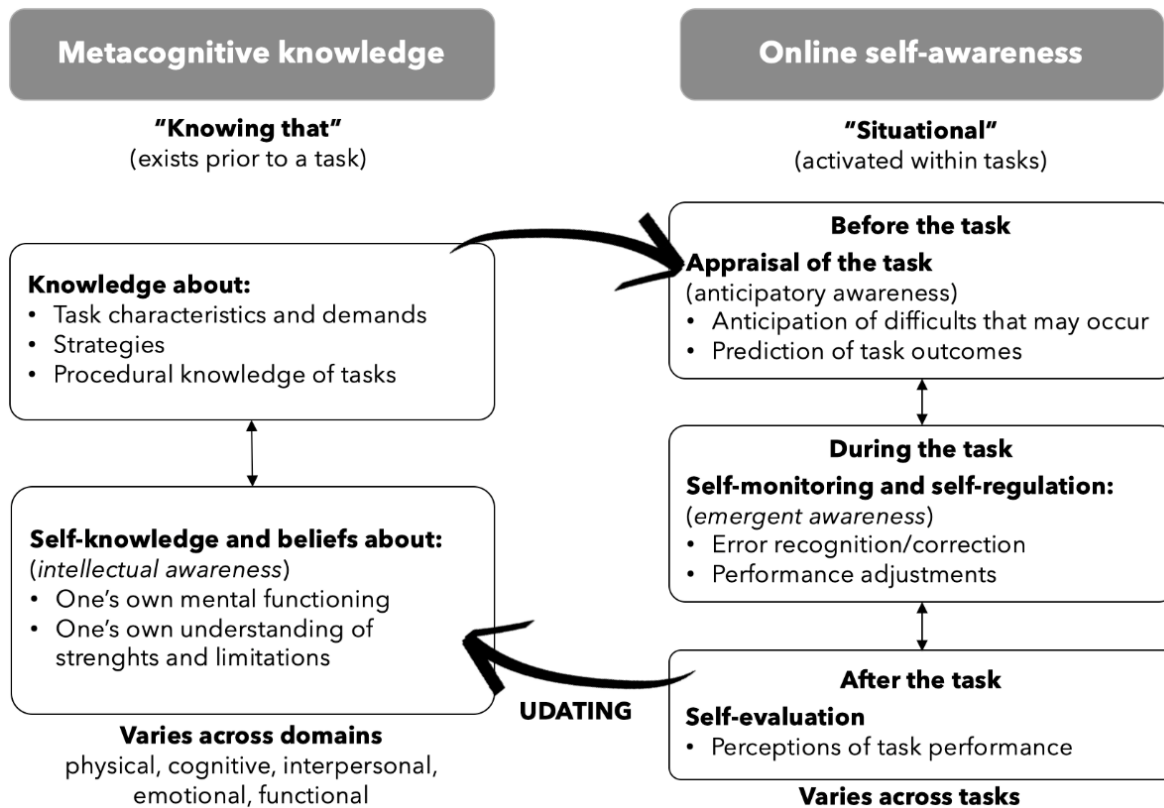


Figure 2.2 Dynamic Comprehensive Model of Awareness by Toglia & Kirk (2000). Adapted from Toglia and Goverover (2022).

The DCMA describes SA as a *multi-faceted* and *multi-domain* construct. In describing its *multi-faceted* nature, the model distinguishes between two major components. The first component, **metacognitive knowledge** or general SA –tightly coupled with intellectual awareness in Crosson’s pyramid model– includes an individual’s beliefs and perceptions about their own cognitive and non-cognitive abilities and limitations (i.e., “*I have a bad memory*”, “*I should make a shopping list so I don’t forget anything*”), as well as knowledge about task characteristics and general factors that may affect overall procedural performance (i.e., “*I’ve never ridden a motorcycle*”, “*riding a motorcycle is harder than riding a bicycle*”). This component is generally described as the SA that exists prior to performing a task, relying on pre-existing information stored in long-term memory (Toglia & Foster, 2022). The second component, **online SA** or awareness of performance, involves a set of skills activated at different stages of task

38

execution. These include **appraisal of the task**, which entails accurately assessing task demands and anticipating potential challenges *before starting* (related to *anticipatory awareness* in Crosson's pyramid model). Additionally, **self-monitoring** and **self-regulation** enable individuals to recognize and correct errors *during task performance* (related to *emergent awareness*). **Self-evaluation** involves comparing actual performance with expected outcomes *after completing the task* (Toglia & Goverover, 2022).

The DCMA emphasizes the *dynamic interaction* between both core components of SA in supporting everyday task performance. According to this model, pre-existing knowledge about one's cognitive and non-cognitive abilities, along with task characteristics stored in metacognitive knowledge, influence how individuals *appraise tasks* and select strategies during the task performance. For instance, *anticipating challenges or predicting outcomes* prior to a task can influence the perceived cognitive demands required to complete the task, such as the ability to *self-monitor* or identify effective strategies for successful completion (Merchán-Baeza et al., 2020; Palermo et al., 2014; Toglia & Foster, 2022). Effective *self-monitoring* and *self-regulation* during the task can enhance error recognition and promote self-correction, leading to successful performance and accurate self-evaluation (Doig, Fleming, & Lin, 2017; FitzGerald et al., 2017; Ownsworth et al., 2010). Finally, integrating information from task performance can update *metacognitive knowledge*, allowing adjustments in future task when discrepancies between expected and actual performance arise (Toglia & Foster, 2022).

However, an individual's ability to acknowledge their general limitations (i.e., *metacognitive knowledge*) doesn't necessarily mean they can recognize these limitations as they occur during an activity (i.e., *online awareness*), and vice versa (O'Keeffe et al., 2007; Toglia, 2018). Given the multifaceted nature of SA, it becomes clear that ISA does not follow a single neurocognitive profile, with different expressions of ISA depending on which cognitive processes are most affected (Lenzoni et al., 2020; Mograbi et al., 2009;

Owensworth et al., 2002; Prigatano, 2014; Toglia & Foster, 2022). This has led several authors to explore the specific cognitive processes underlying its deficits.

2.3 Cognitive processes involved in self-awareness: memory, executive functions and cognitive strategies

The contribution of **memory** in SA has been highlighted in the theoretical frameworks reviewed in the previous section. For instance, Crosson et al., (1989) pyramid model suggests that impaired *intellectual awareness* may result from an inability to recall past experiences, which form the foundation of self-knowledge. Similarly, Toglia and Kirk's (2000) DCMA emphasized that effective *metacognitive knowledge* relies on accurate memory skills, ensuring that information about past and recent task experiences remains integrated and up to date. The role of memory in SA has also been emphasized by other theoretical models, such as the Cognitive Awareness Model (Mograbi et al., 2009). This model proposes a memory-mediated mechanism that is essential for the accurate appraisal of one's cognitive functioning (Zimmermann et al., 2017). This form of ISA, often referred to as the "*petrified self*," has been described in the context of Alzheimer's disease and other neurodegenerative conditions affecting episodic *autobiographical memory* and *anterograde amnesia*, with memory for remote experiences remaining relatively intact and memory for more recent events being specifically impaired (Lenzoni et al., 2020; Mograbi et al., 2009).

A recent review by Lenzoni et al. (2020) emphasized that, while individuals with Alzheimer's disease can make relatively accurate predictions about their performance in objective metamemory tests (Gallo et al., 2012) or recognize errors during task execution (Bertrand et al., 2019), they have difficulties transferring this information from online performance to their "*personal database*" (i.e., metacognitive knowledge), resulting in a self-evaluation that remains stable but outdated, failing to reflect their current abilities. In support of this idea, Stewart et al. (2010) found that while individuals with Alzheimer's

disease demonstrated improved prediction accuracy in post-test compared to pre-test conditions on a memory test, their estimates returned to pre-test levels after a one-hour delay. Similarly, Ansell and Bucks (2006) reported a decrease in prediction accuracy on a memory recognition test between initial predictions and those made after a 20-minute delay. Collectively, these findings suggest that while performance monitoring may remain relatively intact, impairments may result from a failure to update new experiences, which may be a key mechanism underlying ISA in these clinical conditions. While memory has primarily been studied in the context of dementia, it also holds potential for explaining ISA in other clinical conditions. Evidence suggests a positive relationship between the metacognitive knowledge component of SA and memory in individuals with ABI, with greater metacognitive knowledge associated with improved performance on tasks like delayed free recall during verbal learning (Noé et al., 2005; Villalobos et al., 2021; Zimmermann et al., 2017).

Another cognitive domain that is strongly linked to ISA and has been more extensively studied in individuals with ABI is **EF**. Stuss (1991) introduced one of the first executive models of SA, explaining how different levels of SA are associated with different neural systems, particularly within the prefrontal cortex. The model outlines three hierarchical levels of SA, each representing increasing complexity along a bottom-up pathway. This progression culminates in the activation of neurons responsible for higher-order metacognitive-executive processes, which play a key role in the control and sequencing of behavior, as well as *self-monitoring* and *self-regulation* processes (Amanzio et al., 2020). This perspective aligns with educational and cognitive psychology models of EF, which also emphasize self-monitoring and self-regulation as core executive components (Kennedy & Coelho, 2005; Miyake et al., 2000; Schacter, 1990; Zimmerman & Labuhn, 2012). Among different models, Miyake et al. (2000) proposed that EF consists of three core processes: *updating-monitoring*, *inhibition*, and *shifting*. Notably, these processes can be encapsulated within the concept of metacognition –the ability to

regulate, evaluate, and reflect on one's own performance and knowledge (Amanzio et al., 2020).

Furthermore, theories of self-regulation posit that metacognition encompasses both knowledge and regulation of cognitive activities, along with personal beliefs that influence goal-directed behavior (Kennedy & Coelho, 2005; Zimmerman & Labuhn, 2012). According to Kennedy and Coelho (2005), when self-regulation is applied to cognition, it is termed metacognition, or "*thinking about one's thinking*", a concept that encompass metacognitive beliefs, self-monitoring, and cognitive control processes, all of which are crucial for guiding goal-directed behavior. These processes enable individuals to adapt to conflicting situations, allowing for flexible adjustments in behavior to suit the environment, selective processing of relevant task information, and the avoidance of distractions driven by irrelevant external stimuli (Fernandez-Duque et al., 2000; Roebbers, 2017; Shimamura, 2000). Within this framework, when faced with a task that differs slightly from the routine, success depends on the individual's ability to recognize what is different, monitor their performance in response, choose an appropriate strategy, and implement it effectively (Kennedy & Coelho, 2005).

The strong theoretical parallel between most SA models –especially emergent awareness and the online components– and the self-monitoring and self-regulatory processes central to traditional conceptualizations of EF has led to extensive research into executive deficits as key predictors of ISA. However, findings on this relationship have been inconsistent. While some studies have identified a clear link between both the metacognitive knowledge and online components of SA and EF in individuals with different neurological conditions (Bettcher et al., 2008; Bivona et al., 2008, 2019; Bogod et al., 2003; M. H. Chen & Goverover, 2021; Chudoba & Schmitter-Edgecombe, 2020; Ciurli et al., 2010; Hart et al., 2005; Noé et al., 2005; Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Narganes-Pineda, et al., 2024; Schmitter-Edgecombe et al., 2021;

Villalobos et al., 2021; Wise et al., 2005; Zlotnik & Toglia, 2018), others have found no significant association (Belchev et al., 2017; Chiou et al., 2011; Giovannetti et al., 2002).

Notably, research on the EF-SA relationship has largely focused on the metacognitive knowledge component of SA (Bach & David, 2006; Belchev et al., 2017; Bivona et al., 2008, 2019; Bogod et al., 2003; Caldwell et al., 2014; Ciurli et al., 2010; Hart et al., 2005; Kashiwa et al., 2005; Noé et al., 2005; Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Narganes-Pineda, et al., 2024; Villalobos et al., 2021), with fewer studies incorporating measures of *online* SA (Bettcher et al., 2008; M. H. Chen & Goverover, 2021; Chiou et al., 2011; Giovannetti et al., 2002; Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Narganes-Pineda, et al., 2024; Schmitter-Edgecombe et al., 2021). Even fewer have used performance-based ADL tasks to explore the relationship between EF and *online* SA, but they have done so in individuals with a variety of neurological conditions (Bettcher et al., 2008; M. H. Chen & Goverover, 2021; Chudoba & Schmitter-Edgecombe, 2020; Giovannetti et al., 2002). To our knowledge, only Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Narganes-Pineda, et al., (2024) have examined this relationship in individuals with ABI, underscoring the need for further research into how different components of *online* SA and EF interact in more complex, performance-based ADL tasks, particularly in this clinical population.

As previously mentioned, **strategy use** is another key aspect of *metacognition* that is essential for goal-directed behaviors (Kennedy & Coelho, 2005). Effective strategy use is crucial for normal cognitive and functional performance, as it helps to cope with complex situations (Toglia & White, 2020). In fact, using fewer or inefficient strategies has been associated with poorer functional performance in individuals with ABI. For instance, Burns et al. (2020) found that individuals with stroke who employed planning strategies performed better on the MET-Home, whereas self-monitoring, multitasking, and environmental strategies had no significant effect. Similarly, Nott and Chapparo (2020) conducted a longitudinal study showing that efficient strategy use correlated with higher

scores on global measures of functional independence and community participation in individuals with ABI. These findings underscore the importance of promoting effective strategy use to improve functional performance after brain injury (Swanton et al., 2020). Additionally, previous research has highlighted that the number of strategies used can be a significant predictor of real-world functioning (Schmitter-Edgecombe et al., 2021). It is therefore a clinical and research challenge to investigate what is needed to enable people with cognitive deficits to use effective strategies in order to carry out their daily tasks.

In this context, Toglia and White (2020) emphasize that SA and cognitive strategies are essential, flexible components of cognitive function that interact dynamically with both external and internal factors, including life experiences and personal beliefs. The strategies individuals use and their capacity for self-monitoring are not static; they are influenced by task demands, environmental features, and other contextual characteristics (Toglia, 2018). Consequently, recent research has explored into the various sub-components of online SA as crucial prerequisites for independently using strategies in novel and complex tasks. For example, inaccurate *task appraisal* can lead to inaccurate judgments, which negatively impacts strategy selection and the cognitive effort exerted during task performance (Robertson & Schmitter-Edgecombe, 2015; Toglia & Goverover, 2022). Likewise, individuals who inaccurately *self-evaluate* task difficulty or success may overlook the need of using strategies, potentially posing safety risks and limiting their independence (Ownsworth et al., 2006; Toglia & Kirk, 2000). Furthermore, the ability to use strategies independently may be affected by *self-monitoring* and *self-regulation* skills. Goverover et al. (2007) found that individuals are more likely to use effective strategies when they can recognize obstacles during an activity. Indeed, failing to identify and adapt to changes in everyday activities places individuals with ABI at risk of losing functional independence (Jeffay et al., 2023; Yeo et al., 2021). Although online SA appears to be important for effective strategy use, most of the supporting literature relies on quasi-

experimental studies (van Erp & Steultjens, 2020) or studies on the effectiveness of interventions to improve online SA and functional outcomes (Nagelkop et al., 2021; Ownsworth et al., 2006, 2010; Toglia et al., 2010). It remains unclear whether higher levels of *online SA* are essential for the independent use of strategies in efficiently performing novel and complex tasks. Further empirical research is needed to clarify the specific relationship between *online SA*, strategy use, and functional performance, among individuals with ABI (Toglia & Goverover, 2022).

The reviewed literature suggests that various components of SA rely on multiple cognitive functions. Therefore, to gain a deeper understanding of how specific cognitive processes influence ISA and its effects on functional performance, a more detailed assessment of cognitive processes and SA components is essential (Ownsworth et al., 2002). Such findings would not only enhance SA theories but also aid in the development of evidence-based rehabilitation strategies that directly target these components in a fine grained basis (Hart et al., 2005; Toglia & Foster, 2022; Zimmermann et al., 2017).

2.4 Variations in self-awareness across domains

As can be inferred from Toglia and Kirk's (2000) DCMA, SA is not a global process but may instead be underpinned by domain-specific mechanisms. Varying levels of SA can emerge depending on the domain (e.g., physical, cognitive, interpersonal, emotional, functional) and the specific characteristics of the task being performed (Toglia & Goverover, 2022). For example, an individual may recognize physical impairments but remain unaware of difficulties in other areas, such as cognitive or functional impairments. In supporting this idea, Prigatano and Altman (1990) found that SA tends to be more impaired after TBI when individuals are asked about abstract, non-visible aspects like cognition or emotions, as opposed to more observable behaviors, such as ADL or physical difficulties. This pattern has been consistently observed, with lower levels of SA reported for cognitive and emotional impairments compared to physical deficits in

individuals with brain injury (Fleming & Strong, 1999; Hart et al., 2004; Malouf et al., 2014; Sherer, Boake, et al., 1998; Trahan et al., 2006).

While there is broad consensus on domain-specific SA, much of the literature has focused on global measures of cognitive ADL functioning without distinguishing multiple cognitive aspects of SA or exploring different levels of ISA across ADL tasks of varying difficulty, such as BADL vs. IADL (this issue is further discussed in the next chapter). This distinction is important because according to Toglia and Foster (2022), even within the same domain, SA can vary; for instance, someone might acknowledge memory or attention problems but fail to recognize deficits in EF. Similarly, within the functional domain, a person may recognize challenges in simple tasks like dressing (i.e., BADL) but overlook difficulties in complex tasks with a greater cognitive or socioemotional component like cooking or shopping (i.e., IADL).

2.4.1 Self-awareness of different cognitive abilities

Exploring whether SA operates as a general or domain-specific capacity is a complex challenge, leading to few studies examining different levels of SA across multiple cognitive domains, leading to mixed results (Chesnel et al., 2017; Hoofien et al., 2004; Vanderploeg et al., 2007). A notable exception is the research conducted by Fitzgerald et al. (2017), which advocates for a more refined understanding of domain-specific SA. Their findings suggest that SA is not a general capacity but rather manifests differently across various cognitive domains. They measured behavioral inhibition within the attention domain, alongside perception and memory tasks, using a modified error awareness task. Interestingly, their results showed dissociation in SA accuracy across the three tasks, with no significant correlation in SA performance between the domains, though response latencies were correlated. This points to the possibility that domain-specific networks may support accurate SA. These findings align with Shimamura's (2000)

proposal that distinct mechanisms may underpin different types of metacognition, with each cognitive process potentially being monitored by its own metacognitive system.

However, two key questions arise from this study. First, Fitzgerald et al. (2017) collected data from only thirty participants, which may have limited the ability to detect stable correlations, raising concerns about the robustness of the findings. Second, while their method of carefully matching stimulus characteristics across tasks to control for confounding variables is commendable, the selection of experimental tasks used to investigate the generality and specificity of SA also raises additional concerns. As discussed further in the next chapter, these tasks often rely on artificial/novel stimuli and may not fully capture the functional cognitive deficits that manifest in everyday life. To better understand the broader implications of domain-specific SA after brain injury, future research should utilize instruments that allow for a more direct assessment of SA across multiple cognitive domains in the context of more naturalistic ADL tasks.

2.4.2 Self-awareness across tasks of varying difficulty

Recent review studies have sparked debate regarding the level of SA demonstrated by individuals when performing tasks of varying complexity (Toglia & Goverover, 2022). To our knowledge, only two studies have empirically addressed this issue. In one performance-based study in individuals with ABI, SA was assessed by comparing the discrepancy between clinicians' ratings and the individuals' own predictions and evaluations of their performance on ADL tasks of different complexity, both before and after task completion (Rotenberg-Shpigelman et al., 2014). The results showed that individuals with ABI experienced greater challenges with SA during IADL compared to BADL tasks. Similarly, Abreu et al. (2001) reported fewer SA deficits in simpler tasks, like meal preparation or upper body dressing, than in more complex tasks, such as money management. The findings from both studies suggest that individuals with ABI may not struggle with SA uniformly across all tasks but rather experience specific difficulties when

faced with more cognitively demanding tasks. This highlights the potential for task-specific SA deficits, where the complexity of the task, especially in IADL, can exacerbate ISA. However, these studies have primarily focused on measuring the online component of SA, leaving open the question of whether the metacognitive knowledge component of SA varies between BADL and IADL tasks.

Chapter 3

Assessing impaired self-awareness after acquired brain injury: how to best measure each of its components?

Addressing ISA has recently been identified as a critical first step in cognitive rehabilitation following ABI due to its impact on functional independence (Sansonetti et al., 2021) and overall rehabilitation outcomes (Di Somma & Fleming, 2024). Building on Toglia & Kirk's (2000) DCMA, which highlights a potential dissociation between *metacognitive knowledge* and the *online* components of SA, it is clear that comprehensive assessment instruments are needed to assess both components of SA. Furthermore, assessing SA in the context of ADL is particularly important, as familiar and meaningful tasks provide individuals with a relevant basis for assessing and comparing their past and current experiences, thereby enhancing their SA (Toglia & Goverover, 2022). This chapter reviews common approaches to assessing both components of SA and addresses the challenges associated with their measurement.

3.1 Methods for the assessment of the metacognitive knowledge component of self-awareness

Although there is no single gold standard for assessing the metacognitive component of SA, recent systematic reviews by Brown et al. (2019), Dromer et al. (2021a), and Smeets et al. (2012) have identified two reliable methods for assessing it in both clinical and research settings. The first method involves gathering information on an

individual's SA through **semi-structured interviews**, incorporating insights from the individual, the clinician's knowledge of the individual, and additional sources as needed. The second method, known as the **self-proxy rating discrepancy** method, compares the individuals' subjective self-ratings of their functional abilities with ratings provided by a family member or clinician familiar with the individual's daily functioning. Discrepancies between these ratings may indicate the presence of ISA, such as when an individual rates their abilities higher than their proxy. This method offers an external perspective, providing a more objective measure of SA and helping to identify areas where the individual may lack insight into their condition.

Despite the variety of instruments available to assess metacognitive knowledge, many fall short of the psychometric and conceptual rigor needed for reliable clinical and research use. Recent systematic reviews by Dromer et al. (2021a) and Smeets et al. (2012) identified only three reasonably well-validated instruments with fair psychometric properties, solid conceptual foundations, and practical feasibility. Terwee et al. (2007), underscore the importance of explicit quality criteria for developing and validating health status questionnaires to ensure the selection of the best available instruments. Accordingly, the high-quality ISA instruments identified by Dromer et al. (2021a) are reviewed next, with their key characteristics summarized in **Table 3.1**.

First, the **Awareness Questionnaire (AQ)**, Sherer, Bergloff, et al., 1998a) is an instrument with solid psychometric properties that uses the *self-proxy rating discrepancy method*. This 17-item questionnaire asks individuals and their proxies to rate the individual's current functional abilities compared to pre-injury levels on a 5-point Likert scale ranging from 1, "*much worse*"; to 3, "*the same*"; to 5, "*much better*". With a greater discrepancy reflecting greater ISA. The AQ provides a comprehensive assessment of the individual's level of SA across three domains –motor/sensory, cognitive and behavioral/emotional– derived from a factor structure analysis. It has shown sufficient psychometric properties, including a high overall internal consistency (Cronbach's $\alpha = .50$

0.88), and factor scores ranging from $r = 0.68$ to 0.80 for both patient and proxy ratings (Sherer, Bergloff, et al., 1998). In a recent study by Hellebrekers et al. (2017), test-retest reliability of the individual form was high ($r = .80$). However, the test-retest reliability of proxy form was insufficient ($r = .66$).

Table 3.1 Main characteristics of the three reliable instruments for assessing the metacognitive knowledge component of SA (adapted from Dromer et al., 2021a; Smeets et al., 2012)

	PCRS	AQ	SADI
Method	Self-proxy discrepancy	Self-proxy discrepancy	Structured interview
Number of items	30	17	3
Duration	15 min	10 min	20-30 min
Key future	SA of current abilities in 4 areas of functioning	SA of current vs. before injury functioning	SA of deficits and its implications in everyday life
Domains			
Physical/motor	✓	✓	-
Cognitive/behavioral	✓	✓	-
Social/interpersonal	✓	✓	-
Functional	✓	✓	-
Allow for the interpretation of separate sub-scales?	No	Yes	No
Examples of included questions	<i>"How much of a problem do I have in remembering important things I must do?"</i>	<i>"How good is my memory for recent events as compared to before your injury?"</i>	<i>"Does your brain have any effect on your everyday life? What do you hope to achieve in the next 6 months?"</i>

SA, self-awareness; PCRS, patient competency rating scale; AQ, awareness questionnaire; SADI, self-awareness of deficit interview.

The **Patient Competency Rating Scale** (PCRS, Prigatano et al., 1998) is another widely used instrument that also compares individuals' self-ratings of their abilities with those of proxies. This 30-item questionnaire covers a broad range of functional domains,

such as ADL, interpersonal aspects, emotional regulation and cognitive functioning, derived from a factor analysis (Prigatano et al., 1998). Each item is scored on a 5-point scale, ranging from 1 “*can’t do*”, to 5 “*can do with ease*”. Again, a greater discrepancy reflecting greater ISA. Overall, the PCRS has demonstrated good *test-retest reliability*, ($r = 0.92$ to 0.97), and strong *internal consistency* (Cronbach’s $\alpha > 0.90$) (Fleming et al., 1996; Prigatano et al., 1990). Sherer et al. (2003) compared the AQ with the PCRS in a sample of individuals with TBI undergoing inpatient rehabilitation. The study found moderate correlations between the two instruments, leading to the conclusion that both instruments are comparable in assessing ISA after TBI.

Finally, the ***Self-Awareness of Deficits Interview*** (SADI, Fleming et al., 1996) was developed to collect both qualitative and quantitative data on an individual’s SA. A clinician familiar with the individual’s functioning assigns a score from 0 to 3 (with 0 indicating intact SA in three areas: 1) *SA of deficits*; 2) *SA of the functional implications of these deficits*; and 3) the ability to set realistic goals based on their SA. The scores from these sub-scales are summed to produce a total SADI score ranging from 0 to 9, with higher scores indicating lower SA. The SADI also includes open-ended questions to further explore SA and goal-setting abilities, which are crucial for intervention planning. Its validity is supported by satisfactory inter-rater ($r = 0.82$) and test-retest reliability ($r = 0.85$ – 0.94) (Fleming et al., 1996, 1998). A later study by Simmond and Fleming (2003) confirmed its robustness, showing high test-retest reliability for both the total score (ICC = 0.94) and the sub-scale scores (ICC = 0.85 , 0.86 and 0.86 , respectively). Additionally, a study by Ownsworth, Fleming et al. (2019) found a significant and strong correlation between the AQ and the SADI ($r = 0.65$), further supporting the concordance between both measures.

While these instruments have proven reliable and feasible, they each exhibit notable limitations: **First**, the *lack of specificity of item wording in patient-proxy measures* can significantly influence the accuracy and reliability of responses from both individuals

52

and proxies, as noted by several authors (Brown et al., 2019; Toglia & Kirk, 2000). For example, Prigatano and Altman (1990), using the PCRS, found that after brain injury, SA was more impaired when individuals rated abstract, non-visible domains such as cognition or emotions, compared to observable behaviors such as ADL or physical difficulties. Similarly, studies using the AQ have consistently reported lower SA for cognitive and emotional deficits than for physical impairments (Hart et al., 2004; Sherer, Boake, et al., 1998; Trahan et al., 2006). A closer look at these instruments reveals that items assessing cognitive or emotional domains often use more abstract words and questions about general situations, while physical or functional domains are assessed through more specific and concrete items (see examples of included questions in **Table 3.1**). This abstraction can lead to greater subjectivity in interpretation, which may explain the discrepancies in findings across studies. Therefore, when selecting or developing assessment tools, it is critical to ensure that items are clearly defined and precisely worded, particularly those addressing cognitive and emotional processes, to minimize subjectivity and improve the accuracy of assessments.

Second, these instruments rely on global indices of cognitive functioning, which *fail to capture the diverse cognitive manifestations of SA*. They do not reflect the extent to which different cognitive processes contribute to variations in SA across different areas of daily life. Authors like Hurst et al. (2018) and Merchán-Baeza et al. (2020) have advocated for the use of separate subscales to assess SA across different cognitive deficits in ADL performance to explore whether SA is domain general or domain specific even among cognitive abilities.

Third, these instruments also rely on global indices of ADL functioning, which *overlooks the variability in SA across different task contexts*. Recent review studies have raised a debate over the level of SA individuals demonstrate during tasks of varying complexity (Toglia & Goverover, 2022). As discussed in *Chapter 2*, comparisons of therapists' ratings with individuals' predictions and estimates of their performance on ADL

tasks of varying complexity reveal that while individuals may recognize difficulties with simpler BADL, such as dressing or cooking, they often fail to recognize difficulties with more complex IADL, such as managing finances or using the telephone, which require higher-level cognitive skills (Abreu et al., 2001; Rotenberg-Shpigelman et al., 2014). However, these studies have primarily focused on measuring the anticipatory, self-monitoring, and self-regulatory components of *online SA*, leaving the question of whether metacognitive knowledge differs between simpler BADL and more complex IADL.

Fourth, there is a need for more advanced statistical techniques to enhance the diagnostic accuracy of these instruments. For example, including diagnostic accuracy statistics such as ROC curve analysis could help identify optimal clinical cutoff scores, to differentiate between clinical "cases" and "non-cases," improving diagnostic accuracy (Mammen et al., 2022). ROC curve analysis also facilitates consistency checks in the classification of ISA across different instruments, allowing clinicians to identify ISA more reliably by optimizing sensitivity and specificity. To our knowledge, only Ownsworth et al., (2019) have examined the consistency of classification at different scoring thresholds between the AQ and SADI. In an effort to overcome current instruments limitations and in order to better understand the broader implications of domain-specific and task-specific SA after brain injury, **Chapter 6** will present the first empirical study in this thesis, focusing on preliminary data that supports the validation of a novel clinical self-proxy discrepancy instrument developed in our laboratory (Merchán-Baeza et al., 2020) for assessing the metacognitive component of SA across various cognitive-functional domains in Spanish individuals with ABI.

3.2 Methods for the assessment of online component of self-awareness

The instruments outlined in the previous section are the most commonly used instruments for assessing the metacognitive component of SA. However, these instruments fall short when it comes to assessing other components of SA, such as *online*

SA. In fact, assessing *online SA* presents unique challenges due to the lack of standardized methods, in contrast to the more established approaches for assessing metacognitive knowledge (Brown et al., 2019; Dromer et al., 2021a; Mahoney et al., 2019; Toglia & Goverover, 2022). A thorough concept analysis and review by Sansonetti et al. (2024) further explored the complexities of assessing this component of SA and identified *two key aspects*, which are discussed below.

(1) ***The components of online SA that are assessed***. In the previous chapter, online SA was described as comprising several sub-components according to de DCMA (i.e., task appraisal, self-monitoring, self-regulation and self-evaluation). However, the current literature lacks a clear and consistent definition of online SA, leading to significant variation in assessment methods (see **Table 3.2** for an overview) and discrepancies regarding which attributes fall within its boundaries (Sansonetti et al., 2024). This ambiguity has led to inconsistencies in both the structure and content of the methods used to measure online SA. For example, *appraisal of the task* has been assessed in various ways, such as asking individuals to rate the task's difficulty (M. H. Chen & Goverover, 2021; Mahoney et al., 2021) or to estimate the number of errors they anticipate making before starting the task (Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Merchán-Baeza, et al., 2024). Additionally, discrepancies between self-predicted and actual performance –measured by the number of errors, the time taken to complete the task, and the degree of independence– have also been used as indices of *appraisal of the task* (Bivona et al., 2020; Mahoney et al., 2021; Merchán-Baeza et al., 2020; O'Keeffe et al., 2007; Robertson & Schmitter-Edgecombe, 2015; Rotenberg-Shpigelman et al., 2014). *Self-monitoring and self-regulation* are typically assessed through clinical ratings of errors that the individual detects and corrects during task performance (Dockree, et al., 2015; Hart et al., 1998; Hoerold et al., 2013; Jaywant, et al., 2022; McAvinue et al., 2005; O'Keeffe et al., 2007). Finally, *self-evaluation* is assessed by examining discrepancies between self-estimations and actual performance; however, different studies focus on different aspects, such as task difficulty and success,

performance accuracy, or time required to complete the task (M. H. Chen & Goverover, 2021; Jaywant, Arora, et al., 2022; Merchán-Baeza et al., 2020; Morris et al., 2016). Overall, these inconsistencies complicate the assessment process and hinder the comparability of findings across studies. This highlights the need for a more unified and comprehensive framework that assess all components of online SA within the same task and participant group (Merchán-Baeza et al., 2020; Sansonetti et al., 2024).

Table 3.2 Methods identified to measure each component of online SA (adapted from the results of the concept analysis and review by Sansonetti et al., 2024)

Components of online SA	How is it measured?
Before the task	
Appraisal of the task	Discrepancy between self-predictions and actual performance in specific areas such as: • Task difficulty • Number of errors • Level of independence • Time required to complete the task • Task success
During the task	
Self-monitoring and self-regulation	Clinical ratings of: • Error-detection • Error-correction
After the task	
Self-evaluation	Discrepancy between self-estimation and actual performance in specific areas such as: • Task difficulty • Number of errors made • Task success • Accuracy of performance • Compensations/strategies used • Time required for task performance • Level of independence with task

(2) ***The type of tasks used for assessment.*** There is considerable variation in the types of tasks used to assess each component of online SA. Many studies rely on

computer-based tasks or **traditional cognitive tests** (Dockree, et al., 2015; Hoerold et al., 2013; McAvinue et al., 2005; O’Keeffe, et al., 2007; Robertson & Schmitter-Edgecombe, 2015). These measures are specifically designed to isolate cognitive abilities from other influencing factors, allowing for a precise evaluation of domain-specific cognitive deficits, which can be valuable for both diagnostic and prognostic purposes. Additionally, they can be paired with techniques like EEG or fMRI (Iannaccone et al., 2015), offering deeper insights into the cognitive and neural processes involved.

However, these measures have significant limitations when it comes to reliably assessing online SA. *First*, they often rely on artificial and unfamiliar stimuli, which can hinder a comprehensive assessment of all of its components. For example, regarding *self-monitoring*, it is difficult to determine whether errors in computer-based tasks or traditional cognitive tests go undetected due to genuine deficits in online SA or because these errors do not significantly affect overall task progression, making them less obvious to the individual during performance. In contrast, tasks where errors are more evident and directly impact task progression –such as familiar multistep ADL tasks– provide better opportunities to observe an individual’s error detection abilities (Sansonetti et al., 2024). Familiar tasks, where individuals have a performance benchmark, enable them to anticipate challenges more effectively, detect and correct errors, and predict their performance with greater accuracy. These tasks yield a clearer measure of all components of *online SA* because individuals’ responses—whether predicting their performance, evaluating their execution, or recognizing deviations from correct responses (i.e., self-monitoring)—are grounded in their prior knowledge and experience with the task (Merchán-Baeza et al., 2020; Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Merchán-Baeza, et al., 2024; Sansonetti et al., 2024; Toglia & Foster, 2022). The lack of prior knowledge about the characteristics and demands of the tasks (when they are novel) may hinder an individual's ability to predict, monitor and assess the quality of their performance accurately (Toglia & Kirk, 2000).

For these reasons, researchers have become increasingly interested in exploring online SA through more familiar multi-step **performance-based tasks** involving both naturalistic and simulated ADL tasks. Assessing online SA by directly observing the execution of familiar tasks can provide valuable insights into everyday functioning, including error detection and correction behaviors, and overall task performance, leading to a more comprehensive understanding of this component of SA (Sansonetti et al., 2024; Toglia & Goverover, 2022). Many performance-based instruments based on familiar ADL tasks have proven effective in measuring various components of online SA in clinical populations with different neurological conditions (Sansonetti et al., 2024). **Table 3.3** presents an overview of assessment approaches for online SA for individuals with ABI.

First, ***the occupation-based metacognitive approach for assessing online awareness*** developed by Doig, Fleming, Ownsworth, et al. (2017) allows clinicians and researchers to assess an individual's *self-monitoring and self-regulation* skills. This approach was used to evaluate its feasibility in a pilot study with two individuals with TBI and showed promise, when combined with standardized cognitive tests, for providing an in-depth understanding of self-monitoring and self-regulation skills during various multi-step tasks, including cooking, making a drink, organizing time, budgeting, and using an iPad app. This approach has also been used in a recent single-case study with two individuals with severe TBI to evaluate the effectiveness of an occupation-based intervention, aimed at facilitating goal attainment and improving *online SA* and EF (Doig et al., 2020). Although this approach was found to be feasible in both cited studies, it only assesses two components of *online SA* (i.e., *self-monitor and self-regulation*) and combined them into a single index, which does not allow differentiation between both sub-components (Sansonetti et al., 2024). To further validate the feasibility of this assessment approach, additional studies involving larger sample sizes are necessary.

Table 3.3 Overview of assessment approaches identified to measure different components of online SA in individuals with ABI (adapted from the results of the concept analysis and review by Sansonetti et al., 2024)

Instrument or approach	Purpose of the study	Components that assess	Tasks performed
The occupation-based approach to assessing online SA (Doig, Fleming, Ownsworth, et al., 2017)	Describe an online SA assessment approach and evaluate its feasibility.	Self-monitoring and self-regulation	- Cooking - Preparing a drink - Organizing time - Budgeting - Using an iPad app
Multi-Level Action Test (Hart et al., 1998)	Assess error detection and correction during the performance of naturalistic tasks	Self-monitoring, self-regulation, and self-evaluation	- Making toast and coffee - Wrapping a present - Packing a lunchbox
Online SA of three functional tasks, (Rotenberg-Shpigelman et al., 2014)	Examine online SA for functional tasks in individuals with ABI	Anticipation/prediction and self-evaluation	- Dressing - Making hot drinks - Using the telephone
Occupational Therapy Anticipatory Awareness Scale (Mahoney et al., 2021)	Determine the content validity of the instrument	Anticipation/prediction	- Storing items - Medication management
The Breakfast and Dressing Conflict Task (Merchán-Baeza et al., 2020)	Validate an online SA assessment protocol within the context of ADL	Anticipation/prediction, self-monitoring, self-regulation and self-evaluation	- Preparing breakfast - Dressing
10-item Weekly Calendar Planning Activity (Toglia, 2015)	Assess online SA on a C-IADL	Self-monitoring, self-regulation, self-evaluation	- Scheduling 10 tasks in a weekly-calendar

A study by Hart et al. (1998) used the **Multi-Level Action Test** (MLAT; Schwartz et al., 1998) to assess *self-monitoring* and *self-regulation* skills in 30 individuals with TBI and 18 healthy controls during three structured ADL tasks: making coffee with milk and a toast with butter and jelly, wrapping a present, and packing a child's lunchbox. In this study, self-monitoring and self-regulation were assessed separately, and *self-evaluation* was also assessed using a self-rating questionnaire about cognitive behaviors during task performance. The study found that individuals with TBI corrected and recognized proportionally fewer errors compared to controls. Despite making more errors, they did not rate their performance as worse in terms of cognitive demands. Similar findings were observed in studies involving individuals with neurodegenerative diseases using the shortened version –the **Naturalistic Action Test** (NAT; Schwartz et al., 2002)– where self-monitoring and self-regulation were also assessed separately (Bettcher et al., 2008; Giovannetti et al., 2002). However, these studies did not include measures to assess other sub-components of *online SA*, such as *task appraisal* or *self-evaluation*. Moreover, although the external validity of the task has been demonstrated in the above studies, it has rarely been used with individuals with brain damage.

In another study involving 36 adults with ABI, Rotenberg-Shpigelman et al. (2014) assessed *anticipation/prediction* and *self-evaluation* by comparing subjective performance ratings with experienced clinicians ratings on **three functional tasks**: one BADL (e.g., dressing) and two IADL (e.g., making hot drinks and using the telephone). The study found significant discrepancies between individuals' and clinicians' ratings, with individuals often overestimating their functional independence in IADL but not in BADL tasks. These discrepancies remained consistent after performing the tasks and following mediated task monitoring. Similarly, Mahoney et al. (2021) developed the **Occupational Therapy Anticipatory Awareness Test** (OTAAT) to specifically measure *anticipation/prediction* in individuals with neurological conditions. Rather than assessing actual task performance, the OTAAT focuses on assessing an individual's ability to

anticipate difficulties in two specified tasks, such as medication management and item storage, using a combination of self-rating, observation, and interview. Clinicians' gains insight by asking individuals to estimate the difficulty of the tasks and anticipate potential challenges related to their cognitive and physical impairments before performing them. While the two instruments cited above use the well-established discrepancy method to assess task appraisal and self-evaluation, they both rely on functional tasks that are not fully standardized, and overlook important sub-components of *online SA*, such as self-monitoring and self-regulation. Future research, including a control group, is needed to further investigate the external validity of the task.

To address the aforementioned issues, Merchán-Baeza et al. (2020) introduced the ***Breakfast and Dressing Conflict Task***, a novel instrument designed to assess all sub-components of online SA identified in Toglia and Kirk's (2000) DCMA within familiar ADL contexts. Unlike previous instruments that mainly focus on IADL, this tool includes both a BADL (e.g., getting dressed) and an IADL (e.g., preparing breakfast). Both tasks integrate distracting objects and unexpected, conflicting situations that individuals must resolve to complete the task successfully, allowing clinicians to assess *self-monitoring* and *self-regulation* skills by accounting for the proportion of detected and corrected errors. To assess *task appraisal*, individuals are asked to predict their performance, including expected errors, and then, immediately after the task, they estimate their actual number of errors to measure self-evaluation. Both indices are derived from the discrepancy between predicted and actual performance. A recent study by Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Merchán-Baeza, et al. (2024) provided preliminary evidence supporting the validity of this protocol for assessing all of sub-components of online SA within the same familiar ADL tasks in individuals with ABI. In addition, they explored the relationship between these sub-components of online SA and a measure of metacognitive knowledge (e.g., the PCRS), providing empirical support for the DCMA and deepening our understanding of how they interact.

While the instruments reviewed thus far show promise in assessing various components of online SA and provide a controlled environment that mimics real-life settings, they do not offer a comprehensive assessment of online SA. With the exception of the Breakfast and Dressing Conflict Task, most focus on specific sub-components rather than the full spectrum of online SA. In addition, all the instruments reviewed for assessing online SA face the common challenges associated with performance-based ADL instruments. They tend to be costly and time-consuming due to the effort required for administration and scoring, the need to record and categorize multiple types of errors, and their reliance on various objects. These factors significantly hinder their widespread use in clinical practice (Diaz-Orueta et al., 2020; Robertson & Schmitter-Edgecombe, 2016). Furthermore, many of these instruments are either still in early development stages or lack well-established psychometric properties (Sansonetti et al., 2024).

To address some of these challenges, the **10-item Weekly Calendar Planning Activity** (WCPA-10; Toglia, 2015) was recently developed. This easily portable C-IADL task involves presenting individuals with a weekly calendar and a list of 10 tasks or events, such as appointments, meetings, or leisure activities, to schedule. To simulate the complexity and unpredictability of real-life activities, the task incorporates rule constraints, distractions, and challenges that demand effective EF, including planning, organization, information tracking, inhibition of irrelevant details, and cognitive flexibility. Moreover, the WCPA-10 allows for systematic clinical observation of *online SA* both during and immediately after task performance (Arora et al., 2021; Jaywant, Arora, et al., 2022; Toglia, 2015). *Self-monitoring* and *self-regulation* skills are assessed by observing the individual's ability to monitor their ongoing performance, recognize errors, and make necessary adjustments to correct them. After completing the task, individuals undergo a structured interview in which they rate their performance through self-ratings and estimates of task difficulty, accuracy of performance and the time required to complete the task. This information can then be compared to their actual performance.

A study using the WCPA-10 with 77 individuals with stroke showed a tendency to overestimate their performance, along with reduced self-recognition of errors and a lower likelihood of using self-monitoring strategies compared to 77 healthy age-matched controls (Jaywant, Arora, et al., 2022). The WCPA-10 is an easy-to-administer C-IADL measure that takes approximately 15 minutes to complete and can be administered using only paper and pencil on a desktop or table. Additionally, various versions of the WCPA are available to accommodate different age groups and levels of cognitive deficits. It has demonstrated robust psychometric properties, including validity and reliability, across diverse clinical populations, such as college students with and without ADHD (Lahav et al., 2018), individuals with epilepsy (Zlotnik et al., 2020), individuals with multiple sclerosis (Goverover et al., 2020), and those who have suffered a stroke (Jaywant et al., 2021). Furthermore, the WCPA-10 exhibits a high level of inter-rater reliability and moderate to high test-retest reliability (Lahav et al., 2018; Weiner et al., 2012). The instrument has also been translated and culturally adapted into Swedish, Dutch, Chinese, and Hebrew.

Overall, the WCPA-10 effectively combines quantitative scores, qualitative observations, and post-task interview responses, enabling the identification of key EF and online SA subcomponents that are crucial in daily life (Baum et al., 2016; Toglia & White, 2020). This comprehensive approach makes the WCPA-10 a valuable tool for analyzing cognitive factors associated with online SA in familiar task contexts. Additionally, it assesses strategy use, which can be objectively observed, rated, and examined in the post-task interview. By integrating measures of online SA with assessments of strategy frequency, type, and effectiveness, the WCPA-10 addresses the need for detailed assessment tools that evaluate how functional cognitive factors support performance in individuals with ABI (Toglia & White, 2020). This integration enhances functional performance predictions and supports the development of personalized rehabilitation protocols (Jaywant, Arora, et al., 2022). However, as with other ADL-based tools, the WCPA-10 is culturally dependent and requires adaptation and validation for effective clinical use within the Spanish population.

To address the need in neuropsychology and related fields for comprehensive tools that assess various sub-components of online SA, as well as key aspects of functional cognition like EF and strategy use within familiar C-IADL –and recognizing the limited availability of such instruments for Spanish-speaking populations– **Chapter 7** presents data on the translation, cultural adaptation, and validation of the WCPA-10 for Spanish individuals with ABI and healthy individuals. **Chapter 8** further investigates the effectiveness of the Spanish WCPA-10 in measuring multiple components of online SA and examines the potential relationships between online SA and cognitive processes like memory, EF, and strategy use.

Chapter 4

Cognitive rehabilitation of impaired self-awareness after acquired brain injury: what methods work best?

As noted in the previous chapter, a thorough assessment of ISA is essential for understanding the functional difficulties experienced by individuals after an ABI. Such assessments provide critical information for designing, planning, and implementing targeted interventions to improve SA. However, due to the complex and multi-faceted nature of SA, measuring progress and determining the most effective interventions for its various components remain challenging. Cognitive rehabilitation holds promise in addressing SA, offering benefits that extend beyond cognitive improvement to positively impact functional abilities. This chapter reviews current intervention approaches, emphasizing components that effectively enhance SA and promote its generalization across tasks and contexts, contributing to increased levels of independence.

4.1 A general overview of traditional cognitive rehabilitation approaches

The term *approach* refers to the practical application of a model or framework during the rehabilitation process, and determines how to address specific deficits following an ABI. Cognitive rehabilitation traditionally categorizes intervention approaches into two main types: **restorative** and **compensatory**.

First, the *restorative approach* aims to maximize recovery by addressing cognitive impairments through targeted process training, with the goal of restoring cognition to its premorbid state (Maskill & Tempest, 2017; Pinto, Peixoto, et al., 2023). This *bottom-up* approach is based on the principle that improving cognitive abilities may in turn lead to better performance in everyday activities (Skidmore, 2014). It relies on repetitive, standardized pen-and-paper exercises tailored to the individual's ability (Gopi et al., 2022), drawing support from the brain's capacity for recovery and neuroplasticity (Berlucchi, 2011). However, with rapid advances in technology, there has been a shift toward computer-based cognitive interventions, which offer significant advantages over traditional methods. These digital tools provide dynamic, adaptive exercises that adjust in difficulty based on the user's performance, demonstrating greater potential for improving rehabilitation outcomes (Gopi et al., 2022). Adaptive training, driven by algorithms, modifies the challenge level in response to user performance. Each successful task completion increases the difficulty—by introducing more interference (e.g., additional distracting stimuli), shortening response times, or expanding the number of items to remember (Chen et al., 2017; Maier et al., 2020; Pedullà et al., 2016). Conversely, incorrect responses trigger a reduction in difficulty, ensuring a personalized training experience. Additionally, these interventions offer *immediate feedback* when errors occur, further enhancing the chances of success (Wong et al., 2023). Recent systematic reviews and meta-analyses suggest that computer-based interventions are effective tools for cognitive rehabilitation after ABI, demonstrating benefits in areas such as visual and verbal working memory (López & Antoli, 2020), attention, visuospatial function, memory (Bogdanova et al., 2016), and EF (Rose Sin Yi et al., 2024; Van De Ven et al., 2016). However, despite the lack of adverse effects generally associated with these interventions (Gates et al., 2019), they may be perceived as burdensome due to time demands and costs, including equipment, software, or subscription fees (Wong et al., 2023). Furthermore, evidence of sustained improvement and generalization to other cognitive domains (García-Molina & Enseñat, 2019; Poulin et al., 2012; Velikonja et al., 2023) or

real-life functioning remains limited (López & Antoli, 2020; Ponsford et al., 2023; Van De Ven et al., 2016; Yoo et al., 2015).

The second approach, known as the *compensatory approach*, focuses on helping individuals use aids or strategies to reduce cognitive load or perform tasks differently, thereby minimizing the impact of cognitive impairments on daily functioning (Wong et al., 2023). Building on the work of Zangwill (1947) and Luria (1966), this approach shifts emphasis from addressing specific deficits –as in the *restorative approach*– to focusing on intact skills to compensate for limitations. The goal is to promote new ways of learning by training individuals in compensatory strategies, enabling neural networks to reorganize and allowing intact circuits to take over functions lost due to impairment (Luria, 1966; Palacios et al., 2013). This approach uses both internal strategies and external aids to help individuals better manage cognitive limitations and improve functional independence (Wong et al., 2023). For attentional deficits, *internal strategies* such as visual scanning training encourage individuals to focus actively on stimuli from a neglected side, improving visual scanning behaviors. *Mnemonics*, another internal strategy, facilitate memory by using rhymes, acronyms, or stories (Pinto, Peixoto, et al., 2023). *External aids* include environmental modifications –like labeling doors or objects, using directional arrows, or strategically placing objects to reduce cognitive demands (Gopi et al., 2022; Jamieson et al., 2017; Wilson, 2008). Tools such as calendars or smartphone apps can also assist with tasks like creating shopping lists, remembering appointments, or managing medications (Evans et al., 2003; Jamieson et al., 2017). While external assistive devices improve performance in functional tasks, a major limitation is that these gains are often not maintained once the intervention is withdrawn (Poulin et al., 2012). Additionally, there is a lack of guidance on how individuals with brain injuries and their caregivers can integrate these strategies into everyday life –especially when it comes to assistive technology, which may be difficult to learn or access without proper training and support (Gopi et al., 2022; Velikonja et al., 2023).

Another key strategy within the compensatory approach is **errorless learning**, an instructional method designed to prevent individuals from making errors during the learning process. This method focuses on ensuring tasks are performed correctly, allowing individuals to complete them independently (Middleton & Schwartz, 2012). Clinicians facilitate this by providing clear verbal or written instructions, breaking tasks into manageable steps, and guiding individuals through exercises by modeling the correct procedures step-by-step (Clare & Jones, 2008). *Errorless learning* has proven effective, in interventions for individuals with a range of deficits, particularly in the treatment of memory deficits (Clare & Jones, 2008), especially for those individuals with intact procedural memory but impaired declarative memory (Wong et al., 2023). However, a notable limitation of this approach is that it does not allow individuals to make mistakes and learn from them, nor does it readily promote generalization of skills to different real-life contexts (Clare & Jones, 2008; Middleton & Schwartz, 2012).

Although the failure to generalize skills across contexts does not necessarily indicate treatment failure, the ability to apply learned strategies in real-world situations – beyond the controlled environment of the laboratory or clinic– is crucial for long-term recovery and independence (Pinto et al., 2024; Pinto, Peixoto, et al., 2023). Ultimately, treatment success is measured not only by cognitive improvements, but also by its impact on everyday functioning (Wong et al., 2023). This highlights the need to actively integrate intervention strategies that promote generalization, rather than relying on it to occur spontaneously as behavior changes (Tilton-Bolowsky et al., 2023).

Metacognitive Strategy Training (MST) has emerged as a promising approach for achieving improvements that generalize to daily life (Skidmore et al., 2015). MST teaches individuals internal strategies for *self-monitoring* and *self-evaluation*, aiming to improve their ability to perform desired activities while reducing the impact of cognitive impairments (Skidmore et al., 2015). This approach utilizes **error-based learning**, where making and correcting errors is integral to the learning process. A key goal is to help

individuals transfer compensatory strategies across various tasks and contexts (Salazar-Frías et al., 2020). MST places a strong emphasis on improving individuals' SA of their cognitive strengths and weaknesses, encouraging them to recognize task difficulties and errors, and guiding them to develop their own solutions to overcome these challenges, thereby enhancing their independence in everyday activities (Kersey et al., 2019). Unlike the errorless learning approach, where clinicians provide step-by-step instructions to prevent errors, MST encourages clinicians to act as facilitators. They guide individuals in identifying and addressing obstacles through active communication, using systematic prompts and questions to help them develop self-monitoring skills and strategies based on their own experiences (Jaywant et al., 2023).

Few studies have directly compared the effectiveness of *errorless* and *error-based* learning approaches. One notable exception is the Randomized Controlled Trial (RCT) by Ownsworth et al. (2017), which involved 54 individuals with severe TBI. The trial examined both learning approaches as interventions to improve skill acquisition, metacognitive abilities, and behavioral competence. The results revealed that individuals in the error-based learning group achieved significantly greater improvements in metacognitive and behavioral skills compared to those in the errorless learning group. However, error-based learning did not promote the generalization of skills to tasks with significantly different demands. This suggests that gains in SA are more likely to occur when individuals are provided with structured opportunities to make errors, reflect on their functional significance, and engage in problem solving to recognize and correct those errors (Ownsworth et al., 2017). Interestingly, the INCOG 2.0 guidelines for cognitive rehabilitation (Jeffay et al., 2023), along with other systematic reviews (Cicerone et al., 2019), continue to endorse the use of MST as Level A evidence for addressing a range of executive deficits, including problem-solving, planning, and organizational skills, which can help individuals with ABI reduce disability (Skidmore et al., 2011). Nevertheless, further research is needed to identify the active components of MST that contribute to improved skills generalization.

4.2 Cognitive rehabilitation approaches based on activities of daily living to enhance functionality and generalization

Beyond the dichotomy of *restorative* versus *compensatory* approaches, cognitive rehabilitation advocates for more comprehensive interventions that prioritize setting functional goals and engaging in meaningful IADL to help individuals apply their learned skills to new tasks and contexts (Pinto, Peixoto, et al., 2023). Therefore, authors like Prigatano (1999), Sohlberg and Mateer (2001), Wilson (2008), and Ben-Yishay and Diller (2011) emphasize the importance of shifting to comprehensive interventions that address individuals' deficits through meaningful and functionally relevant rehabilitation goals.

In this context, the ***cognitive occupation-based*** approach emerges as a highly effective method for improving functional performance in individuals with cognitive impairments. Unlike traditional rehabilitation approaches that often rely on abstract or simulated tasks, this *top-down approach* prioritizes the individual's functional goals rather than the skill deficits that hinder their ability to function (Mahoney et al., 2023; Park et al., 2015). Its core principle is a person-centered focus, where clinicians collaborate with individuals to identify and engage in tasks that hold personal significance. This tailored approach not only addresses specific cognitive challenges but also enhances motivation, as the tasks align with each individual's unique interests, needs, and life goals (Mahoney et al., 2023; Proffitt et al., 2022). For instance, an individual may practice making a shopping list, checking pantry items, and preparing a simple lunch –essential activities for maintaining independence (Steinberg & Zlotnik, 2019). By practicing in familiar, real-world environments, individuals can build the skills necessary to manage these tasks more effectively, helping them regain control over their routines. A systematic review by Wolf et al. (2015) underscores the effectiveness of this approach, showing strong support for occupation-based interventions in enhancing functional performance. Recent reviews also suggest that combining occupation-based approaches with MST may further strengthen functional performance and facilitate skill transfer (Cicerone et al., 2019; Engel

70

et al., 2019; Jeffay et al., 2023; Villalobos, Bilbao, et al., 2020). However, many of these interventions primarily target BADL tasks, raising questions about whether they also enhance the ability to engage and generalize to more complex IADL (Ahn, 2019).

4.3 Treatment approaches for impaired self-awareness: the importance of actively target functional and cognitive impairments and generalization

Given the complex, multifaceted nature of ISA, most intervention protocols integrate diverse approaches that vary in duration, frequency, and delivery format. Identifying the core active elements suited to individual needs is essential for refining these protocols and advancing comprehensive recovery models for individuals with ISA following ABI. Although research in this area is still emerging, reviews over the past two decades have started to identify promising active elements that hold potential for effectively addressing ISA (Engel et al., 2019; Fleming & Ownsworth, 2006; Jeffay et al., 2023; Schmidt et al., 2011; Schrijnemaekers et al., 2014; Tate et al., 2014; Villalobos, Bilbao, et al., 2020).

A key element emphasized in these reviews is the use of **feedback techniques** aimed at helping individuals recognize areas for improvement and develop strategies to enhance task performance (Sherer & Fleming, 2014). Feedback can be delivered in various forms, such as direct *verbal feedback* during the task or *video-feedback* after completing the task. One direct *verbal-feedback* method, "*pause, prompt, praise,*" is an *error-based* instructional method that encourages individuals to *anticipate challenges* and apply *self-monitoring* and *self-regulation skills*—key components of *online SA*—during task performance. The method teaches individuals to pause, control, and adjust their actions as they complete tasks. Clinicians provide timely feedback that highlights both the positive and negative aspects of performance to promote error detection and correction (Schmidt et al., 2011). For instance, if an individual makes an error, the clinician initially withholds prompting, giving the individual the opportunity to recognize and

correct the mistake independently. If the error persists, the clinician offers a *non-specific prompt*, such as, "*What is the next step?*" Should the error remain uncorrected, a specific prompt is provided (e.g., "*add half a spoonful of sugar*"). Verbal praise is then given when the individual spontaneously corrects an error, uses a compensatory strategy, or corrects the error following a prompt (Schmidt et al., 2011). Feedback can also be provided post-task through video recordings of the individual's performance (Schmidt et al., 2013). During video-feedback sessions, individuals watch their recorded task performance alongside the clinician, who encourages them to identify their errors, compensatory strategies, and strengths. Both errors and successes are highlighted to maintain motivation and a positive emotional state (Schmidt et al., 2015a).

Most studies evaluating the efficacy of SA interventions incorporating feedback for individuals with ABI are exploratory or rely on single-case experimental designs (SCED). SCED studies involve the repeated observation of a single unit (e.g., an individual or group) over a specified period, allowing for the assessment of causal or functional relationships between dependent and independent variables (Kratochwill et al., 2013; Tate & Perdices, 2019; Vlaeyen et al., 2020). Over the past decade, SCED methodology has advanced significantly (Aydin, 2024), with robust statistical methods now widely available through digital tools (Manolov et al., 2016, 2021; Manolov & Solanas, 2018; Onghena, 2020; Tanious et al., 2024). Additionally, guidelines for the quality and reporting of SCED have been established (Tate et al., 2014, 2016). As a result, SCED is now recognized as Level 1A evidence, on par with systematic reviews and RCT (Howick et al., 2011), thereby facilitating the development of scientific rigorous interventions across various fields of psychology and medicine (Vlaeyen et al., 2020).

A systematic review and meta-analysis by Schmidt et al. (2011) identified twelve studies with varied methodologies, including nine SCED and three RCT, that used revised *feedback techniques* to improve SA. For example, one SCED study assessed the effectiveness of an occupation-based intervention aimed at improving *online SA* in an

individual with stroke by reducing error frequency and increasing self-correction rates during a cooking task (Ownsworth et al., 2006). The intervention included various metacognitive strategies, including *video-feedback* and *systematic verbal feedback*, resulting in a significant reduction in errors and an increase in self-corrections during the treatment phase compared to the baseline phase. However, these improvements were only observed in the trained task and did not generalize to an untrained task in a volunteer work setting. Supporting these findings, another SCED study by Ownsworth et al. (2010) demonstrated that systematic verbal and video-feedback enhanced *self-monitoring* and *self-regulation* skills during a meal preparation task in two individuals with TBI. This improvement was reflected in fewer errors and a higher rate of self-corrections. Moreover, both participants and their relatives reported enhanced functional performance, as indicated by higher scores on the PCRS, which assesses metacognitive knowledge. However, increased PCRS discrepancy scores suggested that individuals may have overgeneralized their improvements to other functional areas, including various IADL. While some transfer of skills to everyday tasks is expected following MST, the modest gains reported by relatives indicate that significant generalization may not have occur. This suggests that while *online* SA improvements can be achieved, they do not necessarily correspond to broader increases in metacognitive knowledge.

The meta-analysis of three RCT included in the systematic review by Schmidt et al. (2011) found moderate to large effect sizes for improving functional task performance and individual's satisfaction with therapy. However, due to the limited number of RCTs, small sample sizes, and intervention heterogeneity, the researchers concluded that the evidence for feedback efficacy is not yet substantial and recommended further research to determine the most effective form of feedback. To explore this further, Schmidt et al. (2013) conducted a RCT with 54 individuals with TBI, comparing the effects of three feedback types –*video plus verbal*, *verbal only*, and *experiential only*– on performance during a meal preparation task across four sessions over two weeks. The study revealed that the group receiving video plus verbal feedback, alongside experiential practice,

demonstrated significantly greater improvements in both *online SA*, as indicated by fewer errors, and *metacognitive knowledge*, as shown by reduced AQ discrepancy scores, compared to the other two groups. Additionally, the study found that the video-feedback intervention led to lasting improvements in both aspects of SA, evident 8 to 10 weeks post-intervention, without affecting participants' emotional well-being status (Schmidt et al., 2015b). A key limitation of these studies is that they do not compare the groups under equivalent conditions. One group receives a single intervention (e.g., *verbal feedback*), while another receives that same intervention plus an additional one (e.g., *verbal feedback + video-feedback*). This makes it difficult to determine whether the observed improvements were due to the specific intervention or simply because one group received more intervention techniques overall. Additionally, these studies do not evaluate whether improvements in online SA extend to other tasks or environments, leaving the question of generalization unanswered.

Overall, while feedback techniques hold promise as active interventions for addressing executive deficits and enhancing online SA after ABI, several limitations are notable. In many reviewed studies, participants repeatedly practiced the same tasks with no increase in difficulty. Additionally, tasks were typically selected by clinicians and often centered on meal preparation, leaving the personal relevance of these activities to the individuals uncertain. Furthermore, these studies lacked measures to assess the potential transfer of skills to other ADL tasks. This raises important questions about whether observed improvements, such as error reduction, were primarily the result of task repetition and whether the absence of novel challenges or lack of task relevance may have limited the generalization of learned strategies to untrained tasks and diverse contexts.

To effectively promote the transfer and generalization of learned strategies across different tasks and contexts, Toglia's (2018) **Multi-Context** (MC) approach integrates several key elements. By engaging in multiple relevant activities in different settings,

individuals encounter scenarios that challenge them to adapt and apply their strategies in different contexts. The treatment is structured along a transfer continuum, offering opportunities to experience varying environments and activity demands, progressing from similar (*near transfer*) to visually different activities (*far transfer*) (Toglia & Foster, 2022). Another key component of The MC approach is the use of *MST* techniques before, during, and after each activity to promote strategy generation and enhance SA. *Before the activity*, techniques like self-prediction and guided anticipation of challenges are used. Guided anticipation involves asking individuals to predict potential challenges they might face during a task, the level of assistance they might require, and the estimated time for task completion. In parallel, encouraging individuals to deductively generate strategies—such as considering, "What is the best way to approach this task? *During the activity*, clinicians reinforce strategy use, self-monitoring, and self-regulation skills through direct feedback, or self-questioning. A critical component of this process is the self-evaluation after the activity, where individuals assess their own performance and compare it to their initial predictions. These techniques help individuals connect their experiences across different situations, reinforcing the application of learned strategies in different contexts (Sherer & Fleming, 2014).

This framework emphasizes the dynamic interaction between the individual, the task, and the environment by targeting key components of *online SA* crucial for everyday functioning. It recognizes that SA develops through active engagement with the environment and in response to real-world tasks. By addressing these interactions, the MC approach aims to enhance SA and ensure that therapeutic skills effectively transfer to everyday life, promoting greater independence and improved functional outcomes (Toglia & Foster, 2022). Case and exploratory studies indicate that individuals with chronic ABI show positive changes in self-regulation and strategy use in both trained and untrained activities through the MC approach (Nagelkop et al., 2021; Toglia et al., 2010, 2011). Additionally, recent studies on feasibility, acceptability, and clinician's fidelity in single-case series with acute ABI populations have also shown promising results (Jaywant,

Steinberg, et al., 2022; Jaywant et al., 2023; Toglia et al., 2020). However, many of these studies do not employ appropriate statistical methods to accurately assess the effectiveness of these interventions. As a result, there is a need for more high-quality studies with controlled designs (e.g., SCED, RCT) and robust statistical methods that focus on identifying the most effective components while eliminating inactive elements. Furthermore, generalization should be actively incorporated into every session, as strategies that promote it through ADL practice have shown potential to partially transfer to daily activities, enhancing functional independence in individuals with ABI (Engel et al., 2019). Continued research on skill maintenance, transfer, and generalization is critical requiring intervention grounded in theory, with detailed content descriptions, and precise outcome measures to confirm their true effectiveness (Sansonetti et al., 2024).

Chapter 9 presents the fourth study of this thesis, which focuses on developing and evaluating the effectiveness of a novel cognitive occupation-based intervention. This intervention is designed to target key components of SA, as outlined in Toglia & Kirk's (2000) DCMA, including error-monitoring, self-regulation, and strategy use, with the goal of enhancing functionality in individuals with ABI. The intervention draws on various techniques and procedures shown to be promising in improving SA. To support hypotheses regarding its efficacy, limitations, and generalizability, we will provide a comprehensive description of the intervention's design, including its theoretical foundation, outcome measures, and instructional methods. Preliminary evidence of its effectiveness will be presented through a SCED, providing early insights into its potential for generalizing and maintaining these improvements over time.

Part II: Aims of the research

Chapter 5

Motivation and Aims

ISA has emerged as a critical focus in clinical research due to its complex nature, high prevalence, and significant impact on recovery and rehabilitation outcomes. Understanding how ISA affects daily activities, recovery expectations, and changes across various domains is central to its definition and thus widely studied. A thorough assessment of both components of SA is essential not only for advancing our understanding of its underlying cognitive and functional processes but also for ensuring accurate diagnoses and developing targeted interventions. These interventions must ensure the generalizability of improvements from laboratory to real-world functioning, an essential step toward evidence-based practice. In this context, the *general aim* of this thesis is to enhance our understanding, assessment, and intervention of the different components of SA and their associated cognitive processes in individuals with ABI. We highlight the importance of connecting laboratory research with practical applications in everyday life by advocating for innovative and comprehensive assessment and intervention strategies that address ISA within familiar ADL tasks. Focusing on familiar tasks is particularly valuable for studying and assessing SA, as it enhances the validity of SA measures by ensuring that individuals evaluate their current experiences against well-known tasks-related experiences. Additionally, incorporating familiar and meaningful

ADL in SA interventions may improve individuals' motivation and facilitate the transfer of skills to other familiar but untrained ADLs.

The *specific aims* are: (1) to validate a newly developed self-proxy discrepancy instrument from our laboratory, designed to assess the metacognitive component of SA across various cognitive domains and ADL contexts in Spanish-speaking individuals with ABI; (2) to translate, culturally adapt, and validate the WCPA-10, a novel tool for assessing multiple components of *online SA*, as well as other aspects of functional cognition like EF and strategy use for Spanish-speaking individuals with ABI; and (3) to develop and evaluate the efficacy of a novel cognitive occupation-based intervention aimed at improving *online SA* and related functional cognition components, such as EF and strategy use, to enhance functional outcomes in individuals with brain injury. These aims were addressed through four studies, each with specific aims which are detailed below:

First study. *The Cognitive Awareness Scale for Basic and Instrumental Activities of Daily Living to measure self-awareness after acquired brain injury: preliminary evidence of its validity* (Chapter 6).

The literature review revealed a significant limitation in current instruments used to assess the metacognitive knowledge component of SA. Many of these tools rely on global measures of cognitive ADL functioning, which often prevents them from distinguishing between specific cognitive manifestations of SA or adequately assessing ISA across ADL of varying complexity. Addressing this limitation is crucial, as it limits our understanding of whether ISA manifestations are domain/task general or specific. To fill this gap, this study evaluates the validity of a novel instrument developed in our laboratory: The Cognitive Awareness Scale for Basic and Instrumental Activities of Daily Living, in Spanish-speaking individuals with ABI. This self-proxy discrepancy tool is designed to assess the metacognitive component of SA across various cognitive domains that affect functional

performance, focusing on both simpler BADL and more complex IADL tasks. *The specific aims of this study are:*

1. To examine its *convergent validity* and *level of agreement* with the PCRS (Prigatano et al., 1998), a well-established measure of the *metacognitive* component of SA.
2. To examine its *external validity* by determining the scale's ability to discriminate between healthy individuals and individuals with ABI, both with and without ISA, as indicated by the PCRS.
3. To determine the *sensitivity and specificity* of the scale through ROC curve analysis, providing insights on how accurately it identifies individuals with ISA as "*impaired*" and those without ISA as "*unimpaired*".
4. To provide preliminary evidence of the scale's potential to explore how ISA manifest differently depending on task characteristics, such as task complexity, particularly in differentiating SA levels between BADL and IADL tasks.

Second study. *Translation, cross-cultural adaptation and validation of the 10-item Weekly Calendar Planning Activity in Spanish-speaking ABI patients: a multicenter study* (Chapter 7).

This study addresses the need for reliable instruments that assess multiple components of *online* SA and related aspects of functional cognition, such as EF and strategy use, within the context of familiar ADL. Acknowledging the lack of such tools for Spanish-speaking individuals with ABI, we focus on the translation, adaptation, and validation of the WCPA-10 (Toglia, 2015) for this population. This brief C-IADL instrument requires individuals to schedule appointments on a weekly calendar while managing conflicting situations and adhering to multiple rules. Designed for practical use in inpatient settings, it simultaneously assesses various EF, including working memory, strategy use, problem solving, and inhibition, through different performance measures such as, total strategies used, the number of rules followed, the number of accurately

scheduled appointments, and the total and planning time. Additionally, it measures various components of *online SA*, such as *self-monitoring*, *self-regulation*, and *self-evaluation*, which were further explored in study 3. This study was conducted in two phases. *Phase One* involved the translation and cultural adaptation of the WCPA-10, following the guidelines by the International Society for Pharmacoeconomics and Outcomes (Wild et al., 2005) and the International Test Commission (2017) to ensure semantic and conceptual equivalence between the translated and original versions. *Phase Two* focused on validating the Spanish version of the WCPA-10 and examining its psychometric properties with a sample of Spanish individuals with ABI and healthy controls. The specific aims for testing its validity are:

1. To examine the *convergent and discriminant* validity of its main performance variables by analyzing their association with socio-demographic factors, clinical variables, and standardized cognitive tests of EF and memory in individuals with ABI.
2. To examine the *incremental validity* by determining whether the Spanish WCPA-10 more accurately predicts everyday functional competence in individuals with ABI compared to traditional cognitive tests.
3. To examine the *external validity* by assessing its ability to discriminate between the performance of healthy controls and individuals with ABI, including those with moderate and mild cognitive impairment, as measured by traditional cognitive tests

Third study. *The moderating role of online awareness in the association between strategy use and performance accuracy on a test of functional cognition in individuals with acquired brain injury* (Chapter 8).

This study aims to enhance the utility of the Spanish WCPA-10 as a C-IADL instrument by simultaneously targeting various components of *online SA* –specifically

self-monitoring, self-regulation and self-evaluation– in Spanish-speaking individuals with ABI and healthy controls. In addition, taking advantage of the fact that the Spanish WCPA-10 also measures the number of strategies used and EF, it constitutes a comprehensive instrument for exploring the relationship between *online SA*, strategy use, and functional performance. The specific aims of this study are:

1. To build on previous findings (i.e. study 2) by examining the *external validity*, specifically comparing performance differences in key executive measures between individuals with ABI and healthy controls using a larger sample.
2. To examine its *external validity*, by assessing the instrument's ability to identify different *online SA* deficits in individuals with ABI compared to healthy controls.
3. To explore potential relationships between different components of *online SA* and traditional cognitive tests of memory and EF, as well as various socio-demographic factors and clinical variables.
4. To analyze potential differences in overall strategy use and performance accuracy between individuals with ABI who accurately recognize their performance, those who over-estimate it, and healthy controls.
5. To investigate how cognitive strategies and *online SA* influence functional performance, particularly examining the moderating effect of group (healthy controls, aware individuals with ABI and ABI over-estimators) on the relationship between total strategy use and performance accuracy on the Spanish WCPA-10.

Fourth study. *Training to deal with distractions and conflicting situations in activities of daily living after traumatic brain injury (TBI): Preliminary evidence from a single-case experimental design study* (Chapter 9).

The literature reviewed in Chapter 4 highlights various interventions aimed at enhancing SA after ABI in the context of ADL. While many of these approaches have demonstrated promising results in improving functional performance, further research

employing quantitative analyses and controlled designs is crucial to determine the generalizability of these improvements across different tasks and contexts, ultimately promoting functional independence. Consequently, **the fourth study** aims to provide evidence for an occupation-based intervention focused on enhancing cognitive functional performance in individuals after brain injury, utilizing a SCED study. Following the exploration of how different components of *online SA* and the number of strategies used can influence functional performance (as detailed in Study 3), we recognize the importance of investigating whether interventions targeting these processes can effectively enhance performance across various ADL contexts. This will allow us to formulate hypotheses about the mechanisms underlying the intervention's success or limitations, as well as its potential for broader applicability. Additionally, we present a detailed description of the intervention's design and content, detailing specific outcome measures, the theoretical principles guiding the intervention, the statistical methods employed, the number of sessions conducted, and the strategies implemented throughout the process. This thorough documentation ensures that the results can be replicated in future studies involving larger sample sizes or other SCED studies. The specific aims of the intervention are:

1. To improve EF and *online SA* (e.g., anticipatory awareness, error detection and correction skills, self-evaluation) during IADL performance across training sessions and from pre- to post-intervention phases.
2. To determine whether these improvements are maintained and transferred across sessions, as well as at 2- and 4-week follow-ups.
3. To assess the extent of transfer and generalization to different task contexts (near transfer) and even to untrained tasks (far transfer).

Part III: Empirical studies

Chapter 6

The Cognitive Awareness Scale for Basic and Instrumental Activities of Daily Living to measure self-awareness after acquired brain injury: preliminary evidence of its validity

The content of this chapter has been published as:

Salazar-Frías, D., Rodríguez-Bailón, M., Ricchetti, G., Navarro-Egido, A., & Funes, M. J. (2023). The Cognitive Awareness Scale for Basic and Instrumental activities of daily living to measure self-awareness after acquired brain injury: preliminary evidence of its validity. *The Clinical Neuropsychologist*, 38(5), 1133-1155.

<https://doi.org/10.1080/13854046.2023.2278822>

6.1 Abstract

Objective: There is a crucial need for reliable tools to measure impaired self-awareness in patients with acquired brain injury across cognitive-functional domains. The aim of this study was to assess the psychometric properties of the Cog-Awareness ADL Scale, which is a novel self-proxy discrepancy method for measuring ISA in both basic and instrumental activities of daily living. **Method:** This multicenter study included 54 patients (no-low ISA $n = 33$; severe ISA, $n = 21$) from four outpatient rehabilitation units in Málaga-Granada, Spain, and 51 healthy controls. The participants and proxy raters completed the Cog-Awareness ADL Scale and the Patient Competency Rating Scale (PCRS). Agreement between both scales was assessed using Spearman's correlations and the Bland-Altman plot. Group comparisons were made on measures of SA, cognitive abilities and demographic variables. Sensitivity and specificity were analyzed by ROC curve analysis. **Results:** Convergent validity was supported by strong correlations with the PCRS and its subscales (rho's ranging from 0.51 to 0.80, $p < .01$ for all). The Bland-Altman plot confirmed measurement agreement (only 3.70% of the scores were outside the 95% limits). External validity was demonstrated by effectively discriminating between healthy controls and ABI patients with no-low and severe ISA on each discrepancy index while controlling for cognitive/demographic variables. The Cog-Awareness ADL Scale showed optimal diagnostic accuracy (AUC = 0.95, sensitivity = 0.90, specificity = 0.90). **Conclusions:** The Cog-Awareness ADL Scale proved to be a feasible, valid, and clinical tool to assess ISA across different cognitive-functional domains, in Spanish ABI-patients.

6.2 Introduction

People with brain injury sometimes experience difficulties in performing essential ADL, which can lead to a loss of independence and poor quality of life (Wise et al., 2005). ADL refers to the skills required to meet basic needs such as eating, bathing, and mobility –i.e. BADL– as well as activities that involve higher cognitive demands and social interaction, such as preparing meals, managing finances, or taking medication –i.e. IADL– (Edemekong et al., 2019; Romero-Ayuso et al., 2021). Impaired performance in ADL can result from several cognitive impairments, with deficits in EF and SA being particularly important (Bivona et al., 2019; Ciurli et al., 2010; Prigatano & Sherer, 2020; Schmidt & Ownsworth, 2022; Villalobos, Caperos, et al., 2020a; Villalobos et al., 2021). ISA refers to the inability to accurately identify one's deficits and their impact on daily functioning (Prigatano, 2009). Research suggests that approximately 30%-50% of individuals experience some level of ISA following TBI, leading to long-term negative outcomes, such as poorer functional recovery and limited participation (Bivona et al., 2019; Dromer et al., 2021a; Hart et al., 2009; Hartman-Maeir et al., 2009; Hurst et al., 2018; Toglia & Kirk, 2000). Recent studies have also highlighted the moderating role of SA in the relationship between executive deficits and ADL (Villalobos, Caperos, et al., 2020).

SA has been conceptualized as a *multifaceted construct*, emphasizing the need to differentiate its various components. The Pyramid Model of Awareness, proposed by Crosson et al. (1989) describes SA as a hierarchical structure comprising intellectual awareness, emergent awareness, and anticipatory awareness. According to this model, these levels build upon each other, with intellectual awareness serving as the foundation for subsequent levels. In contrast, Toglia and Kirk (2000) proposed an alternative model considering SA as a dynamic rather than a hierarchical construct. This model distinguishes between *metacognitive knowledge*, which involves understanding task characteristics and having knowledge of one's own abilities, and *online awareness*, which is actively engaged during task performance through self-monitoring and self-evaluation of task

demands. Recent research has also explored the *multidimensional* nature of SA, suggesting that its manifestation may vary depending on the type of information or task being examined (Toglia & Goverover, 2022). For example, Prigatano and Altman (1990), found that SA appeared to be more impaired following TBI when patients were asked about abstract, non-visible information such as cognition or emotions, compared to more observable behaviors such as ADL or physical difficulties. Similar findings have been consistently reported, indicating lower levels of SA related to cognitive and emotional impairments compared to physical impairments in individuals with TBI (Hart et al., 2004; Malouf et al., 2014; Sherer, Boake, et al., 1998).

However, it is important to note that these domains may not be completely separate, but rather interdependent. Numerous studies have demonstrated the dependence of ADL on various cognitive factors. The observed dissociation of SA across cognitive and functional domains (see Dromer et al., 2021 for a recent review) may be due to differences in the level of abstraction within the measurement items, rather than indicating truly different levels of ISA for different domains. Therefore, more research is needed to further disentangle potential confounding between item abstraction and the presence of different domains affected by ISA. The use of assessment tools that explore different cognitive difficulties within the same ADL contexts may contribute to a better understanding of this issue.

Recent review studies have also raised a debate about the level of SA demonstrated by patients while performing tasks of varying complexity (Toglia & Goverover, 2022). To the best of our knowledge, only two studies have addressed this issue. One performance-based study assessed ABI patients' SA, through the discrepancy between therapists' ratings and patients' prediction and estimation of performance on ADL tasks of varying complexity, both before and after completing the task (Rotenberg-Shpigelman et al., 2014). The results indicated that ABI patients faced greater SA challenges when engaging in IADL tasks compared to BADL tasks. Similarly, Abreu et al.

(2001) found fewer SA deficits in simpler tasks, such as meal preparation and upper body dressing, compared to a more complex task, such as money management. These studies suggest that individuals with ABI may have difficulties in accurately predicting and evaluating their performance on complex IADL tasks due to increased cognitive demands that leave fewer cognitive resources for error detection. However, these studies have primarily focused on measuring anticipatory/emergent SA. Thus, it remains unexplored whether metacognitive knowledge differs between BADL and IADL.

Although several assessment tools are available to measure metacognitive knowledge, many of them lack the necessary psychometric and conceptual properties for clinical and research purposes. Recent systematic reviews conducted by Smeets et al. (2012) and Dromer et al. (2021a) identified three methods that demonstrate acceptable psychometric and conceptual properties. These include the SADI (Fleming et al., 2009) and self-proxy discrepancy methods that compare patients' self-report of their abilities with a proxy-report, such as the PCRS (Prigatano et al., 1998) and the AQ (Sherer, Bergloff, et al., 1998). More recently, Bivona et al. (2020) introduced a novel assessment tool called the Self-Awareness Multilevel Assessment Scale (SAMAS). This tool aims to thoroughly assess SA across different levels—namely declarative, emergent, and anticipatory—within different domains such as motor, cognitive, and psycho-behavioral, thus, overcoming some important limitations of prior tools. However, these instruments provide overall measures of cognitive and/or ADL functioning without differentiating specific cognitive aspects of SA or examining different levels of ISA across ADL tasks of different difficulty (i.e., BADL vs. IADL). Therefore, it is still necessary to develop novel instruments that can effectively capture multiple cognitive manifestations during ADL performance and accurately differentiate between basic and more complex tasks such as IADL (Brown et al., 2019; Hurst et al., 2018; Merchán-Baeza et al., 2020).

The present study

To address the aforementioned limitations, our research group has developed the Cog-Awareness ADL Scale as part of a comprehensive assessment protocol to evaluate the main components of SA in Spanish ABI patients (Merchán-Baeza et al., 2020), following the model of Toglia and Kirk (2000). The scale consists of a 31-item questionnaire designed to measure metacognitive knowledge across different cognitive and functional domains. This is an adaptation of the Cog-ADL Scale, an informant-based tool previously developed in our lab that allows the measurement of several cognitive domains (e.g. task schema, error detection, problem-solving, or task self-initiation, among others) across a range of BADL and IADL. The authors used the error coding system typically used in performance-based ADL studies with similar populations (Giovannetti et al., 2002; Humphreys & Forde, 1998; Schwartz et al., 2002) to develop specific items reflecting these types of cognitive errors in the context of a range of ADL of varying complexity. This tool has demonstrated good psychometric properties in individuals with mild cognitive impairment, dementia, and healthy older adults (see Rodríguez-Bailón et al., 2015; Montoro-Membila et al., 2022 for further details).

The Cog-Awareness ADL Scale brings significant innovations to the field. Firstly, it includes multiple cognitive items related to each ADL (see **Table 6.1**). This comprehensive approach allows for the assessment of SA across different cognitive aspects that influence different ADL tasks within a single tool, providing a notable advantage over the other SA scales. Secondly, it measures the same cognitive items in both BADL and IADL, allowing for the identification of potential differences in SA between simple and complex tasks that cannot be attributed solely to variations in cognitive processes. Moreover, it provides numerous examples of each cognitive error type, enhancing the informant's ability to envision and differentiate between the various cognitive impairments that may affect each ADL. By incorporating concrete situations within each ADL, the scale reduces the inherent abstraction that is often associated with

items addressing cognitive processes in other SA questionnaires, such as PCRS and AQ (Brown et al., 2019).

Table 6.1 General structure of the Cognitive Awareness Scale for Basic and Instrumental Activities of Daily Living

Cog-functional abilities measured		
<i>Item 1. Action schema:</i> ability to complete all necessary steps of the task in the correct order.		
<i>Item 2. Distraction:</i> ability to avoid distraction and grabbing or making tangential actions toward irrelevant objects which were not necessary for the task.		
<i>Item 3. Object selection:</i> ability to select the proper objects to perform the task without replacing them with others.		
<i>Item 4. Semantic knowledge:</i> Ability to recognize the use of the objects.		
<i>Item 5. Error detection:</i> ability to detect their own errors.		
<i>Item 6. Problem solving:</i> ability to solve any unexpected situation occurring during the execution of an ADL.		
<i>Item 7. Task self-initiation:</i> ability to self-initiate a task autonomously.		
<i>Item 8. Calculation:</i> ability to perform mathematical operations accurately.		
<i>Item 9. Memory:</i> ability to acquire, retain, and recall information effectively.		
<i>Item 10. Inhibition:</i> ability to control one's immediate desires or impulses and make decisions that consider the potential consequences.		
	BADL	IADL
Activities	Personal care (items 1-7) Getting dressed (items 1-7)	Cooking (items 1-7) Managing finances, shopping (items 1-10)
Number of items	14	17

Note: BADL = basic activities of daily living; IADL = instrumental activities of daily living

The structure of the scale also provides flexibility for different research or clinical purposes. In addition to calculate a general discrepancy index, it also allows for the separate investigation of more specific BADL and IADL discrepancy indexes. From a

clinical perspective, the scale can be used to measure SA even in cases where patients are no longer engaged in IADL following ABI. In such situations, SA can still be assessed by focusing on their performance in BADL. Supplementary material shows the entire tool and illustrates how these different cognitive-functional items were instantiated in each ADL (see measures section for more details).

The overall aim of the present study was to validate the Cog-Awareness ADL Scale as a clinical measure of metacognitive knowledge in Spanish patients with ABI enrolled in a multicenter study. The first objective was to assess its psychometric adequacy by examining its convergent validity and level of agreement with PCRS, which is a well-established measure of metacognitive knowledge. We expected significant correlations between the discrepancy indexes of the Cog-Awareness ADL Scale (total, BADL, and IADL) and PCRS. Specifically, we expected strong correlations between the total, BADL, and IADL discrepancy indexes and PCRS total discrepancy, as well as in its cognitive and ADL domains. The second objective was to assess its external validity, that is, the extent to which it can discriminate between healthy controls and patients with ABI. We hypothesized that patients with severe ISA, as determined by PCRS (see measures section for details), would have higher discrepancy scores on the Cog-Awareness ADL Scale (total, BADL, IADL) compared with patients with no or low ISA and healthy participants. The sensitivity of the scale was also determined using ROC curve analysis. We expected the scale to have good sensitivity and specificity for detecting ABI patients with severe ISA, establishing it as a reliable measure of SA in the Spanish population. Finally, this study aimed to provide initial insights into the potential utility of the Cog-Awareness ADL Scale for investigating domain-specific SA, specifically differences in SA levels between BADL and IADL. Based on previous research on online SA described above, we expected that patients with severe ISA would show greater SA deficits for IADL compared to BADL tasks.

6.3 Methods

Participants

We recruited ABI patients who were undergoing cognitive/occupational rehabilitation in four outpatient units in Málaga and Granada, Spain. To be eligible, patients had to be over 18 years of age and have a confirmed ABI diagnosis from a neurological report at least 3 months prior to the study. There was no restriction on the time elapsed since the onset of the ABI. Patients with hemineglect and significant motor/sensory impairments were excluded, as these may largely affect their ability to perform ADL. In addition, patients with language deficits were excluded to ensure the reliability of our study results. This is because language deficits may make it difficult for patients to understand scale instructions and provide verbal responses. Treating clinicians' judgement, supported by diagnostic/clinical reports, was used to make these exclusion decisions. An additional criterion was the presence of a reliable informant who could provide accurate information about the patient's performance in daily life. This ensured an accurate assessment of SA using the PCRS and the Cog-Awareness ADL Scale.

A total of 69 patients met the inclusion criteria, although 15 were excluded for lack of a reliable informant. Thus, the final sample consisted of 54 ABI patients (19 women) and 54 relatives, of whom 39 (72.1%) were partners (30 wives, 8 husbands and 1 girlfriend), 7 (13%) were daughters, 3 (5.6%) were sons, 2 (3.7%) were mothers, 2 (3.7%) were sisters, and 1 (1.9%) was a brother. The healthy control (HC) group consisted of 71 community-dwelling volunteers recruited from the same geographic area as the patients using snowball sampling conducted by the researchers. The exclusion criteria for the HC group were: absence of a reliable informant, global cognitive decline as determined by psychometric assessment during eligibility screening, and clinically significant ISA based on the PCRS discrepancy score (see method section for details). Twenty participants were excluded: 2 with clinically significant ISA and 18 for lack of a reliable informant. The final HC group consisted of 51 participants (25 women). Ethical approval for the study was

obtained from the Andalusian Ethics Committee for Biomedical Research (AnosognosiaAVD2017, 3/01/2017, 0056-N-17). All participants and their families received written and verbal information about the study and provided their informed consent before participating. Information on the racial and ethnic background of the sample was not available for this study.

Measures

The Cog-Awareness ADL Scale: offline-awareness

The main novelty of the proposed scale in relation to its predecessor (i.e. the Cog-ADL Scale) was the inclusion of two versions: one to be completed by a direct caregiver (informant version) and the other by the patient (patient version). An index of SA can be derived from the discrepancies between the two scores. Furthermore, the Cog-Awareness ADL Scale included a separate form to be completed by the direct caregiver. This additional form consists of specific questions designed to gather information about the patient's level of functioning and support needs related to each task included in the scale. By gathering information from the caregiver, the assessment can gain a more complete understanding of the patient's abilities, limitations, and assistance needs across various ADL (see supplementary material for more details). It also included a reduced number of ADL tasks: two BADL (personal care, getting dressed) and two IADL (cooking and managing finances/shopping). This modification is intended to improve feasibility and reduce administration time. The selection of activities was based on a principal component analysis (PCA) as previously reported (Rodríguez-Bailón et al., 2015, Montoro-Membila et al., 2022), confirming the classical division between b- and IADL proposed by the American Occupational Therapy Association (2014).

Administration. The questionnaire can be self-administered or, if required, the examiner can read each item aloud and record the patient's responses. In either case, the therapist should always verify that all the answers have been provided. The informant

version can be self-administered by the direct caregiver. To ensure that caregivers were completing the scale on behalf of the patient, the wording of each item in the informant's version was modified (e.g. from 'I am able to notice whether the given change is correct' to 'He/she is able to notice whether the given change is correct.'). This modification was accompanied by clear verbal instructions indicating that they were completing the questionnaire on behalf of the patient.

Scoring system. Firstly, the informant independently rates the frequency and level of assistance required by the patient for each b- and IADL before and after the brain injury. Frequency is rated as: 1 = "never", 2 = "sometimes", 3 = "weekly", and 4 = "daily". Similarly, the degree of assistance is rated as: 1 = "someone does the activity for him/her", 2 = "with a lot of help", 3 = "with little help", and 4 = "completely by him/herself". Since the scale is designed to measure a patient's current level of SA and functionality, activities that are no longer performed due to physical or cognitive disability, or irrelevance, are not considered for scoring. In a second step, both the patient and the informant are asked to indicate on a 4-point Likert scale, within each ADL-category (considering only those activities that are in the patient's repertoire), how often the patient exhibits the cognitive-functional errors presented in each item (1 = "never", 2 = "sometimes", 3 = "quite often", 4 = "always"). The clinician is expected to clarify the content of each item at any time. For each version (patient-informant), each item score within an ADL-category is then summed to create a subcategory score ($BADL_{SCORE}$ and $IADL_{SCORE}$). Both scores are also summed to produce a $TOTAL_{SCORE}$. An $ABSOLUTE_{SCORE}$ is also calculated for each subcategory, by estimating the maximum possible score according to the number of activities performed by the participant (see below for an example). Scores are inverted, for items that ask about limitations rather than capacities. Lower scores represent greater impairment.

Indexes. The *Cog-Awareness ADL Scale* provides discrepancy indexes for each of the two ADL categories ($BADL_{DISCREPANCY}$ and $IADL_{DISCREPANCY}$) and a $Total_{DISCREPANCY}$, by considering the $TOTAL_{SCORE}$ and the $ABSOLUTE_{SCORE}$. This enables comparisons between

all participants, including those who no longer perform some of the ADL proposed in the scale. For example, if a participant performs only three activities (two BADL and one IADL), and the patient's version has a $TOTAL_{SCORE}$ of 72 and an $ABSOLUTE_{SCORE}$ of 84, the $Cog-ADL_{PATIENT'S\ INDEX}$ will be 85.7% ($TOTAL_{SCORE} / ABSOLUTE_{SCORE} * 100$). In contrast, if the informant has a $TOTAL_{SCORE}$ of 43 and an $ABSOLUTE_{SCORE}$ of 84, the $Cog-ADL_{INFORMANT'S\ INDEX}$ will be 51.1%. All indexes are expressed as percentages, with lower scores indicating greater functional disability. $Total_{DISCREPANCY}$ is obtained by subtracting the $Cog-ADL_{PATIENT'S\ INDEX}$ from the $Cog-ADL_{INFORMANT'S\ INDEX}$ (34.6% in the cited example). The same can be done for each ADL category, considering only the BADL items ($BADL_{DISCREPANCY}$) or the IADL items ($IADL_{DISCREPANCY}$). Higher scores indicate greater discrepancy. The scale also provides the $Independence_{INDEX}$, which serves as a measure of the patient's functionality. This index is derived from the questions on the scale (degree of assistance that the patient requires for both BADL and IADL), although it is independent from those used to calculate the discrepancy. As the other indexes, it only considers the activities that the patient performs at the time of assessment. Consequently, it calculates a total score and an absolute score using the same procedure as described above. It is expressed as a percentage, with lower scores indicating a higher level of dependence.

Patient Competency Rating Scale: metacognitive knowledge

This 30-item *self-proxy rating discrepancy scale* is used to measure an individual's SA across four subscales: ADL (eight items), cognitive (eight items), interpersonal (seven items) and emotional (seven items) (Prigatano et al., 1998). It requires the patients and their caregivers to independently rate the ease with which the patient is able to perform each functional situation on a 5-point Likert scale ranging from 1 = "Can't do" to 5 = "Can do with ease". Scores range from 30 to 150 points, with higher scores indicating greater perceived competence. The level of SA is determined based on the discrepancy between the patient's self-rating and the caregiver's rating. To classify patients with severe ISA, this study applied the double criterion proposed by Bivona et al. (2019): a) patient's self-rating

score of at least 100 points (indicating minimal self-perceived difficulties); and b) positive discrepancy score of at least 20 points. The PCRS has demonstrated excellent psychometric properties, and has been validated in Spanish-speaking populations (Prigatano et al., 1998).

Cognitive assessment

The Rey Auditory-Verbal Learning Test (RAVLT, Schmidt, 1996) is used to assess the participant's short- and long- term memory. EF are measured with the semantic fluency test, in which participants are asked to name as many animals as possible within 60 s (Ardila et al., 2006), and the INECO Frontal Screening (IFS, Torralva et al., 2009), which is a brief and easy-to-administer screening test that has proved to be sensitive in exploring response inhibition, set shifting, abstraction, and working memory, after ABI (Pinasco et al., 2021). In this study, a Cognitive_{INDEX} was additionally calculated from the average Z-scores of all cognitive tests. This index was used as a dependent variable in some of the statistical analyses presented in the data analysis section.

Procedure

Participants who met the eligibility criteria underwent a testing session that lasted approximately 1 hour. The assessment was conducted by the treating clinician at each rehabilitation center, such as a clinical neuropsychologist or occupational therapist. This set of clinicians was blinded to the specific objectives and hypotheses of the study. The assessment process consisted of the following steps: a) the participants and their caregivers were informed about the study and provided their informed consent; b) an interview was conducted to gather clinical and sociodemographic information; and c) the assessment took place in a quiet room, following specific administration guidelines for each measure. During the assessment, the patient's primary caregiver completed the informant-caregiver version of the PCRS and the Cog-Awareness ADL Scale in a separate room. For the healthy control group, the assessment was conducted at the Mind, Brain,

and Behaviour Research Center (CIMCYC) of the University of Granada and the Faculty of Health Sciences of the University of Málaga. The assessment was administered by the principal investigators, Cognitive Neuroscience Master's students, and final year OT students. All assessors received thorough training in the administration of the tools described above.

Data analysis

The data were analyzed using R Studio software (version 1.3.1093). Descriptive statistics and appropriate nonparametric tests were performed based on the distribution of the data. To assess the *convergent validity* of the Cog-Awareness ADL Scale, firstly, Spearman's correlations were performed in the ABI sample, between its three discrepancy indexes ($BADL_{DISCREPANCY}$, $IADL_{DISCREPANCY}$, and $Total_{DISCREPANCY}$) and the discrepancy index of each of the PCRS subscales. The significance level was set at 0.05 with Bonferroni's correction for multiple comparisons. The r_s coefficients < 0.30 were considered as weak correlations, 0.31 - 0.7 as moderate correlations, and > 0.70 as strong correlations (González, M., Villegas, Atucha, & Fajardo, 2020). Then, we examined the agreement between the $Total_{DISCREPANCY}$ scores on the Cog-Awareness ADL Scale and the PCRS using the Bland-Altman approach (2010), as implemented in the *blandr* R package (version 0.5.1; Datta, 2018). For each participant we calculated the difference between both scores (y-axis), and plotted it against the mean of the same two scores (x-axis). With this method, 95% of the data points are expected to fall within the adjusted 95% limits of agreement. Proportional bias refers to a situation in which one measurement is consistently higher or lower than the other. This bias has the potential to affect the agreement between the two rating scales. To evaluate the presence of such bias, we conducted a linear regression analysis. To assess its *external validity*, the ABI sample was firstly divided into two groups: *no-low ISA* and *severe ISA*, based on the PCRS discrepancy score, as described in the measures section (see **Figure 6.1**). Group differences in continuous variables were assessed using the Mann-Whitney U and Kruskal-Wallis rank

sum tests. The categorical variables were analyzed using Chi-square analysis. Performance on the three discrepancy indexes was compared among the three groups (HC, no-low ISA, severe ISA) using Quade's test, which is a non-parametric alternative to ANCOVA (Quade, 1967). Demographic, clinical, and functional variables that showed significant group differences were selected as covariates. Post-hoc analyses used Tukey-adjusted *p*-values as recommended by McHugh, (2011) to account for unequal group sizes.

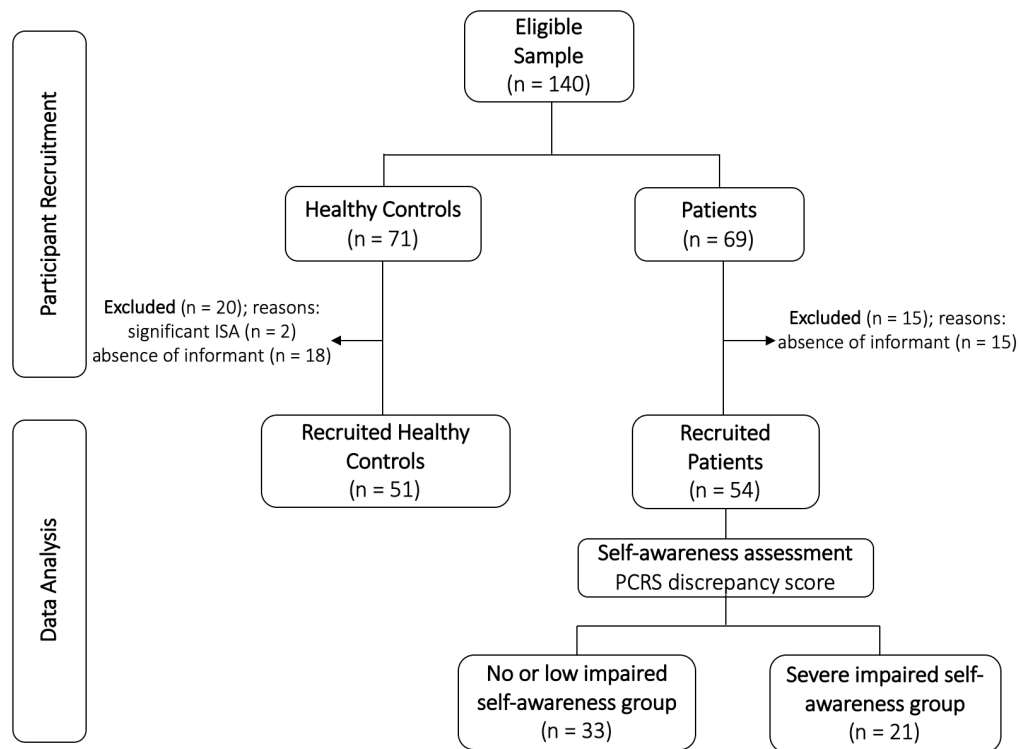


Figure 6.1 Sampling flow chart

To assess the *diagnostic accuracy* of the Cog-Awareness ADL Scale, a ROC curve analysis was performed on the entire sample using the *pROC* R package (version 1.18.0; Robin et al., 2011). The Area Under the Curve (AUC) values were interpreted following the suggestion of Fischer et al. (2003) (> .90 high accuracy; .70 to .90 moderate accuracy; .50 to .70 low accuracy). The optimal cut-off point was determined based on sensitivity, specificity, and Youden's index formula (Youden, 1950), where a higher index indicates

maximization of sensitivity and specificity. The state variable in the ROC curve analysis was the presence of severe ISA according to the PCRS discrepancy score, and the test variable was the Cog-Awareness ADL Scale Total_{DISCREPANCY} score. Finally, the paired-samples Wilcoxon test was performed to explore potential differences in SA levels of functional deficits between BADL and IADL in patients with severe ISA.

6.4 Results

Convergent validity

The Bland-Altman results for the level of agreement between the Total_{DISCREPANCY} scores of both scales are shown in **Figure 6.2**.

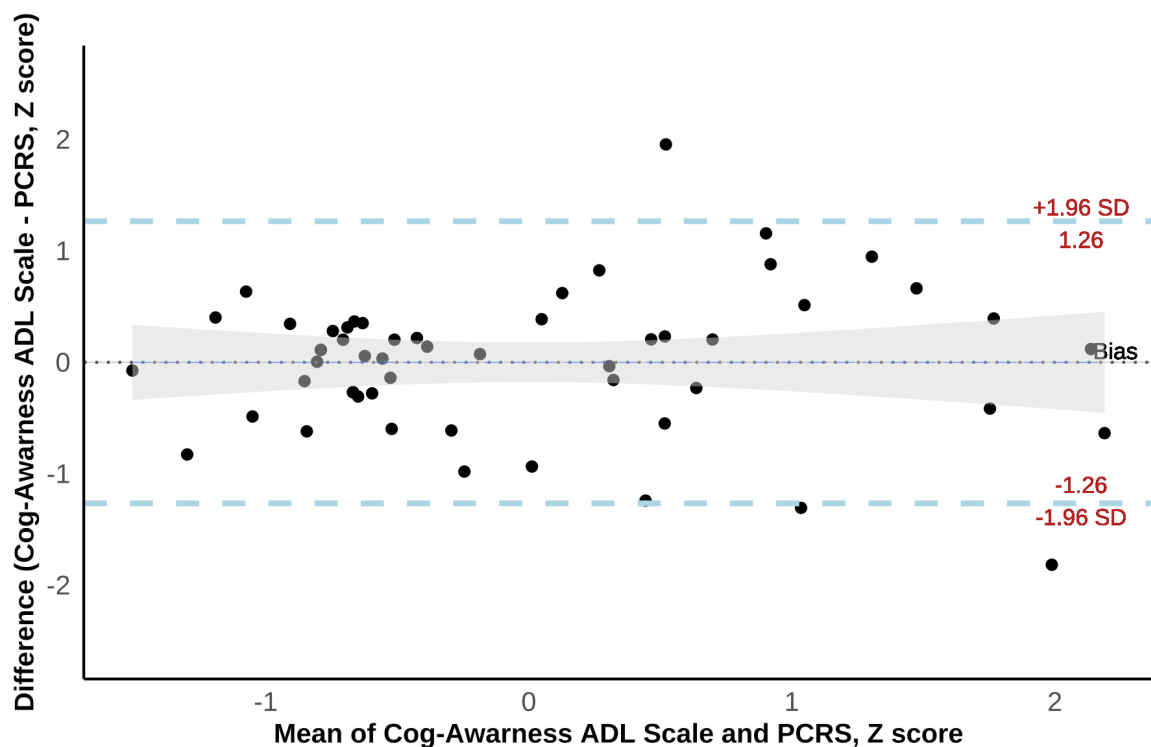


Figure 6.2 Bland-Altman plot of agreement between the Cognitive Awareness Scale for Basic and Instrumental Activities of Daily Living and the Patient Competency Rating Scale (PCRS) in the patient sample ($n=54$). The middle line represents the mean difference in the Total_{DISCREPANCY} scores of both scales. The upper and lower dashed lines represent the upper and lower 95% confidence limits.

Due to the different units of both scores, Z scores were used to avoid creating an artificial proportional error. Visual inspection of the graph revealed that few scores (3.70%) were outside the 95% upper and lower limits of agreement. A linear regression analysis was also performed to examine the relationship between the difference (dependent variable) and the mean scores on the scales (independent variable). The analysis yielded a non-significant p -value ($p > .95$), indicating the absence of proportional bias. This suggests a high level of agreement between the Cog-Awareness ADL Scale and the PCRS Total_{DISCREPANCY} scores. Spearman's rho showed a large positive and significant correlation between the Cog-Awareness ADL Scale and the PCRS Total_{DISCREPANCY} scores, as well as for each of its subscales ($p < .01$). Correlation analyses performed for the BADL_{DISCREPANCY} and IADL_{DISCREPANCY} scores with each PCRS subscale showed consistent results, as shown in **Table 6.2**.

Table 6.2 Spearman correlations between the Cognitive Awareness Scale for Basic and Instrumental Activities of Daily Living and the Patient Competency Rating Scale discrepancy indexes for the patient sample

	Cog-Awareness ADL Scale		
	Total _{DISCREPANCY}	BADL _{DISCREPANCY}	IADL _{DISCREPANCY}
PCRS - Discrepancy	n = 54	n = 54	n = 32
Total	0.80**	0.78**	0.69**
ADL-subscale	0.58**	0.55**	0.61**
Emotional- subscale	0.74**	0.70**	0.65**
Cognitive- subscale	0.67**	0.63**	0.64**
Interpersonal- subscale	0.64**	0.66**	0.51**

Note: PCRS = Patient Competency Rating Scale; ADL = activities of daily living; BADL = basic activities of daily living; IADL = instrumental activities of daily living
Bonferroni's corrected significance levels: * = < .05; ** = < .01

Group differences across demographic, clinical, cognitive and functionality measures

Table 6.3 shows the demographic and clinical characteristics of the three groups: HC ($n = 51$), no-low ISA ($n = 33$), and severe ISA ($n = 21$). Age was not significantly different between groups ($p = .18$). However, there were significant differences in education level and gender. Post-hoc analyses revealed a higher proportion of participants with lower education in the severe ISA group compared to the no-low ISA group, and a marginal difference compared to the HC group ($p = .54$). Significant differences were also found in the proportion of male and female participants in the severe ISA group compared to the no-low ISA and HC groups ($p < .001$ for each comparison).

Regarding the clinical variables, there were no statistically significant differences between the two ISA groups in time since injury onset ($p = .65$) or etiology ($p = .69$). However, significant differences were found in the proportion of patients' lesion location. A series of Kruskal-Wallis rank sum tests were performed to examine group differences in performance on cognitive tests and the Cognitive_{INDEX}. Each group served as a between-subjects factor, and each cognitive test was the dependent variable. Prior to creating the Cognitive_{INDEX}, non-parametric correlation analyses confirmed significant correlations between all test scores (ranging from 0.56 to 0.74, all $p < .001$). The test scores were then converted to Z-scores based on the sample mean and standard deviation, and the average Z-score was calculated. The Cognitive_{INDEX} showed high reliability ($\alpha = .89$). As shown in Table 3, the no-low ISA and severe ISA groups did not differ significantly from each other on any of the cognitive measures, although their performance was significantly lower than that of the HC group. Significant differences were also observed in the Independence_{INDEX}.

Table 6.3 Comparison between participants in each group on demographic and clinical variables.

	HC (Group 1) n = 51	No low ISA (Group 2) n = 33	Severe ISA (Group 3) n = 21	Test ¹ (ES)	Group differences ²
Age (Years)					
Mean (SD)	53 (± 17)	56 (± 11)	59 (± 13)	$\chi^2(2) = 3.44$	ns.
Range	19-81	31-75	25-81	($\eta^2 = .03$)	
Education (Years)					
Mean (SD)	11 (± 3)	11 (± 3)	9 (± 3)	$\chi^2(2) = 7.16^*$	2 > 3*
Range	6-17	5-17	4-17	($\eta^2 = .07$)	
Gender (n, %)					
Female	25 (49%)	17 (52%)	2 (10%)	$\chi^2(2) = 11.36^{**}$ ($\varphi = .30$)	1 > 3*** 2 > 3***
Evolution (Months)					
Mean (SD)	-	14 (± 12)	20 (± 21)	$U = 200$	ns.
Range	-	3-48	3-76	($r_{bis} = .08$)	
Etiology (n, %)					
Stroke	-	25 (83%)	12 (76%)	$\chi^2(3) = 1.44$ ($\varphi = .00$)	ns.
Tumor	-	2 (7%)	2 (12%)		
TBI	-	2 (7%)	2 (12%)		
Infection	-	1 (3%)	0 (0%)		
Lesion location (n, %)					
Left Hemisphere	-	14 (58%)	3 (25%)	$\chi^2(2) = 5.85^*$ ($\varphi = .33$)	-
Right Hemisphere	-	6 (25%)	8 (67%)		
Bilateral	-	4 (17%)	1 (8%)		
Cognitive measures					
INECO	25 (± 3)	19 (± 6)	18 (± 5)	$\chi^2(2) = 34.8^{***}$ ($\eta^2 = .35$)	1 > 3*** 1 > 2***
RAVLT-short term	48 (± 10)	37 (± 13)	30 (± 10)	$\chi^2(2) = 30.3^{***}$ ($\eta^2 = .30$)	1 > 3*** 1 > 2***
RAVLT-long term	10 (± 3)	7 (± 4)	5 (± 4)	$\chi^2(2) = 23.6^{***}$ ($\eta^2 = .23$)	1 > 3*** 1 > 2**
Semantic Fluency	22 (± 6)	15 (± 6)	14 (± 5)	$\chi^2(2) = 27.7^{***}$ ($\eta^2 = .28$)	1 > 3*** 1 > 2***
Cognitive _{INDEX}	.45 (±.61)	-.44 (±.86)	-.82 (±.70)	$\chi^2(2) = 39.1^{***}$ ($\eta^2 = .39$)	1 > 3*** 1 > 2***
Functionality measures(%)⁴					
Independence _{INDEX}	99 (± 3)	74 (± 20)	62 (± 15)	$\chi^2(2) = 74.8^{***}$ $\eta^2 = .71$	1 > 3*** 1 > 2* 2 > 3***

Note: HC = Healthy Controls; ISA = Impaired Self-Awareness; RAVLT = Rey Auditory Verbal Learning Test; Significance levels: * = < .05; ** = < .01; *** = < .001

¹ Kruskal-Wallis rank sum test and Mann-Whitney U for continuous variables; Chi-squared for categorical variables.

² Differences between groups were evaluated with Tukey's post hoc tests

⁴ Derived from the Cog-Awareness ADL Scale. Lower scores (%) represent lower functional level

All participants were involved in all BADL (the two tasks) from the Cog-Awareness ADL Scale. However, more variability was found in the number of IADL tasks performed in each group (see **Table 6.4**). A chi-squared analysis, examining the relationship between the three groups and the number of IADL activities from the Cog-Awareness ADL Scale performed by the participants (zero tasks, one task or two tasks), showed a significant result [$\chi^2 = 43.91, p < .001$, Cramer's $V = .45$ (medium effect size)]. Upon closer examination, we found that the severe ISA group had a greater percentage of participants engaging in zero or only one task (48% and 24%, respectively) compared to the no-low ISA group (30% and 15%, respectively), and the HC group, in which all participants performed both tasks (100%).

Table 6.4. Frequency of participants from each group that perform each type of activity.

	HC group n = 51	No-low ISA n = 33	Severe ISA n = 21
BADL, n(%)			
2 tasks	51 (100%)	33 (100%)	21 (100%)
1 task	-	-	-
0 tasks	-	-	-
IADL, n(%)			
2 tasks	51 (100%)	18 (55%)	6 (29%)
1 task	-	5 (15%)	5 (24%)
0 tasks	-	10 (30%)	10 (48%)

Note: HC = Healthy Controls; ISA = Impaired Self-Awareness; BADL = basic activities of daily living, IADL = instrumental activities of daily living

External validity

To compare group differences in the three discrepancy indexes of the Cog-Awareness ADL Scale, a Quade's test was performed, with covariates including education level, gender, the Cognitive_{INDEX}, and the Independence_{INDEX} (variables that showed significant differences in previous analyses). As expected, a significant difference between the groups was observed for the Total_{DISCREPANCY} score. Post-hoc comparisons with Tukey's correction showed that both the HC and the no-low ISA groups had

significantly lower Total_{DISCREPANCY} scores compared to the severe ISA group. Additionally, when the specific discrepancy indexes were analyzed for the BADL_{DISCREPANCY}, the same pattern of results emerged, as shown in **Table 6.5**. However, for the IADL_{DISCREPANCY} score, although differences in a similar direction were observed, they did not reach statistical significance among the three groups.

Table 6.5 Comparison between participants in each group on the three discrepancy indexes of the Cognitive Awareness Scale for Basic and Instrumental Activities of Daily Living.

	HC group (Group 1) n = 51	No, low ISA (Group 2) n = 33	Severe ISA (Group 3) n = 21	Test ¹ (ES)	Group differences ²
Cog-Awareness Total (%)					
Mean (±SD)	0 (± 3)	2 (± 8)	21 (± 11)	$F = 6.55^{**}$ ($\eta^2 = .11$)	$1 < 3^*$ $2 < 3^{**}$
Range	-11 to 10	-13 to 29	0 to 38		
Median (IQR)	0 (-1, 1)	2 (-1, 4)	20 (13, 29)		
Cog-Awareness BADL (%)					
Mean (±SD)	0 (± 2)	2 (± 8)	18 (± 10)	$F = 6.04^{**}$ ($\eta^2 = .11$)	$1 < 3^*$ $2 < 3^{**}$
Range	-5 to 7	-13 to 21	-5 to 38		
Median (IQR)	0 (0, 0)	2 (-2, 5)	16 (13, 25)		
Cog-Awareness IADL (%)³					
Mean (±SD)	0 (± 6)	3 (± 10)	29 (± 18)	$F = 2.06$ ($\eta^2 = .05$)	ns.
Range	-16 to 20	-10 to 43	4 to 54		
Median (IQR)	0 (-2, 2)	0 (-2, 3)	31 (15, 43)		

Note: Significance levels: * < .05; ** < .01; *** < .001; Greater mean scores (%) represent greater ISA

¹ Quade's ANCOVA (years of education, gender, Cognitive_{INDEX} and functionality as covariates)

² Differences between groups were evaluated with Tukey's post hoc tests.

³ In this analyses sample size for the no-low ISA group was n = 23 and for the severe ISA group was n = 11, as not all participants performed IADL.

Diagnostic accuracy

A ROC curve was then performed (see **Figure 6.3**), and the AUC was 0.95 (95% CI = [0.89 -1]; SE = .02, $p < .001$). This indicates that there is a 95% probability that a randomly selected participant with ISA will have higher discrepancy scores than a randomly selected participant without ISA (Hajian-Tilaki, 2013). The predictive utility of the Cog-Awareness ADL Scale was also examined by calculating its sensitivity and specificity. Using a cut-off point of > .06, the scale showed a sensitivity of 0.90 (95% CI =

[0.76 -1]) and a specificity of 0.90 (95% CI = [0.84 -0.96]). The positive predictive value was 0.70 (95% CI = [0.53-0.87]). This means that, among participants identified as having ISA based on the PCRS, there is a 70% probability that the Cog-Awareness ADL Scale will correctly identify them as having ISA. Conversely, the negative predictive value was 0.97 (95% CI = [0.93 -1]), meaning that there is a 97% chance that a participant without ISA on the PCRS will be correctly identified as not having ISA on the Cog-Awareness ADL Scale. Youden's Index (0.80) and accuracy (0.90, 95% CI = [0.90 -.91]) were also calculated as measures of test performance. Using this criterion, there were 19 true positives, 76 true negatives, 8 false positives, and 2 false negatives.

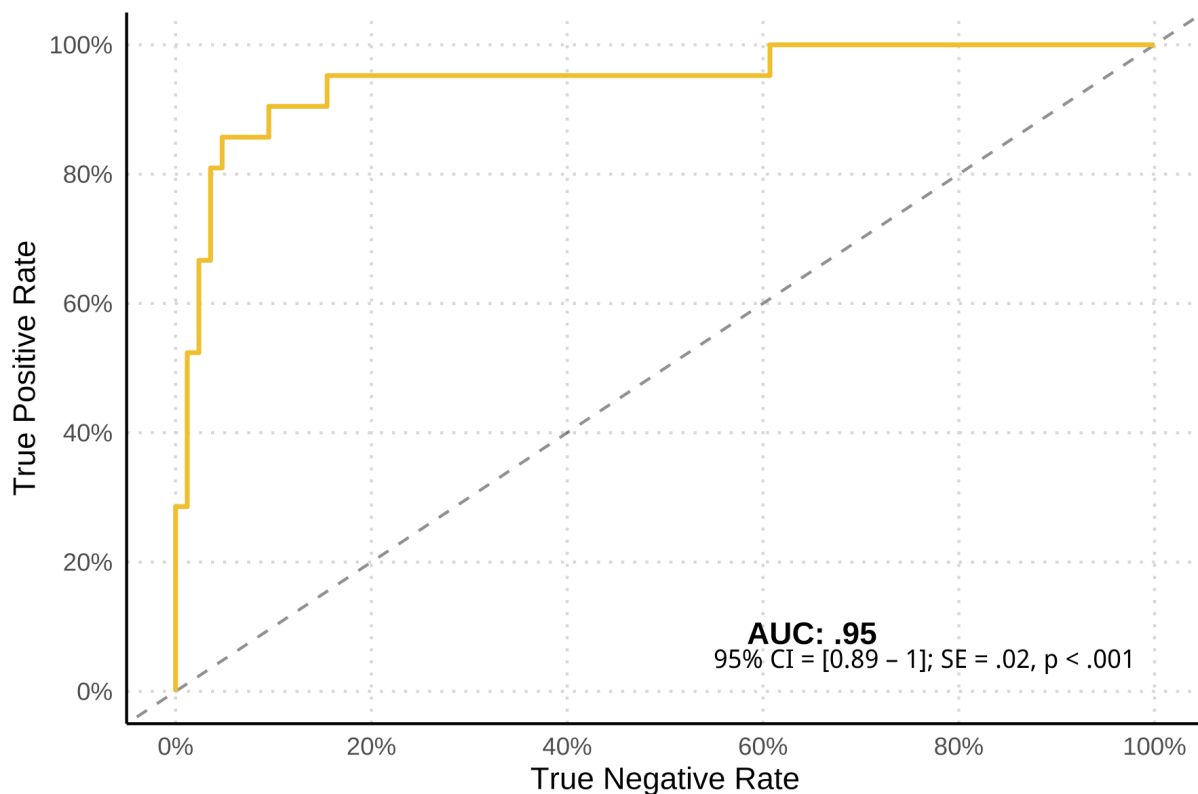


Figure 6.3 Area under the curve (AUC) demonstrating the optimal sensitivity (true positive rate) and specificity (true negative rate) of the Cognitive Awareness Scale for Basic and Instrumental Activities of Daily Living relative to the PCRS ($n= 105$).

Differences in SA levels between BADL and IADL in patients with severe ISA

While all participants with severe ISA completed the BADL tasks, only 11 of them completed the IADL task. Therefore, the results for these patients are presented. The paired-samples Wilcoxon test showed a significant difference in the levels of SA ($Z = 8.00$, $p = .02$). In patients with severe ISA, the IADL_{DISCREPANCY} score (Mdn = 30%) was higher than the BADL_{DISCREPANCY} score (Mdn = 16%), as shown in **Figure 6.4**.

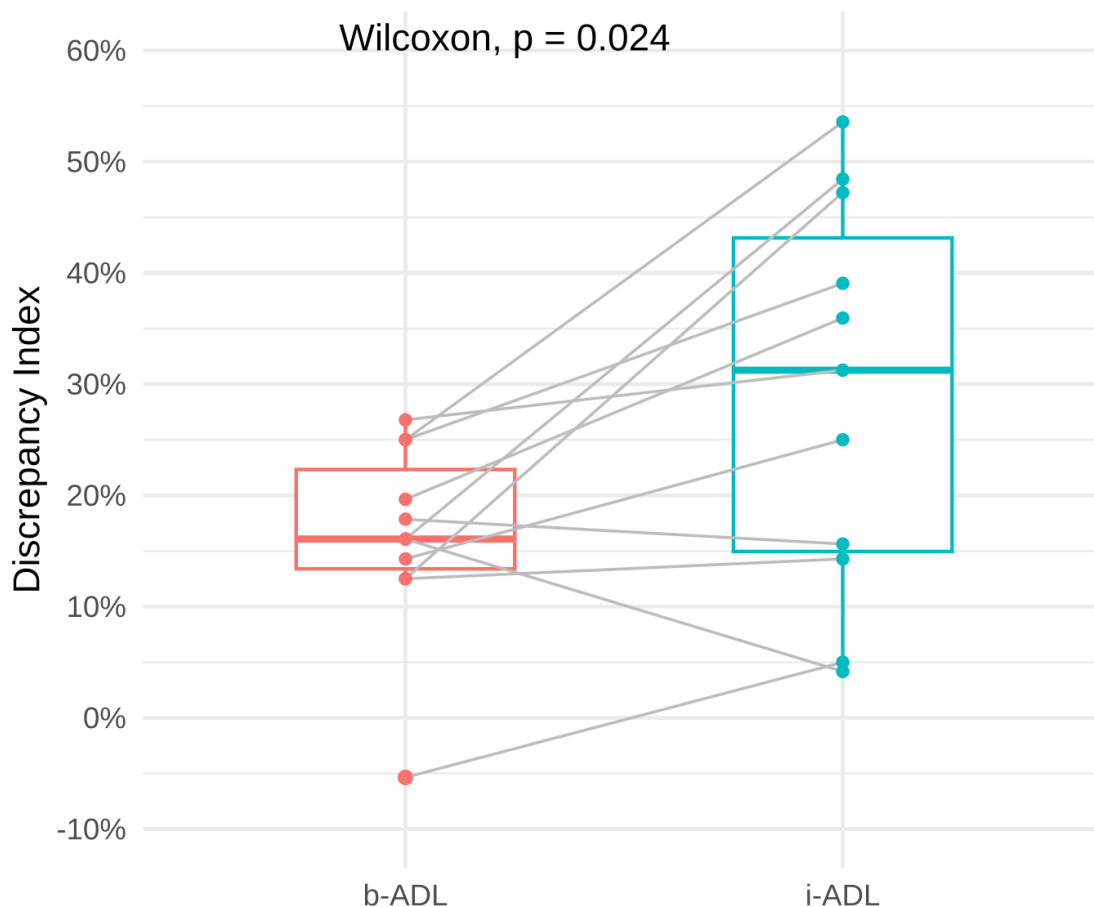


Figure 6.4 Visualization of group and individual change between patients with severe impaired self-awareness ($n = 11$) for the discrepancy index across basic (BADL) and instrumental activities of daily living (IADL).

6.5 Discussion

Convergent validity

The Cog-Awareness ADL Scale showed a strong correlation with PCRS, which is a well-established scale for assessing SA, with acceptable psychometric and conceptual properties (Dromer et al., 2021a; Smeets et al., 2012). The strong correlation between the discrepancy scores of both instruments (globally and in each subscale) suggests a positive association between the existing scale and the newly developed scale. Surprisingly, the correlation between the Cognitive Awareness ADL scale and the ADL-subscale of the PCRS, although strong, had the lowest coefficient compared to others PCRS subscales, especially on the BADL subscale. One possible explanation may be related to the PCRS's design, which appears to prioritize questions about IADL over BADL. Another explanation is that the PCRS is a scale that assesses the person's ability to perform an activity or behaviour, even if he/she does not currently perform it (i.e. potential ability rather than actual ability). In contrast, the Cog-ADL scale requires the person to actually perform the activity in order to answer the items. If the activity is not performed, the items are not answered. Therefore, the absence of the need for hypothesizing about others' or one's ability, as required by the Cog-ADL Scale, might explain the comparatively lower correlations between the two scales. This difference is particularly noticeable in the ADL-subscale of the PCRS, where it is clear whether the person performs the activity or not, unlike other sections such as the emotional, cognitive or interpersonal subscales, which do not involve this kind of hypothesizing as they relate to different aspects of the person's daily life.

However, it is important to point out that a strong correlation does not necessarily mean that these scales provide equally accurate estimates of true values (Bland & Altman, 2010). The Bland-Altman plot showed that the majority of the differences observed between the scales in the Total_{DISCREPANCY} scores fall within the 95% confidence limits,

indicating an acceptable level of agreement. We believe that this is an important finding in favor of the psychometric robustness of the present scale for measuring SA in ABI patients. This is consistent with several studies indicating that agreement examinations are needed to estimate the amount of error in the development and evaluation of health status scales and classification procedures (Boateng et al., 2018; Kottner et al., 2011; Terwee et al., 2007).

In addition, it is important to note that, while these previous instruments are reliable and feasible for routine use in assessing SA, they have limitations in capturing the extent to which cognitive factors contribute to variations in SA across different aspects of daily life. The limited number of items addressing the cognitive domain in these instruments has received considerable attention in clinical and research settings (Bivona et al., 2020; Brown et al., 2019; Dromer et al., 2021a; Toggia & Goverover, 2022). Conversely, the Cog-Awareness ADL Scale provides a comprehensive and complete approach isolating the cognitive processes that impact activities of daily living, by incorporating multiple cognitive items that have proved to be important in predicting functional performance in previous research with performance-based ADL tasks. In addition, the fact that it provides numerous examples of each cognitive error type within the same ADL contexts may facilitate more realistic responses from patients and caregivers and reduce subjectivity. By addressing the cognitive domain in such detail, the Cog-Awareness ADL Scale effectively reduces the inherent abstraction that is often associated with items related to cognitive processes in other self-proxy rating discrepancy scales (Brown et al., 2019). Furthermore, the importance of our scale lies in its unique structure, as it effectively differentiates between BADL and IADL. This novel design allowed us, for the first time, to examine the distinct relationship between the discrepancy in BADL vs. IADL and each subscale of the PCRS. Specifically, our results indicate that discrepancy in both b- and IADL are associated with the different aspects measured by the PCRS. This suggests that our scale has the ability to capture all cognitive and functional dimensions related to ISA. This provides a comprehensive view of ISA, thus

contributing to a more thorough understanding of patients' condition and their ability to assess their own deficits.

Sociodemographic, clinical, cognitive and functional differences among groups

Regarding cognitive measures, the two patient groups showed cognitive deficits in all cognitive areas with lower performance in most cognitive tests and the Cognitive_{INDEX} compared to that obtained by the HC, this was an expected outcome as cognitive dysfunction is a common adverse consequence after ABI (Whyte et al., 2011). More importantly, the two ABI patients' groups did not differ from each other in any of these cognitive measures, except in their level of ISA (greater discrepancy index effect for the severe ISA group than for the no-low ISA and HC groups). We consider that this is a significant finding, as it demonstrates that patient groups specifically differ in their genuine SA abilities, and that these cannot be attributed or confounded with group differences in other cognitive processes. The Cog-Awareness ADL Scale also allowed us to test the relationship between ISA and patients' functional dependence. Chi-squared analyses on the proportion of participants performing or not performing each ADL from the Scale showed that, while all patients continued to perform both BADL, a larger proportion of patients from the severe ABI group performed none or only one of the two IADL and very few performed both, compared to the no-low and HC groups, where most of them continued to perform the two IADL. Altogether, these findings revealed that the presence of ISA after ABI is specifically prone to alter dependence in IADL. To the best of the authors' knowledge, no prior scales have allowed testing this task differentiation.

External Validity

Group comparisons confirmed the expected results. In this study, the patients with severe ISA had significantly higher Total_{DISCREPANCY} scores than the patients with no-low ISA and the HC, suggesting a greater tendency for patients with severe ISA to overestimate their functional abilities on the Cog-Awareness ADL Scale. These findings

are consistent with previous studies examining SA in participants with various ABI populations and healthy controls using other self-proxy discrepancy tools such as PCRS or AQ (Bivona et al., 2019; Noé et al., 2005; Prigatano et al., 1998; Sherer et al., 2003). As expected, the patients with severe ISA had significantly higher discrepancy scores in the BADL subcategory compared to the patients with no-low ISA and the HC. However, in the IADL subcategory, although there was a pattern of higher discrepancy scores in patients with severe ISA, the observed difference, surprisingly, did not reach statistical significance. This finding may be attributed to the fact that several patients in our sample did not participate in the IADL tasks, reducing the sample to only 11 patients in the severe ISA group. This limited sample size could potentially have affected the ability of the test to detect significant differences in the IADL tasks, especially given the observed variability in the data within each group. Indeed, sample size and variability are two important factors known to affect the statistical power of various tests (Rusticus & Lovato, 2014).

Diagnostic accuracy

The diagnosis of ISA is crucial for the management of ABI patients, as it affects daily functioning and influences treatment decisions and prognosis. In our study, we aimed to evaluate the diagnostic accuracy of the Cog-Awareness ADL Scale in identifying ABI patients with and without ISA using a ROC curve analysis. To the best of our knowledge, ROC analysis has only been used for the diagnostic accuracy of one SA tool, i.e., SADI, which is a validated semi-structured interview (Ownsworth et al., 2019), but not for a *self-proxy rating discrepancy scale*. The results of the ROC curve analysis indicate that the Cog-Awareness ADL Scale has excellent sensitivity and specificity with a cut-off score of $> .06$, which is consistent with the convention proposed by Fischer et al. (2003). This indicates that the majority of ABI patients identified as having severe ISA by PCRS were correctly identified by the Cog-Awareness ADL Scale. It should be noted that, although the number of false positives was higher than the number of false negatives, we prioritized minimizing false negatives in our study to prevent the negative consequences

associated with underdiagnosis of ISA, such as delayed intervention (Trevethan, 2017). In this regard, as previously reported (Dromer et al., 2021b; Sansonetti et al., 2021; Smeets et al., 2012; Toglia & Goverover, 2022), the development of sensitive diagnostic tools with acceptable psychometric properties to accurately determine the level of ISA in patients with ABI is essential for their early rehabilitation to increase motivation and engagement, improve functional outcomes, and prevent long-term consequences.

Do SA levels vary across tasks?

Another interesting finding of this study is that individuals with severe ISA showed a significantly reduced ability to accurately predict their cognitive performance on IADL tasks compared to BADL tasks. This finding adds valuable insights to the ongoing discussion in recent studies, highlighting the need to investigate the potential variability of ISA manifestations observed between patients and within the same individual depending on task characteristics such as familiarity and task complexity (Dromer et al., 2021a; Merchán-Baeza et al., 2020; Toglia & Goverover, 2022; Toglia & Kirk, 2000). As described above, to our knowledge, only a few performance-based studies have addressed the effect of task type on the level of SA, also finding greater challenges in SA when ABI patients faced more complex IADL tasks (Abreu et al. 2001; Rotenberg-Shpigelman et al. 2014). The novel structure of the Cog-Awareness ADL Scale, which distinguishes between BADL and IADL, seems to be the first tool to address the issue of task complexity in metacognitive knowledge. Indeed, as was mentioned above, it seems that the inherent complexity of IADL tasks, including higher cognitive and social demands, may lead to a reduced ability of individuals with severe ISA to anticipate steps, foresee errors, and accurately evaluate their performance. These findings have important clinical implications for at least two reasons. Firstly, they underscore the importance of considering different task demands and contextual factors when assessing SA after ABI, as suggested by Toglia and Kirk, (2000). Secondly, as emphasized by Robertson and Schmitter-Edgecombe (2015), the metacognitive knowledge component of SA has

significant implications for an individual's assessment of task difficulty, which may hinder their effort and engagement in certain tasks, thus affecting their commitment in treatment programmes. However, this finding, should be interpreted with caution, as it is based on a small sample size of patients with severe ISA in whom both discrepancy indices for BADL and IADL tasks could be calculated.

Therefore, although these findings are meaningful and provide valuable insights within the specific context of our study population, their generalisability may be limited. Although this limitation could not have been anticipated prior to the study, replication with a larger sample of severe ISA patients would provide further validation and increase the robustness of the results. Nevertheless, the fact that such a reduction in the sample of severe SA ABI patients performing frequent IADL took place seems to be a relevant finding that highlights the impact of SA on complex functionality and the importance of addressing the specific needs of individuals with severe ISA to enhance their ability to carry out daily activities effectively.

6.6 Limitations and future directions

While our multicenter study provides preliminary evidence supporting the validity of the Cog-Awareness ADL Scale for identifying ABI patients with and without ISA in both research and clinical settings, it is important to acknowledge some limitations. Firstly, the factor structure of the Cog-Awareness ADL Scale could not be assessed due to the sample size. Conventional guidelines suggest having a ratio of 5 to 10 participants per item (Kyriazos, 2018), which would recommend a sample size of 155-310 participants for the Cog-Awareness ADL Scale. Therefore, a larger study is needed to confirm and establish the factor structure of the Cog-Awareness ADL Scale. Future studies should also include test-retest and inter-rater reliability analyses, which could not be included in the present study due to COVID-19 restrictions on sample access that were present when the study was conducted. Secondly, due to the heterogeneous nature of our sample, we were

unable to examine whether different etiologies, other clinical factors such as severity of impairment, or lesion location may result in different profiles of SA levels. Future studies with a larger sample of participants may be able to divide patients into subgroups with more homogeneous clinical profiles in order to distinguish between different SA levels. In addition, future investigations using this scale with larger samples could focus on assessing the extent to which SA levels differ among specific cognitive domains (i.e., are patients with ISA less aware of specific cognitive items, such as those related to inhibition, problem-solving or task initiation, than to others? Are potential deficits in SA in specific cognitive domains related to damage into specific brain regions? Gaining insight into these variations seem crucial for advancing our understanding of SA in the context of ABI (Dromer et al., 2021a; Toglia & Goverover, 2022; Villalobos et al., 2021) and for tailoring personalised interventions to improve patient outcomes (Smeets et al., 2012). We consider that the inherent structure of the Cog-Awareness ADL Scale seem promise to start answering these relevant questions. Furthermore, in our study, we were not able to assess the participants' emotional and psychological functioning. The influence of emotional and social factors on SA has received considerable attention in recent systematic reviews by Brown et al. (2021) and Dromer et al. (2021b). It is important for future development of the scale to address this limitation and include additional items to assess these factors, in order to gain a more comprehensive understanding of other potential subdomains of SA.

Chapter 7

Translation, cross-cultural adaptation and validation of the 10-item Weekly Calendar Planning Activity in Spanish-speaking ABI patients: a multicenter study

The content of this chapter has been published as:

Salazar-Frías, D., Funes, M. J., Merchán-Baeza, J. A., Ricchetti, G., Torralba-Muñoz, J. M., & Rodríguez-Bailón, M. (2023). Translation, cross-cultural adaptation and validation of the 10-item Weekly Calendar Planning Activity in Spanish-speaking ABI patients: a multicenter study. *Frontiers in Psychology, 14*, 1-17.

<https://doi.org/10.3389/fpsyg.2023.1018055>

7.1 Abstract

Objective: We present the process of translation, adaptation, and validation in the Spanish context of the 10-item version of the Weekly Calendar Planning Activity (WCPA-10), a performance-based measure of cognitive instrumental activities of daily living (C-IADL). **Method:** The study consisted of two phases: I) translation/cultural adaptation of the WCPA, conducted by professional bilingual translators, a panel of experts, and a pilot study, and II) validation in a sample of 42 acquired brain injury patients (ABI) and 42 healthy participants (HC). **Results:** Spanish WCPA-10 primary outcomes showed expected convergent/discriminant validity patterns with socio-demographical and clinical variables and cognitive processes identifying those Spanish WCPA-10 outcomes that best predicted executive and memory deficits measured with a battery of traditional cognitive tests. In addition, performance on the Spanish WCPA-10 was a significant predictor of everyday functioning over variables such as socio-demographics or global cognition when measured with traditional tests. External validity was established by the Spanish WCPA's ability to identify everyday cognitive deficits in ABI patients compared to HC, even in those with subtle cognitive impairment based on cognitive tests. **Conclusion:** The Spanish WCPA-10 seems an appropriate and sensitive assessment tool to identify cognitive-functional impairment in ABI-patients, even those with subtle cognitive impairment. The results also highlight the relevance of this kind of test, as they indicate a better prediction of patients' real-world functioning than traditional cognitive tests.

7.2 Introduction

ABI results from a sudden injury to the brain that causes various sequelae of a physical, cognitive, and sensory nature. Its causes are diverse, including head injuries, stroke, brain tumors, and infections. A recent review of the epidemiology of ABI in Spain concluded that the population with brain injury is 420,000, with stroke and traumatic brain injury being the leading causes (FEDACE, 2019). In addition, more than 100,000 new cases each year, of which 25% correspond to people under 65 years of age. Overall, ABI can be classified as a complex disability, as almost 89% of these people may present behavioral and cognitive impairments. Among them, EF are affected in most cases since they rely on networks extending to multiple brain regions, including cortical and subcortical structures (Bettcher et al., 2016; Burgess & Stuss, 2017). EF refers to a set of high-order functions that enable a person to operate in novel situations and complex everyday activities independently (Cicerone et al., 2019; Godefroy, 2003; Goldberg & Bougakov, 2005; Jurado & Rosselli, 2007). Despite the abundance of definitions, contemporary conceptualizations of EF, highlight several interrelated skills such as working memory, inhibition, and cognitive flexibility as the fundamental components of EF that allow individuals to perform higher-level functions such as planning, organization, reasoning, and problem-solving (Diamond, 2013; Miyake & Friedman, 2012). In addition, authors like Kennedy & Coelho (2005) and Stuss (2011) have also considered metacognitive skills closely linked to EF, including self-awareness, self-monitoring, and self-regulation.

Evidence from neuropsychological and occupational studies has shown that the impairment of these processes is one of the leading causes of functional alterations, keeping individuals from independently returning to their home, community, and job (Kennedy et al., 2008), significantly affecting their employment status (Atchison et al., 2004; Ownsworth & Shum, 2009), and making them incapable of living independently at home (Ghaffari et al., 2021; Lipskaya-Velikovsky et al., 2018) and engaging in social

relationships (Reid-Arndt et al., 2007). Furthermore, EF has shown to be a strong predictor of the level of dependency in instrumental activities of daily living (IADL) (Overdorp et al., 2016; Villalobos, Caperos, et al., 2020), and it can explain a larger percentage of variance in IADL than other cognitive processes (McAlister & Schmitter-Edgecombe, 2016; Royall et al., 2007). For these reasons, recognizing executive dysfunction and its consequences in everyday activities should be considered when assessing cognitive functions. Thus, it will provide a clearer picture of a patient's neuropsychological functioning and its implications for everyday performance.

Traditional cognitive tests targeting EF are designed to isolate executive components over a short time in controlled environments, using novel tasks involving artificial stimuli and away from patients' significant daily activities (Lezak et al., 2012). Most of these tests have demonstrated good psychometric characteristics, reliability, and validity and can provide indicators of very specific executive deficits. However, due to the artificial nature of the tasks, several authors highlight their poor predictive validity, and thus they may not be sufficient to capture their real-world functional impact (Baum et al., 2008; Gioia & Isquith, 2004). Two criteria have been pointed out for establishing ecological validity: *representativeness* of the task, which refers to the correspondence between the task demands and the demands encountered outside the laboratory in the everyday environment, and *generalizability* of test results, which refers to the degree to which test results reflect and predict functional behavior in everyday performance (Burgess et al., 2006; Chaytor & Schmitter-Edgecombe, 2003; Gioia & Isquith, 2004; Spooner & Pachana, 2006).

The lack of ecological validity of traditional cognitive tests has led to the development of complementary ecologically valid tests, the so-called "performance-based measures of C-IADL," incorporating more complex and significant multistep IADL to target several executive domains at a time, with emphasis on their functional implications in everyday performance (Baum et al., 2008; Chan et al., 2008; Romero-

Ayuso et al., 2021). Some of these measures are the Executive Function Performance Test (EFPT) (Baum et al., 2008), the Naturalistic Action Test (NAT) (Giovannetti et al., 2006; Schwartz et al., 2002), the Cooking Task (CT) (Chevignard et al., 2008), the Sequential Daily Life Multitasking (SDLM) (Jarry et al., 2021), and the Multiple Errands Test (MET) (Shallice & Burgess, 1991). Many studies have documented promising results for the efficacy of these tasks in identifying executive deficits in real-life or simulated settings (Burns et al., 2020; Cuberos-Urbano et al., 2013). However, while some of the current results are promising, their typical poor accessibility and great time and resource consumption hinder their wide implementation in the clinical practice (Diaz-Orueta et al., 2020). Furthermore, since ADL are highly culturally dependent, they need to be adapted to different cultures systematically. Given the lack of standardization of most of these tests with Spanish samples, their administration to Spanish ABI patients is still unavailable.

Therefore, a primary need in research in this field is to develop ADL performance-based tests that improve the ease of administration in clinical settings with lower time and resource consumption. In this vein, Toglia (2015) has developed the WCPA, a paper and pencil C-IADL assessment of EF designed to examine a person's ability to perform a multistep activity that requires scheduling a list of appointments into a weekly calendar sheet, while managing conflicting situations and keeping track of multiple rules. Unlike most traditional tasks, the WCPA was designed to simultaneously measure several specific EF, including planning, working memory, problem-solving, set-shifting, and inhibition (Jaywant et al., 2021; Toglia, 2015). It also provides online self-awareness measures (Arora et al., 2021; Jaywant, Arora, et al., 2022).

The WCPA has demonstrated good psychometric characteristics regarding validity and reliability indices in a wide range of clinical groups, such as college students with and without ADHD (Lahav et al., 2018), patients with epilepsy (Zlotnik et al., 2020), multiple sclerosis (Goverover et al., 2020), and individuals with stroke (Jaywant et al., 2021). Moreover, a high level of inter-rater reliability has been established, as well as moderate

to high test-retest reliability for performance measures (Lahav et al., 2018; Weiner et al., 2012). Translations and cultural adaptations of this test have been made into Swedish, Dutch, Chinese, and Hebrew; however, we are unaware of any study aimed at translating and adapting it into Spanish. In addition, different versions of the WCPA exist to suit different age groups and levels of cognitive deficits. Therefore, in this study, we first aimed to carry out the cultural and linguistic adaptation into Spanish of the WCPA-Short (version A). This reduced 10-appointment version has the same ratio of fixed and variable appointments as the 17-appointment version WCPA, designed to be more practical for the inpatient setting. The second aim of our study was to validate and examine its psychometric properties with a Spanish sample of ABI patients with different etiology (including patients with stroke, traumatic brain injury, and tumors) admitted to various rehabilitation centers, including a healthy control group. To this end, we will first examine the convergent and discriminant validity of the primary variables of the Spanish WCPA-10, by analyzing its association with different socio-demographic, clinical and standardized cognitive tests of EF and memory. Although some studies have found correlations between the WCPA with several standardized tests of EF (Goverover et al., 2020; Toglia, 2015), to the best of our knowledge, no study has tested, to date, its potential association with other cognitive processes, such as memory in a heterogeneous ABI sample. Therefore, in this study, we included a broader battery of cognitive tests to comprehensively analyze the pattern of associations/dissociations between the different outcomes of the Spanish WCPA-10 and different cognitive processes. These analyses might help to elucidate which of the Spanish WCPA-10 outcomes are more sensitive to executive deficits and/or whether some of them might also be related to other processes such as memory. Third, we examined whether the Spanish WCPA-10 might have incremental functional validity in ABI patients, that is, whether it is a better predictor of their competency in everyday functioning compared to traditional cognitive tests. This effect has already been found in a sample of MS patients (Goverover et al., 2020); however, as far as we know, this has not been addressed yet in the case of ABI patients.

Finally, we examined external validity by analyzing performance differences in the Spanish WCPA-10 among ABI patients and healthy controls in a Spanish sample. In addition, we aimed to determine whether the Spanish WCPA-10 is sensitive to identifying functional executive alterations not only in ABI patients with moderate cognitive deficits but also in ABI individuals who had mild cognitive alterations when measured with traditional cognitive tests.

7.3 Methods

The study consisted of two phases: I) translation and cross-cultural adaptation of the 10-item version of the WCPA (Toglia, 2015) for the Spanish population, and II) its validation in a Spanish sample of ABI patients and healthy participants. To ensure semantic and conceptual equivalence between the translated items and the original ones, the translation and cultural adaptation process was carried out following the guidelines for translating and adapting tests recommended by the Quality of Life Special Interest group (QoL-SIG) and the Translation and Cultural Adaptation group (TCA group) of the International Society for Pharmacoeconomics and Outcomes (ISPOR) (Wild et al., 2005) and by the International Test Commission (2017). Before starting the process, we obtained permission from the original author of the WCPA, maintaining constant communication with her via e-mail to clarify doubts about the test items or other questions that arose during the process.

We took the following steps to carry out the translation and cultural adaptation process (**Figure 7.1**). In Phase 1, we aimed to translate and adapt the WCPA-10 to assess EF from a performance-based approach and refine it for the Spanish ABI population. In phase 2, the resulting Spanish WCPA-10 version was administered in different centers to test its convergent and discriminant validity and its relationship to other relevant sociodemographic, cognitive and functional measures, as well as to assess its ability to dissociate among healthy participants and ABI patients with different levels of severity in

their cognitive function. The present study was approved by the Andalusian Ethics Committee for Biomedical Research (Anosognosia AVD2017, 3/01/2017, 0056-N-17). All participants provided their informed consent after receiving the information about the objectives and characteristics of the study.

Phase 1. Translation and cross-cultural adaptation process

In Phase 1, four professional bilingual translators participated in the translation process. Eight clinicians, experts in brain injury (five occupational therapists and three neuropsychologists), and a pilot group (4 ABI patients) were involved in the cultural adaptation process. First, two independent translators translated the original document from English into Spanish. Both translators worked in the health sciences field, one was a native Spanish speaker with a level C proficiency in English, and the other was a bilingual native speaker whose native language was Spanish.

The purpose of this panel was to obtain two Spanish versions of the instrument (version 1a and 1b). Then, discrepancies between the two translations were reviewed and resolved by the lead authors, resulting in a preliminary harmonized Spanish version of the WCPA (version 2), considering the author's opinions to ensure that the original meaning of the questions was maintained in the translation. Then, the back translation of version 2 was performed. Two bilingual translators, different from those who participated in versions 1a and 1b, worked without access to the original text. As a result, two back-translated English versions were obtained (version 2a, version 2b). Finally, both documents were reviewed and reconciled with the original version by a committee composed of the lead authors to identify problematic items between the versions and unify them into a single translation, verifying semantic, idiomatic, empirical, and conceptual equivalence.

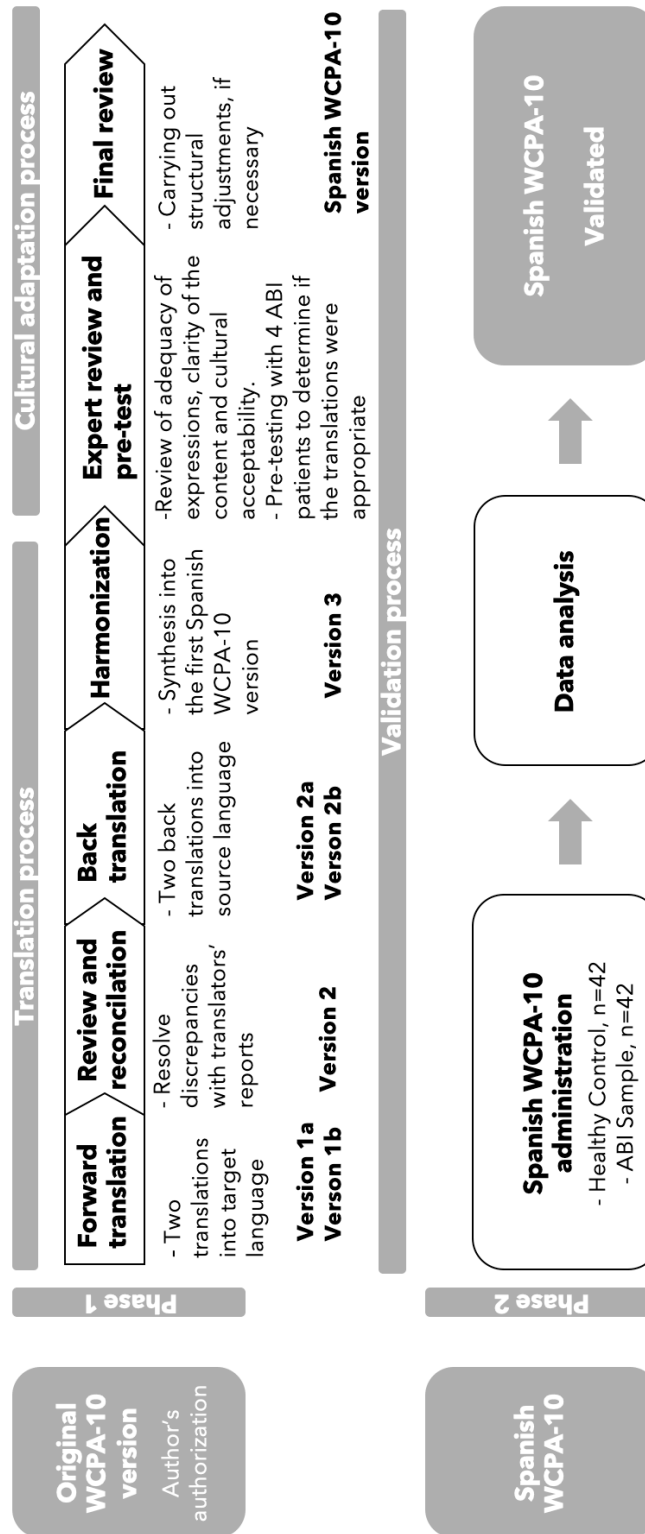


Figure 7.1 Translation, cultural adaptation, and validation process.

After version 3 was obtained, a review was carried out by an expert committee comprised of four occupational therapists and four neuropsychologists with broad expertise in assessing and rehabilitating patients with ABI. This panel aimed to evaluate other important aspects, such as the structure, instrument instructions, administration procedure, the adequacy of expressions, and the cultural acceptability of each item and response category using a five-point Likert scale. In addition, a pilot study with ABI patients (n=4) was carried out to determine whether the translations were appropriate and identify elements that the target population may not understand. Finally, the lead authors and the expert committee carried out the last review based on these findings. The problematic items and those that caused discrepancies were presented to the group individually, and their meaning was explained. Then, each element was discussed until acceptance was achieved. When consensus was not reached, alternative versions of each item proposed by the translator panel were considered and changes were incorporated, obtaining as a result, the final WCPA Spanish version (version 4).

Phase 2. Validation process

Participants

The data for Phase 2 is from forty-two ABI patients (15 women), all of whom received cognitive/occupational rehabilitation from the outpatient rehabilitation service at two hospitals specialized in acute services, and two neuro-rehabilitation centers specialized in chronic services in the cities of Granada and Málaga (Andalucía, Spain). Potential participants were initially approached by the treating clinicians and invited to participate, when attending rehabilitation sessions at each center. Patients older than 18 years were considered for the study if they had a diagnosis of ABI established by neurological report at least three months before the study (time following ABI was not restricted), and presented cognitive deficits concerning EF, metacognition, and/or memory. These deficits were established by an objective cognitive assessment administered by the

treating clinician. Patients presenting visuo-perceptive deficits, hemineglect, severe motor or perceptual disturbances, and language problems (reading and writing alterations) were excluded, as determined by the treating clinicians' criteria. Inclusion was also based on behavioral criteria assessed by the clinician, ensuring that each patient could follow and understand the task instructions and presented adequate arousal and behavioral control for the total time of the session.

Forty-five functionally independent participants that were living independently in the community and drawn from the same geographic area as the patients were invited for assessment as part of the neurologically healthy control group (HC). HC participants were adult volunteers, recruited using snowball sampling by the researchers and their collaborators (master's degree students and final year undergraduate occupational therapy students). A subsample were students from the psychology undergraduate program that participated voluntarily in exchange for course credits. The exclusion criteria were the presence of cognitive deficits or global cognitive decline, based on objective cognitive assessment administered by researchers as a part of a screening for eligibility for all healthy controls. Three participants were excluded due to these criteria, presenting memory and EF scores outside the normal range for their age. A final sample of forty-two participants (22 women) conformed the HC group in the study. **Table 7.1** summarizes participants' demographic and clinical characteristics.

Measures

Spanish WCPA-10 version. The test requires the participant to schedule 10 appointments (some with "fixed" or "flexible" days and times) into an empty weekly calendar sheet while following a set of specific rules and guidelines that remain visible throughout the assessment session: (1) leave Wednesday free, (2) do not cross out appointments after they are entered in the weekly calendar sheet, (3) ignore distracting questions from the examiner, (4) inform the examiner when it is a specified time, and (5)

inform the examiner when finished. Based on the key scores extracted from the original WCPA (Toglia, 2015), we included the total strategy use, the number of rules followed out of 5, total accuracy (number of accurate appointments scheduled out of 10), planning time (time from the start of the activity to the entry of the first appointment), and total time to complete the task. In addition, based on previous studies (Arora et al., 2021; Jaywant et al., 2021), we also examined the type of cognitive strategy used by each participant. Immediately after the task, and based on the standard WCPA (Toglia, 2015), we included a semi-structured interview in which participants were asked if they were familiar with the task (i.e., if they used a weekly schedule regularly).

Table 7.1 Socio-demographic and clinical variables among groups

	HC group n = 42	ABI group n = 42	Test¹ (ES)
Age (Years)			
Mean (SD)	42.3 (17.08)	55.6 (12.35)	$U = 477^{***}$
Range	18-72	24-75	($r_{bis} = .46$)
Education (Years)			
Mean (SD)	12.2 (2.77)	10.9 (3.47)	$U = 680$
Range	8-17	3-17	($r_{bis} = .23$)
Gender			
Female	22 (52%)	15 (36%)	$\chi^2 = 2.37$
Male	20 (48%)	27 (64%)	($\phi = .13$)
Evolution (Years)			
Mean (SD)	-	2.9 (3.1)	
Range	-	.5-14	
Etiology			
Stroke	-	27 (64%)	
Tumor	-	6 (14%)	
TBI	-	5 (12%)	
Infection	-	4 (10%)	
Damage			
Left Hemisphere	-	19 (45%)	
Right Hemisphere	-	11 (26%)	
Bilateral	-	10 (24%)	
Cerebellar	-	2 (5%)	

¹Mann-Whitney U for continuous variables; Chi-squared for categorical variables.

Note: Significance levels: * < .05; ** < .01; *** < .001

Cognitive measures

INECO Frontal Screening (Torralva, Roca, Gleichgerricht, López, et al., 2009). A brief, sensitive, specific, and easy-to-administer screening test for health professionals to detect executive deficits in clinical settings. It has a maximum total score of 30 and its structure incorporates 8 subtests traditionally used to assess EF: motor programming (0-3 points), conflicting instructions (0-3 points) and a go-no go test (0-3 points) to assess response inhibition and set shifting. It also includes a proverb interpretation test (0-3 points) to assess abstract capacity; a backward digit span (0-6 points), verbal working memory (0-2 points), and spatial working memory tests (0-4 points) to assess working memory; and an abbreviated and modified Hayling test (0-6 points) to measure verbal inhibitory control. It has shown high levels of sensitivity and specificity for the detection of executive dysfunction in patients with brain injury (Pinasco et al., 2021) and other conditions (Bruno et al., 2015).

Controlled Oral Word Association Test (COWAT) (Benton & Hamsher, 1989). The participants must produce as many words as possible, beginning with the letters F, A, and S, in three separate 60-second trials. Proper nouns were scored as incorrect. In addition, a Semantic Verbal Fluency task is included, where the person has to generate as many animal names as possible within 60 seconds. The total number of words produced across the three trials was the dependent variable from the COWAT. For animal fluency, the dependent variable was the total number of correct animals.

Rey Auditory-Verbal Learning Test (RAVLT). In this test, the participant is presented with a list of 16 words on five occasions, recording, after each repetition/trial, the number of words that the person remembers (Schmidt, 1996). It analyzes the verbal learning curve of the person tested (comparing the number of words acquired between the first and the fifth trial), immediate memory, and delayed recall. It also allows evaluating executive

aspects of memory, such as free recall compared to the recognition test and the presence of intrusions and perseverations.

Functional measures

Patient Competency Rating Scale (PCRS). A 30-item rating scale evaluates the competency to perform various functional tasks after ABI in four different areas: activities of daily living (ADL), interpersonal, cognitive, and emotional (Prigatano et al., 1998). Each item is rated on a 5-point Likert scale ranging from 1 = “cannot do” to 5 = “can do with ease”. The PCRS consists of the PCRS patients’ and the PCRS informants’ versions. We used the informants’ total score for this study to measure the patient’s functional level, as in a previous study (Gaertner et al., 2020).

Procedure

The ABI participants were assessed individually between April and December 2021 in four different centers, where the sample was recruited. The core research team developed a 4-hour training course with detailed and specific instructions and examples for the group of neuropsychologists and occupational therapists from the collaborating centers to learn how to administer the assessment tools described above. This set of clinicians were blinded to the specific objectives and hypotheses of the study. The training consisted of 2 online modules in which the different phases of the assessment were presented in a practical way and applied to the clinic. In addition, there were later practice sessions in which feedback was given to resolve doubts about the application of the tests, and recommendations were established on best practices to maintain the tests' safety in clinical and research environments. The assessment was divided into three parts: (a) initially, all patients were informed verbally and in writing about the study, and the informed consent form was signed by all patients and by their primary caregivers; (b) an interview to obtain socio-demographic information such as age, and years of education,

was conducted; clinical characteristics such as etiology, time since injury, and lesion location was obtained from medical records for all participants; finally, (c) the assessment was administered following the standardized instructions for each test across two 30-50 minute sessions to minimize fatigue. The PCRS, INECO Frontal Screening and RAVLT, were administered at the first session, and the Spanish WCPA-10 and COWAT at the second session. The assessment sessions took place in quiet settings. The primary caregiver filled out the informant-caregiver version of the PCRS on a separate room, while the assessment was conducted with the patient at the first session. The same tests were administered to all participants in the HC group. In the case of healthy controls, the assessment was administered in one 50-70-minute session, in the Mind, Brain and Behavior Research Center (CIMCYC in Spanish) of the University of Granada and at the Health Sciences Faculty of the University of Málaga by the researchers and their collaborators (Cognitive Neuroscience master's degree students and final year undergraduate OT students, who received a similar training course as the clinicians).

Data analysis

We performed a sensitivity power analysis in G*power 3.1 (Faul et al., 2009) to determine the minimum effect size we could detect with the present study's sample, setting the power level at 0.80. For the correlation analyses ($n = 42$), assuming a two-sided test and an alpha level of 0.01, the minimum detectable effect size was $r = 0.39$. For the regression analyses ($n = 42$), we set an alpha level of 0.05 and based on the number of predictors, the sensitivity power analysis indicated a minimum detectable effect size of $f^2 = 0.32$. Finally, assuming an alpha of 0.05, between-group analyses showed that with the total sample of the present study ($n=84$), the minimum detectable effect size for the ANCOVAs with two groups (1 covariate) was $\eta^2 = 0.08$ and three groups (2 covariates) was $\eta^2 = 0.10$. Therefore, 42 participants per group were sufficient to detect medium effect sizes according to Cohen (2013). Descriptive statistics (means, medians, SDs, skewness, and kurtosis) were calculated for all variables. The Shapiro-Wilk test showed

that almost all variables of interest deviated from a normal distribution. Therefore, all analyses were made using non-parametric statistical tests. Next, group differences in clinical and socio-demographic variables such as time since injury, age, and education were examined with the Kruskal-Wallis test. Finally, the Chi-square analysis was used to evaluate group differences in categorical socio-demographic and clinical variables, including gender, etiology, and location of brain damage.

To examine convergent and discriminant validity, Spearman rank-order correlation analyses were conducted for the ABI sample to study the association of the Spanish WCPA-10 main outcome measures (number of strategies used, planning time, total time, rules followed, and total accuracy) with the degree of familiarity with the task, potentially relevant socio-demographic (i.e., age, years of education) and clinical (i.e., time since injury) variables, and with two cognitive composite scores: a memory composite score encompassing the Rey Auditory-Verbal Learning Test variables of short-term/long-term memory; and an executive composite computed from several EF tests encompassing the INECO, COWAT, and Semantic Verbal Fluency task variables. Composites were used to reduce the number of predictors in the regression models, given the small size of our sample. For creating these composites, first, non-parametric correlation analyses were carried out to confirm that the variables for each composite were significantly correlated to each other. The correlation coefficient of the tests conforming the memory composite was 0.84 ($p < .001$), and the correlation coefficients between the tests conforming the executive composite ranged from 0.61-0.69, $p < .001$ both. Then, the scores of these variables were converted into Z-scores based on the mean and standard deviation of the entire sample. Finally, the average Z-score for Memory and EF was calculated to form each composite. Both composites found to be highly reliable ($\alpha = .92$ and $\alpha = .84$, respectively). Due to the high number of comparisons, the significance level was set at $p \leq 0.01$.

Next, a three-stage hierarchical linear regression analysis was performed on the ABI sample to examine the extent to which executive-related vs. memory-related cognitive measures best explained each of the Spanish WCPA-10 outcome measures. First, those measures that were previously correlated with the executive and memory composites in ABI patients were entered as dependent variables (i.e. *total strategy use*, *rules followed* and *total accuracy*). Next, those socio-demographic and clinical variables that were correlated significantly with the Spanish WCPA-10 measures were entered as independent variables in the first model, the memory composite was entered in the second model, and an executive composite was entered in the third model.

A hierarchical regression analysis was conducted to test whether performance on the Spanish WCPA-10 might have incremental functional validity compared to traditional cognitive tests, in which the caregiver PCRS score was entered as the dependent variable. Socio-demographic variables of age and years of education were entered as independent variables in the first model, a general cognitive composite was entered in the second model, and a Spanish WCPA-10 composite was entered in the third model. The general cognitive composite score was calculated from the average Z-scores of each cognitive raw score described in the measures section. The correlation coefficients between the tests ranged from 0.53-0.84, $p < .001$ all. The Spanish WCPA-10 composite score was created from the average Z-scores of total strategy use, rules followed, and accuracy, as these measures are better performance indicators (Goverover et al., 2020). The correlation coefficients between these scores ranged from 0.55-0.74, $p < .001$ all. Cronbach's alphas for the five cognitive and the three Spanish WCPA-10 items were .90 and .83, respectively.

To analyze external validity, performance on the Spanish WCPA-10 measures (i.e., total strategy use, planning time, total time, rules followed, and total accuracy) was compared across both groups (Healthy control and ABI sample) using the Quade's distribution-free test, a non-parametric alternative to ANCOVA (Quade, 1967), and

selecting as covariates those socio-demographic/clinical variables in which significant group differences were found. Regarding the types of strategies observed, we used a chi-square test to compare the frequency of use by each group. This analysis was restricted to the strategy used by at least 50% of the control group. We also used a chi-square test to compare the frequency of yes vs. no responses in the task familiarity question. Furthermore, we were interested in identifying which of the Spanish WCPA-10 measures could discriminate healthy participants from ABI patients with moderate cognitive deficits and those with subtler cognitive impairment. To this end, further analyses were performed to compare healthy participants with the ABI sample sub-divided into subtle (S-Cog group) and moderate (M-Cog group) cognitive deficit groups. Based on the cognitive composite mean score of the healthy control group, ABI patients with z-scores below 2SD constituted the M-Cog group; all other ABI participants formed the S-Cog group (Poncet et al., 2015). Using several Quade's tests, performance on the main Spanish WCPA-10 measures was then compared across the three groups. For those analyses in which the variable group was significant, post-hoc, pairwise comparisons were performed with Bonferroni adjusted *p*-values.

7.4 Results

Phase 1. Translation and cross-cultural adaptation process

The syntactical structure and the use of words of the original WCPA-10 version were maintained whenever its equivalent was acceptable in Spanish. When the literal translation did not adapt to semantic understanding in Spanish, it was decided to select a translation that was culturally adapted to the population. The feedback from the expert committee and the pilot test with the ABI sample resulted in several adjustments, ensuring that the items and instructions were correctly understood in Spanish and without losing the meaning and sense of the original language. To maintain a logical format and the same terminology throughout all the test forms, the core research team and the

expert committee analyzed the linguistic patterns, adjusting or changing the selection of words and adding synonyms, so that the context of the item could be correctly interpreted by both the examiner and the participants. For example, the word "paciente" was used to refer to the client or examinee, as it is an understandable term and most commonly used in the clinical context in Spain. It was also decided to use the word "examinador" when referring to the clinical staff who performed the evaluation. Additionally, "weekly calendar" and "weekly schedule" were translated as "horario semanal" throughout all the test forms. **Table 7.2** shows the test format sheets translated and adapted to the Spanish ABI population.

Table 7.2 WCPA Adult/Older Adult Level II-Short (Version A) format sheets translated and adapted to Spanish

Examiner forms	Patient forms
Calendar Scoring Worksheet	Appointments to be Scheduled
Directions Sheet	Instruction sheet
Adult Background form	Weekly Calendar sheet
WCPA Recording form	Weekly Calendar example sheet
Strategies Observed sheet	
After-Task Interview and Rating Scale	

In the Appointments and Errands to Be Scheduled form, five activities had to be changed due to their lack of relevance in the context of daily life in Spain (e.g. we change the "carpool" activity to "go to the gym", because carpool is not a usual activity in Spain) or to the scheduled time proposed in the original version (e.g. we change the time of the dentist's appointment from 15:00 to 16:00). This decision was made after being approved by the original author of the instrument and ensuring that all the activities and their schedules, although changed, maintained their structure and were related to each other in the same way as the original version. In addition, the time system was adjusted from 12 to 24 hours for all activities (this change was also made in the Weekly Calendar sheet and

the Weekly Calendar example sheet). In some cases, the syntactic construction of sentences was also modified to ensure cultural adaptation. In the instruction sheet, some of the verbs were changed to words of conceptual equivalence that are more understandable for the Spanish population. For example, the verbs “mark” or “enter” was translated as “*introduzca*.” However, during the pilot study and the expert committee review, it was noted that this verb was “difficult to understand.” Therefore, it was agreed to use: “*apunte*” in the final version.

Phase 2. Validation process

Socio-demographic and clinical characteristics of the sample

Table 7.1 displays the socio-demographic characteristics of both groups. There was a significant difference in age between groups, with a greater proportion of young adults in the healthy control group. Both groups had similar percentages of male and female participants and similar years of education. The patients’ primary diagnosis was stroke, while a smaller percentage of tumor, traumatic brain injury and infection etiology were observed. Moreover, magnetic resonance imaging scan showed a higher proportion of left hemisphere lesion location among the ABI patients’ sample compared to the right hemisphere, bilateral or cerebellar lesion location.

Convergent and Discriminant Validity

Spearman’s coefficients for the relation between the main Spanish WCPA-10 measures and task familiarity, socio-demographic, clinical, executive, and memory composites of the ABI sample are reported in **Table 7.3**. The r_s coefficients between 0.31 and 0.7 were considered moderate correlations, indicating convergent validity, and values < 0.30 were considered low correlations, indicating discriminant validity (González, et al., 2020). No significant correlations were observed between the Spanish WCPA-10 measures and task familiarity. Low correlations were observed between most

Spanish WCPA-10 measures and the socio-demographic and clinical variables. However, a moderate correlation was found between years of education and total accuracy score. Regarding the association of the main Spanish WCPA-10 measures and the executive and memory composites, we first observed that the number of strategies used and the total accuracy score in the Spanish WCPA-10 correlated moderately and positively with cognitive tests that assessed EF. Therefore, a higher executive composite score was associated with a higher number of accurate appointments and the number of strategies used in the Spanish WCPA-10. The memory composite score showed moderate positive correlations with total accuracy, total strategy use, and rules followed scores.

Table 7.3 Spearman's r coefficients between the main Spanish WCPA-10 measures and task familiarity, socio-demographic, clinical and cognitive composites variables for the ABI sample ($n = 42$)

	Spanish WCPA-10 performance scores				
	Strategies used	Planning time	Total time	Rules followed	Total accuracy
Spanish WCPA-10					
Task familiarity	0.15	0.03	-0.10	0.03	0.32
Socio-demographic					
Education	0.07	-0.14	-0.32	0.19	0.54**
Age	-0.25	0.10	0.13	-0.27	-0.16
Clinical					
Evolution (Years)	-0.00	-0.28	0.09	-0.15	-0.08
Executive					
Executive composite	0.52**	-0.24	-0.11	0.35	0.51**
Memory					
Memory composite	0.42*	-0.31	-0.27	0.39*	0.48**

Significance levels: * $p < .01$, ** $p < .001$

Incremental neuropsychological validity: cognitive processes that best explain performance on the Spanish WCPA -10

Three hierarchical linear regression analyses were performed to determine whether Spanish WCPA-10 total strategy use, rules followed, and total accuracy were predicted

by the socio-demographic variables of age and education, together with the memory and executive composites. Prior to conducting these analyses, the assumptions of multicollinearity, homoscedasticity, normality of the residuals, and examination of outliers were tested. The assumptions of multicollinearity, normality of the residuals, and homoscedasticity were all satisfied for the rules followed, and total accuracy regression models. An examination of Cook's distance scores detected two outliers for the accuracy score and one for the rules followed score. The removal of outliers did not influence the results of the regression analyses, therefore, results with the outliers are presented. For the total strategy use regression model, collinearity statistics (i.e., Tolerance and VIF), and homoscedasticity were all within acceptable limits. However, an examination of Cook's distance scores identified one outlier, which affected the normal distribution of the residuals (Shapiro-Wilk test $p = .02$). By removing the outlier, the residuals became normally distributed (Shapiro-Wilk test $p = .19$). There were no significant changes in the results of this analysis when the observation was deleted, therefore, results with the outlier are presented.

For *total strategy use*, in step 1, the socio-demographic variables (age, education) were entered and did not account for significant variance ($p = .79$). In step 2, the memory composite score significantly contributed in the amount of the variance to the model [$\Delta R^2 = .219$; $F(1, 38) = 10.81$; 95% CI $[-.00, .44]$; $p < .01$], and emerged as the only significant predictor ($p < .01$) in this model. In step 3, the executive composite was entered to assess its contribution, over and above the socio-demographic variables and the memory composite. A significant additional amount of the variance in *total strategy use* was accounted by the executive composite [$\Delta R^2 = .090$; $F(1, 37) = 4.92$; 95% CI $[-.05, .24]$; $p = .03$]. In this final model, the executive composite emerged as the only significant predictor ($p = .03$) (**Table 7.4**).

Table 7.4 Summary of regression analyses for the prediction of the total strategy score of the Spanish WCPA-10 by the socio-demographic variables, memory and executive composites in ABI patients (n=42)

Predictor	<i>b</i>	SE	<i>t</i>	Model fit
Step 1				
(Intercept)	3.58*	1.52	2.34	
Age	-0.01	0.02	-0.58	
Education	0.02	0.07	0.28	
				$R^2 = .012$ F (2, 39) = 0.23 95% CI [.00, .10] $f^2 = .01$
Step 2				
(Intercept)	4.81**	1.41	3.40	
Age	-0.01	0.01	-0.62	
Education	-0.05	0.07	-0.74	
Memory composite	0.85**	0.25	3.28	
				$R^2 = .231^*$ F (3, 38) = 3.79 95% CI [.01, .39] $f^2 = .30$
Step 3				
(Intercept)	4.64**	1.34	3.44	
Age	0.00	0.01	0.14	
Education	-0.08	0.06	-1.17	
Memory composite	0.48	0.30	1.59	
Executive composite	0.88*	0.39	2.21	
				$R^2 = .321^{**}$ F (4, 37) = 4.37 95% CI [.04, .47] $f^2 = .47$

Significance levels: * $p < .05$; ** $p < .01$

For the prediction of *total accuracy* score, the socio-demographic variables (age, education) in step 1 accounted for significant 24% of the variance, ($p < .01$). Only years of education emerged as a significant predictor ($p < .01$). In step 2, the memory composite explained a significant additional 10% of the variance [$\Delta R^2 = .108$; F (1, 38) = 6.29; 95% CI [-.05, .26]; $p = .01$]. Years of education ($p < .05$) and the memory composite ($p < .05$) emerged as significant independent predictors in this model. Overall, the final regression

model accounted for a significant contribution to the variance ($p < .001$). However, the additional 5% of the variance in *total accuracy* score was not significant, after accounting for the executive composite from step 2 to step 3. Moreover, in the final model, the variance explained by the memory composite was no longer significant ($p = .27$), and the years of education emerged as the only significant predictor ($p = .02$) (**Table 7.5**).

Table 7.5 Summary of regression analyses for the prediction of the total accuracy score of the Spanish WCPA-10 by the socio-demographic variables, memory and executive composites in ABI patients (n=42)

Predictor	<i>b</i>	SE	<i>t</i>	Model fit
Step 1				
(Intercept)	0.44	2.04	0.21	
Age	-0.01	0.02	-0.49	
Education	0.35**	0.10	3.41	
				$R^2 = .240^{**}$ F (2, 39) = 6.17 95% CI [.03, .42] $f^2 = .32$
Step 2				
(Intercept)	1.77	1.99	0.88	
Age	-0.01	0.02	-0.50	
Education	0.27*	0.10	2.65	
Memory composite	0.92*	0.36	2.50	
				$R^2 = .348^{**}$ F (3, 38) = 6.77 95% CI [.08, .50] $f^2 = .52$
Step 3				
(Intercept)	1.57	1.94	0.80	
Age	0.00	0.02	0.11	
Education	0.24*	0.09	2.36	
Memory composite	0.49	0.43	1.12	
Executive composite	1.01	0.57	1.77	
				$R^2 = .399^{**}$ F (4, 37) = 6.15 95% CI [.10, .53] $f^2 = .64$

Significance levels: * $p < .05$; ** $p < .01$

In the prediction of *rules followed*, only the memory composite made a significant contribution ($p < .05$) when socio-demographic variables were considered, in step 2 [$R^2 = .189$; $F(3, 38) = 2.95$; 95% CI $[-.00, .35]$; $p < .05$]. No other variable accounted for a significant contribution to the variance in the outcome of rules followed (**Table 7.6**).

Table 7.6 Summary of regression analyses for the prediction of the rules followed score of the Spanish WCPA-10 by the socio-demographic variables, memory and executive composites in ABI patients ($n=42$)

Predictor	<i>b</i>	SE	<i>t</i>	Model fit
Step 1				
(Intercept)	3.47**	0.95	3.63	
Age	-0.02	0.01	-1.13	
Education	0.04	0.04	0.89	
				$R^2 = .056$ $F(2, 39) = 1.15$ 95% CI $[-.00, .20]$ $f^2 = .05$
Step 2				
(Intercept)	4.09**	0.93	4.39	
Age	-0.01	0.01	-1.18	
Education	0.01	0.04	0.11	
Memory composite	0.43*	0.17	2.49	
				$R^2 = .189^*$ $F(3, 38) = 2.95$ 95% CI $[-.00, .35]$ $f^2 = .22$
Step 3				
(Intercept)	4.06**	0.94	4.31	
Age	-0.01	0.01	-0.90	
Education	0.00	0.04	0.00	
Memory composite	0.36	0.20	1.71	
Executive composite	0.16	0.27	0.57	
				$R^2 = .196$ $F(4, 37) = 2.25$ 95% CI $[-.00, .34]$ $f^2 = .24$

Significance levels: * $p < .05$; ** $p < .01$

Incremental functional validity. Predicting PCRS performance from socio-demographic variables, cognitive and the Spanish WCPA-10 composites

Collinearity statistics and homoscedasticity were all within acceptable limits. However, an examination of Cook's distance scores identified two outliers, which affected the normal distribution of the residuals (Shapiro-Wilk test $p = .01$). By removing the outliers, the residuals became normally distributed (Shapiro-Wilk test $p = .10$). There were no significant changes in the results of this analysis when the observation was deleted, therefore, results with the outlier are presented. To examine whether Spanish WCPA-10 is a better predictor of functionality than traditional cognitive tests, we conducted a three-step hierarchical regression analysis using the PCRS score (caregiver's version) as the dependent variable. Age and education were entered at step 1, accounting for a significant 31% of the variance in PCRS score ($p < .05$).

However, as it is reported in **Table 7.7**, only age emerged as a significant predictor ($p = .02$). A similar outcome was found from the step 2 regression equation accounting for 34% of the variance. In this step, age was a significant predictor of PCRS score ($p = .03$), while education and the cognitive composite were not, and change in R^2 was not significant either. Overall, when the Spanish WCPA-10 composite was entered in the regression model, it contributed 14% more variance to the PCRS score ($\Delta R^2 = .141$; $F(1, 22) = 6.01$; 95% CI $[-.06, .32]$; $p < .01$). In step 3, age and the Spanish WCPA-10 composite score emerged as the only significant predictors. Cumulative values of the regression models at the time they were entered are shown in Table 7.7.

Table 7.7 Summary of regression analyses for the prediction of the relative's version score of the PCRS by the socio-demographic variables, cognitive composite and the Spanish WCPA-10 composite in ABI patients (n=27)

Predictor	<i>b</i>	SE	<i>t</i>	Model fit
Step 1				
(Intercept)	135.77**	25.13	5.40	
Age	-0.81*	0.32	-2.46	
Education	2.15	1.22	1.76	
				R² = .313* F (2, 24) = 5.46 95% CI [.02, .51] f² = .45
Step 2				
(Intercept)	146.00**	27.10	5.38	
Age	-0.76*	0.33	-2.29	
Education	1.36	1.50	0.93	
Cognitive composite	6.71	6.64	1.00	
				R² = .342* F (3, 23) = 3.98 95% CI [.01, .52] f² = .52
Step 3				
(Intercept)	149.92**	24.60	6.09	
Age	-0.67*	0.30	-2.22	
Education	1.19	1.32	0.90	
Cognitive composite	-1.84	7.00	-0.26	
Spanish WCPA-10 composite	19.47*	7.94	2.45	
				R² = .483** F (4, 22) = 5.14 95% CI [.06, .61] f² = .92

Significance levels: **p* < .05; ***p* < .01

External Validity. Difference between groups in the Spanish WCPA-10 performance

First, the Chi-square test revealed non-significant differences ($X^2(1) = 0.76, p = .38$) in the proportion of yes vs. no responses to the familiarity question between the healthy control group (yes = 57%, no = 43%) and the ABI sample (yes = 48%, no = 52%). Mean

and median scores on the main Spanish WCPA-10 for each group are presented in **Table 7.8**.

Table 7.8 Performance scores of healthy control participants and ABI patients on the Spanish WCPA-10

	HC group n = 42	ABI group n = 42	Test ¹ (ES)
Total strategies			
Mean	6.26 (1.73)	3.12 (1.64)	50.00**
Median	6 (2.75)	3 (2)	($\eta^2 = .37$)
Rules Followed			
Mean	4.62 (0.58)	3.10 (1.05)	39.48**
Median	5 (1)	3 (2)	($\eta^2 = .32$)
Total accuracy			
Mean	8.60 (1.17)	3.43 (2.52)	75.02**
Median	9 (1)	3 (3)	($\eta^2 = .47$)
Planning time (sec)			
Mean	160 (202)	63.5 (56.4)	3.22
Median	68.5 (214)	50 (45.3)	($\eta^2 = .07$)
Total time (sec)			
Mean	884 (332)	928 (360)	0.04
Median	790 (341)	850 (506)	($\eta^2 = .00$)

¹Quade's distribution-free test

Significance levels: * $p < .05$; ** $p < .01$

Note. The same pattern of results was found when removing the patients with less frequent lesion locations (cerebellar lesions $n=2$). We found non-significant differences among groups in planning time (Quade's $F = 3.41$, $p = .06$), and total time (Quade's $F = .03$, $p = .86$), and significant differences across groups for total strategies (Quade's $F = 48.7$, $p < .001$, $\eta^2 = .38$), rules followed (Quade's $F = 38.01$, $p < .001$, $\eta^2 = .33$) and total accuracy (Quade's $F = 71.94$, $p < .001$, $\eta^2 = .47$).

First, a Rank Analysis of Covariance for non-parametric data was conducted (Quade, 1967) with the a-priori covariate of age to examine the differences in the Spanish WCPA-10 primary scores relative to each group. No group differences were found in the planning time or total time outcomes. However, with respect to the HC group, the ABI group performed significantly worse in total strategy use, rules followed, and total accuracy.

A positive correlation was found between the number of strategies used and total accuracy score ($r = 0.72, p < .001$). Six strategies were used significantly more by the HC group: pausing and re-reading ($X^2(1) = 8.40, p < .01, \phi = .30$), self-checking ($X^2(1) = 17.68, p < .001, \phi = .45$), entering fixed appointments first ($X^2(1) = 23.92, p < .001, \phi = .53$), rearranging materials ($X^2(1) = 15.57, p < .001, \phi = .42$), crossing off entered appointments ($X^2(1) = 7.00, p < .05, \phi = .27$), and finger use ($X^2(1) = 8.02, p < .01, \phi = .29$).

Next, the ABI sample was divided into two groups, S-Cog ($n = 15$) and M-Cog ($n = 27$), to examine whether the Spanish WCPA-10 was able to discriminate healthy participants from ABI patients with moderate cognitive impairment (i.e., the M-Cog group), as well as from patients with subtle cognitive impairment (i.e., the S-Cog group). The socio-demographic variables significantly differ between the 3 groups for age, $\chi^2(2) = 14.58; p < .01; \eta^2 = .18$, and years of education, $\chi^2(2) = 8.51; p = .01; \eta^2 = .10$. Bonferroni post-hoc analyses revealed a significantly higher proportion of younger adults and more years of education in the HC group compared to the M-Cog group ($p < .05$ in each comparison). In addition, the S-Cog group had less time since injury onset than the M-Cog group (1.9 vs. 3.3 years, respectively), although this difference was not statistically significant (Mann-Whitney $U = 163, p = .29, r_{bis} = .19$). Diagnoses included stroke (S-Cog = 67%, M-Cog = 63%), traumatic brain injury (S-Cog = 7%, M-Cog = 15%), and others (S-Cog = 26%, M-Cog = 22%) (e.g., tumor, infection). No significant differences were observed for this variable in any of the groups.

Group differences were examined using the Rank Analysis of Covariance for non-parametric functions, with the socio-demographic variables (i.e., age and years of education) as covariates. There were no significant differences among groups in the planning time and total time variables. However, there were significant differences across groups for total strategies (Quade's $F = 27.31, p < .001, \eta^2 = .40$), rules followed (Quade's $F = 19.05, p < .001, \eta^2 = .32$) and total accuracy (Quade's $F = 37.10, p < .001, \eta^2 = .47$). Post-hoc comparisons with Bonferroni's correction showed that the HC group was

significantly more accurate, used more strategies and followed more rules in comparison to both ABI subgroups (all comparisons $p < .01$). There were no significant differences between both ABI groups in these variables.

7.5 Discussion

Phase 1. Translation and cross-cultural adaptation process

The lack of ecologically valid assessment tests for recognizing executive deficits and their consequences in daily functioning has become an increasingly important issue over the last years. For this reason, in the current study, we aimed to translate, adapt and validate to the Spanish language and culture the WCPA-10 item (version A), which is a C-IADL test to measure several executive components simultaneously with a daily-life task. Translation and cross-cultural adaptation of cognitive tests is a complex procedure that requires rigorous planning to maintain the linguistic and conceptual equivalence of the original version in order to support its psychometric properties and general validity for the target population (Borsa et al., 2012). In the present study, we used the method proposed by ISPOR (Wild et al., 2005) and the International Test Commission (2017). This approach allowed us to provide evidence of the idiomatic/semantic equivalence of the items and the good psychometric properties. Moreover, during the translation and adaptation process, we considered some key aspects listed by Borsa et al. (2012): (1) review of the original instrument's author regarding the proposed changes in the new version of the instrument to ensure semantic and conceptual correspondence, (2) collaborative work with experts in the field of occupational therapy and neuropsychology, who commented and made suggestions on the different translated items to ensure methodological quality, and (3) prior to the validation process, to ensure their acceptance and feasibility, the evaluation of the items in the ABI population was also carried out through a pilot study.

Phase 2. Validation in ABI patients and healthy control participants

Once the Spanish version of the WCPA-10 was obtained, quantitative analyses were performed to assess the extent to which the translated test's validity was equivalent to the original test's validity to support its use in the Spanish ABI population. In addition, the fact that the participants could be tested with a battery of additional cognitive and functional tests, together with the inclusion of an ABI patient sample with highly heterogeneous socio-demographic and clinical variables, allowed us to test several unanswered questions regarding the WCPA-10, such as the specific cognitive processes tagged by the different outcomes derived from the WCPA-10, its incremental functional validity in an ABI sample and its sensitivity to identify cognitive-functional difficulties even in patients with mild cognitive impairment based on traditional cognitive tests.

Relationship of the Spanish WCPA-10 outcomes with socio-demographic and clinical variables

The correlation analyses with the group of ABI patients supported the divergent validity of the main Spanish WCPA-10 measures with relevant socio-demographic variables, which is a desirable although uncommon property of cognitive tests. On the one hand, all Spanish WCPA-10 primary variables showed low correlations with age. Similar relationships were evident between the Spanish WCPA-10 main variables and years of education, except for the total accuracy score, where a significantly moderate relationship was evident. Moreover, we also found divergent validity for the Spanish WCPA-10 measures with familiarity with the task and time since injury, indicating that neither of these variables significantly affected the ABI participants' performance on the Spanish WCPA-10. To the extent of our knowledge, the relationship between the WCPA primary outcome variables and these socio-demographic and clinical variables has never been studied in a sample of participants with ABI. Prior WCPA studies with neurological patients have typically included more homogenous samples in terms of age, years of education or time since injury (Jaywant et al., 2021). Conversely, the ABI sample in our

study are quite heterogeneous in these terms, including younger and less educated participants.

Relationship and predictive value of the Spanish WCPA-10 measures of cognitive deficits

The introduction of a battery of cognitive tests in this study allowed us to test, for the first time in a sample of Spanish ABI patients, the specific pattern of relationship between the primary Spanish WCPA-10 outcomes and executive and other cognitive processes, such as memory. We observed a pattern of convergent validity with the executive composite for the *total strategy use* and *total accuracy* scores. This is in line with prior studies on the WCPA with other neurological conditions like multiple sclerosis (Goverover et al., 2020), and adolescents with ABI (Doherty et al., 2022), which have also found a significant relationship between accurate performance and strategy use in WCPA and established measures of EF. Furthermore, the relationship between the total accuracy score and cognitive tests that measure EF has also been observed in studies with Parkinson's patients (Foster et al., 2022). These findings support prior work highlighting the role of EF for successful everyday activity completion (Lipskaya-Velikovsky et al., 2018; Poncet et al., 2017). Interestingly, in our study, *total accuracy*, *strategy use*, and *rules followed* also correlated positively with the memory domain. We expected memory deficits to influence the performance in the Spanish WCPA-10, since memory has also been established as an important predictor of adequate performance in IADL after ABI (Overdorp et al., 2016; Tiznado et al., 2021). These results may partly be explained by the fact that the performance of multiple-step tasks such as the Spanish WCPA-10 test involves a broader range of cognitive processes compared to traditional tests (Burgess et al., 2006).

Meanwhile, the correlation analyses revealed that both EF and memory skills were associated with several Spanish WCPA-10 measures. The second aim of this study was to further specify the extent to which memory and/or executive processes best predict each

Spanish WCPA-10 outcome when controlling for potential socio-demographic variables. To this end, several hierarchical linear regression analyses were performed. Interestingly, these analyses showed that, after controlling for the effect of age and years of education, the executive composite emerged as a unique significant predictor for the Spanish WCPA-10 *total strategy use* score. Recent work suggests that the effective use of cognitive strategies during novel and complex tasks is closely linked to better EF (Bottari et al., 2014; Toglia et al., 2012), and to an improved functional performance (Nott & Chapparo, 2020), which is in line with the results obtained in the present study. Therefore, according to our results, the total strategy use score seems to be the best index of the Spanish WCPA-10 to identify EF deficit in ABI patients.

On the other hand, the memory composite emerged as a unique significant predictor of the rules followed score. This is a particularly surprising result if we consider that the rules to be followed in the WCPA are related to inhibition, planning, and prospective memory (Toglia, 2015), which are typically related to EF (Stuss & Alexander, 2000). Therefore, although the rules are visible throughout the activity, they may represent a significant increase in the cognitive demands of the task, thus, the participants forget to refer back to them and follow them as the task progresses, as suggested by Toglia (2015). Considering this evidence, it seems that *keeping track of the rules* while simultaneously engaging in the activity depends more on memory processes. However, there is evidence that EF could relate differently to separate aspects of memory such as encoding and immediate/delayed recall, which may influence performance scores on learning and memory measures (John et al., 2022). Therefore, another possible explanation could be that keeping track of rules depends more on the executive/strategic components of memory. To further test that, it would be useful to explore in the future the specific association of the Spanish WCPA-10 variables, such as the rule-followed score, with other memory tests that allow to measure encoding strategies, such as the Verbal Learning Test Spain-Complutense (TAVEC, Benedet and Alexandre, 2014) which is the Spanish version of the California Verbal Learning Tests (Delis et al., 1987).

Although we hypothesized that both executive and memory processes would be predictors of the *total accuracy score*, given its potentially global nature in terms of processes, a surprising finding was that this relationship disappeared when considering the variable “years of education” in the regression analysis, which emerged as a unique significant predictor. As was stated above, prior studies on the WCPA with neurological patients did not analyze the potential contribution of this variable, probably due to the lack of heterogeneity of their samples in this factor, with most studies including highly educated participants (Jaywant et al., 2021). In our study, we included a more heterogeneous group of ABI patients in terms of years of education, which allowed measuring its potential influence. Numerous studies have demonstrated the protective role of education on cognitive, functional and behavioral outcomes following ABI (Fraser et al., 2019; Leary et al., 2018). Therefore, it is possible to conclude that education level could be an important precondition for successful task performance, at least on this more general outcome, and that some caution might be required to interpret ABI patients’ scores in these variables. A further normative study comparing groups of participants differing in this variable is necessary to fully account for the role of education and performance in the Spanish WCPA-10.

Finally, the Spanish WCPA-10 measures *planning time* and *total time* exhibited no significant correlations with any cognitive process. This is in line with prior WCPA-10 studies (Goverover et al., 2020; Jaywant et al., 2021), which suggest that both outcomes could not be as informative as the rest of the outcomes to identify the cognitive-functional deficits in neurological patients. Therefore, we can conclude that the Spanish WCPA-10 seems to tap several cognitive processes (not only executive) and that different outcomes derived from the test are differently sensitive to identifying executive and/or memory deficits. Similarly, some outcomes seem more dependent than others on socio-demographic variables, such as education level, which highlights the need to consider this factor for clinical assessment and future studies

Incremental Validity

The third aim of this study sought to determine the extent to which patients' performance on the Spanish WCPA-10 can predict real-world functioning, over and above other measures such as traditional cognitive tests. Our findings provide convergent evidence supporting the ecological validity of the Spanish WCPA-10, extending previous work that addressed this issue with patients with multiple sclerosis (Goverover et al., 2020). The finding that a composite score of the Spanish WCPA-10 predicted functionality based on the main caregiver report about the functional competency of the patients in their real settings (i.e., through the PCRS, caregiver version) might constitute an even more straightforward evidence of the relevance of the Spanish WCPA-10 as a quick and easy-to-administer tool to predict future functional outcomes in ABI patients. The regression analysis suggests that the Spanish WCPA-10 test is a better predictor of daily functioning compared to traditional cognitive tests and socio-demographic variables when measured in a Spanish ABI sample. From a clinical point of view, this is perhaps the most relevant finding for two reasons. First, it responds to the need to improve the ecological validity of cognitive tests, and to move towards an assessment that captures the real impact of cognitive deficits on everyday functioning (Casaletto & Heaton, 2017; Ruff, 2003). Although several tests have been developed to fulfill this characteristic, the Spanish WCPA-10 is a good example of a functionally important multitask comparable to those found in the real world, developed to capture different aspects of everyday functioning. Thus, it would seem that, as the growing evidence suggests (Chaytor et al., 2006; Chaytor & Schmitter-Edgecombe, 2003; García-Molina et al., 2012; Poncet et al., 2017; Robertson & Schmitter-Edgecombe, 2016; Ruff, 2003; Spooner & Pachana, 2006; Toglia, 2015), the WCPA allows detecting deficits in higher-level functioning and understanding the underlying nature of performance problems, providing relevant information for the development of more personalized, occupational/cognitive therapy treatments.

External validity

The Spanish WCPA-10 showed good external validity, as the ABI-sample's performance was significantly worse than that of the HC group in most of the measures of the test. The Spanish WCPA-10 uses a functionally and cognitively challenging multitask to provide information on the multiple executive processes that influence the successful performance of activities of daily living (Toglia, 2015). In this study, ABI patients were *less accurate* on the task, *followed fewer rules* and *used fewer strategies*. These results align with previous studies using the WCPA, with ABI patients and other neurological populations from North America (Doherty et al., 2022; Goverover et al., 2020; Jaywant et al., 2021; Zlotnik et al., 2020).

A detailed analysis of the strategy use score was also performed in this study. Prior studies have noted the importance of cognitive strategies to facilitate performance in complex everyday situations (Bottari et al., 2014; Nott & Chapparo, 2020; Toglia et al., 2012), the importance of assessing their use for predicting everyday cognitive abilities (Chaytor et al., 2006), as well as for the selection of the types of cognitive rehabilitation techniques that may be most beneficial for each patient (Toglia et al., 2012). Based on previous studies with the WCPA in other neurological conditions like epilepsy (Zlotnik et al., 2020) and stroke (Jaywant et al., 2021), we expected to find significant differences in the number and type of strategies used during the Spanish WCPA-10 performance in both groups. In the present study, the ABI participants tended to be less efficient and effective at applying cognitive strategies during task performance compared to the HC group. These results agree with those of Jaywant et al. (2021), who also found lower use of strategies during the completion of the WCPA-10 in a stroke sample compared to healthy individuals. Moreover, in line with Jaywant et al. (2021), the least frequently used cognitive strategies in our clinical sample were: entering fixed appointments first, using the finger to maintain concentration, crossing out entered appointments, and self-checking errors. Additionally, in our study, the ABI participants used the pause and re-

150

read and re-range materials strategy less frequently than the HC group. As previous studies have noticed, it seems plausible that the limited or ineffective use of cognitive strategies may have placed greater cognitive demands, negatively impacting general task performance in the ABI participants (Arora et al., 2021; Jaywant et al., 2021; Toggia, 2015). In addition, we could replicate the results of Jaywant et al. (2021) by demonstrating that a higher accuracy score was associated with greater strategy use in our ABI sample. These results are also consistent with previous studies suggesting that interventions to promote strategy use may be important for improving job performance (Levine et al., 2011; Polatajko et al., 2012; Toggia et al., 2010). In the same vein, previous studies have also identified lower use of cognitive strategies such as self-checking and pausing and re-reading during WCPA completion as important indicators of self-monitoring deficits in stroke patients (Jaywant, Arora, et al., 2022) and in an older patients population (Arora et al., 2021). Additionally, several studies (Fogel, 2022; Villalobos, Caperos, et al., 2020) have considered the use of strategies and metacognition (i.e. self-awareness) as factors capable of modulating the typical relationship between ADL and EF. Further work, including a larger sample is required to understand better the possible relationship between cognitive strategies, self-awareness, and the Spanish WCPA-10 performance.

Interestingly, our results did not differentiate individuals with ABI from HC participants in the variables "mean planning time" and "mean time to complete the Spanish WCPA-10". However, a previous study on persons with stroke (Jaywant et al., 2021) found a larger time for completion in the stroke group, although it did not find significant differences in planning time relative to the HC group. One possible explanation for these contrasting results is that, in their study, the healthy controls and the stroke patient group were more homogeneous in terms of age and were globally older than our sample. Therefore, it seems possible that age may have important implications for time management variables, as previous studies have suggested (Arora et al., 2021).

The main problem with traditional cognitive tests is that they are not sufficiently sensitive to capture changes in functioning in everyday real-life settings. Consequently, patients with adequate or slight performance deficits in traditional tests of EF may go undiagnosed and be severely impaired in highly demanding tasks like those encountered in the real world (Torralva, Roca, Gleichgerricht, Bekinschtein, et al., 2009). After grouping the ABI patients into one subtle (S-Cog) and one moderate (M-Cog) cognitive deficit group based on cognitive testing, performance in Spanish WCPA-10 was compared between the HC group and both ABI groups. The fact that the M-Cog group and the S-Cog group showed significant differences with respect to the HC group demonstrates that the Spanish WCPA-10 is a highly sensitive diagnostic tool with the potential to capture deficits associated with functional performance even in patients typically identified with subtle cognitive deficits. This result is relevant from a clinical point of view, since tools such as the Spanish WCPA-10 would allow for an early diagnosis of functional difficulties that patients may encounter in their everyday life after ABI, enabling the design of interventions focused on the goals and needs of each patient.

According to these data, we can infer that the Spanish WCPA-10 is an adequate instrument to measure EF as well as other cognitive functions such as memory. However, our study indicates that not all of its primary outcomes seem to reflect these processes with the same accuracy. If the goal is to have an exhaustive measure of whether executive processes are impaired in a given patient and have the potential to impact their IADL negatively, we should especially observe their strategy use score, while the rules used score would be rather related to memory. Time-related outcomes derived from this test, such as planning time or total time, do not seem sensitive enough to measure cognitive deficits of this nature. Nevertheless, current theoretical models consider EF as a broad collection of interconnected higher-order cognitive processes, which include working memory, initiation, inhibition, and cognitive flexibility (Diamond, 2013; Miyake & Friedman, 2012). In addition, the use of strategies and other aspects of metacognition

(i.e. self-awareness, monitoring, etc) has also been considered as key aspects of EF by other models (Kennedy & Coelho, 2005; Stuss, 2011; Toglia & Foster, 2022). The division of EF into separate processes is supported by the fact that they are associated with a broad network of cortical structures in the anterior and posterior region, as well as other subcortical structures such as the basal ganglia and cerebellum (Burgess & Stuss, 2017; Stuss, 2011). We believe that the Spanish WCPA-10 can be a sensitive tool to identify specific difficulties within these different instances of EF. For example, a person can have difficulty in the general performance of the task due to an inability to hold in working/immediate memory all the information needed like the appointment name, time, location, and day, or to have the tendency to enter several appointments twice without realizing it (i.e. cognitive flexibility and/or working memory deficits), or not following the written instructions and rules during task performance (i.e. inhibition and/or working memory deficits), or not using useful cognitive strategies. Further research with a larger sample of ABI patients grouped by lesion site together with the inclusion of additional tests to measure more specific manifestations of EF is needed to investigate how more specific executive/memory deficits impact performance on the Spanish WCPA-10. Furthermore, the present study highlights that more attention should be paid to the relationship of some socio-demographic variables, such as years of education, which could explain some WCPA outcomes to a larger extent than other cognitive factors. Future research including larger samples with a larger range of years of education will help to test its potential influence better.

7.6 Limitations and future directions

Some limitations of the present study must be considered. We acknowledge that the etiology and lesion sites of our sample were very heterogeneous, with some etiology being much more frequent (i.e. stroke) than others (tumors, TBI, or infection). The fact of analyzing them all as a single group doesn't allow us to examine whether these variables could reveal specific patterns of deficits in the Spanish WCPA-10 resulting from different

etiologies and lesion locations. We consider this a relevant issue that requires further consideration in future work. Also, incremental functional validity analyses were only conducted for a small sample group, due to the small number of caregivers who could complete the PCRS informant version. Further work with a larger sample will be necessary to verify the functional predictive capacity of the Spanish WCPA-10. Moreover, in this study, we used the PCRS informant version as a measure of patients' daily functionality, future work is recommended to include more direct measures of functionality, such as a naturalistic performance-based assessment of the individual's ability to complete IADL. On the other hand, although several cognitive tests were administered to our ABI sample to measure memory and EF, they were not sufficient to obtain a comprehensive assessment of all instances of EF. Therefore, a larger pool of tests dissociating different executive components are needed in the future research. Also, we acknowledge that there are multiple limitations regarding the use of composite scores, including but not limited to the fact that it provides broader measures of cognitive functions, making it difficult to acknowledge the contribution of each of the memory (e.g. encoding, immediate/delayed recall) or executive components (e.g., task switching, problem-solving, inhibitory control, etc.) for the prediction of functional deficits. Finally, additional measures of other cognitive domains should be included in future work, to further clarify their association with performance in the Spanish WCPA-10 after ABI.

7.7 Conclusions

This study reports the process of translation, cultural adaptation, and validation of the WCPA-10 for the Spanish ABI population. To ensure the results' reliability and to allow the test to be used in the target population, our study used direct and reversed translations and group and expert cognitive debriefing in translation and cultural adaptation. In addition, this study offers the first initial evidence for the validation process in a Spanish ABI population. It establishes the Spanish WCPA-10 as a reliable and valid ecological tool for improving the understanding of the impact of executive dysfunction

on the activities of daily living. Our work provides relevant knowledge about the cognitive processes underlying the different Spanish WCPA-10 main outcomes, the degree to predict global functionality, and its ability to identify cognitive-functional alterations in ABI patients, even those with subtle cognitive impairments. The availability and validation of this type of performance-based tools are of great value for clinicians working with ABI patients to provide better treatments to improve cognition that impact instrumental activities of daily living. Although these kinds of assessment tools are increasing (Romero-Ayuso et al., 2021), there is still a great need for adaptation and validation for different neurological patients of different cultures. This study represents a straightforward attempt to fill the gap in this direction to evaluate Spanish ABI samples, given the lack of tools of this sort adapted in our culture.

Chapter 8

The moderating role of online awareness in the association between strategy use and performance accuracy on a test of functional cognition in individuals with acquired brain injury

Article under review

Salazar-Frías, D., Funes, M. J., Szot, A. C., Gómez, L. L., Navarro-Egido, A., & Rodríguez-Bailón, M. (under review). The moderating role of online awareness in the association between strategy use and performance accuracy on a test of functional cognition in individuals with acquired brain injury. *Archives of Clinical Neuropsychology*.

8.1 Abstract

Objective: Deficits in online self-awareness are common after acquired brain injury (ABI), leading to safety concerns and impacting daily activities and rehabilitation outcomes. Early identification is recommended as a critical first step in cognitive rehabilitation following ABI. The aim of this observational study was to examine differences in online self-awareness and strategy use between individuals with ABI and healthy controls. It also investigated whether online self-awareness moderates the relationship between strategy use and performance accuracy on a test designed to assess cognitive-functional deficits.

Method: 80 individuals with ABI and 76 controls completed the Spanish Weekly Calendar Planning Activity-10. Measures of online self-awareness included strategy use and self-recognized errors assessed during task. An after-task interview assessed individuals' self-evaluation of task difficulty and accuracy of performance. **Results:** Individuals with ABI performed worse than controls on most measures of online self-awareness. They were less likely to self-recognize errors and use self-monitoring strategies. They also tended to overestimate their performance and showed greater discrepancy between self-rated and actual performance. Moderation analyses show that better performance was significantly associated with greater strategy use among ABI individuals who were aware of their performance. **Conclusions:** Online self-awareness appears to moderate the use of cognitive strategies during functional cognitive performance after ABI. Therefore, it is important to include assessments of online self-awareness and strategy use for individuals with ABI. Furthermore, these findings highlight the importance of focusing on self-awareness and self-generated strategies as key goals of cognitive rehabilitation aimed at improving daily functioning after ABI.

8.2 Introduction

ISA has been frequently reported following acquired brain injury (ABI) (Dockree, et al., 2015; Doig, et al., 2017; Villalobos et al., 2019). Often, these deficits hinder individuals' ability to perform ADL, resulting in increased distress and caregiver burden (Prigatano, 2005; Toglia & Goverover, 2022). Thus, early detection is crucial for improving individuals' functional status (Bivona et al., 2020). To gain a better understanding of ISA as a clinical phenomenon, research has been focused on exploring the cognitive components that may underpin its complex nature. Toglia and Kirk (2000) proposed a multifaceted model with two main components. The first component is *metacognitive knowledge* (or general awareness), which is activated outside the context of a task and is related to beliefs and perceptions about one's cognitive abilities. The second component is *online awareness*, a task-specific phenomenon that occurs at different moments in the activity: 1) appraisal, anticipation, and prediction, immediately before the task; 2) self-monitoring and self-regulation, during the task; and 3) self-evaluation, after the task.

The importance of measuring SA in clinical practice is widely recognized. Most SA instruments focus primarily on assessing its metacognitive component through interviews or self- and informant-based questionnaires (Fleming et al., 1996; Prigatano et al., 1986; Salazar-Frías, Rodríguez-Bailón, et al., 2023; Sherer, Bergloff, et al., 1998). Conversely, recent reviews by Toglia and Goverover (2022) and Sansonetti et al. (2024) highlight challenges in measuring online SA, particularly due to the heterogeneity in the specific components under evaluation. For task *appraisal*, studies often asked individuals to rate task difficulty (M. H. Chen & Goverover, 2021; Mahoney et al., 2021) or estimate the number of errors before starting the task (Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Merchán-Baeza, et al., 2024). *Anticipation and prediction* are usually assessed through self-predictions of errors, ratings of task success (Mahoney et al., 2021; O'Keeffe et al., 2007; Ricchetti et al., 2024), performance accuracy (Robertson & Schmitter-Edgecombe, 2015), or potential challenges that may arise (Bivona et al., 2020;

158

Chen & Toglia, 2019; Merchán-Baeza et al., 2020). *Self-monitoring and self-regulation* are measured by the number of errors detected and corrected during tasks, respectively (Bettcher et al., 2011; Dockree, O'Connell, et al., 2015; Hart et al., 1998; Hoerold et al., 2013; Jaywant et al., 2022; McAvinue et al., 2005; O'Keeffe et al., 2007; Ricchetti et al., 2024). Lastly, *self-evaluation* involves self-ratings of task difficulty and success (M. H. Chen & Goverover, 2021; Jaywant, Arora, et al., 2022; Morris et al., 2016; Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Merchán-Baeza, et al., 2024), performance accuracy (Jaywant, et al., 2022), or time required to complete the task (M. H. Chen & Goverover, 2021).

Various types of tasks have been used to examine different components of online SA. Some studies have used *computerised tasks* or *cognitive tests* (Dockree, et al., 2015; Hoerold et al., 2013; McAvinue et al., 2005; O'Keeffe, et al., 2007; Robertson & Schmitter-Edgecombe, 2015), while others have used *performance-based tests* of ADL, such as dressing, meal preparation, or wrapping a present (Arora et al., 2021; Bettcher et al., 2008; Chudoba & Schmitter-Edgecombe, 2020; E. Doig, Fleming, & Lin, 2017; Giovannetti et al., 2002; Hart et al., 1998; Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Merchán-Baeza, et al., 2024; Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Narganes-Pineda, et al., 2024).

Few of these studies using ADL *performance-based tasks* have examined the relationship between different cognitive processes and components of online SA, leading to mixed results. For example, Chudoba and Schmitter-Edgecombe (2020) found that in individuals with amnesic mild cognitive impairment accurate pre- and post-task *predictions* on the Day Out Task correlated more with EF than with memory tests. In contrast, Chen and Goverover (2021) found no association between *prediction* accuracy on the Actual Reality functional task and test of EF in individuals with multiple sclerosis. Other studies by Bettcher et al. (2008) and Giovannetti et al. (2002) reported that reduced performance on EF tests predicted poorer *self-monitoring* (i.e. *error detections*) and *self-*

regulation (i.e. error corrections) in individuals with dementia, as demonstrated in the Naturalistic Action Test and the short form of the original Multi-Level Action Test, respectively. Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Merchán-Baeza, et al. (2024) also observed an association between *self-monitoring* during the Breakfast and Dressing Conflict Task with a cognitive test of EF, while *self-evaluation* was associated with short-term memory abilities. These inconsistencies may be partly due to the fact that different clinical populations and different tests were used to investigate this relationship. To our knowledge, only Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Merchán-Baeza, et al. (2024) have explored the relationship between various executive/cognitive processes and specific components of online SA (during and after task) in individuals with ABI. However, their study was preliminary, involving a small sample size. Furthermore, the tasks they used, while executive in nature, were generally simple and familiar. This highlights the need for further research to examine the association between online SA and cognitive processes in more complex performance-based ADL tasks, particularly within this clinical population. These tests are generally considered more effective for exploring these relationships, as they allow clinicians to observe an individual's ability to detect and correct errors, as well as their perceived task difficulty (Sansonetti et al., 2024). Additionally, these tests can provide insight into the use of *strategies* and help identify common error behaviors contributing to performance deficits (Toglia & Foster, 2022).

Effective strategy use is crucial for normal cognitive and functional performance, as it helps to cope with complex situations (Toglia & White, 2020). In fact, using fewer or inefficient strategies has been associated with poorer performance in various clinical populations (Aronov et al., 2015; Geary et al., 2011; Kaizerman-Dinerman et al., 2019). However, despite their importance, there is currently a lack of clinical tools to formally assess their use in the context of instrumental activities of daily living (IADL). Schmitter-Edgecombe et al. (2014) examined strategy use in a sample of normal ageing adults and

individuals with mild cognitive impairment and dementia using the Instrumental Activities of Daily Living - Compensation (IADL-C) scale, which captures self- and informant-reported use of compensatory strategies when performing various IADL. They found an increase in both self- and informant-reported strategy use for individuals in the mild cognitive impairment group compared to the healthy and dementia groups. Specifically, individuals with mild cognitive impairment used more strategies in response to perceived cognitive decline, whereas individuals with dementia found it difficult to use such strategies and/or recognized the need to use them. Similarly, Tomaszewski Farias et al. (2020) used the *Everyday Compensation Scale (EComp)*, which is an informant-based questionnaire designed to measure compensatory strategies for performing IADL. They found that strategy use can minimize the effects of cognitive decline on IADL performance in older adults. While these studies confirm that strategy use increases the probability of successful independent performance, both self- and informant-based questionnaires are subject to reporter bias (Arora et al., 2021; Schmitter-Edgecombe et al., 2014).

Further examples come from studies examining the association between strategy use and functional performance-based tasks in individuals with ABI. Evidence for this comes from a recent study by Burns et al. (2020), who investigated whether strategy use in 23 individuals with stroke and 23 matched controls was associated with better performance on the Multiple Errands Test Home version (MET-Home) a test that aim to measure EF within the context of Instrumental ADL. Their results indicated that individuals with stroke who used planning strategies performed better on the MET-Home, while self-monitoring, multitasking, and environmental strategies showed no significant impact. In contrast, the control group showed significant associations between self-monitoring, multitasking, and environmental strategies, which were linked to overall improved performance on the MET-Home. Another study by Nott and Chapparo (2020) examined the role of cognitive strategies in daily functioning and participation among 16 individuals with ABI. Results from this prospective longitudinal study showed that more efficient and effective strategy use was associated with better scores on global measures of functional

independence and community participation. Confirmation of this relationship is important, as it highlights the relevance of using methods that promote effective strategy use to improve functional performance after brain injury (Swanton et al., 2020). Indeed, previous studies have emphasized the importance of process-related variables, such as the total number of strategies used, in predicting real-world functioning (Schmitter-Edgecombe et al., 2021). It is therefore a clinical and research challenge to investigate what is needed to enable people with cognitive deficits to use effective strategies in order to carry out their daily tasks.

In this sense, recent research has identified various components of online SA as important prerequisites for independent strategy use in novel and complex tasks. For example, inaccurate *task appraisal* may lead to inaccurate judgments, affecting strategy selection and the cognitive effort exerted during task performance (Robertson & Schmitter-Edgecombe, 2015; Toglia & Goverover, 2022). Similarly, individuals who inaccurately *self-evaluate* task difficulty or success may not see the need to use strategies, which can pose safety risks and limit their independence (Ownsworth et al., 2006; Toglia & Kirk, 2000). In addition, independent strategy use may be influenced by *self-monitoring* and *self-regulation* skills. Previous work by Goverover et al. (2007) showed that effective strategies are more likely to be used when obstacles during performance of an activity are recognized. Indeed, failure to recognize and adjust to changes in everyday activities places individuals with ABI at risk of losing functional independence (Jeffay et al., 2023; Yeo et al., 2021). Although *online* SA appears to be important for effective strategy use, most of the supporting literature relies on quasi-experimental studies (van Erp & Steultjens, 2020) or studies on the effectiveness of interventions to improve online SA and functional outcomes (Nagelkop et al., 2021; Ownsworth et al., 2006, 2010; Toglia et al., 2010). Further empirical research is critical to explore online awareness of performance and strategy use within the context of ADL tasks, particularly among individuals with ABI (Toglia & Goverover, 2022). Additionally, there is a shortage of functional measures that

consider an individual's awareness of their own performance and the use of strategies (Arora et al., 2021). Functional measures that take into account both strategy use and performance awareness in the context of more complex and cognitively demanding IADL can provide valuable insights into the real-life challenges faced by ABI individuals, thereby improving treatment recommendations (Jaywant, et al., 2022).

The WCPA-10 is one of the few examples of an easily portable C-IADL measure designed to assess an individual's EF, the use of strategies and different components of online SA at a time (Toglia, 2015). Individuals are provided with a weekly calendar template and a list of 10 tasks or events to plan, such as appointments, meetings, or leisure activities. Rule constraints, challenges, and distractions are also incorporated to simulate the executive requirements to deal with the complexity and novelty of real-life activities. It provides information about the patient's ability to accurately enter appointments into a calendar while simultaneously examining the patient's frequency, type and effectiveness of strategies used (Toglia & White, 2020). Clinical observation of *online* SA takes place both during and immediately after task performance. This includes assessing the patient's ability to self-recognize errors, identify task challenges, and make realistic assessments of their performance through observation, semi-structured interview, and self-ratings and estimations of performance, which can then be compared with actual performance (Toglia, 2015).

Research using the WCPA-10 in different clinical and non-clinical populations suggests that the test is effective in identifying deficits in EF and *online* SA. For example, Jaywant et al. (2022) found that individuals with stroke tended to overestimate their performance, exhibited lower self-recognition of errors, and were less likely to use self-monitoring strategies during the task compared to a healthy control group. Furthermore, overestimation was associated with worse overall performance. Similarly, Arora et al. (2021) found a gradual decline in WCPA-10 performance and lower effective strategy use across the adult lifespan. In their study, overestimation was associated with both poorer

performance as well as with lower strategy use across all age groups. In particular, older adults with diminished SA used fewer strategies, self-recognized fewer errors, and presented worse overall performance in the WCPA. These findings align with those of a recent study by Marks et al. (2024), which used the more complex WCPA-17 and found a stronger correlation between accuracy and the number of strategies used by individuals in the aware group from a sample of community-dwelling adults. However, the authors did not include group as a variable in their analysis, leaving open the question of whether online SA moderates this relationship. Further research is needed to investigate this potential effect, particularly in individuals with ABI. Our previous research involved translating and adapting the WCPA-10 to the Spanish context (Salazar-Frías, Funes, et al., 2023). providing initial validation for its use among Spanish individuals with ABI. In line with a previous study by Jaywant et al. (2021) on the WCPA-10 and individuals with stroke, our findings reveal significantly poorer performance in accuracy, rules followed, and strategy use among individuals with ABI compared to healthy participants.

The present study aimed to increase the utility of the WCPA-10 as a functional cognitive assessment for Spanish individuals with ABI. Firstly, we sought to extend our previous findings regarding performance differences in the Spanish WCPA-10 between individuals with ABI and a healthy control group. Secondly, we aimed to investigate the external validity of this instrument to identify online SA deficits in Spanish ABI patients. To do so we tested potential differences in *online* SA measures of the Spanish WCPA-10 between individuals with ABI and healthy individuals. Building upon previous research by Arora et al. (2021) and Jaywant et al. (2022), we assessed *online* SA by observing the percentage of self-recognized errors and the use of self-monitoring strategies during the task.

To assess *online* SA after the task, we generated two binary classifications – *over-estimators* vs. *aware* and *over-raters* vs. *aware* – based on the discrepancies between actual and estimated accuracy, as well as subjective self-ratings of performance

compared to actual performance (see measures section for further description). Thirdly, we sought to explore the relation between the *online* SA measures and various sociodemographic, clinical, and cognitive variables, within the ABI patient group. These might help to determine which of the *online* SA measures are more sensitive to cognitive, socio-demographic or clinical variables. Fourthly, we aimed to explore the potential differences in *total strategy use* and *performance accuracy* on the Spanish WCPA-10 between individuals with ABI who are *aware* of their performance and those who *over-estimate* it. Finally, we wanted to examine the potential moderating role of group (HC, aware and over-estimators) in the relationship between *number of strategies used* and *accuracy* on the Spanish WCPA-10. To test that, we conducted a moderation analysis. We expected this relationship to be stronger in individuals with ABI, especially in those who are *aware* of their abilities.

8.3 Methods

Participants

The study included a total of 156 participants, including 80 individuals with ABI and 76 healthy controls (HC), all of whom were native Spanish speakers. Individuals with ABI were recruited from cognitive/occupational rehabilitation services in four neuro-rehabilitation units in Granada and Malaga, Spain. The inclusion criteria were: (a) ABI diagnosis confirmed by neurological report at least 3 months prior to the study, with no specific restriction on the time since the onset of the ABI; (b) over 18 years of age; (c) presence of executive, metacognitive, and/or memory deficits as objectively assessed by the clinician; and (d) adequate arousal and behavioral control for the assessment. Exclusion criteria included: (a) severe motor or visual-perceptual deficits; (b) hemineglect; and (c) language impairments, such as reading and writing difficulties. Each rehabilitation center employed different measures to assess participant eligibility. For perceptual assessment, the team relied on clinical observation in daily activities and the Visual Object

and Space Perception Battery (Warrington & James, 1991). To rule out attentional neglect, clinical observation during ADL was used, supplemented by the line cancellation test from the Behavioral Inattention Test in uncertain cases (Sánchez-Cabeza et al., 2017). Language abilities were evaluated using the Boston Sentence Reading Test (Goodglass et al., 1986). HC individuals were adult volunteers recruited from the same geographical area as the individuals with ABI through snowball sampling by the researchers and their staff. The exclusion criteria for this group were the presence of global cognitive decline (based on the Mini-Mental assessment with standardized cognitive tests listed in Table 8.1), or a reported history of neurological, psychiatric, or other medical illness. Data from 53% of the sample (42 individuals with ABI and 42 HC) were taken from our previous study with the Spanish WCPA-10 (Salazar-Frías, Funes, et al., 2023). All individuals received a full explanation of the study before providing written informed consent. The study was approved by the Andalusian Ethics Committee for Biomedical Research (Anosognosia AVD2017, 3/01/2017, 0056-N-17). Table 8.1 summarizes the demographic and clinical characteristics of the sample.

Measures

The Spanish Weekly Calendar Planning Activity 10

The WCPA-10 is a C-IADL test of EF, originally developed by Toglia, (2015) and recently translated and validated in the Spanish context by Salazar-Frías, Funes, et al. (2023). It measures an individual's ability to perform a multistep activity, providing a comprehensive analysis of their ability to manage and cope with cognitively demanding tasks. *Before starting the task*, individuals are verbally instructed to schedule 10 appointments into a weekly calendar (some of which are fixed at a specific date/time, while others are flexible with multiple date/time options), following certain rules: keep track of time, ignore distracting questions, avoid scheduling on Wednesday, do not cross out appointments once entered, and inform the examiner when finished. *During the task*,

the examiner carefully analyzed the quality of the performance, including accuracy, the number and type of strategies used and self-monitoring skills, to identify performance difficulties. Common strategies include: a) those that help keep track of information, such as verbal rehearsal, crossing off the designated day, or talking aloud about a strategy or plan; b) those that assist in organizing information, such as entering fixed appointments before flexible ones, rearranging materials, using a written plan, or categorizing appointments; c) those that enhance attention to key details, such as crossing off entered appointments, using a finger to direct attention, or highlighting key words; and d) those that promote self-monitoring through self-checking or pausing to re-read (Arora et al., 2021). These strategies are documented on a checklist included in the instrument, with the examiner noting each strategy used by the participant (Toglia, 2015). *After completing the task*, individuals undergo an interview in which they rate their performance using a 4-point Likert scale (1 = 'agree', 2 = 'somewhat agree', 3 = 'somewhat disagree', 4 = 'disagree'), responding to statements about their performance, such as: "This task was easy for me", "I used efficient methods to complete this task", "I completed this task accurately", and "I kept track of everything I needed to do". They also estimate the number of correctly scheduled appointments and whether they were familiar with the task (i.e., whether they regularly used a weekly schedule). The task takes about 15 minutes to complete. The combination of quantitative scores, qualitative data, and responses to post-interview questions allows identifying several *performance* and *online SA* measures, which are described below.

Performance measures. Based on the original WCPA-10, the main performance outcomes used in this study are: 1) total strategies recorded by the examiner and reported by the individuals after completion of the task, strategy use was dichotomized (used vs. not used) without differentiating frequency; 2) number of rules followed out of 5; 3) number of accurately scheduled appointments out of 10; 4) planning time (time between starting the activity and entering the first appointment); and 5) total time to complete the task. Our previous study showed that the Spanish WCPA-10 has sufficient

psychometric properties to be considered for detecting executive deficits that are likely to affect the quality of performance of everyday tasks in individuals with ABI and mild-to-severe cognitive deficits (Salazar-Frías, Funes, et al., 2023).

Online SA measures. Based on previous research, we assessed online SA by directly observing performance and probing during the post-task interview (Arora et al., 2021; Jaywant, Arora, et al., 2022; Marks et al., 2024). *During the task*, the examiner recorded instances of self-recognized errors, including verbal or non-verbal acknowledgement of errors or attempts to correct them. The proportion of self-recognized errors to total errors served as the first online SA outcome. To reduce potential ceiling or floor effects, only individuals who made two or more errors were included in this analysis. Furthermore, individuals' use of self-monitoring strategies was assessed, specifically "*self-checking*" (i.e., double-checking appointments or reviewing their work spontaneously) and "*pause and re-reading*" (re-read instructions or review the list of appointments before proceeding). This categorization has been used in previous studies (Arora et al., 2021; Jaywant, Arora, et al., 2022) and served as the second outcome for *online SA*. After the task, online SA was assessed using two methods. Firstly, the discrepancy between actual performance and estimated accuracy was computed. A discrepancy score of zero indicates agreement between the estimated and actual performance. A positive discrepancy score indicates that the individual's estimate exceeded their actual performance, whereas a negative score indicates the opposite. The sample was then divided into two groups: *over-estimators* and those *aware* of their performance based on the median estimation discrepancy of individuals with ABI, as described in Arora et al. (2021). Individuals with a negative discrepancy score were included in the "*aware*" group, since underestimation implies that the individual recognized their errors (Arora et al., 2021; Jaywant, Arora, et al., 2022). Secondly, we compared the subjective self-ratings of the performance to the actual performance. We calculated the average self-rating score for each individual, which was then used to categorize the individuals into two groups:

those who rated the task as easy (average self-rating ≤ 2) and those who rated it as difficult (average self-rating >2). We further divided the sample based on the patients' median accuracy score. Those who rated the task as easy but performed poorly (accuracy score < 4) were categorized as "*over-raters*", while individuals who rated the task as easy and performed well (accuracy score ≥ 4) or rated it as difficult and performed poorly (accuracy score < 4) were classified as "*aware*" of their performance. Individuals who rated the task as difficult and performed well (accuracy score ≥ 4) were included in the aware group (Arora et al., 2021). Categorization based on subjective self-ratings (*aware* vs. *over-raters*) was used for Aim 2. In contrast, categorization based on discrepancy score (*aware* vs. *over-estimators*) was used for Aims 4 and 5, as a previous study found it to be more sensitive in capturing awareness deficits (Marks et al., 2024)

Cognitive Assessment

A standardized battery of cognitive tests was administered to assess memory and EF. These cognitive domains were chosen for their critical role in contributing to functional limitations (Overdorp et al., 2016; Tiznado et al., 2021; Villalobos, Caperos, et al., 2020) and their strong association with SA in individuals with ABI systematically found in prior studies (Bivona et al., 2008; Ciurli et al., 2010; O'Keeffe et al., 2007; Zimmermann et al., 2017). The memory tests include the Rey Auditory-Verbal Learning Test, which involved recalling a list of 15 words over five learning trials. After each trial, individuals recall as many words as possible immediately (immediate memory) and after a delay period (15 minutes) (delayed recall). It also analyses the verbal learning curve and executive aspects of memory, such as free recall compared to the recognition test and the presence of intrusions and perseverations (Schmidt, 1996). EF were assessed using the INECO Frontal Screening (Torralva et al., 2009) and the Controlled Oral Word Association Test (Benton and Hamsher, 1989). The IFS is a brief cognitive screening test used to detect executive deficits in various neurological disorders (Bruno et al., 2015; Custodio et al., 2017; Pinasco et al., 2021). The maximum total score is 30 points; higher

scores indicate better EF. For the Controlled Oral Word Association Test, individuals were given 60 seconds to produce as many words as possible that began with a given letter. Three trials were administered using the letters F, A, and S. In addition, a semantic verbal fluency task was included, in which individuals were given 60 seconds to provide as many animal names as possible. Composite scores for each cognitive domain were created by averaging the Z-scores of each test, serving as dependent variables in certain statistical analyses, as outlined in the next section. Composite scores were used in this study to minimize measurement error and reduce the risk of type I error associated with multiple comparisons.

Procedure

The research team developed a 4-hour training course with detailed instructions and examples to guide neuropsychologists and occupational therapists from collaborating neuro-rehabilitation units in administering the specified assessment tools. Follow-up practice sessions were held to provide feedback, clarify any questions regarding test administration and scoring. All assessments were conducted according to standardized protocols for each test by six experienced clinicians specializing in both rehabilitation and assessment of individuals with ABI. Importantly, the clinicians were blinded to the specific objectives and hypotheses of the study. Testing for individuals with ABI was conducted in quiet, office-like environments within each neuro-rehabilitation unit. For participants in the HC group, testing was conducted in similar settings at the Mind, Brain and Behavior Research Center (CIMCYC in Spanish) at the University of Granada and at the Faculty of Health Sciences of the University of Málaga. The tests were administered by researchers and two trained graduate students of occupational therapy, who received the same training as the clinicians.

Data Analyses

All analyses were performed using R Studio (version 1.3.1093). The Shapiro-Wilk test indicated deviations from normal distribution for all variables of interest ($p < .01$ all), thus non-parametric tests were used. Group differences in demographic and clinical characteristics were assessed using the chi-square test for categorical variables, and Mann-Whitney U-test was applied for continuous variables. A non-parametric alternative to ANCOVA (Quade, 1967) and chi-square analyses were used to compare group differences in *performance* and *online SA* measures. The chi-square test examined the distribution of yes vs. no responses to the task familiarity question by group. Independent samples t-tests examined potential differences in *total accuracy* in the Spanish WCPA-10 based on familiarity within each group separately. Spearman's correlations determined the association between both online SA classifications and accuracy, as well as associations between the *online SA* measures and task familiarity, socio-demographic and clinical variables, and cognitive measures of EF and memory in the ABI sample. Correlations were considered as ($< .3$), moderate ($.31-.7$), and strong ($> .71$) (González, et al., 2020). Furthermore, differences in *total strategies used* and *total accuracy* were compared by group (HC, aware and over-estimators) using Quade's test. Post-hoc analyses use Tukey-adjusted p -values to account for unequal group sizes (McHugh, 2011). Finally, we performed a regression analysis to examine the potential moderating role of group in the relationship between *total strategies used* and cognitive functional performance. The model included *total accuracy* in the Spanish WCPA-10 as the dependent variable, with *total strategies used*, group, and their interaction as predictors. The group variable was dummy-coded (0/1), thus aware individuals were the reference group. This analysis was performed using PROCESS version 4.3.1 for R, Model 1 (Hayes, 2022). The independent variable was mean-centred before the analysis. The bootstrapping method based on 5,000 bootstrap samples was also used to estimate the confidence interval (CI) for the significance of the effects (Hayes & Rockwood, 2017). Simple slope analyses were then performed for each group to determine the

relationships between *total strategies used* and *total accuracy* in the Spanish WCPA-10. Before conducting these analyses, standard regression diagnostic analyses were carried out using the performance R package (version 0.10.1; Lüdtke et al., 2021). Demographic variables, including age and years education, were controlled in all main analyses due to their well-documented influence on psychological testing outcomes, and specifically on the WCPA (Arora et al., 2021; Marks et al., 2024; Salazar-Frías, Funes, et al., 2023).

8.4 Results

Demographic and clinical characteristics

Significant differences in age ($p < .01$) and years of education ($p < .05$) were observed between the HC and ABI groups, with the HC group having a higher proportion of younger adults and individuals with more education. There were no gender differences between groups. The primary diagnosis was stroke, with smaller percentages presenting etiologies, such as tumors, traumatic brain injury, and infections. There was also a higher prevalence of left hemisphere lesions with respect to right hemisphere, bilateral, and cerebellar lesions in the ABI sample (**Table 8.1**).

Differences between groups in performance measures of the Spanish WCPA-10

The chi-squared test showed no significant differences in the proportion of yes vs. no responses to the task familiarity question. No significant differences in total accuracy were found between individuals who reported regular use of a schedule and those who did not, neither in the ABI group ($t_{(77)} = 1.86, p = .07$) nor in the HC group ($t_{(74)} = 0.14, p = .88$). **Table 8.2** shows differences between groups in the performance measures. Specifically, compared to the HC group, the ABI group scored significantly lower in total strategies ($p < .01$), rules followed ($p < .01$), and total accuracy ($p < .01$). No group differences were found for planning and total time scores.

Table 8.1 Demographic and clinical data by group

	HC group n = 76	ABI group n = 80	Test¹ (ES)
Age (years)			
Mean (SD)	46 (± 15)	55 (± 13)	$U = 2037^{**}$
Range	18-75	24-76	($r_{bis} = .33$)
Education (years)			
Mean (SD)	12 (± 3)	11 (± 3)	$U = 3672^*$
Range	8-17	8-17	($r_{bis} = .21$)
Gender (n, %)			
Female	31 (41%)	25 (31%)	$\chi^2(1) = 1.54$ ($\phi = .06$)
Time since injury (months)			
Mean (SD)	-	16 (± 16)	-
Range	-	3-96	-
Etiology (n, %)			
Stroke	-	63 (79%)	-
Tumour	-	7 (9%)	-
Traumatic Brain Injury	-	6 (7%)	-
Infection	-	4 (5%)	-
Lesion location (n, %)			
Left Hemisphere	-	39 (49%)	-
Right Hemisphere	-	21 (26%)	-
Bilateral	-	17 (20%)	-
Cerebellar	-	4 (5%)	-
Cognitive measures²			
INECO	26.6 (±1.4)	20.7 (±4.6)	$U = 201^{**}$ ($r_{bis} = .76$)
Semantic Fluency	22.9 (±5.6)	15.5 (±5.1)	$U = 280^{**}$ ($r_{bis} = .67$)
COWAT	43.5 (±13.1)	26.4 (±12.9)	$U = 295^{**}$ ($r_{bis} = .65$)
RAVLT-short term	51.3 (±8.6)	37.4 (±11.4)	$U = 311^{**}$ ($r_{bis} = .64$)
RAVLT-long term	11.3 (±2.5)	7.1 (±4.2)	$U = 373^{**}$ ($r_{bis} = .57$)
Executive composite	0.5 (0.5)	-0.6(0.7)	$U = 166^{**}$ ($r_{bis} = .81$)
Memory composite	0.5(0.6)	-0.5(0.9)	$U = 308^{**}$ ($r_{bis} = .65$)

Note: Significance levels: *p <.05, **p <.01

¹ Mann-Whitney U-test for continuous variables; Chi-square test for categorical variables.

² Mean raw scores; these analyses were performed on a sample of n=42 HC and n=42 ABI, since not all individuals with an ABI could be assessed with the same cognitive tests.

Table 8.2 Performance scores in the Spanish WCPA-10 by group

Performance Measures	HC group n = 76	ABI group n = 80	Test ¹ (ES)
Familiarity, n (%)			
Yes	29 (38%)	35 (44%)	$\chi^2(1) = 0.60$
No	47 (62%)	45 (56%)	($\varphi = .00$)
Total strategies used			
Mean (SD)	6.38 (± 1.9)	4.40 (± 2.4)	$F_{(1,154)} = 23.28^{**}$
Median (IQR)	7 (5, 8)	4 (3, 6)	($\eta^2 = .13$)
Rules followed			
Mean (SD)	4.53 (± 0.6)	3.48 (± 1.2)	$F_{(1,154)} = 27.57^{**}$
Median (IQR)	5 (0, 50)	4 (0, 12)	($\eta^2 = .15$)
Total accuracy			
Mean (SD)	8 (± 1.6)	4.06 (± 2.6)	$F_{(1,154)} = 91.51^{**}$
Median (IQR)	8 (7, 9)	4 (2, 6)	($\eta^2 = .37$)
Planning time (sec)			
Mean (SD)	178 (± 288)	158 (± 317)	$F_{(1,154)} = 1.89$
Median (IQR)	70 (35, 189)	60 (30, 116)	($\eta^2 = .01$)
Total time (sec)			
Mean (SD)	945 (± 434)	1089 (± 534)	$F_{(1,154)} = 0.78$
Median (IQR)	846 (660, 1169)	923 (764, 1319)	($\eta^2 = .00$)

¹ Quade's distribution-free test (age and years of education as covariates) for continuous variables; Chi-square test for categorical variables.

Note: Significance levels: * $p < .05$, ** $p < .01$

Differences between groups in online SA measures of the Spanish WCPA-10

During-task awareness. **Table 8.3** summarizes the differences between groups in the online SA measures after controlling for age and years of education. The participants of the ABI group were less likely to use *self-monitoring strategies* compared to those of the HC group. Specifically, a significantly lower percentage of individuals in the ABI group (74%) used the *pause-and-read strategy* compared to the HC group (91%). Similarly, 60% of the ABI group used the *self-checking strategy*, compared to 87% of the HC group.

Additionally, the participants of the ABI group were significantly less likely to recognize their errors than those of the HC group ($p < .05$).

Table 8.3 Online self-awareness scores in the Spanish WCPA-10 by group

	HC group n = 76	ABI group n = 80	Test ¹ (ES)
During-task awareness			
Self-monitoring strategies, n (%)²			
Pause and read	69 (91%)	59 (74%)	$\chi^2(1) = 7.68^{**}$ ($\phi = .21$)
Self-checking	66 (87%)	48 (60%)	$\chi^2(1) = 14.27^{**}$ ($\phi = .29$)
Self-recognition of errors, %³			
Mean (SD)	23.55 (± 31.8)	8.79 (± 17.9)	$F_{(1,117)} = 4.78^*$
Median (IRQ)	0 (0, 50)	0 (0, 13)	($\eta^2 = .04$)
After-task awareness			
Estimation discrepancy			
Mean (SD)	1.13 (± 1.7)	3.90 (± 2.6)	$F_{(1,154)} = 30.62^{**}$
Median (IRQ)	1 (0, 2)	4 (2, 6)	($\eta^2 = .16$)
Awareness groups, n (%)			
Aware	74 (97%)	47 (59%)	$\chi^2(1) = 33.40^{**}$
Over-estimators	2 (3%)	33 (41%)	($\phi = .46$)
Self-rating, n (%)⁴			
Awareness groups, n (%)			
Aware	68 (96%)	54 (69%)	$\chi^2(1) = 17.65^{**}$
Over-raters	3 (4%)	24 (31%)	($\phi = .35$)

¹ Quade's distribution-free test (age and years of education as covariates) for continuous variables; Chi-square test for categorical variables.

² Individuals that use every self-monitoring strategy.

³ Only individuals who made >2 errors were included in this analysis, HC (n = 42), ABI (n = 76).

⁴ This analysis was performed on a sample of 71 HC and 78 individuals with ABI due to missing values

Note: Significance levels: * $p < .05$, ** $p < .01$

After-task awareness. Estimation discrepancy differed significantly between groups ($p < .01$). Individuals in the ABI group overestimated their performance by a median of four appointments, compared to one appointment in the HC group (Table 8.3). When divided into *over-estimators* and *aware*, 41% of individuals with ABI were over-estimators

compared to 3% of the HC group. Regarding subjective self-ratings, 31% of individuals with ABI were *over-raters* compared to 4% of the HC group. The correlation between both classifications was significant ($r^s_{(149)} = 0.48$, $p < .001$). Correlation between online SA measures, socio-demographic, clinical and cognitive variables and task familiarity in individuals with ABI

Table 8.4 summarizes the relationships between the online SA measures and various socio-demographic, clinical and cognitive variables in individuals with ABI. The use of *self-monitoring strategies* correlated positively and moderately with EF. Similarly, a higher percentage of *self-recognized errors* was moderately associated with higher scores in EF and memory. Finally, the *estimation discrepancy* scores showed a significant moderate negative correlation with EF, indicating that greater discrepancies were associated with worse performance in tests of EF.

Table 8.4 Spearman's correlations between the online SA measures, with socio-demographic, clinical and cognitive variables in the sample of individuals with acquired brain injury

Variables	Self-monitoring strategies	Self-recognized errors	Estimation discrepancy
Spanish WCPA-10			
Task familiarity	0.06	-0.11	-0.06
Socio-demographic			
Age	-0.13	-0.10	0.02
Years of education	0.17	0.04	-0.05
Clinical			
Time since injury	0.15	-0.04	0.00
Cognitive Composites ¹			
Executive function	0.33*	0.46**	-0.34*
Memory	0.27	0.35*	-0.04

¹ These analyses were performed on a small sample (n=42), since not all individuals with an ABI could be assessed with the cognitive tests.

Note: Bonferroni's adjusted significance levels: * $p < .05$, ** $p < .01$

Differences in total strategy use and performance accuracy on the Spanish WCPA-10 between healthy controls, individuals with ABI that are aware of their performance, and individuals with ABI who are over-estimators

Quade's ANCOVA compared the performance of the HC group, individuals with ABI that are aware of their performance and over-estimators on measures of total accuracy and total strategy use, while controlling for age and years of education. Significant between-group differences were found in total accuracy [$F_{(2,153)} = 60.61, p < .01, \eta^2 = 0.44$] and total strategy use [$F_{(2,153)} = 16.37, p < .01, \eta^2 = 0.17$]. Tukey's HSD test revealed that the HC group was significantly more accurate ($M = 8.00, SD = 1.61$) than the aware ABI group ($M = 4.89, SD = 2.86, p < .01$) and the ABI over-estimator group ($M = 2.88, SD = 1.49, p < .01$).

Aware ABI individuals showed significantly higher accuracy than ABI over-estimators ($p < .01$). For total strategy use, Tukey's HSD test showed that the HC group used significantly more strategies ($M = 6.38, SD = 1.93$) than both aware ABI individuals ($M = 4.87, SD = 2.32, p < .01$) and ABI over-estimators ($M = 3.73, SD = 2.30, p < .01$). Aware ABI individuals used significantly more strategies than ABI over-estimators ($p = .04$). **Figure 8.1** shows box and whisker plots of each measure by group.

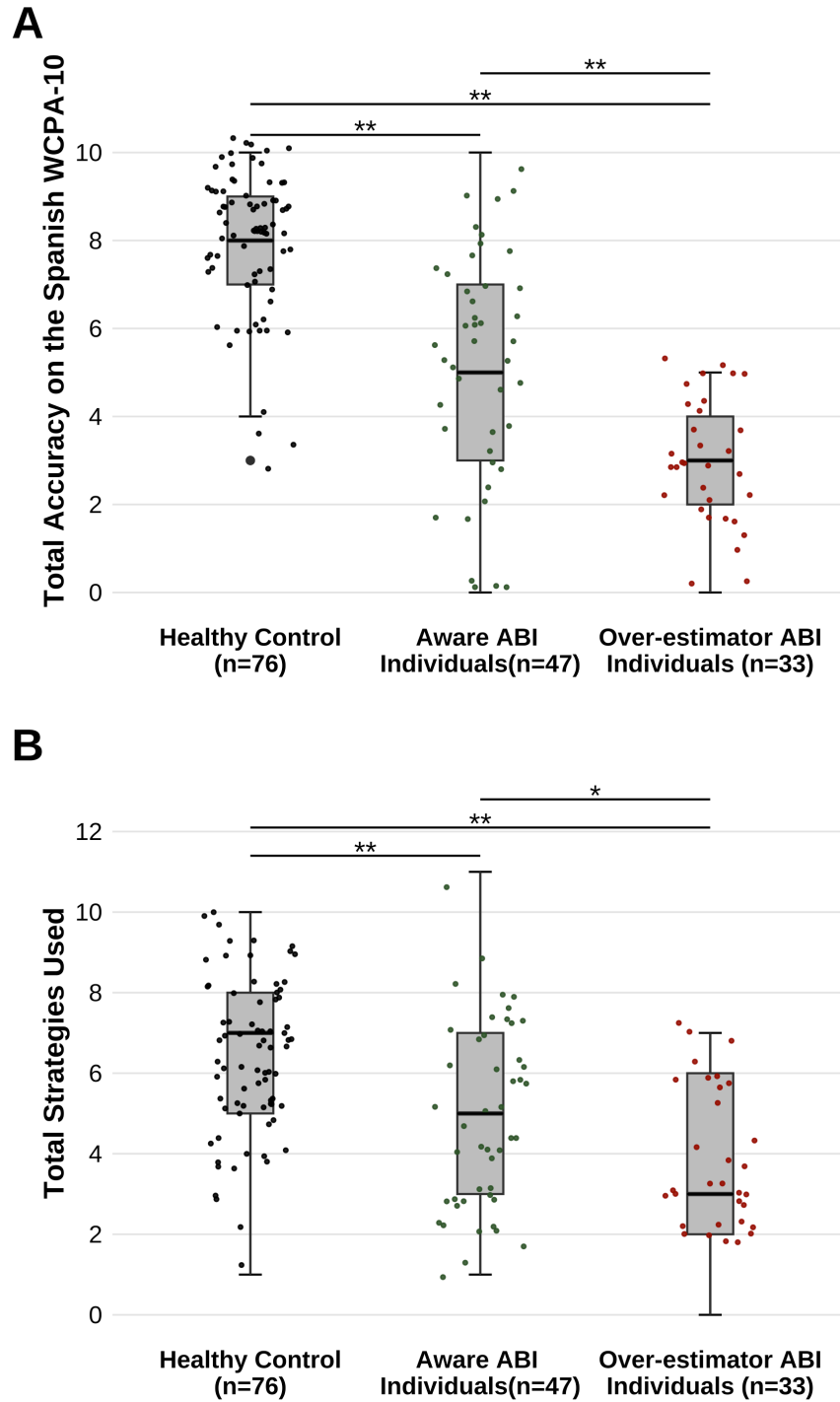


Figure 8.1 Box and whisker plots of (A) total accuracy and (B) total strategies used on the Spanish WCPA-10 for the healthy controls, aware, and over-estimator groups. * $p < .05$; ** $p < .01$.

Relationship between total strategies used and performance on the Spanish WCPA-10.
Moderating effect of group: healthy control, ABI aware individuals and ABI over-estimators

The assumptions of multicollinearity, homoscedasticity, normality of the residuals, and the examination of outliers were all met for this analysis. **Table 8.5** displays the regression coefficients for the whole model. The dependent variable was *total accuracy*, with *total strategies used* as the predictor variable and dummy-coded *group* as the moderator variable. Age and years of education served as control variables. A statistically significant interaction effect was found between *total strategies used* and dummy-coded group, with both HC ($p < .01$) and ABI *over-estimators* ($p < .05$) being significantly different from ABI *aware* individuals.

Table 8.5. Regression coefficients for moderating effects of group on the relationship between total strategies used and performance accuracy on the Spanish WCPA-10

Predictor variables	Spanish WCPA-10 total accuracy				
	Estimate	SE	t	Bootstrapping	
				95% CI ¹	
				LLCI	ULCI
(Intercept)	4.76**	0.90	5.27	3.14	6.42
Age	-0.02**	0.01	-2.80	-0.04	-0.01
Years of Education	0.17**	0.05	3.41	0.07	0.27
Total strategies used	0.61**	0.11	5.45	0.36	0.86
Dummy 1: Healthy Control ²	2.31**	0.35	6.44	1.54	3.06
Dummy 2: Over-estimators ³	-1.94**	0.48	-3.97	-2.78	-1.13
Total strategies used*Dummy 1: Healthy Control	-0.52**	0.15	-3.39	-0.83	-0.21
Total strategies used*Dummy 2: Over-estimators	-0.40*	0.20	-2.01	-0.75	-0.04
Model summary	$R^2 = 0.65, F_{(7,148)} = 39.66^{**}$				

¹ Based on $n=5,000$ bootstrap samples.

² First dummy-coded group variable (0 = Aware, 1 = Healthy Control).

³ Second dummy-coded group variable (0 = Aware, 1 = Over-estimators)

SE = standard error; LLCI = lower levels for confidence interval; ULCI = upper levels for confidence interval.

Significance levels: * $p < .05$, ** $p < .01$

As shown in **Figure 8.2**, simple slope analyses for these interactions indicated that *total strategies used* were positively correlated with *total accuracy* for ABI aware individuals ($b = 0.61$, $SE = 0.11$, $p < .01$), suggesting that a larger number of *strategies used* was associated with better performance on the Spanish WCPA-10 (i.e., *total accuracy*). In contrast, *total strategies used* did not show a significant relationship with *total accuracy* for HC ($b = 0.09$, $SE = 0.11$, $p = .40$) or ABI over-estimator individuals ($b = 0.20$, $SE = 0.16$, $p = .22$).

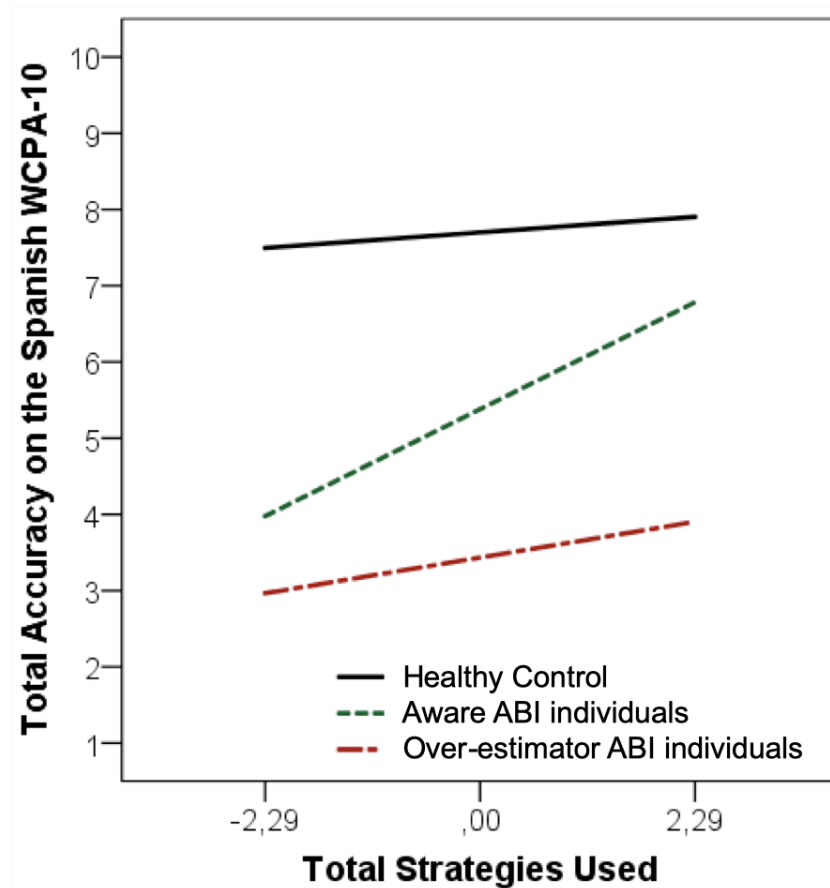


Figure 8.2 Simple slopes of the total strategies used (mean-centered) over total accuracy on the Spanish WCPA-10 for each group.

8.5 Discussion

Differences between groups in performance measures of the Spanish WCPA-10

The first aim of this study was to extend our previous findings on performance measures using the Spanish WCPA-10 in individuals with ABI, by employing a larger sample size. In agreement with our previous study (Salazar-Frías, Funes, et al., 2023), the ABI group exhibited poorer overall performance compared to the HC group. Specifically, individuals with ABI demonstrated lower task accuracy, adhered to fewer rules, and employed fewer strategies. Moreover, in line with our previous findings, no significant differences were observed between the groups in terms of planning time and total time. Previous studies have also identified impairment in the performance measures of the WCPA, indicating that individuals with stroke (Jaywant et al., 2021) and other clinical populations (Doherty et al., 2022; Goverover et al., 2020; Zlotnik et al., 2020) experience more difficulties in everyday functioning compared to cognitively healthy individuals. These results highlight the utility of the Spanish WCPA-10 as a promising tool with strong external validity, capable of detecting executive difficulties that may arise in real-world situations for Spanish individuals with ABI.

Differences between groups in online SA measures of the Spanish WCPA-10

More importantly, this study aimed to investigate the external validity of this instrument to identify online SA deficits in Spanish ABI patients. Overall, we found significant differences in both *during-task* and *after-task* measures of online SA across the two groups. Specifically, our findings revealed a significantly lower percentage of individuals with ABI using *self-monitoring strategies* compared to HC. This aligns with findings from Jaywant et al. (2021), who reported that individuals with stroke were less likely to use *self-checking strategies* while completing the WCPA-10, compared to an age-matched HC group. To our knowledge, their study and ours are the only ones that have

assessed the external validity of the WCPA-10 in identifying different online SA deficits in individuals with brain injury, based on US and Spanish samples, respectively.

Several ways of categorizing cognitive strategies have been proposed in the literature (Dole et al., 2009; Toglia & Foster, 2022; Weinstein et al., 2011), including *self-monitoring strategies*, such as *self-checking* (i.e., double-checking appointments or reviewing their work spontaneously) and *pausing and re-reading* (i.e., re-read instructions or review the list of appointments before proceeding). These types of strategies are defined as routines and procedures that allow individuals to monitor and evaluate their ongoing performance while accomplishing a task (Dole et al., 2009). These findings highlight the importance of examining the *frequency and types of strategies* used during task performance in individuals with ABI, as there is consistent evidence that they use strategies less frequently than healthy individuals (Burns et al., 2020; Jaywant et al., 2021). It also has important implications for identifying the most beneficial techniques for early cognitive rehabilitation after ABI, to successfully support the performance of complex everyday tasks (Schmitter-Edgecombe et al., 2021).

Our results also revealed significant group differences in the rate of *self-recognized errors* during task performance; specifically, individuals in the ABI group were less likely to recognize their own errors than those in the HC group. This ability is commonly observed in healthy adults and reflects the ability to monitor ongoing actions within the context of an activity (Arora et al., 2021; Toglia, 2015). Previous studies have also found that individuals with brain injury exhibited a diminished ability to self-correct their errors in both computer-based (McAvinue et al., 2005; O'Keeffe et al., 2007) and structured naturalistic tasks (Doig et al., 2020; Hart et al., 1998). These findings are somewhat consistent with those of Jaywant, et al. (2022). While their study also found that individuals with stroke were less likely to self-recognize errors than healthy controls, the difference they observed was not statistically significant. This may be due in part to their homogeneous sample, in terms of age, years of education, and time since injury. In

contrast, our ABI sample was quite heterogeneous, including younger, and less educated individuals, as well as chronic individuals. Further research is needed to clarify the potential role of these variables in the online SA measures of the Spanish WCPA-10.

Regarding the after-task measures, our results indicate that individuals in the ABI group showed a greater discrepancy between their self-rating of performance and their actual performance compared to HC. They were also more likely to *overestimate their accuracy*, that is, their perceived accuracy was higher than their actual accuracy. This is supported by additional studies by Rotenberg-Shpigelman et al. (2014) and Barrett et al. (2014), who also found overestimation of performance in various ADL among individuals with ABI. These findings have important implications for occupational safety, as individuals with ABI who overestimate their performance often fail to recognize their errors and use compensatory strategies, leading them to engage in activities beyond their capabilities (Rotenberg-Shpigelman et al., 2014; Sansonetti et al., 2024; Tyson et al., 2012). This finding is in line with the study by Jaywant et al. (2022), who also found overestimation in individuals with stroke. However, unlike Jaywant et al. (2022), we did not observe a tendency for the HC group to overestimate their performance on the WCPA-10. This difference might be due to the age disparity between our HC group including younger participants (mean = 46 years; SD = 15) and the older healthy individuals in Jaywant et al. (2022) (mean = 60 years; SD = 14). This is in line with previous findings showing that older adults tend to overestimate their performance more than younger adults on the WCPA-10 (Arora et al., 2021), and other IADL tasks (Huang et al., 2020; Sunderaraman et al., 2020). Future work is needed to develop normative data for different age groups for the Spanish WCPA-10.

Overall, these findings contribute to the growing body of research by enhancing the understanding of *online* SA in individuals with ABI, using an instrument specifically selected to measure C-IADL. This is important, as authors such as Sansonetti et al. (2024) and Toglia and Goverover (2022) have stressed the importance of carefully selecting

methods to assess *online* SA in the context of familiar tasks, particularly through functional performance-based ADL activities. Different tasks may be more sensitive for the measurement of specific aspects of online SA, such as self-evaluation or self-recognition of errors. For example, experimental tasks or cognitive tests may be less effective at measuring error detection, since errors in these tasks do not significantly affect task progression, thus individuals are less likely to detect them during performance, compared to highly familiar tasks such as ADL, where the errors are more obvious and have an impact on task progression (Sansonetti et al., 2024). This approach enables a more ecologically valid assessment, providing a comprehensive understanding of the cognitive functioning, and specific aspects of online SA. Such information is essential to guide tailored rehabilitation strategies for the improvement of functional outcomes (Arora et al., 2021).

Correlation between online SA measures, socio-demographic, clinical and cognitive variables and task familiarity in individuals with ABI

This study also aimed to explore the relationship between online SA, cognitive, socio-demographic, and clinical variables, and task familiarity. In agreement with a previous study by Ricchetti et al. (2024), who examined the association of *online* SA with cognitive variables in individuals with ABI in the context of everyday activities, the results from this study provide further evidence for the association of specific components of *online* SA with EF. The positive correlations found between during-task measures of SA and EF indicated that individuals with ABI who performed better on tests of EF also made greater use of self-monitoring strategies and presented a greater proportion of self-recognized errors. This is consistent with most theoretical models of EF that include processes such as *monitoring* and *regulation* as core executive components (Kennedy & Coelho, 2005; Miyake et al., 2000; Stuss & Alexander, 2000). As suggested by numerous authors (Fernandez-Duque et al., 2000; Roebbers, 2017; Shimamura, 2000), EF are essential for goal-directed behaviour, particularly in conflict situations that require

individuals to adapt to changing environments, selectively process task-relevant information, and avoid irrelevant external stimuli. These components share a theoretical parallel, with specific components of *online* SA, such as self-monitoring and self-regulation (Toglia & Foster, 2022). Indeed, self-regulation has been recently shown to depend on a range of cognitive abilities, such as EF and memory (Sansone et al., 2024; Toglia & Foster, 2022). Overall, these findings are particularly relevant, as most of the evidence supporting the association between online-SA deficits with deficient EF in individuals with ABI comes from studies using experimental tasks (Dockree, Tarleton, et al., 2015; McAvinue et al., 2005; F. O’Keeffe et al., 2007), or by addressing the metacognitive component of SA (Bivona et al., 2008, 2019; Ciurli et al., 2010; Villalobos et al., 2021). To our knowledge, only the previous study by Ricchetti et al. (2024) had examined this relationship in the context of a naturalistic task in individuals with ABI. These findings have significant implications for further understanding the relationship between online SA and EF, as this type of task may provide stronger evidence for common cognitive processes involved in self-monitoring and self-regulation in everyday life. A note of caution is due here, as these analyses were not conducted with the full sample, since not all individuals were assessed with the cognitive tests.

Finally, it was found that the Spanish WCPA-10 online SA measures were not affected by task familiarity, age, years of education, or time since injury. While this is a desirable property of any cognitive test, it is somewhat surprising, as previous research has shown that age affects some online SA components in the WCPA (Arora et al., 2021). This finding may be partly explained by the fact that they measure online SA across a wide age range, from 18 to 92 years, which includes periods of old age. To our knowledge, the relationship between the online SA measures of the WCPA and these socio-demographic and clinical variables has not been investigated in a sample of individuals with ABI. Further research is needed to explore the relationship of these variables with online SA.

Differences in total strategy use and performance accuracy on the Spanish WCPA-10 between healthy controls, individuals with ABI that are aware of their performance, and individuals with ABI who are over-estimators

We also explored how strategy use and accuracy on the Spanish WCPA-10 differs among individuals with ABI who are aware of their performance, those who overestimate it, and HC. Our findings show that individuals with ABI who were aware of their performance used more strategies and had better accuracy than those who overestimated it. The HC group had higher strategy use and accuracy than both groups of ABI individuals. These results corroborate the ideas of Toglia and White (2020) who suggested that effective strategy use is a central aspect of healthy functional performance. They are also consistent with other literature reporting that individuals with ABI often experience cognitive deficits that affect their ability to perform everyday tasks and to use cognitive strategies to improve it (Nott & Chapparo, 2020). This is further supported by additional studies that have reported lower or inefficient strategy use and poorer functional performance in individuals with ABI (Bottari et al., 2014; Burns et al., 2020; Nott & Chapparo, 2020) and in a variety of clinical populations (Brum et al., 2013; Johnson et al., 2005; Kaizerman-Dinerman et al., 2019; Schmitter-Edgecombe et al., 2014).

Relationship between total strategies used and performance on the Spanish WCPA-10. Moderating effect of group: healthy control, ABI aware individuals and ABI over-estimators

Taking advantage of the WCPA's ability to simultaneously measure strategy use and online SA in the context of a functional task, we aimed to investigate whether online SA moderates the relationship between *total strategies used* and performance accuracy on the Spanish WCPA-10. To our knowledge, this is the first study to systematically examine strategy use in relation to performance on the WCPA-10 in individuals with ABI, both with

and without online SA deficits, and in healthy controls. Results from the moderator analysis revealed stronger positive associations between strategy use and accuracy in individuals with ABI who were aware of their performance compared to over-estimators and HC. Specifically, a greater number of strategies used was associated with better accuracy in the group of individuals with ABI who were aware of their performance, whereas this association was not significant in the over-estimators or the HC group.

These findings support the idea that individuals with ABI who have low levels of *online* SA may have inaccurate self-evaluations of their performance, due to undetected errors or task difficulties (Jaywant, et al., 2022; Sansonetti et al., 2024). This lack of accurate self-evaluation can lead them to perceive a reduced need to use strategies, or to use them ineffectively, thereby hindering their ability to manage and adapt to cognitively demanding tasks. Conversely, individuals with enhanced online SA are more likely to accurately understand the demands and challenges of a task (Toglia & Foster, 2022). This might enable them to recognize the importance of using strategies or seeking assistance when necessary. As a result, these individuals may be more likely to employ appropriate and efficient strategies to enhance their performance. This approach to task management contributes to greater functional independence, as they can better navigate and adapt to the challenges they encounter in daily life.

Toglia and White (2020) suggested that the ability to accurately self-evaluate and utilize strategies effectively is a critical component of successful rehabilitation and independent performance. Our study found that individuals in the HC group, who typically performed optimally on cognitive tests, completed the task accurately regardless of the number of strategies they used. Toglia and Foster (2022) noted that strategies yield the best results when activities present an optimal level of challenge. This is particularly relevant, as we used the most simple 10-item version of the WCPA, which is designed for inpatient settings where patients may have lower levels of functioning or time constraints (Toglia, 2015). This may explain the lack of association between the

number of strategies used and performance on the Spanish WCPA-10 in HC individuals, with many individuals performing adequately on the task regardless of the number of strategies used. Further moderation studies using more complex versions of the WCPA are needed to explore the relationship between the number of strategies used, performance, and online SA in HC individuals. In contrast, individuals with ABI who were aware of their performance and used more strategies achieved performance levels comparable to those without brain injury. However, over-estimators who inaccurately assessed their abilities tended to use fewer strategies and when they used them they did it inefficiently, resulting in poorer task performance. These results suggest that, while strategies can serve as cognitive compensation tools for individuals with cognitive deficits, their effective use requires a certain level of online SA. A prior study by Schmitter-Edgecombe et al. (2014) also noted the importance of strategies and awareness for successful independent performance in a sample of normal ageing adults and individuals with mild cognitive impairment and dementia. They found a higher self- and informant-reported use of strategies in individuals with mild cognitive impairment, in response to perceived cognitive decline, compared to more cognitively impaired individuals with dementia, who exhibited a lack of insight of their deficits. In addition to the differences in clinical samples, a key distinction between the latter study and ours is that we used a performance-based C-IADL task to more directly measure awareness and strategy use, rather than self- and informant-based questionnaires. To reduce the potential misinterpretation of an individual's abilities inherent in these questionnaires (Arora et al., 2021; Schmitter-Edgecombe et al., 2014), future research should rely on direct observation during performance-based tasks, such as the WCPA-10. These tasks allow for a more comprehensive assessment, including the number and types of strategies used, the ability to self-recognize errors, and a more realistic self-evaluation of the individual's performance through observation, semi-structured interviews, and self-reports (Toglia & White, 2020). Overall, these findings shed light on the learning potential of individuals with ABI and support the effective implementation of interventions that prioritize the

enhancement of strategy use and online SA, through metacognitive approaches to improve cognitive functional performance and promote greater independence, as systematically recommended by various recent studies and reviews (Cicerone et al., 2019; Jeffay et al., 2023; Salazar-Frías et al., 2024; Swanton et al., 2020; Toglia & Foster, 2022). Furthermore, these results underscore the need for further research on the mechanisms underlying online SA and strategy use, as well as the development of targeted interventions to support individuals with ABI in their recovery.

8.6 Limitations and future directions

The current study has a number of limitations. Firstly, our analysis focused primarily on the total number of strategies used. A large body of literature suggest that strategies should be examined beyond their total number and include different types, depending on the level of mental effort invested in their implementation (Dole et al., 2009; Toglia & Foster, 2022; Weinstein et al., 2011). To better understand the underlying factors that influence strategy use and to develop more tailored rehabilitation approaches, future studies should explore the different types of strategies, their effectiveness, and the effort required for their implementation. Secondly, we only considered the *online component of SA*. Further research should investigate how the *metacognitive knowledge* relates to strategy use to gain a better understanding of its impact on functional independence. We acknowledge that our sample presented significant heterogeneity in both etiology and lesion location, with some etiologies, such as stroke, being far more prevalent than others. By analyzing these diverse cases as a single group, we were unable to explore whether specific patterns of deficits on the online SA measures of the Spanish WCPA-10 might emerge based on different etiologies or lesion sites. We recognize this as an important issue that warrants further investigation in future research. We also recognize the various limitations of using composite scores, including but not limited to the fact that it provides broader measures of cognitive functions. A more comprehensive and differentiated assessment of EF, as well as other cognitive processes such as memory and attention will

be essential in future studies to further clarify their association with online SA in individuals with ABI. Finally, additional psychometric data, including test-retest and inter-rater reliability studies, are needed to confirm the temporal stability of the Spanish WCPA-10 outcomes and to ensure that subjective judgments do not influence the results.

Chapter 9

Training to deal with distractions and conflicting situations in activities of daily living after traumatic brain injury (TBI): Preliminary evidence from a single-case experimental design study

The content of this chapter has been published as:

Salazar-Frías, D., Rodríguez-Bailon, M., Ricchetti, G., Navarro-Egido, A., de los Santos, M., & Funes, M. J. (2024). Training to deal with distractions and conflicting situations in activities of daily living after traumatic brain injury (TBI): preliminary evidence from a single-case experimental design study. *Neuropsychological Rehabilitation*, 1-36.

<https://doi.org/10.1080/09602011.2024.2375495>

9.1 Abstract

Objective: This study investigated the impact of an occupation-based intervention targeting executive and metacognitive functions to improve participants' daily performance after traumatic brain injury (TBI). The intervention was designed to challenge participants with activities that require the management of multiple distracting and conflicting situations. Participants receive structured online and offline feedback on their performance, focusing on how to handle distracting and conflicting situations they previously failed and solved (i.e., metacognitive training). **Method:** This study used a changing-criterion design by increasing the level of executive requirements across each session. A participant with TBI was trained to complete two significant activities (i.e., making a sandwich and setting the table). **Results:** We found a significant reduction in errors made and addressed through the feedback sessions in post-intervention performance compared with baseline. These improvements were observed along with the intervention sessions, with most of the errors addressed in prior intervention sessions being successfully corrected in the following sessions and generalized to different contexts (i.e., near transfer) and to an untrained task (i.e., far transfer). Several outcomes were maintained one month after completing the intervention. **Conclusion:** Based on these findings, the present intervention shows promising results as an effective tool to address executive and metacognitive deficits after TBI.

9.2 Introduction

Some commonly affected cognitive abilities following ABI are EF, defined as a set of high-order cognitive abilities such as working memory, inhibitory control, and cognitive flexibility (Lezak et al., 2012). Research suggests a link between EF and self-awareness, which interact to ensure optimal daily performance (M. H. Chen & Goverover, 2021; Kennedy & Coelho, 2005; Stuss, 2011; Toglia & Goverover, 2022; Villalobos et al., 2021). Other studies have found that self-awareness is associated with specific EF such as conflict monitoring (Iannaccone et al., 2015; O'Connell et al., 2007; Ridderinkhof et al., 2004). Toglia and Kirk (2000) describe SA as having two components: *metacognitive knowledge*, which refers to the general understanding of one's cognitive abilities, which is activated outside of a specific task; and *online SA*, which is activated during task performance and includes skills such as appraisal of task difficulty (anticipatory awareness), error detection and correction (emergent awareness), and the ability to evaluate current performance (self-evaluation).

Deficits in these skills strongly predict dependency in IADL such as, preparing meals or taking medication) (Burgess, 2000; Ciurli et al., 2010; Overdorp et al., 2016; Ownsworth & Clare, 2006) and can explain a significant percentage of the variance in IADL when compared to other cognitive processes (McAlister & Schmitter-Edgecombe, 2016; Royall et al., 2007). Studies of TBI have shown that executive deficits can lead to difficulties in monitoring and inhibiting actions toward irrelevant distractors during performance-based tests, resulting in longer task completion times and risky behaviours (Chevignard et al., 2000; Chevignard et al., 2008; Hendry et al., 2016; Niki et al., 2009). Indeed, recent research by Villalobos, Caperos, et al. (2020a) highlighted the moderating role of self-awareness in the relationship between executive deficits and functional independence in brain injury patients. These findings highlight the need for targeted interventions addressing EF and SA deficits in the context of functional tasks after ABI.

Recently, various strategies have been proposed to address these processes. Novel computer-based interventions show promise by using machine learning to adjust task difficulty in real time, effectively targeting executive and monitoring deficits (Bogdanova et al., 2016; López & Antoli, 2020; Van De Ven et al., 2016). These personalized rehabilitation programs adapt cognitive demands based on participants' performance, either by increasing sources of interference to deal with or by limiting response times (Chen et al., 2017; Faria et al., 2020; Maier et al., 2020). Similarly, Chiou and Hillary (2012) found that sequencing items in ascending order of difficulty during an artificial task improved both task performance and metacognitive accuracy in individuals with TBI and healthy adults. Certainly, this detailed method of adjusting the difficulty of a specific task is a promising implementation for improving ADL in individuals with TBI. However, its generalization to everyday tasks has rarely been reported (Bogdanova et al., 2016; López & Antoli, 2020; Van De Ven et al., 2016). One possible reason for this is the lack of reliable measures to determine the practical value of progress in artificial tasks, which are often unrelated to ADL. Further research is needed to investigate whether these effects extend to ADL tasks and other metacognitive domains (Chiou & Hillary, 2012; López & Antoli, 2020).

The cognitive occupation-based approach offers a promising solution for improving performance in functional activities. Participants are directly engaged in learning to complete real-world multistep tasks in a setting similar to their own (Mahoney et al., 2023; Park et al., 2015). This method adopts a person-centred approach, in which the therapist works with the participant to select meaningful tasks that are aligned with the participant's interests and needs (Mahoney et al., 2023). Examples of such tasks include making a shopping list, checking pantry items, and preparing a simple lunch (Steinberg & Zlotnik, 2019). A key feature of this approach is errorless learning, in which participants are given precise instructions to prevent errors during the learning process. This method, which might enhance automaticity, has proven highly effective for

participants with severe memory deficits (Cicerone et al., 2019). It is worth noting, however, that such a strategy may not be useful once the stimuli and contexts change from those presented during the intervention sessions.

In contrast to errorless learning, error based approaches, such as metacognitive strategy training, involve training individuals to increase their awareness of their strengths and weaknesses, to help them become aware of task difficulties and their own errors, and to support them in developing their own solutions to overcome barriers to task performance, thereby increasing their independence in performing everyday tasks (Kersey et al., 2019). A recent study by Ownsworth et al. (2017) demonstrated the superiority of using the error based approach over errorless learning in individuals with ABI by improving metacognitive and behavioural skills. Through structured and systematic feedback techniques, this approach provides individuals with information about their functional performance. These techniques range from *online verbal feedback*, such as the *pause, prompt, praise*, which teaches participants to stop, monitor, and modify their actions while performing a task, to *offline feedback* techniques, such as video-feedback, which uses video recordings after task completion, about the participant's own actions, to facilitate verbal discussions between therapists and participants aimed at identifying errors and corrective strategies (Schmidt et al., 2013). Research on the implementation of the *pause, prompt, praise* technique with individuals with ABI has consistently demonstrated its effectiveness in reducing error rates on trained IADL tasks and enhancing self-awareness, as shown in several SCED studies (Ownsworth et al., 2010; Ownsworth, Fleming, et al., 2006). In addition, further studies comparing different forms of feedback found that verbal plus video-feedback was most effective in improving self-awareness and error self-regulation in trained IADL tasks (Schmidt et al., 2013, 2015b). Feedback techniques represent active intervention elements that have been shown to be effective in addressing executive and awareness deficits following ABI, with positive effects on daily living outcomes (Engel et al., 2019; Jeffay et al., 2023). Therefore, evidence-based practice suggests integrating the cognitive occupation-based

approach with metacognitive strategy training (Cicerone et al., 2019; Engel et al., 2019; Jeffay et al., 2023; Tate, Kennedy, et al., 2014; Villalobos, Bilbao, et al., 2020). Although promising, it is worth noting that the participants in these studies repeated the same IADL tasks throughout the training sessions and at the same level of difficulty. Questions remain about whether the improvements in these tasks can be partly explained by task repetition and whether the lack of new difficulties might hinder the transfer of strategy learning to other tasks and contexts. As far as we know, this possibility has not yet been tested, and more research is necessary.

Finally, to facilitate the person's ability to transfer learned strategies to various contexts and tasks, Toglia (2018) proposed the multicontext approach. This framework underscores the importance of participants recognising similarities between situations and applying previously learned strategies to new scenarios (Toglia & Foster, 2022). It organises activities along a continuum, progressing from similar (near transfer) to visually different activities (far transfer), while maintaining consistent cognitive demands. This framework also incorporates guided questions before, during, and after each activity to foster strategy generation and improve performance anticipation, monitoring, and self-evaluation. Preliminary evidence from case and exploratory studies indicates that participants with chronic ABI show positive changes in self-regulation skills and strategy use in both trained and untrained activities, enhancing their sense of mastery and control over various meaningful activities (Nagelkop et al., 2021; Toglia et al., 2010, 2011). Recent studies testing feasibility, acceptability, and therapist fidelity in single-case series of participants with acute ABI have shown positive results (Jaywant, Steinberg, et al., 2022; Toglia et al., 2020). However, to our knowledge, evidence based on quantitative results, such as SCED or group studies, is still lacking to test the positive effects of this promising approach.

Although the intervention approaches described above have shown promising results, they have some weaknesses. Further research with quantitative analyses, larger

sample sizes, and control groups is necessary to establish their effectiveness and determine the components that most significantly impact participant improvement. Furthermore, as emphasised by Engel et al. (2019), it is crucial to develop new interventions that are firmly grounded in theory. This ensures clear identification of the links between theory and intervention elements, facilitating the formulation of hypotheses regarding the mechanisms behind intervention success or failure, and thereby guiding generalization to diverse populations or settings.

The present study

Based on the literature, we designed an intervention to improve specific executive and metacognitive processes, following Toggia and Kirk's (2000) model, to improve functional independence in individuals' ADL (Toggia & Foster, 2022; Toggia & Goverover, 2022). The intervention combines evidence-based components from the approaches described above for optimal effectiveness. *First*, we used a *cognitive occupation-based approach*, creating meaningful IADL tasks that participants could choose to align with their goals, thereby increasing engagement and generalization (Mahoney et al., 2023; Steinberg & Zlotnik, 2019). *Second*, we incorporated the adaptive training from the *computer-based approach*, gradually increasing task difficulty by introducing semantically related distractors and controlled conflicting situations based on participants' prior performance. In our recent study assessing error detection and correction during activities of daily living, we found that these measures correlated with conventional assessments of EF and self-awareness among participants with ABI (Ricchetti et al., 2024). *Third*, we implemented metacognitive strategy training, providing two forms of explicit feedback to improve self-awareness components based on Toggia and Kirk's (2000) DCMA (Toggia & Foster, 2022; Toggia & Goverover, 2022). We focused on targeting emergent awareness skills, such as error detection and correction, using the "*pause, prompt, praise*" technique. We also targeted post-task self-awareness, including self-evaluation, by providing *verbal plus video-feedback* immediately after the task was

completed. *Finally*, we incorporated components of the multicontext approach to promote strategy transfer to new contexts and untrained tasks. Feedback focused on making participants aware of how to manage distracting and conflicting situations through constantly changing contexts and on drawing connections between different scenarios to facilitate skill transfer. We propose a SCED study to gather preliminary evidence of effectiveness, reporting results at both group and individual levels for better understanding and data interpretation (Crawford & Howell, 1998). To our knowledge, no other intervention proposal includes all these elements within the same design, and there are no studies providing comparative normative data on IADL performance with healthy participants.

The specific aims of the intervention were: (1) to improve the participant's executive and online self-awareness (i.e., anticipatory awareness, error detection and correction skills, self-evaluation) during IADL performance across training sessions and from pre to post-intervention; (2) to determine whether these gains can be maintained and transferred across intervention sessions and at a 2/4-week follow-up; and (3) to determine the extent of generalization to different task contexts (near transfer) and untrained tasks (far transfer). We predict that the participant will show improved task performance following the implementation of the intervention. Specifically, we expect to observe: (1) a reduction in error frequency throughout the intervention, (2) an improvement in error detection and self-correction during each session, as well as an improvement in the ability to anticipate and self-evaluate their performance before and after (i.e., anticipatory and self-evaluation), and (3) a generalization of behavioural improvements to tasks involving novel distractors and conflicting situations, and other untrained tasks with similar executive and self-awareness requirements. For hypotheses 1 and 2, we also expected that the effects of the intervention would be maintained for 4 weeks at the end of the intervention.

9.3 Methods

To ensure a clear, comprehensive, and transparent presentation of the study findings, we adhered to the Single Case Reporting Guideline in Behavioural Interventions (SCRIBE) through the design, conduct, and manuscript preparation (see Tate et al., 2014, 2016, for detailed information). This guideline includes a checklist of 26 items, with specific methodological aspects that need to be reported, with recommendations on how to report them effectively. In addition, the intervention protocol has been preregistered on the National Library of Medicine (NLM) ClinicalTrials.gov website under the registration ID NCT03958487.

Case description

A 35-year-old right-handed Latin American male with 9 years of education, who had been working as a construction worker in Spain for approximately 8 years, sustained a moderate closed head injury in July 2018. The participant was referred by occupational therapists from his rehabilitation service in Andalusia, Spain. Computed tomography scan revealed left and right temporal contusions along with traumatic subarachnoid haemorrhage, resulting from a 5-meter fall at his workplace. Before the intervention, a brief cognitive assessment was performed to assess the participant's cognitive status. The main difficulties were in categorising, planning, and organising his behaviour, with a tendency towards cognitive inflexibility; he was also unable to modify his answers or find alternative solutions during the tasks. The Barthel Index score indicated difficulty in performing IADL tasks. A summary of the cognitive and functional screening results is presented in **Table 9.1**. Written informed consent was obtained from the participant and his main caregiver (i.e., wife) to participate in this study.

Table 9.1 Cognitive assessment results, conducted 1 year after the injury

Test	Raw score	Performance in percentiles
Color Trails Test		
Trails A	72 sec	21, Impaired
Trails B	159 sec	<1, Impaired
Rey Auditory Verbal Learning Test		
Total (1-5)	36	Low Average
Delayed Recall	4	Impaired
Recognition	15	No Impairment
Recognition, commission errors	12	Impaired
INECO	10	Impaired
Wisconsin Card Sorting Test		
Number of categories completed	1	<1, impaired
Perseverative responses	80	<1, impaired
Verbal fluency		
Animal Fluency	10	Low Average
COWAT	30	No Impairment
Barthel	75	Moderate Dependency
Dass-21	21	
Glasgow Coma Score	9/15	Moderate Head Injury*

*The duration of post-traumatic amnesia was 9 days

Design

This study employed a single-case changing-criterion design with a baseline, three-level intervention, and post-intervention phase. Prior to the intervention, a baseline for the target behaviour was established for the trained and not trained IADL tasks. Baseline data were collected over four sessions, scheduled twice a week for two consecutive weeks, until the number of errors appeared stable by visual inspection. Generalization measures were also administered during this phase to measure the potential transfer effects of the intervention (see outcome measures section for a detailed description). Performance on the trained tasks was assessed for three consecutive weeks *during the intervention phase*. The decision to increase or maintain the level of executive demands was adjusted according to the participant's performance at the previous level. Thus, the participant would be scheduled to train at the next level of executive demands in the

following session only if he reduced the mean of the errors on the previous phase assessment by at least 50% on the last measure of each session. If the participant did not meet this criterion, the same task and level were repeated in the next session. To provide greater experimental control, varying levels of difficulty were introduced within each task for each level of intervention, as recommended by Klein et al. (2017) (2 new distractor objects and 1 new conflict situation from Level I to Level II; 4 new distractor objects and 2 new conflict situations from Level II to III). Given the incremental difficulty of tasks at each level, an immediate improvement in performance due to the intervention was not expected, and some data overlap was expected within each sub-phase of the intervention. To test for maintenance effects, performance on trained and untrained tasks was assessed 2 and 4 weeks after the intervention. To test for potential transfer effects, generalization measures were administered during this phase and then compared with those administered during the baseline phase. A blind assessor, different from the one who delivered the intervention, collected baseline and post-intervention data. Performance on the trained tasks at baseline, intervention, and post-intervention was videotaped for subsequent assessment.

The participants' performance on both the trained and untrained tasks was subsequently compared with the control group comprising eight volunteers with no history of neurological disease (8 men; mean age = 35.8 years; SD = 3.3, range = 31-42; mean education = 9.1; SD = 3.4, range = 9-16). These individuals were recruited from the same geographical area as the participant using snowball sampling conducted by the researchers. This approach was suggested by Crawford and Howell (1998), Crawford et al., (2010), and Crawford and Garthwaite (2002) for single-case analysis with tasks where normative data are not available. The inclusion of a control group will then allow us to determine whether participant's performance on our tasks significantly differed from that of a control sample. All participants provided written informed consent to participate in the study. This study was reviewed and approved by the Junta de Andalucía Committee for Biomedical Research (AnosognosiaAVD2017, 0056-N-17).

Outcome measures

Outcomes were chosen to target the online components of Toglia and Kirk's (2000) model, comprising *emergent awareness*, *anticipatory awareness*, and *self-evaluation*. Additionally, generalization outcomes were selected, encompassing both physically similar (near transfer) and physically dissimilar tasks (far transfer). All measures are described below and are presented in **Table 9.2**.

Table 9.2 Description of the outcomes of the study

Outcomes	Description
Primary Outcomes	
Functional performance	Frequency of errors during the trained performance-based ADL tasks
Online awareness	
Emergent awareness	Rate of new, treated, and corrected errors Error correction behaviors
Anticipatory awareness	Discrepancy between participant's prediction of performance and actual performance (number of errors)
Self-evaluation	Discrepancy between participant's estimation of performance and actual performance (number of errors)
Generalization in functional-cognitive performance (near transfer)	Frequency of errors in trained tasks within a completely new context of distractors and conflicting situations Frequency of errors in a related but new, untrained ADL task
Secondary Outcomes	
Generalization in functional-cognitive performance (far transfer)	Frequency of errors in a performance-based assessment of functional cognition: the Spanish WCPA-10.
Generalization to conventional tests of executive functions (far transfer)	Scores on two cognitive tests that assess executive and metacognitive skills: INECO Frontal Screening, Wisconsin Card Sorting Test.
Conventional measures of potential changes in emotional distress	Scores in the validated Spanish version of the DASS-21, which measures symptoms of depression, anxiety and stress

Primary outcomes

Functional performance in trained tasks. Improvements in participants' executive and online monitoring skills (i.e., error detection and correction) were measured based on the approach proposed in recent studies with people with ABI (Doig, Fleming, Ownsworth, et al., 2017; Merchán-Baeza et al., 2020; Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Merchán-Baeza, et al., 2024), by observing the *number of errors* made on two IADL tasks in the intervention and post-intervention phases compared with the baseline. The classification system used to identify the types of errors was based on that proposed by Giovannetti et al. (2002) and Humphreys and Forde (1998), which included omissions and several types of commission errors. To classify subtle errors, we relied on the classification system proposed by Rycroft et al. (2018), which consists of the sum of different subtypes of micro-errors. These error categories were summed to calculate spontaneous errors with target objects, errors induced by the distractors, or conflicting situations included in our design. Errors with distracting objects were considered whenever an action was directed to an object that was not the target. In contrast, errors with conflicting situations were considered whenever the conflict was not detected or was not correctly solved. These measures were taken during the baseline, intervention, and post-intervention phases to measure potential maintenance benefits.

Online awareness. Emergent awareness. Errors in each intervention session were categorised as *new, treated, or corrected*. If an error was not corrected, we categorised whether it had been addressed in previous intervention sessions (i.e., treated) or not (i.e., new). The aim of such a distinction was to measure the extent to which the participant could transfer learning strategies from one session to another. Finally, errors were coded as self-corrected errors or errors corrected in response to therapist-specific or unspecific prompts, as in a previous study (Ownsworth, Fleming, et al., 2006). This will be a direct measure of executive and emergent awareness (i.e., self-detection and correction abilities).

Online awareness. Anticipatory awareness and self-evaluation. Participant's anticipatory awareness was assessed on the basis of the approach proposed in prior work (Merchán-Baeza et al., 2020; Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Merchán-Baeza, et al., 2024), in which the participant is asked to predict the number of errors they will make while performing trained tasks (e.g., "*Do you think you will make errors during this task?*", "*How many errors do you think you will make?*"). This estimate was compared to the the actual performance. The discrepancy between these measures provides a measure of anticipatory awareness, which can be positive (underestimation) or negative (overestimation). Participant's self-evaluation of errors was also assessed immediately after completing each task by asking the participant to estimate the number of errors made during the performance of each task. This estimation was also compared to the actual performance. The difference between both measures provided a measure of self-evaluation of the participants' IADL performance.

Generalization to functional performance (near transfer). Main generalization skills were measured by the participants' performance in the same trained tasks within a new distracting and conflicting context at week 7. These tasks required the same steps, instructions, and target objects as the trained tasks, although completely new semantically and physically related distractors and conflicting situations were added. In addition, a step forward in transfer abilities was measured by performance on a related but untrained task in which the participant was asked to prepare breakfast without assistance. The classification system described above for trained tasks was used to determine the frequency of errors made during the performance of these two functional generalization tasks. Performance was assessed by comparing the number of errors made in post-intervention performance with baseline performance.

Secondary outcomes

Generalization to functional cognitive performance (far transfer). Spanish WCPA-10, a performance-based assessment of EF developed by Toglia (2015), translated and adapted to the Spanish context by Salazar-Frías et al. (2023), was used to examine the participant's ability to perform a multi-step daily activity. The test provides scores for accuracy, error types, number of rules followed, planning time, total time, and number of strategies used. The total number of errors was used as a measure of improvement. The WCPA-10 has shown robust psychometric properties with favourable validity and reliability indices across various clinical groups, including individuals with brain injury (Jaywant et al., 2021; Salazar-Frías, Funes, et al., 2023). Discriminant validity has been established not only between healthy controls and participants with severe ABI but also among participants with subtle cognitive impairment (Salazar-Frías, Funes, et al., 2023).

Generalization to conventional test of EF (far transfer). Two cognitive tests were administered focusing on executive skills. The INECO Frontal Screening (Torralva, Roca, Gleichgerrcht, López, et al., 2009) is a brief and sensitive test to assess frontal dysfunction. It included different subtests to assess different executive processes, such as working memory, abstraction, response inhibition, and set-shifting. This test has shown good sensitivity and specificity for detecting executive impairments in participants with brain injury (Pinasco et al., 2021). The Wisconsin Card Sorting Test (Heaton et al., 2009) assesses the ability to abstract thinking, form concepts, and change cognitive strategies in response to changes in environmental contingencies. This test has psychometric properties that have been shown to be reliable and valid for use by clinicians and researchers in assessing EF in a range of neurological participants, including those with brain injury (Chiu et al., 2018; Gómez-de-Regil, 2020).

Emotional distress. To measure whether the intervention could produce changes in emotional distress, we administered the validated Spanish version of the DASS-21 (Daza

et al., 2002). It measures symptoms of depression, anxiety, and stress in both clinical and non-clinical adults. It included 21 items, with seven items per subscale. Participants were asked to rate each item on a scale from 0 ("does not apply to me at all") to 3 ("applies to me very much"). These measures were administered during the baseline phase and immediately after completion of the intervention, at week 5.

All these measures were taken before and after the treatment for subsequent analysis to confirm the effects of the treatment. In addition, the cognitive measures and the trained and untrained tasks were administered to the control group at the end of the intervention to compare the participants' performance with that of the control group.

Intervention

The intervention was delivered by a clinical psychologist with specialized training in both clinical and research settings, along with over 10 years of experience in brain injury rehabilitation and assessment. The intervention consisted of six 90-minute sessions delivered twice a week for three consecutive weeks. It targeted two IADL tasks (see **Figure 9.1**). Each task was trained alternately once a week. One task was chosen by the participant and the other by the therapist to ensure that both tasks were relevant to improving his independence, which is a fundamental aspect of motivation and commitment in therapy (Ownsworth, Fleming, et al., 2006; Steinberg & Zlotnik, 2019; Toglia et al., 2010). The participant was asked about his level of familiarity and how often he performed these tasks prior to the start of the intervention. Each task had specific instructions and consisted of 10-15 steps. The executive demands of each task gradually increased across sessions by adding new distractors and conflicting situations to solve from level I to level III. Items were displayed on a table in randomised locations for each session.



Figure 9.1 Objects used on level III (maximum executive demands) for each intervention task

Each intervention session had four time points, as detailed in **Figure 9.2**.

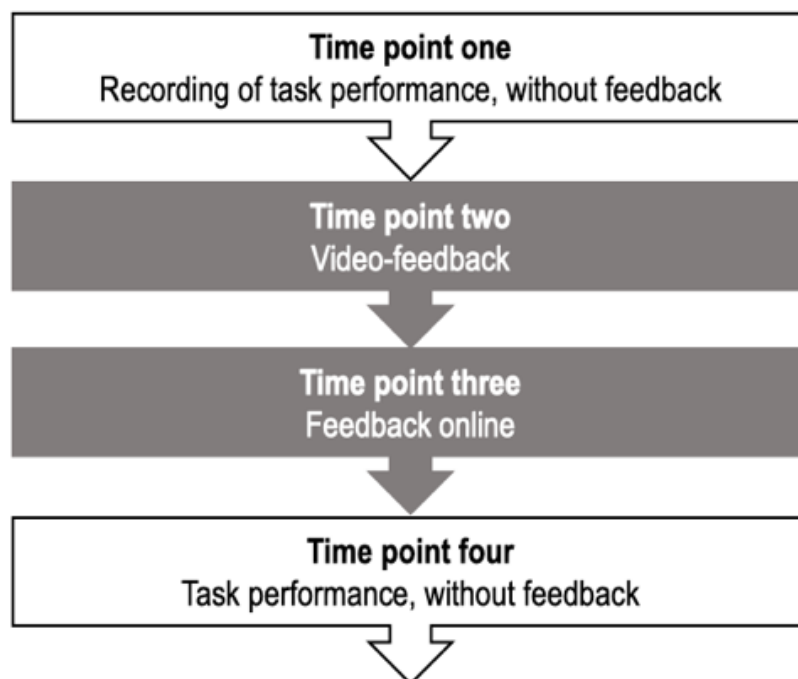


Figure 9.2 Intervention sessions' phases; gray rectangles denote the active intervention phase and white rectangles denote performance assessment within the intervention phase

Time point one: recording of IADL performance without feedback. After ensuring that the participant had recognised all the objects required to perform the activity, the therapist gave the participant specific instructions and ensured that he had understood and memorised them by asking him to repeat them. Next, a series of questions to measure anticipatory awareness were administered to rate the degree of difficulty or challenge that the participant could predict about the task. The participant was then asked to perform the task. At this time point, the therapist did not answer any questions or provide any feedback on the participant's behaviour and could only intervene if a potentially dangerous situation arose. After completing each task, a similar set of questions was administered to assess the self-perception of performance. The first time point of each intervention session was videotaped using a Sony digital video camera recorder (model DCR-SR21E). Video recording was used for two reasons: first, to provide the appropriate material to guide the intervention at Time Point Two (i.e., video-feedback, see below), and second, to allow subsequent assessment of task performance to track potential behavioural improvement across intervention sessions. The camera was strategically placed in front of the participant (about a metre and a half away) so as not to interfere with the participant's performance during the task.

Time point two: offline feedback through video feedback. A 22" monitor was used to view the videos in the best possible quality. Initially, the entire video was watched to allow the participant to identify his errors and correct the steps execution spontaneously. Next, the participant watched his performance again, guided by the therapist, to discuss the previous performance and possible strategies for improving performance. If the participant failed to identify errors and suggest solutions, a guided anticipation and strategy generation technique was used. This technique helped the participant develop methods for proactively managing challenges and contributing to effective strategy use in various functional situations. Therefore, the feedback in this phase was twofold: to detect errors and to learn to solve them. The guided error detection process was based

on the suggestion of Toglia et al. (2010) to improve participant error detection by gradually providing cues (e.g., *"it seems that you have noticed something"*, *"you are reacting as if you had seen an error"*, *"what things could you have done to solve the error?"*, *"try to think of similar situations; what have you done before to solve them?"*). The video feedback was guided by the seven core intervention principles outlined by (Schmidt et al., 2015b) to avoid emotional issues that could arise during this phase.

Time point three: Online feedback through the "pause, prompt, praise" technique. At the end of the video feedback, the activity was performed a second time. This time, the therapist provided online feedback on the actual performance, giving the participant the opportunity for immediate self-detection and correction of errors using the *pause, prompt, praise* technique (for detailed description of the technique see: Ownsworth et al., 2010; Schmidt et al., 2013). At this point, if the participant asked for advice on the task or for verification of an action, the therapist asked the participant to solve the problems independently, providing direct guidance only if the participant could not generate a solution.

Time point four: task performance without feedback. At the end of the active intervention phase, the participant was asked to perform the task under the same conditions as at time point one. Therefore, the performance at this time point was videotaped. This served as a second measure to track any improvement in performance during the intervention phase. After completing the task, the therapist discussed and summarised with the participant his performance, focusing on the strategies discussed and the support provided to help him perform the task correctly in the future. In addition, the therapist explained the relationship between the trained task and other daily activities and encouraged the participant to think of other tasks in which he could use the learned strategies to promote generalization. Some of the questions asked at this time point were as follows: *"Wouldn't it be nice if you could do this again with other tasks?"*, *"is this similar to what you usually do at home?"*, *"what other activities could you do at home to practice*

what we have done today?”. After the four time points had been completed, the training session ended. The training procedure was programmed to continue until the performance on both tasks reached the criterion at level III of executive demand (additional detailed information on the intervention protocol is available from the authors upon request).

Data Analysis

First, we calculated the intra-class correlation coefficient (ICC) using a two-way random effects model to assess the agreement between two raters on total error ratings. Fifteen randomly selected videotapes were independently reviewed and rated by both the therapist and a blinded researcher, with videos presented in random order and without contextual phase information. Inter-rater reliability was classified as poor for ICC scores below 0.40, fair for scores between 0.40 and 0.59, good for scores between 0.60 and 0.74, and excellent for scores above 0.75 (Cicchetti, 2001).

We examined *level*, *trend*, and *variability* to analyse data patterns within and between phases. Level refers to the magnitude of data points within a condition (mean or median), trend refers to the direction of data movement over time, and stability refers to the variability within a condition (Lane & Gast, 2014). The intervention aimed to reduce errors, expecting a decreasing trend. Split-middle trend estimation visualised trends for each condition. Variability was estimated using Lane and Gast’s (2014) procedure, which establishes a stability envelope in which at least 80% of data points fall within $\pm 25\%$ of the median. These analyses were performed using the website <https://manolov.shinyapps.io/Overlap/> (Manolov, 2018). The *scplot* R package (version 0.3.8; Wilbert, 2023) was used to plot error performance, with measurement time on the horizontal axis, total error on the vertical axis, and phase changes as vertical lines.

Visual analyses were supplemented with *piecewise linear regression* using the scan R package (version 0.60.0; Wilbert & Lueke, 2022) to quantify performance changes in trained and untrained tasks. This approach fits the structure of SCED studies by allowing the analysis of time-series data divided into phases (Manolov & Solanas, 2018; Moeyaert et al., 2014; Wilbert et al., 2022). To facilitate phase comparisons, the piecewise regression model calculated the intercept and slope parameters separately for each AB comparison. The intervention effects are then determined based on the differences in slopes and intercepts. Each coefficient provides estimates of the level at the first time point in phase A (intercept), the linear trend in phase A (slope), the change in level at the start of phase B (treatment effect on level), and the change in trend in phase B (treatment effect on slope). First, we wanted to explore the intervention effect in level and slope beyond level I and II, particularly at level III and in the post-intervention phase, where the level of executive demands was directly comparable to that at baseline. To do so, we compared the baseline with each intervention level (i.e., baseline to levels I, II and III) and the post-intervention phase.

Additionally, to identify changes within each phase, we also compared subsequent intervention levels and the post-intervention phase between them. Given the progressive increase in task difficulty from one level to the next, we expect a delayed onset of the intervention's effect at the beginning of each intervention level. We therefore focused only on the difference in slope between each phase comparison, rather than the change in level. Also, to explore the extent to which the intervention effect was maintained, a comparison was made of the change in slope between the level III and post intervention phase data points in both tasks. Using the piecewise regression, we will construct a linear model for each phase comparison, including B weights and *p*-values, for trend, level, and slope effects. However, given the lack of random sampling of participants and behaviours, for these analyses we will rely on descriptive measures (i.e., estimates of treatment effect on level and trend) rather than statistical significance for its clinical interpretation (Manolov et al., 2021; Manolov & Solanas, 2018; Onghena, 2020).

To explore differences between the pre- and post-intervention measures, individuals' performance on trained and untrained tasks was compared with that of a matched sample of healthy controls using Crawford and Howell (1998) modified t-test. This procedure allows appropriate parametric statistical analysis of deficits (Crawford & Garthwaite, 2002) to complement the intra-individual comparisons described above. Z-scores for these analyses are also reported as an effect size index, together with the interval estimates of the effect size for the difference between the participant and the controls, following the methods reported by Crawford et al. (2010). These analyses were performed using the R package *singcar* (version 0.1.5; Rittmo & McIntosh, 2021). A two-proportion z-test with a significance level of $p < .05$ was used to determine whether *error correction behaviours* and the proportion of new vs. treated errors differed significantly between intervention sessions. Changes in emotional distress and cognitive tests were assessed using the Reliable Change Index (RCI), using normative data and reliability coefficients from the relevant literature (Daza et al., 2002; Jory et al., 2013; Paolo et al., 1996; Sierra Sanjurjo et al., 2019). Reliable change was determined according to Jacobson and Truax (1991), where a minimum index of 1.96 is required to be considered a statistically significant change. We were unable to apply the RCI to the Spanish WCPA-10, due to the lack of test-retest reliability coefficients available in Spanish; however, we compared individual performance at baseline and post-intervention with the control group using the modified t-test analyses described above.

9.4 Results

Reliability of the scoring system

Inter-rater reliability was first assessed for the frequency and type of errors that occurred during both the trained and untrained tasks. Fifteen randomly selected videotapes were viewed and rated independently by the therapist and a researcher who was blind to the phase in which the probes were delivered. The videos were presented to this researcher in random order, with no information to reveal the phase in which they were completed. The intra-class correlation coefficient (ICC) was calculated, as recommended by Cicchetti (2001), to assess the extent to which the two raters agreed in their ratings of total errors across videotapes using a two-way single-measure random model; the resulting ICC was in the excellent range (ICC = 0.92).

Primary outcomes

Functional performance in trained tasks

Structured visual analyses. **Table 9.3** provides quantifications of key indices derived from the visual analyses applied to the participant's data. Trend lines have been superimposed on **Figure 9.3** using the split-middle method to visualize the trend for each condition (red lines). Visual inspection of the data from both tasks revealed stability in the baseline condition, with an apparent upward trend towards worsening performance in the table set-up task. The intervention levels exhibited consistent patterns in both tasks, displaying an accelerating trend towards improved performance, with greater variability in data points in the table set-up task. Furthermore, the data revealed a change in level between baseline, each intervention level, and post-intervention for both tasks.

Table 9.3 Quantifications of visually assessed data aspects

	Sandwich task			Table set-up task		
	Trend regression coefficient	Variability ^a	Median range	Trend regression coefficient	Variability ^a	Median range
Baseline	0.25	4/4 (100%)	9.5 (8-10)	0.75	4/4 (100%)	11 (10-13)
Intervention						
level I	-2.5	3/3 (100%)	4 (1-6)	-2.5	2/3 (66.7%)	2 (2-7)
level II	-3.5	2/3 (66.7%)	1 (0-7)	-2.5	2/3 (66.7%)	0 (0-5)
level III	-2	2/3 (66.7%)	1.7 (0-4)	-1	2/3 (66.7%)	0 (0-2)
Post-intervention	0	2/3 (66.7%)	2 (2-3)	2	2/3 (66.7%)	1 (1-5)

^a Trend stability envelope is represented around the split-middle trend line. Variability refers to the number of data points within this envelope

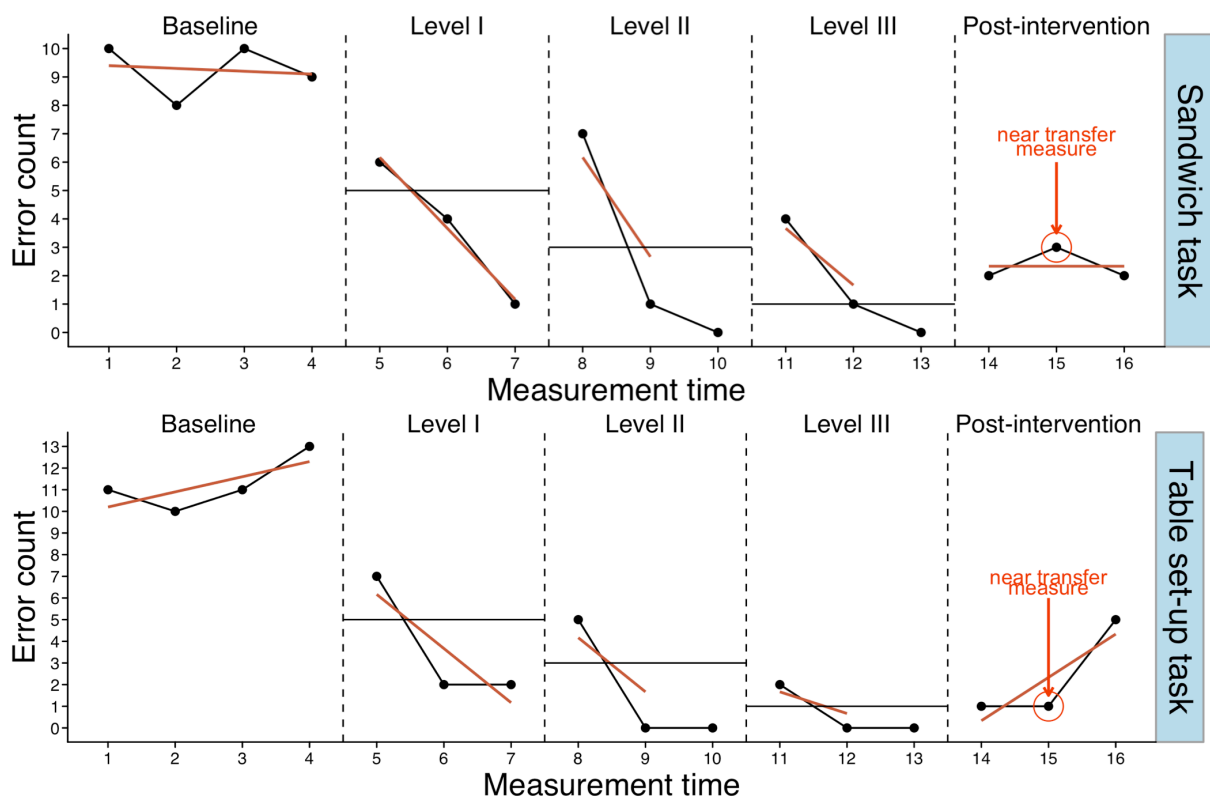


Figure 9.3 Frequency of errors across baseline, each intervention level and post-intervention phases in the trained tasks. Red line represents the split-middle trend line and solid horizontal line segments indicate criterion for each treatment phase.

Intra-subject statistical analyses.

Change in level and slope between baseline and each phase. **Table 9.4** summarizes the regression coefficients for all comparisons between baseline and each phase for the *sandwich task*, however, as mentioned in the data analysis section, we focused the analyses of error behaviour specifically on three phases: baseline, intervention level III and post-intervention, where the level of executive demands was directly comparable. The results show that the initial baseline level is 9.40. In addition, the baseline trend was negative, with a value of -0.10, meaning that for every one-point increase in measurement time, the score decreased by 0.10. The treatment effect on level was statistically significant in both the intervention level III, and the post-intervention phase compared to the baseline, indicating an immediate decrease of 5.33 and 6.67 errors, respectively. The treatment effect on the slope for the intervention level III was steeper than the baseline trend with a negative coefficient of -1.90. In the post-intervention phase the coefficient was 0.10.

Table 9.4 Results of piecewise linear regression analyses for the Sandwich task

Sandwich task	Intercept	Trend	Treatment effect on level	Treatment effect on slope
	B (SE)	B (SE)	B (SE)	B (SE)
Baseline to each phase comparisons				
Baseline to level II	9.40 (1.27)*	-0.10 (0.68)	-2.83 (2.31)	-3.40 (1.27)
Baseline to level III	9.40 (0.89)*	-0.10 (0.47)	-5.33 (1.62)*	-1.90 (0.89)
Baseline to Post-intervention	9.40 (0.89)*	-0.10 (0.47)	-6.67(1.62)*	0.10 (0.89)
Adjacent phase comparisons				
Baseline to level I	9.40 (0.82)*	-0.10 (0.44)	-2.83 (1.49)	-2.40 (0.82)
Level I to Level II	6.17 (1.34)*	-2.50 (1.04)	7.50 (2.62)	-1.00 (1.47)
Level II to Level III	6.17 (1.42)*	-3.50 (1.10)	8.00 (2.77)	1.50 (1.55)
Level III to Post-intervention	3.67 (0.74)*	-2.00 (0.58)	4.67 (1.45)	2.00 (0.82)

Significance levels: * $p < .05$; ** $p < .01$; *** $p < .001$

Similar results were obtained for the *table set-up task*, as shown in **Table 9.5**. The intercept of the regression line in the baseline phase starts at 10.20, showing trend with

a positive coefficient of 0.70. Results reveal a statistically significant treatment effect on level between the baseline and both the intervention level III, and the post-intervention phase, showing a reduction of 11.33 and 12.67 errors, respectively. The treatment effect on the slope for the intervention level III was steeper than the baseline trend with a negative coefficient of -1.70. In the post-intervention phase the coefficient was 1.30.

Table 9.5 Results of piecewise linear regression analyses for the Table set-up task

Sandwich task	Intercept	Trend	Treatment effect on level	Treatment effect on slope
	B (SE)	B (SE)	B (SE)	B (SE)
Baseline to each phase comparisons				
Baseline to level II	10.20 (1.23)*	0.70 (0.66)	-8.83 (2.24)*	-3.20 (1.23)
Baseline to level III	10.20 (0.83)*	0.70 (0.44)	-11.33 (1.52)*	-1.70 (0.83)
Baseline to Post-intervention	10.20 (1.08)*	0.70 (0.58)	-12.67 (1.97)*	1.30 (1.08)
Adjacent phase comparisons				
Baseline to level I	10.20 (1.23)*	0.70 (0.66)	-6.83 (2.24)*	-3.20 (1.23)
Level I to Level II	6.17 (1.86)	-2.50 (1.44)	5.50 (3.63)	0.00 (2.04)
Level II to Level III	4.17 (1.42)	-2.50 (1.10)	5.00 (2.77)	1.50 (1.55)
Level III to Post-intervention	1.67 (1.18)	-1.00 (0.91)	1.67 (2.30)	3.00 (1.29)

Significance levels: * $p < .05$; ** $p < .01$; *** $p < .001$

Inter-subject statistical analyses. In addition to the intra-subject analyses, we also examined whether the baseline and post-intervention error scores had changed relative to the scores from a healthy control group, following the procedure described by Crawford and Garthwaite (2002). As is shown in **Table 9.6**, the participant's baseline performance on both tasks was statistically significantly different from the control group. In contrast, post-intervention performance was not statistically significantly different from that of the control group during the sandwich task ($t = -1.03$, $p = .83$) and the table set-up task ($t = -0.17$, $p = .87$). Table 9.6 shows the Z-scores and the effect size estimates for these differences.

Table 9.6 Differences between the individuals' and healthy controls' performance in trained tasks

Task	Case's mean	Control sample	Significance test ^a	Percentage of the control population obtaining a lower score than the case ^b	Estimated effect size (Zcc) ^c
		n =8			
		Mean (SD)	t	Point (95% CI)	Point (95% CI)
Sandwich					
Baseline	9.25	2.5	5.95 ***	99.97 (99.8 to 100)	6.31 (3.02 to 9.62)
Post-intervention	1.33	(1.07)	-1.03	16.83 (2.48 to 42.9)	-1.09 (-1.96 to -0.18)
Table set-up					
Baseline	11.25	2.2	6.11***	99.97 (99.9 to 100)	6.48 (3.10 to 9.87)
Post-intervention	2	(1.39)	-0.17	56.50 (29.91 to 80.87)	-0.18 (-0.87 to 0.53)

^a Crawford and Howell (1998); the results are for a one-tailed test.

^b Crawford and Garthwaite (2002).

^c Crawford, J. R., Garthwaite, P. H., and Porter, S. (2010).

Significance levels: * $p < .05$; ** $p < .01$; *** $p < .001$

Online awareness. Emergent awareness

Rate of new, treated and corrected errors. Even though the number of distracting objects and conflicting situations increased from one week (i.e., level) to the next, the participant showed a general trend towards reducing the number of errors in both trained tasks across intervention sessions. **Figure 9.4A** shows the percentage of treated vs. new errors at each intervention level, depending on whether they were already addressed during the previous intervention session or whether they were self-corrected. Immediately after level I, functional performance on the sandwich task improved, as indicated by a significant increase in the percentage of self-corrected errors ($p = .04$, see **Table 9.7**) and a decrease in new errors ($p = .05$) from level II (new = 50%, treated = 9%, corrected = 41%), to level III (new = 20%, treated = 7%, corrected = 73%). Although the same pattern of improvement can be seen in the table set-up task, the increase in the

proportion of self-corrected errors was marginally significant ($p = .06$) from level II (50%) to level III (82%). The proportion of treated errors remained constant in the sandwich task and decreased in the table set-up task from level II (30%) to level III (9%), although this decrease did not reach statistical significance ($p = .11$).

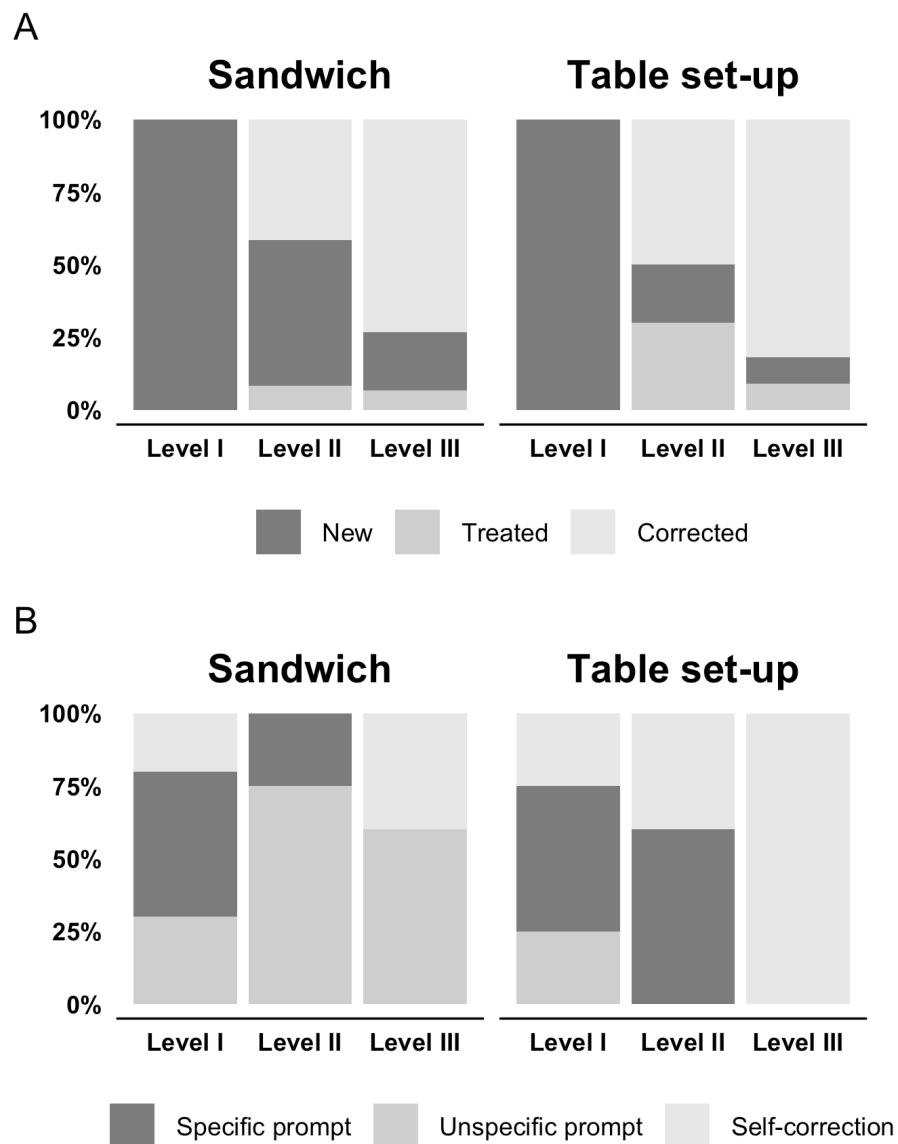


Figure 9.4 Error behaviour across intervention sessions for both tasks. (A) % of new, treated and corrected errors during each level of the intervention phase; (B) % of error correction behaviors observed in the performance in both tasks over the intervention phase

Table 9.7 New, treated and corrected errors during each level of the intervention phase

Task	Type of error	Level I vs Level II		Level II vs Level III	
		Z	p	Z	p
Sandwich	New	2.12	0.01*	1.64	0.05*
	Treated	-	-	0.16	0.43
	Corrected	-	-	-1.66	0.04*
Table set-up	New	3.25	0.001*	0.71	0.23
	Treated	-	-	1.22	0.11
	Corrected	-	-	-1.54	0.06

Significance levels: * $p < .05$; ** $p < .01$; *** $p < .001$

Error correction behaviours. The need for assistance from the therapist (specific and unspecific prompts) and self-corrections showed clear patterns of change across the intervention sessions, as shown in **Figure 9.4B**. During the sandwich task in level I, the participant required specific and unspecific prompts for correction, and he was able to self-correct only 20% of his errors; however, the proportion of self-corrected errors increased significantly from level II to level III ($p < .01$, see **Table 9.8**).

In the table set-up task, the proportion of specific prompts decreased significantly from level I to level II ($p = .03$); the participant mainly needed 60% of unspecific prompts to correct his errors in level II, and self-corrected 100% of his errors in level III. Therefore, even though the cognitive demands became more difficult across the intervention levels, the participant reduced the need for specific prompts and progressively replace them with a greater ability to correct his errors with unspecific prompts or self-corrections.

Table 9.8 Assistance needed to complete the tasks during each level of the intervention

Task	Error correction behaviour	Level I vs II		Level II vs III		Level I vs III	
		Z	p	Z	p	Z	p
Sandwich	Specific prompt	1.08	0.14	1.22	0.11	1.94	0.02**
	Unspecific prompt	-1.9	0.02*	1.26	0.1	-0.39	0.65
	Self-corrections	1.34	0.09	-2.5	0.006**	-1.55	0.06
Table set-up	Specific prompt	1.76	0.03*	-	-	1.18	0.11
	Unspecific prompt	-0.97	0.16	1.45	0.07	0.96	0.16
	Self-corrections	-0.71	0.23	-1.45	0.07	-2.07	0.01**

Significance levels: * $p < .05$; ** $p < .01$; *** $p < .001$

Online awareness. Anticipatory awareness and self-evaluation

The participant showed a tendency to overestimate his performance during the baseline phase. After the intervention, the discrepancy between the prediction and actual performance decreased. During the baseline, this represented an unrealistic view of his performance, and his predictions became more accurate after the intervention. A similar pattern was observed with the self-evaluation during the baseline and post-intervention sessions (**Table 9.9**).

Table 9.9 Comparison of anticipatory awareness and self-evaluation of performance between baseline and post-intervention

	Baseline				Post-intervention		
	S1	S2	S3	S4	S13	S14	S16
Sandwich task							
Prediction of errors	3	2	3	4	1	1	2
Estimation of errors	2	2	3	2	2	2	2
Actual performance	10	8	10	9	2	2	3
Anticipatory awareness	-7	-6	-7	-5	-1	-1	-1
Self-evaluation	-8	-6	-7	-7	0	0	-1
Table set-up task							
Prediction of errors	4	4	3	4	1	1	2
Estimation of errors	3	2	2	2	1	4	2
Actual performance	11	10	11	13	1	5	3
Anticipatory awareness	-7	-7	-8	-7	0	-4	-1
Self-evaluation	-8	-8	-9	-11	0	-1	-1

Generalization outcomes

Functional performance

Near transfer. Trained tasks. In week 7 we examined the near transfer of the trained tasks by asking the participant to perform both tasks (data point 15), including novel executive and monitoring demands (new distractors and conflicting situations). In this session, the participant's error frequency was three in the sandwich task and one in the table set-up task, which was consistent with his average performance in data points 14, and 16 (Figure 9.3). The modified t-test analysis showed no significant differences between the participants' error frequencies in the post-intervention phase for the sandwich near-transfer task (participant's error score = 3, Mean_{Post Intervention} = 2, SD_{Post Intervention} = 1.15, $t = 1.25$, $p = .16$) and for the table set-up near-transfer task (participant's error score = 1, Mean_{Post Intervention} = 3, SD_{Post Intervention} = 2.64, $t = 0.32$, $p = .38$).

Near transfer. Untrained task. Intra-subject statistical analyses. According to the piecewise regression analysis, the initial baseline level is 6.9, showing a positive baseline trend of 0.9, that is almost two more errors every two measurement occasions. After the intervention, results show an immediate decrease of 4.5 errors, with an improving of - 2.9.

Figure 9.5 shows the trends in original data.

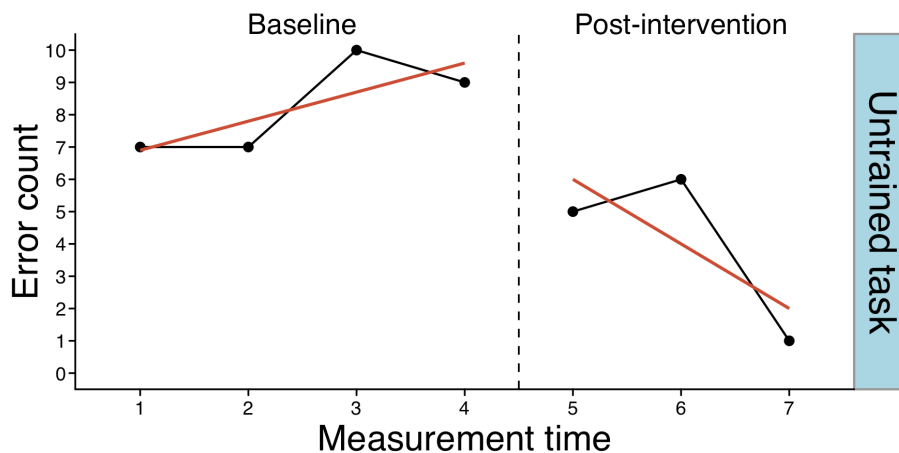


Figure 9.5 Total errors across baseline and post-intervention phase in the untrained task

Inter-subject statistical analyses. The modified t-test analysis revealed that the participant performance still showed a statistically significant difference between his number of errors and the average of the control group during the post-intervention condition ($t = 3.14, p < .01$), as shown in **Table 9.10**.

Table 9.10 Differences between the individuals' and healthy controls' performance in the untrained task and the Spanish WCPA-10

Task	Case's mean	Control sample	Significance test ^a	Percentage of the control population obtaining a lower score than the case ^b	Estimated effect size (Zcc) ^c
		n =8			
		Mean (SD)	t	Point (95% CI)	Point (95% CI)
Untrained					
Baseline	8.25	1.5	8.41 ^{***}	99.99 (99.99 to 100)	8.92 (4.33 to 13.34)
Post-intervention	4	(0.76)	3.14 [*]	99.16 (92.86 to 100)	3.30 (1.47 to 5.12)
Spanish WCPA-10					
Baseline	7	1.25	7.66 ^{***}	99.99 (99.99 to 100)	8.13 (3.93 to 12.35)
Post-intervention	3	(0.71)	2.33 (0.052)	97.40 (96.10 to 98.99)	2.47 (1.01 to 3.90)

^a Crawford and Howell (1998); the results are for a one-tailed test.

^b Crawford and Garthwaite (2002).

^c Crawford, J. R., Garthwaite, P. H., and Porter, S. (2010).

Significance levels: * $p < .05$; ** $p < .01$; *** $p < .001$

Functional-cognitive performance

Far transfer. The total number of errors on the Spanish WCPA-10 was reduced by more than half after the intervention. When we compared the individual performance of the participant after the intervention with that of the control group, there was a marginally significant difference between the participant and the control group. ($t = 2.32, p = .052$) (Table 9.10).

Secondary outcomes

Emotional distress and cognitive status. We also examined the effects of the intervention on several cognitive tests assessing EF. We found that the participant showed no reliable change (improvement) on the INECO Frontal Screening (RCI = -0.75) or the Wisconsin Card Sorting Test (RCI = 1.06). Finally, we found that our intervention did not have a negative impact on his emotional state, as no change was observed on the DASS-21 (RCI = -0.63) following the intervention.

9.5 Discussion

In this study, we have provided preliminary evidence of an occupation-based intervention aimed at improving executive and metacognitive deficits and its impact on functional performance. One of the main expected finding was an improvement in task performance with the introduction of the intervention. The participant significantly reduced his error rate in both trained tasks in the post-intervention phase compared with baseline. In addition, a group analysis comparing the participant's post-intervention performance with that of the control group showed no significant differences in the number of errors in either task. These findings are consistent with recent evidence and highlight the importance of selecting meaningful, real-life functional tasks that are tailored to the individual's therapeutic goals to improve motivation, engagement in therapy, and functional performance after brain injury (Park et al., 2015; Wolf et al., 2015). As in previous studies that combined occupation-based tasks and structured feedback techniques (Doig et al., 2017; Doig et al., 2020; Ownsworth et al., 2017; Schmidt et al., 2013), the present single-case study led to significant improvements in the ability to self-monitor and self-correct errors through the intervention sessions. Regarding the self-correction of errors, the participant demonstrated greater independence across the intervention sessions for both trained tasks; in particular, the participant reduced the need for specific prompts, which were progressively replaced by a greater ability to

correct his errors with unspecific prompts or self-corrections. Furthermore, in line with previous studies (Toglia et al., 2011, 2010), the gradual improvements in self-monitoring ability led the participant to better predict and recognise difficulties across activities. These results provide a strong argument against the possibility that these improvements were due to practice effects experienced by the participant. We designed the tasks to gradually add new conflict and problem-solving situations and semantically related irrelevant objects to reflect real-life difficulties. This key aspect is an improvement over previous studies, as it helped the participant gradually develop the ability to inhibit task-irrelevant stimuli, detect and self-correct errors, and learn to apply them in changing situations throughout the intervention sessions. These findings support the ideas of Chen et al. (2006, 2020) who consider adaptive interventions with progressive increases in cognitive demands as an essential component of intervention programmes rather than repetitive practice. Another important finding was that following the intervention, the participant demonstrated an improved ability to more accurately predict and estimate his own performance (i.e., estimation of the number of errors he will make or has made) in both trained tasks, that is, an improvement in both anticipatory awareness and self-evaluation online components of self-awareness. We believe that this is crucial, as the ability to anticipate task challenges may encourage participants to use compensatory strategies and allocate adequate attentional resources to deal with the oncoming task. In addition, self-evaluation abilities might also be crucial for updating the offline component of self-awareness, that is, the metacognitive knowledge (Toglia & Goverover, 2022). Future research, including measures of the offline component of self-awareness, will be crucial to assess whether the present intervention strategy can improve not only online but also offline components.

A critical component of any cognitive intervention should be to promote the maintenance of gains to determine its effectiveness (Cicerone et al., 2019; Jeffay et al., 2023). In this regard, improvements in functional performance in terms of the number of

errors remained stable immediately after the intervention and were maintained 2-4 weeks after the participant received the final intervention session on the sandwich task. While the number of errors in the table set-up task remained below the pre-treatment levels, a trend towards the baseline level was evident. It is possible to hypothesise that greater stability of the observed gains may occur with the inclusion of follow-up intervention sessions, a gradual rather than abrupt withdrawal from the intervention, or longer intervention periods, as suggested by several studies (Schmidt et al., 2015; Toglia et al., 2011, 2010).

Another aim of the intervention, which is of particular interest from a clinical perspective, was to investigate the extent of generalization of the learned skills beyond the trained tasks. This single-case study demonstrated a near-transfer effect when measured by performance on two activities structurally similar to the trained tasks, although with novel distractors and conflicting situations. The participant's performance in both tasks maintained a similar error rate that closely matched the levels observed after the intervention on the trained tasks. This result supports the findings of Ownsworth et al. (2017), who found increased skill generalization to a related task within the same functional context after severe TBI following an error-based learning approach. This is also consistent with previous observations showing the importance of varying practice situations as a critical factor in improving skill generalization (Chen et al., 2006; Geusgens et al., 2007; Toglia, 2018). We employed feedback techniques following metacognitive strategy training and the multicontext approach, with an emphasis on guided questioning before, during, and after each intervention session to promote self-strategy generation and challenge anticipation (Toglia et al., 2020). In line with previous studies (Jaywant, Steinberg, et al., 2022; Toglia et al., 2010, 2011), we focused on therapeutic methods that encouraged the participant to actively make connections within and across different sessions, identify strategies that led to successful performance, and continue their use in different tasks and contexts. It seems plausible that the emphasis on the guided strategy generation technique, combined with the task characteristics, contributed to the

participant's improved ability to anticipate, detect, and self-correct errors by improving his performance on both trained and untrained tasks.

Furthermore, this approach also showed potential generalization effects to a related untrained near-transfer task (preparing breakfast). The participant's post-intervention performance improved significantly compared with his baseline performance, with the error rate halved. A similar pattern of results was observed when we measured performance on a far-transfer task, which required the participant to enter 10 appointments in a weekly calendar into an empty weekly calendar sheet. Even if the demands of this task were very different from those of the trained tasks, the participant also decreased his error rate by just over half, showing better overall task performance and improved problem-solving behaviour after the intervention. These findings add to a growing body of evidence supporting the use of the multicontext approach to enhance effective transfer across functional tasks and contexts (Jaywant et al., 2020; Landa-Gonzalez, 2001; Nagelkop et al., 2021; Toglia et al., 2011, 2010, 2020). A note of caution is needed here, as although the participant's performance on both untrained tasks improved significantly according to the intra-subject analyses, the inter-subject analyses showed a significant difference between the participant's performance and that of the control group in the related untrained near-transfer task and a marginally significant difference on the far-transfer task after the intervention. This is an important issue that raises important questions about the difference between statistical and clinical significance when interpreting clinical research results of interventions tailored to the specific needs of an individual. However, as noted by Wilson (1987), ideally, the treatment should demonstrate both clinical and statistical significance; however, questions remain about the best intervention approaches to capture patterns of change at the inter-individual level.

In the current study, we also examined the effects of the intervention on a battery of conventional cognitive tests to measure EF and emotional states (i.e., secondary

226

outcomes). Our results show that the intervention had no significant effects on the cognitive tests assessed. Participant's performance in these cognitive domains (i.e., EF) remained consistent throughout the study, and no significant improvements or deteriorations were observed. This null finding can be interpreted as a difficulty in transferring the learning at least towards tasks that are not functional or significant in nature, as is the case with conventional cognitive tests (i.e., INECO or Wisconsin Card Sorting Tests). Finally, participants' emotional well-being remained stable, with no detectable changes in emotional distress following our intervention. This finding holds significance, because it underscores the importance of interventions that improve self-awareness without compromising emotional status (Villalobos, Bilbao, et al., 2020). Our results are in line with previous studies that have shown an improvement in self-awareness through the use of video feedback, without resulting in a significant increase in emotional distress (Schmidt et al., 2013). This reinforces the importance of fostering a supportive and non-confrontational therapeutic environment to mitigate the potentially distressing impact of learning about one's post-injury impairments.

In summary, our findings provide novel empirical evidence regarding the effects of an occupation-based executive and metacognitive rehabilitation intervention aimed at enhancing participants' activities of daily living after brain injury. Although the clinical implications of this study are preliminary, they suggest that integrating these intervention approaches within functionally relevant activities and contexts into conventional rehabilitation therapies could improve executive and self-awareness abilities to better face participants' cognitive limitations.

9.6 Limitations and future directions

Several limitations can be found in this single-case study. First, the scientific literature has reported the need to work collaboratively with families and/or other support systems in the therapeutic process (Sohlberg & Mateer, 2001; Tate et al., 2018). Indeed,

moving cognitive training into the home environment with the involvement of the family has been identified as a critical component for improving community participation and cognitive functioning after TBI (Bogner et al., 2019; Wulf-Andersen & Mogensen, 2017). Family participation was not possible because of time and logistical constraints, and it is unclear whether the response to the intervention would have been greater with increased family attendance. The second limitation was the lack of maintenance data beyond 4 weeks. The study was completed approximately 2 months before the onset of the pandemic; therefore, it was not possible to determine whether the intervention would be sustained beyond that time. Similarly, generalization data in additional tasks and settings would have been valuable if more time had been available. Third, we were only able to take four measurements at baseline, whereas the What Works Clearinghouse (2022) recommended a minimum of six for changing criterion designs. Fourth, to further evaluate the effectiveness of the cognitive rehabilitation techniques implemented in this study, future research should conduct an additional social validity assessment to examine the feasibility and effectiveness of this approach across different therapists and participants. This could include the use of interviews, surveys, or scales to assess the acceptability and feasibility of the intervention (Snodgrass et al., 2018). Finally, replication of the results, including the element of randomisation is essential to provide further evidence about the effectiveness and application of the current occupation-based approach in the ABI population and to ensure reproducibility and internal validity (Tanious et al., 2024).

Part IV: General Discussion

Chapter 10

General Discussion

The complexity of ISA, especially concerning its impact on ADL, highlights the need for ongoing research into the relationship between ISA and functional performance in individuals with ABI. Such insights are essential for improving diagnostic accuracy and tailoring interventions to improve the quality of life of these individuals. Notably, Woods (2021) highlights that, despite more than 10,000 studies published in major neuropsychology journals over the past 35 years, only about 1% have examined the connection between cognition and everyday functioning. This significant research gap underscores the need for more empirical studies to deepen our understanding of cognitive deficits like ISA and its real impact in real-world contexts. Advancing research in this area could lead to more precise diagnostic instruments for predicting functional outcomes and developing more effective interventions. This thesis aimed to contribute new insights into how the components of SA, as outlined in Toggia and Kirk's (2000) DCMA, interact with cognitive and task-related factors in everyday life. The studies presented in this thesis validate novel ADL-based approaches for assessing and intervening in specific SA processes following ABI, highlighting its *multi-faceted* nature and its impact on functional outcomes. The theoretical and clinical implications of the results of these studies are discussed in the following sections.

10.1 Improving the assessment of the metacognitive knowledge component of self-awareness: accounting for variations in cognitive domains and task complexity

While instruments like the SADI, PCRS, and AQ reliably assess the *metacognitive knowledge* component of SA, they often fall short in identifying ISA across specific cognitive domains, including memory, attention, inhibition, and monitoring. Moreover, these tools often fail to capture ISA within the context of ADL tasks of varying difficulty (Brown et al., 2019; Dromer et al., 2021a; Toglia & Goverover, 2022). To address these limitations, we developed *The Cognitive Awareness Scale for Basic and Instrumental Activities of Daily Living*, a novel self-proxy discrepancy scale designed to measure multiple cognitive and functional dimensions of ISA.

The *first study* (Chapter 6) focused on validating this tool for Spanish-speaking individuals with ABI. This scale offers several advantages over existing instruments. First, unlike previous tools, it adopts a comprehensive approach by incorporating multiple cognitive items known to predict functional performance, such as task schema, error detection, problem solving or task self-initiation (Giovannetti et al., 2002; Humphreys & Forde, 1998; Schwartz et al., 2002). Another significant advantage is its item specificity, which enhances response accuracy by providing clear examples of cognitive error types, thereby reducing subjectivity. Research suggests that greater specificity in item content improves agreement between individuals and their proxies (Brown et al., 2019; Gasquoine, 1992; Toglia & Kirk, 2000). Additionally, this scale distinguishes itself by offering a more detailed assessment of metacognitive knowledge, particularly in differentiating between BADL and more cognitively demanding IADL tasks. By capturing these distinctions, the scale provides a clearer picture of an individual's SA regarding their cognitive and functional deficits, allowing clinicians to design targeted interventions aimed at improving SA in the types of tasks that are most affected.

The study results demonstrated that the proposed scale possesses acceptable psychometric properties, exhibiting optimal sensitivity and specificity –key criteria for designing and reporting health status questionnaires (Terwee et al., 2007). These findings validate our scale as a reliable clinical tool for assessing ISA across various cognitive and functional domains. This is particularly significant given recent reviews that highlighted the lack of psychometrically sound tools for assessing the metacognitive knowledge component of SA (Brown et al., 2019; Dromer et al., 2021a; Smeets et al., 2012). Notably, our findings indicate that individuals with severe ISA were significantly less accurate in predicting their cognitive performance on more complex IADL compared to BADL tasks, highlighting the importance of considering task demands and contextual factors, such as familiarity and task complexity when assessing SA after ABI (Dromer et al., 2021a; Merchán-Baeza et al., 2020; Toglia & Goverover, 2022).

However, it should be noted that this preliminary study is part of an ongoing effort to further evaluate the scale's psychometric properties by expanding the sample size. This will allow for a more thorough analysis of its factor structure, dimensionality, and reliability (Boateng et al., 2018). Consequently, further systematic research using the scale is warranted to explore how levels of SA may vary across cognitive domains and ADL tasks of varying complexity. Such studies could help address the ongoing debate regarding whether SA is domain-general or domain-specific (Fitzgerald et al., 2017; Hurst et al., 2018; Toglia & Goverover, 2022) or examine whether ISA in specific cognitive domains correlate with damage to specific brain regions. To further investigate whether SA is domain-general or -specific, our research group is developing a new version of the scale to measure social cognition within the same ADL tasks used to assess SA across different cognitive domains. This approach will allow us to compare ISA across social and cognitive domains, providing an independent measure of SA in social cognition. In fact, a recent systematic review by Dromer et al. (2021b) identified several studies exploring the

relationship between ISA and social cognition, suggesting that ISA may impact social cognition independently of broader cognitive deficits.

10.2 Improving the assessment of the online component of self-awareness: the importance of evaluating its different sub-components simultaneously in the context of performance-based C-IADL tasks

As discussed in *Chapter 3*, the lack of a clear, consistent definition of online SA in the literature has hindered the development of targeted assessment tools, leading to inconsistencies in the structure and content of existing instruments designed to measure it (Sansonetti et al., 2024). Nevertheless, there is general agreement that online SA is best assessed through performance-based C-IADL instruments (Sansonetti et al., 2024; Toglia & Goverover, 2022). While some instruments show promise by simulating familiar ADL tasks in laboratory settings, their limited accessibility and high demands on time and resources restrict their practical use in clinical settings. Moreover, standardized instruments with these characteristics are still lacking for Spanish-speaking populations.

In response of these limitations, *the second study* (Chapter 7) focused on translating, adapting, and validating the WCPA-10 (Toglia, 2015) for Spanish-speaking individuals with ABI. Given the significant influence of cultural factors in shaping ADL performance (Alves et al., 2021; Jang & Kawachi, 2019), we employed a rigorous cross-cultural adaptation process. This included direct and reverse translations, along with group and expert cognitive debriefing, to ensure that the instrument was both reliable and relevant for the target population (Wild et al., 2005). Preliminary findings from the validation process support the Spanish WCPA-10 as a reliable, performance-based C-IADL tool for assessing cognitive abilities in a functional context. Unlike traditional cognitive tests that assess isolated cognitive abilities, the Spanish WCPA-10 offers a comprehensive analysis of functional performance by examining how individuals handle complex, multitasking activities. It evaluates a range of executive processes –such as

strategy use, working memory, problem-solving, set-shifting, and inhibition—alongside key sub-components of online SA (Toglia & Foster, 2022). A notable strength of this study was its inclusion of a battery of cognitive tests, which allowed us to establish, for the first time, the *construct validity* of the Spanish WCPA-10 by examining relationships between its key outcome measures (e.g., total accuracy score, number of strategies used, and rule adherence) and cognitive domains like EF and memory in Spanish individuals with ABI. Interestingly, the number of strategies used emerged as the most sensitive indicator of executive deficits, consistent with previous research linking strategy use during ADL tasks to better EF and functional performance after ABI (Bottari et al., 2014; Nott & Chapparo, 2020; Toglia et al., 2012). These findings provided the basis for further exploration of online SA and its relationship to strategy use, as discussed in the third study.

Additionally, the Spanish WCPA-10 effectively distinguish between healthy individuals from two ABI groups with mild and subtle cognitive deficits, demonstrating its high sensitivity in identifying real-world cognitive challenges. This demonstrates the Spanish WCPA-10's *external validity* and highlights its potential as a valuable diagnostic tool for identifying the functional impact of cognitive impairments on daily living (Pinto, Dores, et al., 2023; Spooner & Pachana, 2006). To bridge laboratory and clinical findings and real-world functionality, we also examined the *incremental validity* of the Spanish WCPA-10 in predicting everyday performance. Results showed that it significantly contributed to the prediction of everyday performance beyond traditional cognitive tests of EF and memory, even after controlling for demographic factors like age and education. This is particularly noteworthy, as it adds to the growing body of evidence supporting for the use of instruments that better reflect real-life cognitive challenges and their impact on daily functioning (Casaletto & Heaton, 2017; Chaytor et al., 2006; Chaytor & Schmitter-Edgecombe, 2003; García-Molina et al., 2012; Poncet et al., 2017; Robertson & Schmitter-Edgecombe, 2016; Ruff, 2003; Spooner & Pachana, 2006; Toglia, 2015).

By controlling for potential confounders like age and education, accounting for multiple comparisons, and performing incremental validity analyses, this study addresses to calls for greater scientific rigor in establishing the ecological validity of new face-valid assessments (Suchy, DesRuisseaux, et al., 2024; Suchy, Mora, et al., 2024). However, further research is needed to fully explore the Spanish WCPA-10's predictive ability for functional outcomes. In this study, the PCRS (proxy version) was used as a measure of daily function, although prior research has questioned the heavy reliance on participant or proxy-reported IADL when assessing the relationship between EF and daily activities (Robertson & Schmitter-Edgecombe, 2016; Suchy, Gereau Mora, et al., 2024). To strengthen the Spanish WCPA-10's predictive capacity, future studies with larger samples should incorporate direct functional assessments, such as naturalistic in-home evaluations or other performance-based ADL measures. Additional psychometric data, including test-retest and inter-rater reliability, are also necessary to confirm its temporal stability. Studies examining age and education effects on Spanish WCPA-10 performance could establish normative data, allowing clinicians to interpret results relative to demographically matched groups (delCacho-Tena et al., 2023; Innocenti et al., 2023).

In the third study (Chapter 8), we expanded the sample size to further validate the Spanish WCPA-10 as a brief C-IADL tool for assessing online SA. Our findings confirmed the Spanish WCPA-10's external validity in detecting online SA deficits among Spanish-speaking individuals with ABI. Specifically, individuals with ABI used fewer self-monitoring strategies compared to healthy controls, consistent with Jaywant et al. (2022), who also reported reduced self-checking in individuals with stroke using the WCPA-10. Self-monitoring strategies enable individuals to observe and evaluate their own performance while completing tasks (Dole et al., 2009; Toglia & Foster, 2022). These findings suggest that individuals with ABI could benefit from early cognitive rehabilitation targeting these strategies to improve performance in complex tasks (Schmitter-Edgecombe et al., 2021). We also observed that individuals with ABI were less likely to recognize their own errors, an ability generally well-developed in healthy adults (Arora et

al., 2021). Previous studies have similarly documented impaired error self-recognition in individuals with brain injuries, both in computer-based (McAvinue et al., 2005; O’Keeffe et al., 2007) and naturalistic tasks (Doig et al., 2020; Hart et al., 1998). These findings are in the same direction as those of Jaywant et al. (2022), though their homogeneous ABI sample (with similar age, education, and time since injury) showed no statistically significant differences in error recognition. Our more diverse ABI sample highlights the need for further research on the influence of factors such as age, education, and injury chronicity on SA in brain injury assessments.

Additionally, findings on after task measures of online SA show that individuals with ABI tended to overestimate their performance compared to healthy controls. This pattern of overestimation, which has also been documented in previous ADL studies (Barrett et al., 2014; Jaywant, et al., 2022; Rotenberg-Shpigelman et al., 2014), has significant safety implications as it can prevent individuals with ABI from recognizing errors and using compensatory strategies, potentially leading to them taking on tasks beyond their abilities (Rotenberg-Shpigelman et al., 2014; Sansonetti et al., 2024; Tyson et al., 2012). These results reinforce the Spanish WCPA-10’s potential for accurately measuring various sub-components of online SA in clinical and research contexts. They also underscore the importance of assessing online SA in individuals with ABI, particularly within the context of performance-based C-IADL instruments (Sansonetti et al., 2024; Toglia & Goverover, 2022). Such assessments provide a direct observation of task execution, capturing whether individuals’ SA enhances or hinders their performance by influencing strategy use, error detection and correction, and realistic self-evaluation (Toglia & White, 2020).

This study also explored the relationship between different sub-components of online SA and traditional cognitive assessments of memory and EF. Consistent with Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Narganes-Pineda, et al. (2024) who examined online SA during everyday activities in individuals with ABI, the findings confirmed that specific sub-components of online SA are linked to EF. Positive

correlations showed that individuals with ABI with better EF used more self-monitoring strategies and recognized a greater proportion of errors, supporting models that consider monitoring and regulation as core executive processes (Kennedy & Coelho, 2005; Miyake et al., 2000). These findings highlight EF's importance in goal-directed behavior, particularly in situations requiring adaptation and selective processing of task-relevant information. Overall, this research contributes to the expanding literature on online SA in ABI populations. Researchers like Sansonetti et al. (2024) and Toglia and Goverover (2022) have emphasized the need for thorough online SA assessment, particularly through C-IADL tools like the Spanish WCPA-10, which allow for the study of the complex interplay between online SA, EF, and strategy use within real-world tasks.

10.3 Relationship between online self-awareness, strategy use and functionality

The *third study (Chapter 8)* also provides key findings on the interaction between cognitive strategies, online SA, and functional performance—an area with limited exploration in clinical research. The study revealed that individuals with ABI who demonstrated better awareness of their performance achieved significantly better outcomes on the Spanish WCPA-10 through more effective strategy use compared to those without awareness and healthy controls. Specifically, ABI participants who were aware of their performance applied strategies more effectively, enhancing their functional cognitive performance on a complex task. In contrast, individuals with ABI lacking performance awareness were less likely to utilize or benefit from strategies, likely due to challenges in detecting errors or adapting their approach to task demands. These findings suggest that online SA plays a critical role in optimizing cognitive strategy use, as it enables individuals to assess when a strategy is working or needs adjustment—an especially relevant factor in individuals with ABI, where cognitive deficits often impact functional outcomes. To our knowledge, this is the first study to systematically examine

the relationship between strategy use and performance accuracy on a C-IADL task in individuals with ABI, both with and without SA deficits, alongside healthy controls.

Moreover, these findings underscore the potential of metacognitive interventions that target online SA to significantly enhance functional performance by promoting more effective strategy use in individuals with cognitive deficits (Toglia & Foster, 2022). By fostering SA, such interventions may not only strengthen cognitive abilities but also improve functional outcomes and support greater independence—an approach increasingly advocated in recent studies and reviews (Cicerone et al., 2019; Jeffay et al., 2023; Swanton et al., 2020; Toglia & Foster, 2022). The Spanish WCPA-10, by combining detailed assessments of strategy use and online SA, provides essential insights into real-world challenges faced by individuals with ABI, enabling clinicians to make more accurate functional predictions and guide personalized rehabilitation plans (Jaywant, Arora, et al., 2022). Future research with the Spanish WCPA-10 should further explore the types of strategies employed, their effectiveness, and the cognitive effort they require, as this could refine our understanding of which strategies most benefit functional performance and support targeted intervention planning.

10.4 Defining the treatment outcomes and active intervention elements for addressing impaired self-awareness

Cognitive intervention is a multidisciplinary field that integrates a range of disciplines, including neuropsychology, special education, occupational, and speech therapy (Tempest & Maskill, 2017). This diversity makes its precise definition difficult. As a result, Wilson (2008) advocates for a broader definition, that views cognitive intervention as a collaborative process that addresses real-world functional challenges through a goal-oriented approach involving the individual, their family, the multidisciplinary team, and the community. The focus on comprehensive interventions that prioritize functional outcomes is recognized as the primary goal of cognitive

intervention protocols (Ben-Yishay & Diller, 2011; Pinto, Peixoto, et al., 2023; Wong et al., 2023). Because the purpose of cognitive interventions extends beyond addressing specific cognitive deficits, *the fourth study* (Chapter 9) examined the importance of selecting effective intervention approaches to improve SA after brain injury. Based on the third study of this thesis, it is clear how the level of online SA and the use of cognitive strategies contribute to enhanced functional performance in individuals with ABI, so in this study we examine whether interventions targeting these processes can effectively improve performance on different ADL tasks

. This study presented the results of a changing-criterion SCED, offering new empirical evidence for the efficacy of an intervention that used a top-down approach to improve performance in meaningful occupations through conflict-based experiential feedback. SCED studies are particularly useful when large-scale RCT are impractical, or when interventions must be tailored to address specific needs, such as those in individuals with neurological impairments, cognitive disabilities, or other complex conditions (Wong et al., 2023). When well-designed, SCED studies provide strong internal validity and can establish clear cause-and-effect relationships comparable to those seen in large RCT studies (Tanious et al., 2024). Combined with MST, the intervention focused on improving self-monitoring, error correction, and strategy use, to foster skill generalization to different ADL activities following brain injury. In this study, meaningful IADL tasks were collaboratively chosen by the individual and the clinician, emphasizing the importance of aligning activities with the individual's therapeutic goals. This alignment fosters greater engagement, motivation, and improved functional outcomes (Mahoney et al., 2023; Park et al., 2015). Additionally, consistent with previous studies that integrated occupation-based interventions with structured feedback (Doig, Fleming, Ownsworth, et al., 2017; Doig et al., 2020; Ownsworth et al., 2006, 2010, 2017; Schmidt et al., 2013), the participant in this SCED study demonstrated increased independence during intervention sessions. Notably, there was a reduction in the need

for specific prompts, which were gradually replaced by more self-corrections or reliance on non-specific prompts, highlighting improved self-regulation and error correction.

In line with previous research, these findings further underscore the potential benefits of *conflict-based experiential feedback* for improving SA (Merchán-Baeza et al., 2020; Ricchetti, Navarro-Egido, Rodríguez-Bailón, Salazar-Frías, Merchán-Baeza, et al., 2024). We carefully designed the intervention tasks to progressively introduce new conflicts, problem-solving scenarios, and semantically related irrelevant objects, simulating real-life challenges. Each task had specific instructions and consisted of 10-15 steps. This approach marks an enhancement over prior studies by helping the participant gradually develop the ability to inhibit task-irrelevant stimuli, detect and self-correct errors, and apply these skills in dynamic situations throughout the intervention. Notably, these improvements were evident not only in the trained tasks but also in an untrained task, indicating a promising level of skill transfer. These findings align with the work of Chen et al. (2006; 2019), Geusgens et al. (2007) and Toglia (2018) who emphasize the importance of adaptive interventions that progressively increase cognitive demands, rather than relying on repetitive practice alone, as a crucial element of successful intervention programs and enhanced skill generalization.

Another significant outcome was the improvement in the individual's ability to accurately predict and assess their performance—specifically, estimating expected and actual errors—across both trained tasks following the intervention. This reflects improvements in both anticipatory awareness and self-evaluation skills, essential sub-components of online SA. This improvement is especially valuable, as the ability to anticipate potential task challenges can encourage the use of compensatory strategies and better allocation of attentional resources. The intervention used feedback techniques rooted in MST and MC approaches, emphasizing guided questioning before, during, and after each session to encourage self-generated strategies and anticipation (Toglia et al., 2020). This structured approach to strategy development, coupled with the

240

characteristics of each task, likely contributed to the participant's enhanced capacity for anticipating, detecting, and self-correcting errors, ultimately leading to improved performance on both trained and novel tasks. Moreover, the approach demonstrated potential for generalization, with improvements observed not only in a near-transfer task (preparing breakfast) but also in a far-transfer task (Spanish WCPA-10).

In summary, our findings provide new empirical support for the effectiveness of an occupation-based intervention targeting EF and metacognition to improve functional performance after brain injury. This intervention engages individuals in meaningful, problem-solving tasks using a top-down framework that promotes skill generalization to real-life contexts. SCED studies, particularly those using changing-criterion designs, enable researchers to systematically adjust intervention components and monitor their effects in a controlled, individualized manner. This design is particularly useful for illustrating how gradual, criterion-based adjustments can support skill acquisition in practical, everyday tasks, offering important insights into the intervention's impact on individuals' performance. While the clinical implications remain preliminary, they suggest that integrating these methods—focused on relevant activities and real-world contexts—into standard rehabilitation could enhance EF and SA. Further SCED studies with controlled designs across diverse settings and therapists are recommended to validate this intervention's efficacy.

10.5 Limitations and future directions

This thesis presents several limitations that warrant consideration for future research. *First*, guided by Toggia and Kirk's (2000) DCMA this thesis focused primarily on the cognitive factors influencing ISA in individuals with ABI. However, other relevant theoretical frameworks, like the Biopsychosocial Model of Consciousness (Ownsworth, Clare, et al., 2006), suggests that psychological and social factors also play key roles in ISA. These additional dimensions add complexity to the study of SA and were beyond the

scope of this thesis. Future research should investigate how psychological and social factors, in conjunction with cognitive elements, influence SA, shaping individuals' responses to task challenges and performance difficulties. This broader perspective will ultimately lead to more comprehensive approaches to assessment and treatment.

A *second* limitation concerns sample size limitations in some studies. In Study 1, the current sample size limits certain analyses, such as factor analysis, which would help confirm a homogeneous grouping of cognitive items across the tasks of the scale. In this way, future studies could explore more deeply into SA levels within specific cognitive domains. For example, researchers could examine whether patients with ISA have lower SA of specific cognitive functions, such as inhibition, problem solving, or task initiation. In addition, although the finding that individuals with severe ISA have a reduced ability to accurately predict their cognitive performance on more complex IADL tasks compared to BADL tasks provides valuable insight into the study of SA in individuals with ABI, this finding should be interpreted with caution due to the small subset of patients with severe ISA in whom both discrepancy indices could be calculated. A larger sample may allow for subgrouping according to clinical profiles, helping to clarify SA variations across cognitive domains and tasks of varying difficulty—a critical step in advancing our understanding of SA in individuals with ABI (Dromer et al., 2021a; Toglia & Goverover, 2022; Villalobos et al., 2021) and developing tailored interventions to improve outcomes (Smeets et al., 2012). Meanwhile, questions regarding sample size must also be raised about Study 2, where the examination of the incremental validity of the WCPA-10 was also limited by a small sample size. A larger sample would increase the robustness of these findings and their implications for clinical practice. In the fourth intervention study, although we used a robust design, future research could benefit from expanding to group studies through RCT or replication across various SCED studies to provide additional insights into the intervention's effectiveness. Such studies could help clarify which cognitive and neural variables contribute to better outcomes, allowing researchers

to identify the factors that most effectively support skill transfer across contexts. By examining patterns in cognitive function, brain structure, and neural activity, future studies could uncover key variables driving successful outcomes and sustained generalization. This approach would deepen our understanding of individual differences in response to intervention and lay the foundation for more personalized, effective rehabilitation strategies.

Also, at the brain functional level, future studies would benefit from incorporating advanced neuroimaging techniques, to identify specific brain regions and networks associated with different types of ISA, including metacognitive knowledge and online components. This could help clarify how distinct neural substrates underlie various components of ISA, providing a deeper understanding of the neuroanatomical and functional foundations of these processes. Understanding the relationship between brain structure, functional connectivity, and ISA could offer insight into which brain regions are most critical for maintaining SA, as well as how disruptions to these areas impact SA in individuals with ABI.

A third limitation of this work is the heterogeneity of the study samples. Participants in Studies 1, 2, and 3 differed significantly in time since injury, etiology, and lesion location. For example, stroke was a more common etiology, while other causes such as tumor, TBI, and infection were less common. By analyzing these individuals as a single group, we were unable to explore whether these variables contribute to different patterns of ISA. Future research should consider analyzing these factors separately based on time since injury, etiology, and lesion characteristics. By doing so, it may be possible to uncover specific relationships between these variables and ISA.

Finally, exploring the assessment tools derived from this thesis across diverse patient populations – including those with varying types of memory impairments, such as episodic and semantic memory deficits – could reveal how ISA differences manifest in

relation to underlying memory profiles. Future research should aim to assess whether metacognitive knowledge and online SA deficits are distinct across these memory-impaired groups and how other cognitive domains, such as attention or EF, may moderate or exacerbate these deficits in different populations.

References

- Abreu, B. C., Seale, G., Scheibel, R. S., Huddleston, N., Zhang, L., & Ottenbacher, K. J. (2001). *Levels of Self-Awareness After Acute Brain Injury : How Patients ' and Rehabilitation Specialists ' Perceptions Compare*. 82(January), 49-56. <https://doi.org/10.1053/apmr.2001.9167>
- Ahn, S.-N. (2019). Effectiveness of occupation-based interventions on performance's quality for hemiparetic stroke in community-dwelling: A randomized clinical trial study. *NeuroRehabilitation*, 44(2), 275-282. <https://doi.org/10.3233/NRE-182429>
- Alves, W. L. T., Faria-Fortini, I. de, Galvão, A. C. D. R., Cardoso, F. E. C., & Scalzo, P. L. (2021). Cross-cultural adaptation of the Activities of Daily Living Questionnaire-Brazil in Parkinson's disease. *Arquivos de Neuro-Psiquiatria*, 79(12), 1101-1108.
- Amanzio, M., Bartoli, M., Cipriani, G. E., & Palermo, S. (2020). Executive Dysfunction and Reduced Self-Awareness in Patients With Neurological Disorders. A Mini-Review. *Frontiers in Psychology*, 11, 1697. <https://doi.org/10.3389/fpsyg.2020.01697>
- Amanzio, M., Palermo, S., Zucca, M., Rosato, R., Rubino, E., Leotta, D., Bartoli, M., & Rainero, I. (2018). Neuropsychological correlates of instrumental activities of daily living in neurocognitive disorders: a possible role for executive dysfunction and mood changes. *International Psychogeriatrics*, 30(12), 1871-1881. <https://doi.org/DOI: 10.1017/S1041610218000455>
- American Occupational Therapy Association. (2014). Occupational Therapy Practice Framework: Domain and Process (3rd Edition). *The American Journal of Occupational Therapy*, 68(1), 1-48. <https://doi.org/10.5014/AJOT.2014.682006>
- Ansell, E. L., & Bucks, R. S. (2006). Mnemonic anosognosia in Alzheimer's disease: a test of Agnew and Morris (1998). *Neuropsychologia*, 44(7), 1095-1102. <https://doi.org/10.1016/j.neuropsychologia.2005.10.019>
- Ardila, A., Ostrosky-Solís, F., & Bernal, B. (2006). Cognitive testing toward the future: The example of Semantic Verbal Fluency (ANIMALS). *International Journal of Psychology*, 41(5), 324-332. <https://doi.org/10.1080/00207590500345542>
- Aretouli, E., & Brandt, J. (2010). Everyday functioning in mild cognitive impairment and its relationship with executive cognition. *International Journal of Geriatric Psychiatry*, 25(3), 224-233. <https://doi.org/10.1002/gps.2325>

- Aronov, A., Rabin, L. A., Fogel, J., Chi, S. Y., Kann, S. J., Abdelhak, N., & Zimmerman, M. E. (2015). Relationship of cognitive strategy use to prospective memory performance in a diverse sample of nondemented older adults with varying degrees of cognitive complaints and impairment. *Neuropsychology, Development, and Cognition. Section B, Aging, Neuropsychology and Cognition*, 22(4), 486-501. <https://doi.org/10.1080/13825585.2014.984653>
- Arora, C., Frantz, C., & Toglia, J. (2021). Awareness of Performance on a Functional Cognitive Performance-Based Assessment Across the Adult Lifespan. *Frontiers in Psychology*, 12, 5195. <https://doi.org/10.3389/fpsyg.2021.753016>
- Atchison, T. B., Sander, A. M., Struchen, M. A., High, W. M., Roebuck, T. M., Contant, C. F., Wefel, J. S., Novack, T. A., & Sherer, M. (2004). Relationship between neuropsychological test performance and productivity at 1-year following traumatic brain injury. *The Clinical Neuropsychologist*, 18(2), 249-265. <https://doi.org/10.1080/13854040490501475>
- Aydin, O. (2024). Rise of single-case experimental designs: A historical overview of the necessity of single-case methodology. *Neuropsychological Rehabilitation*, 34(3), 301-334. <https://doi.org/10.1080/09602011.2023.2181191>
- Bach, L., & David, A. (2006). Self-awareness after acquired and traumatic brain injury. *Neuropsychological Rehabilitation*, 16(4), 397-414. <https://doi.org/10.1080/09602010500412830>
- Bangen, K. J., Jak, A. J., Schiehser, D. M., Delano-Wood, L., Tuminello, E., Han, S. D., Delis, D. C., & Bondi, M. W. (2010). Complex activities of daily living vary by mild cognitive impairment subtype. *Journal of the International Neuropsychological Society: JINS*, 16(4), 630-639. <https://doi.org/10.1017/S1355617710000330>
- Barrett, A. M., Galletta, E. E., Zhang, J., Masmela, J. R., & Adler, U. S. (2014). Stroke survivors over-estimate their medication self-administration (MSA) ability, predicting memory loss. *Brain Injury*, 28(10), 1328-1333. <https://doi.org/10.3109/02699052.2014.915984>
- Bassingthwaighte, L., Gustafsson, L., & Molineux, M. (2024). Lifespace and occupational participation following acquired brain injury during driving disruption: a mixed methods study. *Disability and Rehabilitation*, 1-15. <https://doi.org/10.1080/09638288.2024.2338192>
- Baum, C. M., Connor, L. T., Morrison, T., Hahn, M., Dromerick, A. W., & Edwards, D. F. (2008). Reliability, Validity, and Clinical Utility of the Executive Function Performance Test: A Measure of Executive Function in a Sample of People With Stroke. *The American Journal of Occupational Therapy*, 62(4), 446-455. <https://doi.org/10.5014/AJOT.62.4.446>
- Baum, C. M., Lau, S. C. L., Heinemann, A. W., & Connor, L. T. (2023). Functional Cognition: Distinct From

- Fluid and Crystallized Cognition? *The American Journal of Occupational Therapy*, 77(3), 7703205020.
<https://doi.org/10.5014/ajot.2023.050010>
- Baum, C. M., Wolf, T. J., Wong, A. W. K., Chen, C. H., Walker, K., Young, A. C., Carlozzi, N. E., Tulskey, D. S., Heaton, R. K., & Heinemann, A. W. (2016). Validation and clinical utility of the executive function performance test in persons with traumatic brain injury. *Neuropsychological Rehabilitation*, 27(5), 603–617. <https://doi.org/10.1080/09602011.2016.1176934>
- Belchev, Z., Levy, N., Berman, I., Levinzon, H., Hoofien, D., & Gilboa, A. (2017). Psychological traits predict impaired awareness of deficits independently of neuropsychological factors in chronic traumatic brain injury. *British Journal of Clinical Psychology*, 56(3), 213–234. <https://doi.org/10.1111/bjc.12134>
- Ben-Yishay, Y., & Diller, L. (2011). *Handbook of holistic neuropsychological rehabilitation: outpatient rehabilitation of traumatic brain injury*. Oxford University Press.
- Benedet, M. J., & Alexandre, M. A. (2014). *TAVEC: test de aprendizaje verbal*. TEA Ediciones.
- Benton, A. I., & Hamsher, K. (1989). *Multilingual Aphasia Examination*. IA: AJA Associates.
- Berlucchi, G. (2011). Brain plasticity and cognitive neurorehabilitation. *Neuropsychological Rehabilitation*, 21(5), 560–578. <https://doi.org/10.1080/09602011.2011.573255>
- Bertrand, J. M., Mazancieux, A., Moulin, C. J. A., Béjot, Y., Rouaud, O., & Souchay, C. (2019). In the here and now: Short term memory predictions are preserved in Alzheimer's disease. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, 119, 158–164.
<https://doi.org/10.1016/j.cortex.2019.03.027>
- Besnard, J., Richard, P., Banville, F., Nolin, P., Aubin, G., Le Gall, D., Richard, I., & Allain, P. (2016). Virtual reality and neuropsychological assessment: The reliability of a virtual kitchen to assess daily-life activities in victims of traumatic brain injury. *Applied Neuropsychology. Adult*, 23(3), 223–235.
<https://doi.org/10.1080/23279095.2015.1048514>
- Bettcher, B. M., Giovannetti, T., Libon, D. J., Eppig, J., Wambach, D., & Klobusicky, E. (2011). Improving Everyday Error Detection, One Picture at a Time: A Performance-Based Study of Everyday Task Training. *Neuropsychology*, 25(6), 771–783. <https://doi.org/10.1037/a0024107>
- Bettcher, B. M., Giovannetti, T., MacMullen, L., & Libon, D. J. (2008). Error detection and correction patterns in dementia: A breakdown of error monitoring processes and their neuropsychological correlates. *Journal of the International Neuropsychological Society*, 14(2), 199–208.
<https://doi.org/10.1017/S1355617708080193>
- Bettcher, B. M., Mungas, D., Patel, N., Elofson, J., Dutt, S., Wynn, M., Watson, C. L., Stephens, M., Walsh, C. M., & Kramer, J. H. (2016). Neuroanatomical substrates of executive functions: Beyond prefrontal

structures. *Neuropsychologia*, 85, 100-109.

<https://doi.org/10.1016/J.NEUROPSYCHOLOGIA.2016.03.001>

Bivona, U., Ciurli, P., Barba, C., Onder, G., Azicnuda, E., Silvestro, D., Mangano, R., Rigon, J., & Formisano, R. (2008). Executive function and metacognitive self-awareness after Severe Traumatic Brain Injury.

Journal of the International Neuropsychological Society, 14(5), 862-868.

<https://doi.org/10.1017/S1355617708081125>

Bivona, U., Ciurli, P., Ferri, G., Fontanelli, T., Lucatello, S., Donvito, T., Villalobos, D., Cellupica, L., Mungliello, F., Lo Sterzo, P., Ferraro, A., Giandotti, E., Lombardi, G., Azicnuda, E., Caltagirone, C., Formisano, R., & Costa, A. (2020). The Self-Awareness Multilevel Assessment Scale, a New Tool for the Assessment of Self-Awareness After Severe Acquired Brain Injury: Preliminary Findings. *Frontiers in Psychology*, 11, 1732. <https://doi.org/10.3389/fpsyg.2020.01732>

Bivona, U., Costa, A., Contrada, M., Silvestro, D., Azicnuda, E., Aloisi, M., Catania, G., Ciurli, P., Guariglia, C., Caltagirone, C., Formisano, R., & Prigatano, G. P. (2019). Depression, apathy and impaired self-awareness following severe traumatic brain injury: a preliminary investigation. *Brain Injury*, 33(9), 1245-1256. <https://doi.org/10.1080/02699052.2019.1641225>

Bland, J. M., & Altman, D. G. (2010). Statistical methods for assessing agreement between two methods of clinical measurement. *International Journal of Nursing Studies*, 47(8), 931-936.

<https://doi.org/10.1016/j.ijnurstu.2009.10.001>

Blömer, A.-M. V., van Mierlo, M. L., Visser-Meily, J. M., van Heugten, C. M., & Post, M. W. (2015). Does the frequency of participation change after stroke and is this change associated with the subjective experience of participation? *Archives of Physical Medicine and Rehabilitation*, 96(3), 456-463.

<https://doi.org/10.1016/j.apmr.2014.09.003>

Boateng, G. O., Neilands, T. B., Frongillo, E. A., Melgar-Quiñonez, H. R., & Young, S. L. (2018). Best Practices for Developing and Validating Scales for Health, Social, and Behavioral Research: A Primer. *Frontiers in Public Health*, 6(June), 1-18. <https://doi.org/10.3389/fpubh.2018.00149>

Bogdanova, Y., Yee, M. K., Ho, V. T., & Cicerone, K. D. (2016). Computerized cognitive rehabilitation of attention and executive function in acquired brain injury: A systematic review. *Journal of Head Trauma Rehabilitation*, 31(6), 419-433. <https://doi.org/10.1097/HTR.0000000000000203>

Bogner, J., Hade, E. M., Peng, J., Beaulieu, C. L., Horn, S. D., Corrigan, J. D., Hammond, F. M., Dijkers, M. P., Montgomery, E., Gilchrist, K., Giuffrida, C., Lash, A., & Timpson, M. (2019). Family involvement in traumatic brain injury inpatient rehabilitation: a propensity score analysis of effects on outcomes during the first year after discharge. *Archives of Physical Medicine and Rehabilitation*, 100(10), 1801-

1809. <https://doi.org/10.1016/j.apmr.2019.04.008>

Bogod, N. M., Mateer, C. A., & MacDonald, S. W. S. (2003). Self-awareness after traumatic brain injury: A comparison of measures and their relationship to executive functions. In *Journal of the International Neuropsychological Society* (Vol. 9, Issue 3, pp. 450–458). J Int Neuropsychol Soc.

<https://doi.org/10.1017/S1355617703930104>

Borsa, J., Figueiredo, B., Denise, D., & Bandeira, R. (2012). Cross-cultural adaptation and validation of psychological instruments: some considerations. *Paidéia (Ribeirão Preto)*, 22(53), 423–432.

<https://doi.org/10.1590/S0103-863X2012000300014>

Bottari, C., Gosselin, N., Guillemette, M., Lamoureux, J., & Ptito, A. (2011). Independence in managing one's finances after traumatic brain injury. *Brain Injury*, 25(13–14), 1306–1317.

<https://doi.org/10.3109/02699052.2011.624570>

Bottari, C., Wai Shun, P. L., Dorze, G. Le, Gosselin, N., & Dawson, D. (2014). Self-generated strategic behavior in an ecological shopping task. *American Journal of Occupational Therapy*, 68(1), 67–76.

<https://doi.org/10.5014/ajot.2014.008987>

Brazinova, A., Rehorcikova, V., Taylor, M. S., Buckova, V., Majdan, M., Psota, M., Peeters, W., Feigin, V., Theadom, A., Holkovic, L., & Synnot, A. (2021). Epidemiology of Traumatic Brain Injury in Europe: A Living Systematic Review. *Journal of Neurotrauma*, 38(10), 1411–1440.

<https://doi.org/10.1089/neu.2015.4126>

Brown, L., Fish, J., Mograbi, D. C., Bellesi, G., Ashkan, K., & Morris, R. (2019). Awareness of deficit following traumatic brain injury: A systematic review of current methods of assessment. *Neuropsychological Rehabilitation*, 31(1), 154–188. <https://doi.org/10.1080/09602011.2019.1680393>

Brum, P. S., Yassuda, M. S., & Forlenza, O. V. (2013). Subjective memory and strategy use in mild cognitive impairment and healthy aging. *Psychology & Neuroscience*, 6, 89–94.

<https://doi.org/10.3922/j.psns.2013.1.13>

Bruno, D., Torralva, T., Marengo, V., Ardilla, J. T., Baez, S., Gleichgerricht, E., Sinay, V., & Roca, M. (2015). Utility of the INECO frontal screening (IFS) in the detection of executive dysfunction in patients with relapsing-remitting multiple sclerosis (RRMS). *Neurological Sciences : Official Journal of the Italian Neurological Society and of the Italian Society of Clinical Neurophysiology*, 36(11), 2035–2041.

<https://doi.org/10.1007/S10072-015-2299-6>

Brunswik, E. (1955). Representative design and probabilistic theory in a functional psychology.

Psychological Review, 62(3), 193.

Burgess, P. W. (2000). Strategy application disorder: The role of the frontal lobes in human multitasking.

Psychological Research, 63(3-4), 279-288. <https://doi.org/10.1007/s004269900006>

- Burgess, P. W., Alderman, N., Forbes, C., Costello, A., Coates, L. M. A., Dawson, D. R., Anderson, N. D., Gilbert, S. J., Dumontheil, I., & Channon, S. (2006). The case for the development and use of "ecologically valid" measures of executive function in experimental and clinical neuropsychology. *Journal of the International Neuropsychological Society: JINS*, 12(2), 194-209. <https://doi.org/10.1017/S1355617706060310>
- Burgess, P. W., & Stuss, D. T. (2017). Fifty Years of Prefrontal Cortex Research: Impact on Assessment. *Journal of the International Neuropsychological Society: JINS*, 23(9-10), 755-767. <https://doi.org/10.1017/S1355617717000704>
- Burns, S. P., Dawson, D. R., Perea, J. D., Vas, A. K., Pickens, N. D., Marquez de la Plata, C., & Neville, M. (2020). Associations between self-generated strategy use and MET-Home performance in adults with stroke. *Neuropsychological Rehabilitation*, 30(8), 1543-1557. <https://doi.org/10.1080/09602011.2019.1601112>
- Caldwell, S. B., Wilson, F. C., McBrinn, J., Carton, S., Delargy, M., McCann, J. P., Walsh, J., & McGuire, B. E. (2014). Self-awareness following acquired brain injury: measurement and relationship to executive functioning. *The Irish Journal of Psychology*, 35(2-3), 53-68. <https://doi.org/10.1080/03033910.2014.921228>
- Casaletto, K. B., & Heaton, R. K. (2017). Neuropsychological Assessment: Past and Future. *Journal of the International Neuropsychological Society: JINS*, 23(9-10), 778. <https://doi.org/10.1017/S1355617717001060>
- Chan, R. C. K., Shum, D., Touloupoulou, T., & Chen, E. Y. H. (2008). Assessment of executive functions: Review of instruments and identification of critical issues. *Archives of Clinical Neuropsychology*, 23(2), 201-216. <https://doi.org/10.1016/J.AC.N.2007.08.010>
- Chaytor, N., & Schmitter-Edgecombe, M. (2003). The Ecological Validity of Neuropsychological Tests: A Review of the Literature on Everyday Cognitive Skills. *Neuropsychology Review* 2003 13:4, 13(4), 181-197. <https://doi.org/10.1023/B:NERV.0000009483.91468.FB>
- Chaytor, N., Schmitter-Edgecombe, M., & Burr, R. (2006). Improving the ecological validity of executive functioning assessment. *Archives of Clinical Neuropsychology*, 21(3), 217-227. <https://doi.org/10.1016/j.acn.2005.12.002>
- Chen, A. J.-W., Loya, F., & Binder, D. (2017). Technological innovations to enhance neurocognitive rehabilitation. In R. L. Kane & T. D. Parsons (Eds.), *The Role of Technology in Clinical Neuropsychology* (pp. 329-389). Oxford University Press. <https://doi.org/10.1093/oso/9780190234737.003.0019>

- Chen, A. J. W., Abrams, G. M., & D'Esposito, M. (2006). Functional reintegration of prefrontal neural networks for enhancing recovery after brain injury. *Journal of Head Trauma Rehabilitation*, 21(2), 107–118. <https://doi.org/10.1097/00001199-200603000-00004>
- Chen, A., Novakovic-Agopian, T., & Loya, F. (2019). Interventions to improve cognitive functioning after traumatic brain injury (TBI). In *Traumatic Brain Injury: A Clinician's Guide to Diagnosis, Management, and Rehabilitation: Second Edition* (pp. 329–376). Springer International Publishing. https://doi.org/10.1007/978-3-030-22436-3_17
- Chen, M. H., & Goverover, Y. (2021). Self-awareness in multiple sclerosis: Relationships with executive functions and affect. *European Journal of Neurology*, 28(5), 1627–1635. <https://doi.org/10.1111/ene.14762>
- Chen, P., & Toglia, J. (2019). Online and offline awareness deficits: Anosognosia for spatial neglect. *Rehabilitation Psychology*, 64(1), 50–64. <https://doi.org/10.1037/REP0000207>
- Cheng, S. K. W., & Man, D. W. K. (2006). Management of impaired self-awareness in persons with traumatic brain injury. *Brain Injury*, 20(6), 621–628. <https://doi.org/10.1080/02699050600677196>
- Cheng, W.-Y., Klonoff, P. S., & Perumparaichallai, R. K. (2024). Components of self-awareness affecting caregiver burden: a long-term follow-up study. *Brain Injury*, 38(1), 26–31. <https://doi.org/10.1080/02699052.2024.2304883>
- Chesnel, C., Jourdan, C., Bayen, E., Ghout, I., Darnoux, E., Azerad, S., Charanton, J., Aegerter, P., Pradat-Diehl, P., Ruet, A., Azouvi, P., & Vallat-Azouvi, C. (2017). Self-awareness four years after severe traumatic brain injury: discordance between the patient's and relative's complaints. Results from the PariS-TBI study. *Clinical Rehabilitation*, 32(5), 692–704. <https://doi.org/10.1177/0269215517734294>
- Chevignard, M. P., Taillefer, C., Picq, C., Poncet, F., Noulhiane, M., & Pradat-Diehl, P. (2008). Ecological assessment of the dysexecutive syndrome using execution of a cooking task. *Neuropsychological Rehabilitation*, 18(4), 461–485. <https://doi.org/10.1080/09602010701643472>
- Chevignard, M., Pillon, B., Pradat-Diehl, P., Taillefer, C., Rousseau, S., Le Bras, C., & Dubois, B. (2000). An ecological approach to planning dysfunction: Script execution. *Cortex*, 36(5), 649–669. [https://doi.org/10.1016/S0010-9452\(08\)70543-4](https://doi.org/10.1016/S0010-9452(08)70543-4)
- Chiou, K. S., Carlson, R. A., Arnett, P. A., Cosentino, S. A., & Hillary, F. G. (2011). *Metacognitive Monitoring in Moderate and Severe Traumatic Brain Injury*. 720–731. <https://doi.org/10.1017/S1355617711000658>
- Chiou, K. S., & Hillary, F. G. (2012). Benefits of order: The influence of item sequencing on metacognition in moderate and severe traumatic brain injury. *Journal of the International Neuropsychological Society*, 18(2), 379–383.

- Chiu, E.-C., Wu, W.-C., Hung, J.-W., & Tseng, Y.-H. (2018). Validity of the Wisconsin Card Sorting Test in patients with stroke. *Disability and Rehabilitation*, 40(16), 1967-1971.
<https://doi.org/10.1080/09638288.2017.1323020>
- Chudoba, L. A., & Schmitter-Edgecombe, M. (2020). Insight into memory and functional abilities in individuals with amnesic mild cognitive impairment. *Journal of Clinical and Experimental Neuropsychology*, 42(8), 822-833. <https://doi.org/10.1080/13803395.2020.1817338>
- Cicchetti, D. V. (2001). The precision of reliability and validity estimates re-visited: Distinguishing between clinical and statistical significance of sample size requirements. *Journal of Clinical and Experimental Neuropsychology*, 23(5), 695-700. <https://doi.org/10.1076/jcen.23.5.695.1249>
- Cicerone, K. D., Goldin, Y., Ganci, K., Rosenbaum, A., Wethe, J. V., Langenbahn, D. M., Malec, J. F., Bergquist, T. F., Kingsley, K., Nagele, D., Trexler, L., Fraas, M., Bogdanova, Y., & Harley, J. P. (2019). Evidence-Based Cognitive Rehabilitation: Systematic Review of the Literature From 2009 Through 2014. In *Archives of Physical Medicine and Rehabilitation* (Vol. 100, Issue 8, pp. 1515-1533).
<https://doi.org/10.1016/j.apmr.2019.02.011>
- Ciurli, P., Bivona, U., Barba, C., Onder, G., Silvestro, D., Azicnuda, E., Rigon, J., & Formisano, R. (2010). Metacognitive unawareness correlates with executive function impairment after severe traumatic brain injury. *Journal of the International Neuropsychological Society*, 16(2), 360-368.
<https://doi.org/10.1017/S135561770999141X>
- Clare, L., & Jones, R. S. P. (2008). Errorless learning in the rehabilitation of memory impairment: a critical review. *Neuropsychology Review*, 18(1), 1-23. <https://doi.org/10.1007/s11065-008-9051-4>
- Clearinghouse, W. W. (2022). *Procedures and Standards Handbook, Version 5.0. U.S. Department of Education, Institute of Education Sciences*.
- Cohen, J. (2013). Statistical Power Analysis for the Behavioral Sciences. *Statistical Power Analysis for the Behavioral Sciences*. <https://doi.org/10.4324/9780203771587>
- Cortés Pascual, A., Moyano Muñoz, N., & Quílez Robres, A. (2019). The Relationship Between Executive Functions and Academic Performance in Primary Education: Review and Meta-Analysis. In *Frontiers in psychology* (Vol. 10, p. 1582). <https://doi.org/10.3389/fpsyg.2019.01582>
- Crawford, J. R., & Garthwaite, P. H. (2002). Investigation of the single case in neuropsychology: Confidence limits on the abnormality of test scores and test score differences. *Neuropsychologia*, 40(8), 1196-1208. [https://doi.org/10.1016/S0028-3932\(01\)00224-X](https://doi.org/10.1016/S0028-3932(01)00224-X)
- Crawford, J. R., Garthwaite, P. H., & Porter, S. (2010). Point and interval estimates of effect sizes for the case-

- controls design in neuropsychology: Rationale, methods, implementations, and proposed reporting standards. *Cognitive Neuropsychology*, 27(3), 245-260.
<https://doi.org/10.1080/02643294.2010.513967>
- Crawford, J. R., & Howell, D. C. (1998). Comparing an individual's test score against norms derived from small samples. *Clinical Neuropsychologist*, 12(4), 482-486. <https://doi.org/10.1076/clin.12.4.482.7241>
- Crosson, B., Barco, P. P., Velozo, C. A., Bolesta, M. M., Cooper, P. V., Werts, D., & Brobeck, T. C. (1989). Awareness and compensation in postacute head injury rehabilitation. *Journal of Head Trauma Rehabilitation*, 4(3). <https://doi.org/10.1097/00001199-198909000-00008>
- Cuberos-Urbano, G., Caracuel, A., Vilar-López, R., Valls-Serrano, C., Bateman, A., & Verdejo-García, A. (2013). Ecological validity of the Multiple Errands Test using predictive models of dysexecutive problems in everyday life. *Journal of Clinical and Experimental Neuropsychology*, 35(3), 329-336.
<https://doi.org/10.1080/13803395.2013.776011>
- Curiel Cid, R. E., Acevedo, A., & Loewenstein, D. A. (2022). The relationship between instrumental activities of daily living and neuropsychological performance. In T. D. Marcotte, M. Schmitter-Edgecombe, & I. Grant (Eds.), *Neuropsychology of everyday functioning*. (2nd ed., pp. 93-112). Guilford Press.
- Custodio, N., Montesinos, R., Lira, D., Herrera-Perez, E., Bardales, Y., & Valeriano-Lorenzo, L. (2017). Evolution of short cognitive test performance in stroke patients with vascular cognitive impairment and vascular dementia: Baseline evaluation and follow-up. *Dementia & Neuropsychologia*, 11(4), 381-388. <https://doi.org/10.1590/1980-57642016dn11-040007>
- Datta, D. (2018). *blandr: a Bland-Altman Method Comparison package for R*.
<https://doi.org/10.5281/zenodo.824514>
- Daza, P., Novy, D. M., Stanley, M. A., & Averill, P. (2002). The depression anxiety stress scale-21: Spanish translation and validation with a Hispanic sample. *Journal of Psychopathology and Behavioral Assessment*, 24(3), 195-205. <https://doi.org/10.1023/A:1016014818163>
- delCacho-Tena, A., Christ, B. R., Arango-Lasprilla, J. C., Perrin, P. B., Rivera, D., & Olabarrieta-Landa, L. (2023). Normative Data Estimation in Neuropsychological Tests: A Systematic Review. *Archives of Clinical Neuropsychology*, 39(3), 383-398. <https://doi.org/10.1093/arclin/acad084>
- Delis, D. C., Kramer, J. H., Kaplan, E., & Ober, B. A. (1987). *California Verbal Learning Test*. APA PsycTests.
- Di Somma, R., & Fleming, P. (2024). A systematic literature review of the impact of impaired self-awareness on the process of rehabilitation in acquired brain injury. *Brain Injury*, 1-12.
<https://doi.org/10.1080/02699052.2024.2392161>
- Diamond, A. (2013). Executive functions. In *Annual Review of Psychology* (Vol. 64, pp. 135-168).

<https://doi.org/10.1146/annurev-psych-113011-143750>

Diaz-Orueta, U., Blanco-Campal, A., Lamar, M., Libon, D. J., & Burke, T. (2020). Marrying Past and Present Neuropsychology: Is the Future of the Process-Based Approach Technology-Based? *Frontiers in Psychology*, 11. <https://doi.org/10.3389/fpsyg.2020.00361>

Divers, R., Ham, L., Matchanova, A., Hackett, K., Mis, R., Howard, K., Rycroft, S. S., Roll, E., & Giovannetti, T. (2021). When and how did you go wrong? Characterizing mild functional difficulties in older adults during an everyday task. *Aging, Neuropsychology, and Cognition*, 28(2), 308-326. <https://doi.org/10.1080/13825585.2020.1756210>

Dockree, P. M., O'Connell, R. G., & Robertson, I. H. (2015). Connecting clinical and experimental investigations of awareness in traumatic brain injury. *Handbook of Clinical Neurology*, 128, 511-524. <https://doi.org/10.1016/B978-0-444-63521-1.00032-7>

Dockree, P. M., Tarleton, Y. M., Carton, S., & FitzGerald, M. C. C. (2015). Connecting Self-Awareness and Error-Awareness in Patients with Traumatic Brain Injury. *Journal of the International Neuropsychological Society*, 21(7), 473-482. <https://doi.org/10.1017/S1355617715000594>

Doherty, M., Dickerson, D., Kadela, K., Noetzel, M., Wolf, T. J., Berg, C., & Dodd, J. (2022). Initial Validation of the Weekly Calendar Planning Activity With Adolescents With ABI. *OTJR: Occupation, Participation and Health*. <https://doi.org/10.1177/15394492221087191>

Doherty, T. A., Barker, L. A., Denniss, R., Jalil, A., & Beer, M. D. (2015). The cooking task: making a meal of executive functions. *Frontiers in Behavioral Neuroscience*, 9, 22. <https://doi.org/10.3389/fnbeh.2015.00022>

Doig, E., Fleming, J., & Lin, B. (2017). Comparison of online awareness and error behaviour during occupational performance by two individuals with traumatic brain injury and matched controls. *NeuroRehabilitation*, 40(4), 519-529. <https://doi.org/10.3233/NRE-171439>

Doig, E., Fleming, J., Ownsworth, T., & Fletcher, S. (2017). An occupation-based, metacognitive approach to assessing error performance and online awareness. *Australian Occupational Therapy Journal*, 64(2), 137-148. <https://doi.org/10.1111/1440-1630.12322>

Doig, E. J., Fleming, J., & Ownsworth, T. (2020). Evaluation of an occupation-based metacognitive intervention targeting awareness, executive function and goal-related outcomes after traumatic brain injury using single-case experimental design methodology. *Neuropsychological Rehabilitation*, 31(10), 1527-1556. <https://doi.org/10.1080/09602011.2020.1786410>

Dole, J. A., Nokes, J. D., & Drets, D. (2009). Cognitive strategy instruction. In G. G. Duffy & S. E. Israel (Eds.),

Handbook of research on reading comprehension (pp. 347–372). Routledge.

Dreer, L. E., Devivo, M. J., Novack, T. A., & Marson, D. C. (2012). Financial capacity following traumatic brain injury: a six-month longitudinal study. *Rehabilitation Psychology, 57*(1), 5–12.
<https://doi.org/10.1037/a0025818>

Dromer, E., Kheloufi, L., & Azouvi, P. (2021a). Impaired self-awareness after traumatic brain injury: a systematic review. Part 1: Assessment, clinical aspects and recovery. *Annals of Physical and Rehabilitation Medicine, 64*(5), 101468. <https://doi.org/10.1016/j.rehab.2020.101468>

Dromer, E., Kheloufi, L., & Azouvi, P. (2021b). Impaired self-awareness after traumatic brain injury: A systematic review. Part 2. Consequences and predictors of poor self-awareness. *Annals of Physical and Rehabilitation Medicine, 64*(5). <https://doi.org/10.1016/j.rehab.2021.101542>

Dubuc, É., Gagnon-Roy, M., Couture, M., Bier, N., Giroux, S., & Bottari, C. (2019). Perceived needs and difficulties in meal preparation of people living with traumatic brain injury in a chronic phase: Supporting long-term services and interventions. *Australian Occupational Therapy Journal, 66*(6), 720–730. <https://doi.org/10.1111/1440-1630.12611>

Edemekong, P. F., Bomgaars, D. L., Sukumaran, S., & Schoo, C. (2019). Activities of Daily Living. In *Encyclopedia of the Neurological Sciences* (pp. 47–48). StatPearls Publishing.
<https://doi.org/10.1016/B978-0-12-385157-4.00464-4>

Egeto, P., Badovinac, S. D., Hutchison, M. G., Ornstein, T. J., & Schweizer, T. A. (2019). A Systematic Review and Meta-Analysis on the Association Between Driving Ability and Neuropsychological Test Performances after Moderate to Severe Traumatic Brain Injury. *Journal of the International Neuropsychological Society : JINS, 25*(8), 868–877. <https://doi.org/10.1017/S1355617719000456>

Engel, L., Chui, A., Goverover, Y., & Dawson, D. R. (2019). Optimising activity and participation outcomes for people with self-awareness impairments related to acquired brain injury: An interventions systematic review. *Neuropsychological Rehabilitation, 29*(2), 163–198.
<https://doi.org/10.1080/09602011.2017.1292923>

Erler, K. S., Juengst, S. B., Smith, D. L., O'Neil-Pirozzi, T. M., Novack, T. A., Bogner, J. A., Kaminski, J., Giacino, J. T., & Whiteneck, G. G. (2018). Examining Driving and Participation 5 Years After Traumatic Brain Injury. *OTJR : Occupation, Participation and Health, 38*(3), 143–150.
<https://doi.org/10.1177/1539449218757739>

Evans, J. J., Wilson, B. A., Needham, P., & Brentnall, S. (2003). Who makes good use of memory aids? Results of a survey of people with acquired brain injury. *Journal of the International Neuropsychological Society : JINS, 9*(6), 925–935. <https://doi.org/10.1017/S1355617703960127>

- Faria, A. L., Pinho, M. S., & Bermúdez i Badia, S. (2020). A comparison of two personalization and adaptive cognitive rehabilitation approaches: a randomized controlled trial with chronic stroke patients. *Journal of Neuroengineering and Rehabilitation*, 17, 1-15.
<https://doi.org/https://doi.org/10.1186/s12984-020-00691-5>
- Farias, S. T., Gravano, J., Weakley, A., Schmitter-Edgecombe, M., Harvey, D., Mungas, D., Chan, M., & Giovannetti, T. (2020). The Everyday Compensation (EComp) Questionnaire: Construct Validity and Associations with Diagnosis and Longitudinal Change in Cognition and Everyday Function in Older Adults. *Journal of the International Neuropsychological Society*, 26(3), 303-313.
<https://doi.org/10.1017/S135561771900119X>
- Farley, K. L., Higginson, C. I., Sherman, M. F., & MacDougall, E. (2011). The ecological validity of clinical tests of visuospatial function in community-dwelling older adults. *Archives of Clinical Neuropsychology : The Official Journal of the National Academy of Neuropsychologists*, 26(8), 728-738.
<https://doi.org/10.1093/arclin/acr069>
- Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, 41(4), 1149-1160.
<https://doi.org/10.3758/BRM.41.4.1149>
- FEDACE. (2019). *Las personas con daño cerebral adquirido en españa*. Ministerio de Sanidad, Servicios Sociales e Igualdad. <https://fedace.org/>
- Feigin, V. L., Brainin, M., Norrving, B., Martins, S., Sacco, R. L., Hacke, W., Fisher, M., Pandian, J., & Lindsay, P. (2022). World Stroke Organization (WSO): Global Stroke Fact Sheet 2022. *International Journal of Stroke : Official Journal of the International Stroke Society*, 17(1), 18-29.
<https://doi.org/10.1177/17474930211065917>
- Fernandez-Duque, D., Baird, J. A., & Posner, M. I. (2000). Executive Attention and Metacognitive Regulation. *Consciousness and Cognition*, 9(2), 288-307. <https://doi.org/10.1006/ccog.2000.0447>
- Feuerstein, R., Falik, L., & Feuerstein, R. S. (2015). *Changing minds and brains—The legacy of Reuven Feuerstein: Higher thinking and cognition through mediated learning*. Teachers College Press.
- Fischer, J. E., Bachmann, L. M., Jaeschke, R., Fischer, J. E., & Bachmann, L. M. (2003). A readers' guide to the interpretation of diagnostic test properties: clinical example of sepsis. *Intensive Care Med*, 29, 1043-1051. <https://doi.org/10.1007/s00134-003-1761-8>
- Fitzgerald, L. M., Arvaneh, M., & Dockree, P. M. (2017). Domain-specific and domain-general processes underlying metacognitive judgments. *Consciousness and Cognition*, 49, 264-277.
<https://doi.org/10.1016/J.CONCOG.2017.01.011>

- FitzGerald, M. C. C., O'Keeffe, F., Carton, S., Coen, R. F., Kelly, S., & Dockree, P. (2017). Rehabilitation of emergent awareness of errors post traumatic brain injury: A pilot intervention. *Neuropsychological Rehabilitation*, 2011(July), 1-23. <https://doi.org/10.1080/09602011.2017.1336102>
- Fleming, J., & Ownsworth, T. (2006). A review of awareness interventions in brain injury rehabilitation. *Neuropsychological Rehabilitation*, 16(4), 474-500. <https://doi.org/10.1080/09602010500505518>
- Fleming, J., & Strong, J. (1999). A Longitudinal Study of Self-Awareness: Functional Deficits Underestimated by Persons with Brain Injury. *The Occupational Therapy Journal of Research*, 19(1), 3-17. <https://doi.org/10.1177/153944929901900101>
- Fleming, J., Strong, J., & Ashton, R. (1996). Self-awareness of deficits in adults with traumatic brain injury: How best to measure? *Brain Injury*, 10(1), 1-16. <https://doi.org/10.1080/026990596124674>
- Fleming, J., Strong, J., & Ashton, R. (1998). Cluster analysis of self-awareness levels in adults with traumatic brain injury and relationship to outcome. *The Journal of Head Trauma Rehabilitation*, 13(5), 39-51. <https://doi.org/10.1097/00001199-199810000-00006>
- Fogel, Y. (2022). Cognitive Strategies: Moderating the Relationship between Executive Functions and Daily Functioning. *International Journal of Environmental Research and Public Health*, 19(24). <https://doi.org/10.3390/IJERPH192416845>
- Foster, E. R., Carson, L., Jonas, J., Kang, E., Doty, T., & Togli, J. (2022). The Weekly Calendar Planning Activity to Assess Functional Cognition in Parkinson Disease. *OTJR : Occupation, Participation and Health*. <https://doi.org/10.1177/15394492221104075>
- Fraser, E. E., Downing, M. G., Biernacki, K., McKenzie, D. P., & Ponsford, J. L. (2019). Cognitive Reserve and Age Predict Cognitive Recovery after Mild to Severe Traumatic Brain Injury. *Journal of Neurotrauma*, 36(19), 2753-2761. <https://doi.org/10.1089/NEU.2019.6430>
- Gaertner, L. H. C., Tsur, N., & Haller, C. S. (2020). Patients' recovery after severe TBI is associated with their close relatives' interpersonal functioning: a 12-months prospective cohort study. *Brain Injury*, 34(6), 764-772. <https://doi.org/10.1080/02699052.2020.1753241>
- Gallo, D. A., Cramer, S. J., Wong, J. T., & Bennett, D. A. (2012). Alzheimer's disease can spare local metacognition despite global anosognosia: revisiting the confidence-accuracy relationship in episodic memory. *Neuropsychologia*, 50(9), 2356-2364. <https://doi.org/10.1016/j.neuropsychologia.2012.06.005>
- García-Molina, A., & Enseñat, A. (2019). Neuropsychological rehabilitation in the 20th century. *Revista de neurologia*, 69(9), 383-391. <https://doi.org/10.33588/rn.6909.2019247>
- García-Molina, A., Tormos, J. M., Bernabeu, M., Junqué, C., & Roig-Rovira, T. (2012). Do traditional

- executive measures tell us anything about daily-life functioning after traumatic brain injury in Spanish-speaking individuals? *Brain Injury*, 26(6), 864-874. <https://doi.org/10.3109/02699052.2012.655362>
- Gasquoine, P. G. (1992). Affective state and awareness of sensory and cognitive effects after closed head injury. *Neuropsychology*, 6(3), 187.
- Gates, N. J., Vernooij, R. W., Di Nisio, M., Karim, S., March, E., Martínez, G., & Rutjes, A. W. (2019). Computerised cognitive training for preventing dementia in people with mild cognitive impairment. *The Cochrane Database of Systematic Reviews*, 3(3), CD012279. <https://doi.org/10.1002/14651858.CD012279.pub2>
- Geary, E. K., Kraus, M. F., Rubin, L. H., Pliskin, N. H., & Little, D. M. (2011). Verbal learning strategy following mild traumatic brain injury. *Journal of the International Neuropsychological Society: JINS*, 17(4), 709-719. <https://doi.org/10.1017/S1355617711000646>
- Geusgens, C. A. V., Winkens, I., van Heugten, C. M., Jollens, J., & van den Heuvel, W. J. A. (2007). Occurrence and measurement of transfer in cognitive rehabilitation: A critical review. *Journal of Rehabilitation Medicine*, 39(6), 425-439. <https://doi.org/10.2340/16501977-0092>
- Geytenbeek, M., Fleming, J., Doig, E., & Ownsworth, T. (2017). The occurrence of early impaired self-awareness after traumatic brain injury and its relationship with emotional distress and psychosocial functioning. *Brain Injury*, 31(13-14), 1791-1798. <https://doi.org/10.1080/02699052.2017.1346297>
- Ghaffari, A., Rostami, H. R., & Akbarfahimi, M. (2021). Predictors of Instrumental Activities of Daily Living Performance in Patients with Stroke. *Occupational Therapy International*, 2021. <https://doi.org/10.1155/2021/6675680>
- Giles, G. M., Clark-Wilson, J., Baxter, D. M., Tasker, R., Holloway, M., & Seymour, S. (2019). The interrelationship of functional skills in individuals living in the community, following moderate to severe traumatic brain injury. *Brain Injury*, 33(2), 129-136. <https://doi.org/10.1080/02699052.2018.1539762>
- Giles, G. M., Edwards, D. F., Baum, C., Furniss, J., Skidmore, E., Wolf, T., & Leland, N. E. (2020). Making functional cognition a professional priority. *The American Journal of Occupational Therapy*, 74(1), 1-6. <https://doi.org/10.5014/ajot.2020.741002>
- Gillen, G., & Raphael-Greenfield, E. (2020). Performance-Based Assessments and Neuropsychological Assessments: A Comparison. In B. J. Hemphill & C. K. Urish (Eds.), *Assessments in Occupational Therapy Mental Health* (4th ed., pp. 155-178). Slack Incorporated.
- Gioia, G. A., & Isquith, P. K. (2004). Ecological assessment of executive function in traumatic brain injury.

Developmental Neuropsychology, 25(1-2), 135-158.

<https://doi.org/10.1080/87565641.2004.9651925>

Giovannetti, T., Bettcher, B. M., Brennan, L., Libon, D. J., Kessler, R. K., & Duey, K. (2008). Coffee With Jelly or Unbuttered Toast: Commissions and Omissions Are Dissociable Aspects of Everyday Action Impairment in Alzheimer's Disease. *Neuropsychology*, 22(2), 235-245. <https://doi.org/10.1037/0894-4105.22.2.235>

Giovannetti, T., Britnell, P., Brennan, L., Siderowf, A., Grossman, M., Libon, D. J., Bettcher, B. M., Rouzard, F., Eppig, J., & Seidel, G. A. (2012). Everyday action impairment in Parkinson's disease dementia. *Journal of the International Neuropsychological Society : JINS*, 18(5), 787-798. <https://doi.org/10.1017/S135561771200046X>

Giovannetti, T., Libon, D. J., & Hart, T. (2002). Awareness of naturalistic action errors in dementia. *Journal of the International Neuropsychological Society*, 8(5), 633-644. <https://doi.org/10.1017/S135561770280131X>

Giovannetti, T., Mis, R., Hackett, K., Simone, S. M., & Ungrady, M. B. (2021). The goal-control model: An integrated neuropsychological framework to explain impaired performance of everyday activities. *Neuropsychology*, 35(1), 3-18. <https://doi.org/10.1037/neu0000714>

Giovannetti, T., Schmidt, K. S., Gallo, J. L., Sestito, N., & Libon, D. J. (2006). Everyday action in dementia: evidence for differential deficits in Alzheimer's disease versus subcortical vascular dementia. *Journal of the International Neuropsychological Society : JINS*, 12(1), 45-53. <https://doi.org/10.1017/S1355617706060012>

Godefroy, O. (2003). Frontal syndrome and disorders of executive functions. *J Neurol*, 250, 1-6. <https://doi.org/10.1007/s00415-003-0918-2>

Goldberg, E., & Bougakov, D. (2005). Neuropsychologic Assessment of Frontal Lobe Dysfunction. *Psychiatric Clinics of North America*, 28, 567-580. <https://doi.org/10.1016/j.psc.2005.05.005>

Gómez-de-Regil, L. (2020). Assessment of executive function in patients with traumatic brain injury with the Wisconsin card-sorting test. *Brain Sciences*, 10(10), 699.

González, M. Á. M., Villegas, A. S., Atucha, E. T., & Fajardo, J. F. (2020). *Bioestadística amigable* (2nd ed.). Elsevier.

Goodglass, H., Kaplan, E., García Albea, J. E., & Sánchez Bernardos, M. L. (1986). *Evaluación de la afasia y de trastornos relacionados*. Editorial Médica Panamericana.

Gopi, Y., Wilding, E., & Madan, C. R. (2022). Memory rehabilitation: restorative, specific knowledge acquisition, compensatory, and holistic approaches. *Cognitive Processing*, 23(4), 537-557.

<https://doi.org/10.1007/s10339-022-01099-w>

Goverover, Y., Genova, H., Smith, A., Chiaravalloti, N., & Lengenfelder, J. (2017). Changes in activity participation following traumatic brain injury. *Neuropsychological Rehabilitation*, 27(4), 472-485.

<https://doi.org/10.1080/09602011.2016.1168746>

Goverover, Y., Johnston, M. V., Toglia, J., & DeLuca, J. (2007). Treatment to improve self-awareness in persons with acquired brain injury. *Brain Injury*, 21(9), 913-923.

<https://doi.org/10.1080/02699050701553205>

Goverover, Y., Toglia, J., & DeLuca, J. (2020). The weekly calendar planning activity in multiple sclerosis: A top-down assessment of executive functions. *Neuropsychological Rehabilitation*, 30(7), 1372-1387.

<https://doi.org/doi:10.1080/09602011.2019.1584573>

Hajian-Tilaki, K. (2013). Receiver operating characteristic (ROC) curve analysis for medical diagnostic test evaluation. In *Caspian Journal of Internal Medicine* (Vol. 4, Issue 2, pp. 627-635). Babol University of Medical Sciences.

Hart, T., Giovannetti, T., Montgomery, M. W., & Schwartz, M. F. (1998). Awareness of errors in naturalistic action after traumatic brain injury. *Journal of Head Trauma Rehabilitation*, 13(5), 16-28.

<https://doi.org/10.1097/00001199-199810000-00004>

Hart, T., Seignourel, P. J., & Sherer, M. (2009). A longitudinal study of awareness of deficit after moderate to severe traumatic brain injury. *Neuropsychological Rehabilitation*, 19(2), 161-176.

<https://doi.org/10.1080/09602010802188393>

Hart, T., Sherer, M., Whyte, J., Polansky, M., & Novack, T. A. (2004). Awareness of behavioral, cognitive, and physical deficits in acute traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, 85(9), 1450-1456. <https://doi.org/10.1016/J.APMR.2004.01.030>

Hart, T., Whyte, J., Junghoon, K., & Vaccaro, M. (2005). Executive function and self-awareness of "real-world" behavior and attention deficits following traumatic brain injury. *Journal of Head Trauma Rehabilitation*, 20(4), 333-347. <https://doi.org/10.1097/00001199-200507000-00005>

Hartman-Maeir, A., Soroker, N., Oman, S. D., & Katz, N. (2003). Awareness of disabilities in stroke rehabilitation--a clinical trial. *Disability and Rehabilitation*, 25(1), 35-44.

Hartman-Maeir, A., Soroker, N., Oman, S. D., & Katz, N. (2009). Awareness of disabilities in stroke rehabilitation a clinical trial. *Disability and Rehabilitation*, 25(1), 35-44.

<https://doi.org/10.1080/0963828021000007897>

Hayes, A. F. (2022). *Introduction to mediation, moderation, and conditional process analysis: A regression-*

based approach (Third Edit). Guilford publications.

- Hayes, A. F., & Rockwood, N. J. (2017). Regression-based statistical mediation and moderation analysis in clinical research: Observations, recommendations, and implementation. *Behaviour Research and Therapy*, 98, 39-57. <https://doi.org/10.1016/j.brat.2016.11.001>
- Heaton, R., Chelune, G., Talley, J., Kay, G., & Curtiss, G. (2009). Test de Clasificación de Tarjetas de Wisconsin (WCST). In *TEA Ediciones*.
- Hellebrekers, D., Winkens, I., Kruiper, S., & Van Heugten, C. (2017). Psychometric properties of the awareness questionnaire, patient competency rating scale and Dysexecutive Questionnaire in patients with acquired brain injury. *Brain Injury*, 31(11), 1469-1478. <https://doi.org/10.1080/02699052.2017.1377350>
- Hendry, K., Ownsworth, T., Beadle, E., Chevignard, M. P., Fleming, J., Griffin, J., & Shum, D. H. K. (2016). Cognitive Deficits Underlying Error Behavior on a Naturalistic Task after Severe Traumatic Brain Injury. *Frontiers in Behavioral Neuroscience*, 10, 190. <https://doi.org/10.3389/fnbeh.2016.00190>
- Hoerold, D., Pender, N. P., & Robertson, I. H. (2013). Metacognitive and online error awareness deficits after prefrontal cortex lesions. *Neuropsychologia*, 51(3), 385-391. <https://doi.org/10.1016/j.neuropsychologia.2012.11.019>
- Hoofien, D., Gilboa, A., Vakil, E., & Barak, O. (2004). Unawareness of cognitive deficits and daily functioning among persons with traumatic brain injuries. *Journal of Clinical and Experimental Neuropsychology*, 26(2), 278-290. <https://doi.org/10.1076/jcen.26.2.278.28084>
- Hoskin, K. M., Jackson, M., & Crowe, S. F. (2005). Can neuropsychological assessment predict capacity to manage personal finances? A comparison between brain impaired individuals with and without administrators. *Psychiatry, Psychology and Law*, 12(1), 56-67. <https://doi.org/10.1375/pplt.2005.12.1.56>
- Howick, J., Chalmers, I., Glasziou, P., Greenhalgh, T., Heneghan, C., Liberati, A., Moschetti, I., Phillips, B., & Thornton, H. (2011). The 2011 Oxford CEBM levels of evidence (introductory document). *Oxford CEBM*. Retrieved January, 20, 2011.
- Huang, G., Luster, M., Karagol, I., Park, J. W., & Pitts, B. J. (2020). Self-perception of driving abilities in older age: A systematic review. *Transportation Research Part F: Traffic Psychology and Behaviour*, 74, 307-321. <https://doi.org/10.1016/j.trf.2020.08.020>
- Humphreys, G. W., & Forde, E. M. E. (1998). Disordered action schema and action disorganisation syndrome. *Cognitive Neuropsychology*, 15(6-8), 771-811.
- Hurst, F. G., Ownsworth, T., Beadle, E., Shum, D. H. K., & Fleming, J. (2018). Domain-specific deficits in self-

- awareness and relationship to psychosocial outcomes after severe traumatic brain injury. *Disability and Rehabilitation*, 42(5), 651–659. <https://doi.org/10.1080/09638288.2018.1504993>
- Iannaccone, R., Hauser, T. U., Staempfli, P., Walitza, S., Brandeis, D., & Brem, S. (2015). Conflict monitoring and error processing: new insights from simultaneous EEG-fMRI. *Neuroimage*, 105, 395–407.
- Innocenti, F., Tan, F. E. S., Candel, M. J. J. M., & van Breukelen, G. J. P. (2023). Sample size calculation and optimal design for regression-based norming of tests and questionnaires. *Psychological Methods*, 28(1), 89–106. <https://doi.org/10.1037/met0000394>
- International Test Commission. (2017). *The ITC Guidelines for Translating and Adapting Tests (Second edition)*. <https://www.intestcom.org/>
- Jacobson, N. S., & Truax, P. (1991). Clinical Significance: A Statistical Approach to Defining Meaningful Change in Psychotherapy Research. *Journal of Consulting and Clinical Psychology*, 59(1), 12–19. <https://doi.org/10.1037/0022-006X.59.1.12>
- Jamieson, M., Cullen, B., McGee-Lennon, M., Brewster, S., & Evans, J. (2017). Technological memory aid use by people with acquired brain injury. *Neuropsychological Rehabilitation*, 27(6), 919–936. <https://doi.org/10.1080/09602011.2015.1103760>
- Jang, S.-N., & Kawachi, I. (2019). Why Do Older Korean Adults Respond Differently to Activities of Daily Living and Instrumental Activities of Daily Living? A Differential Item Functioning Analysis. *Annals of Geriatric Medicine and Research*, 23(4), 197–203. <https://doi.org/10.4235/agmr.19.0047>
- Jarry, C., Osiurak, F., Baumard, J., Lesourd, M., Coiffard, C., Lucas, C., Merck, C., Etcharry-Bouyx, F., Chauviré, V., Belliard, S., Moreaud, O., Croisile, B., & Le Gall, D. (2021). Daily life activities in patients with Alzheimer's disease or semantic dementia: Multitasking assessment. *Neuropsychologia*, 150, 107714. <https://doi.org/10.1016/J.NEUROPSYCHOLOGIA.2020.107714>
- Jaywant, A., Arora, C., Lussier, A., & Toglia, J. (2021). Impaired Performance on a Cognitively-Based Instrumental Activities of Daily Living Task, the 10-Item Weekly Calendar Planning Activity, in Individuals With Stroke Undergoing Acute Inpatient Rehabilitation. *Frontiers in Neurology*, 12. <https://doi.org/10.3389/fneur.2021.704775>
- Jaywant, A., Arora, C., & Toglia, J. (2022). Online awareness of performance on a functional cognitive assessment in individuals with stroke: A case-control study. *Neuropsychological Rehabilitation*. <https://doi.org/10.1080/09602011.2022.2050409>
- Jaywant, A., Mautner, L., Waldman, R., O'Dell, M. W., Gunning, F. M., & Toglia, J. (2023). Feasibility and Acceptability of a Remotely Delivered Executive Function Intervention That Combines Computerized

- Cognitive Training and Metacognitive Strategy Training in Chronic Stroke. *International Journal of Environmental Research and Public Health*, 20(9). <https://doi.org/10.3390/ijerph20095714>
- Jaywant, A., Steinberg, C., Lee, A., & Toglia, J. (2022). Feasibility and acceptability of the multicontext approach for individuals with acquired brain injury in acute inpatient rehabilitation: A single case series. *Neuropsychological Rehabilitation*, 32(2), 211-230. <https://doi.org/10.1080/09602011.2020.1810710>
- Jeffay, E., Ponsford, J., Harnett, A., Janzen, S., Patsakos, E., Douglas, J., Kennedy, M., Kua, A., Teasell, R., & Welch-West, P. (2023). INCOG 2.0 guidelines for cognitive rehabilitation following traumatic brain injury, part III: executive functions. *The Journal of Head Trauma Rehabilitation*, 38(1), 52-64. <https://doi.org/10.1097/HTR.0000000000000838>
- John, S. E., Ritter, A., Wong, C., & Parks, C. M. (2022). The roles of executive functioning, simple attention, and medial temporal lobes in early learning, late learning, and delayed recall. *Neuropsychology, Development, and Cognition. Section B, Aging, Neuropsychology and Cognition*, 29(3), 400-417. <https://doi.org/10.1080/13825585.2021.2016583>
- Johnson, A. M., Pollard, C. C., Vernon, P. A., Tomes, J. L., & Jog, M. S. (2005). Memory perception and strategy use in Parkinson's disease. *Parkinsonism & Related Disorders*, 11(2), 111-115. <https://doi.org/10.1016/j.parkreldis.2004.06.005>
- Jory, J. I., Bruna, A. A., Muñoz-Neira, C., & Chonchol, A. S. (2013). Chilean version of the INECO Frontal Screening (IFS-Ch): Psychometric properties and diagnostic accuracy. *Dementia e Neuropsychologia*, 7(1), 40-47. <https://doi.org/10.1590/s1980-57642013dn70100007>
- Jurado, M. B., & Rosselli, M. (2007). The elusive nature of executive functions: A review of our current understanding. *Neuropsychology Review*, 17(3), 213-233. <https://doi.org/10.1007/s11065-007-9040-z>
- Kaizerman-Dinerman, A., Josman, N., & Roe, D. (2019). The use of cognitive strategies among people with schizophrenia: a randomized comparative study. *The Open Journal of Occupational Therapy*, 7(3), 1-12. <https://doi.org/10.15453/2168-6408.1621>
- Kashiwa, Y., Kitabayashi, Y., Narumoto, J., Nakamura, K., Ueda, H., & Fukui, K. (2005). Anosognosia in Alzheimer's disease: Association with patient characteristics, psychiatric symptoms and cognitive deficits. *Psychiatry and Clinical Neurosciences*, 59(6), 697-704. <https://doi.org/10.1111/j.1440-1819.2005.01439.x>
- Kelley, E., Sullivan, C., Loughlin, J. K., Hutson, L., Dahdah, M. N., Long, M. K., Schwab, K. A., & Poole, J. H. (2014). Self-awareness and neurobehavioral outcomes, 5 years or more after moderate to severe brain injury. *The Journal of Head Trauma Rehabilitation*, 29(2), 147-152.

<https://doi.org/10.1097/HTR.0b013e31826db6b9>

- Kennedy, M. R. T., & Coelho, C. (2005). Self-regulation after traumatic brain injury: A framework for intervention of memory and problem solving. *Seminars in Speech and Language*, 26(4), 242-255. <https://doi.org/10.1055/s-2005-922103>
- Kennedy, M. R. T., Coelho, C., Turkstra, L., Ylvisaker, M., Moore Sohlberg, M., Yorkston, K., Chiou, H. H., & Kan, P. F. (2008). Intervention for executive functions after traumatic brain injury: A systematic review, meta-analysis and clinical recommendations. In *Neuropsychological Rehabilitation* (Vol. 18, Issue 3, pp. 257-299). Neuropsychol Rehabil. <https://doi.org/10.1080/09602010701748644>
- Kenworthy, L., Freeman, A., Ratto, A., Dudley, K., Powell, K. K., Pugliese, C. E., Strang, J. F., Verbalis, A., & Anthony, L. G. (2020). Preliminary Psychometrics for the Executive Function Challenge Task: A Novel, "Hot" Flexibility, and Planning Task for Youth. *Journal of the International Neuropsychological Society : JINS*, 26(7), 725-732. <https://doi.org/10.1017/S135561772000017X>
- Kersey, J., Juengst, S. B., & Skidmore, E. (2019). Effect of strategy training on self-awareness of deficits after stroke. *The American Journal of Occupational Therapy*, 73(3), 7303345020p1-7303345020p7. <https://doi.org/10.5014/ajot.2019.031450>
- Kersey, J., McCue, M., & Skidmore, E. (2020). Domains and dimensions of community participation following traumatic brain injury. *Brain Injury*, 34(6), 708-712. <https://doi.org/10.1080/02699052.2020.1757153>
- Klein, L. A., Houlihan, D., Vincent, J. L., & Panahon, C. J. (2017). Best Practices in Utilizing the Changing Criterion Design. *Behavior Analysis in Practice*, 10(1), 52-61. <https://doi.org/10.1007/s40617-014-0036-x>
- Klepo, I., Sangster Jokić, C., & Tršinski, D. (2022). The role of occupational participation for people with traumatic brain injury: a systematic review of the literature. *Disability and Rehabilitation*, 44(13), 2988-3001. <https://doi.org/10.1080/09638288.2020.1858351>
- Knight, C., Alderman, N., & Burgess, P. W. (2002). Development of a simplified version of the multiple errands test for use in hospital settings. *Neuropsychological Rehabilitation*, 12(3), 231-255. <https://doi.org/10.1080/09602010244000039>
- Kottner, J., Audigé, L., Brorson, S., Donner, A., Gajewski, B. J., Hróbjartsson, A., Roberts, C., Shoukri, M., & Streiner, D. L. (2011). Guidelines for reporting reliability and agreement studies (GRRAS) were proposed. *Journal of Clinical Epidemiology*, 64(1), 96-106. <https://doi.org/10.1016/j.jclinepi.2010.03.002>

- Kratochwill, T. R., Hitchcock, J. H., Horner, R. H., Levin, J. R., Odom, S. L., Rindskopf, D. M., & Shadish, W. R. (2013). Single-Case Intervention Research Design Standards. In *Remedial and Special Education* (Vol. 34, Issue 1, pp. 26-38). SAGE PublicationsSage CA: Los Angeles, CA.
<https://doi.org/10.1177/0741932512452794>
- Krynicky, C. R., Jones, C. A., & Hacker, D. A. (2023). A meta-analytic review examining the validity of executive functioning tests to predict functional outcomes in individuals with a traumatic brain injury. *Applied Neuropsychology. Adult*, 1-18. <https://doi.org/10.1080/23279095.2023.2225666>
- Kyriazos, T. A. (2018). Applied Psychometrics: Sample Size and Sample Power Considerations in Factor Analysis (EFA, CFA) and SEM in General. *Psychology*, 09(08), 2207-2230.
<https://doi.org/10.4236/PSYCH.2018.98126>
- Lahav, O., Ben-Simon, A., Inbar-Weiss, N., & Katz, N. (2018). Weekly Calendar Planning Activity for University Students: Comparison of Individuals With and Without ADHD by Gender. *Journal of Attention Disorders*, 22(4), 368-378. <https://doi.org/10.1177/1087054714564621>
- Landa-Gonzalez, B. (2001). Multicontextual occupational therapy intervention: A case study of traumatic brain injury. *Occupational Therapy International*, 8(1), 49-62. <https://doi.org/10.1002/oti.131>
- Lane, J. D., & Gast, D. L. (2014). Visual analysis in single case experimental design studies: Brief review and guidelines. *Neuropsychological Rehabilitation*, 24(3-4), 445-463.
<https://doi.org/10.1080/09602011.2013.815636>
- Lau, S. C. L., Connor, L. T., Heinemann, A. W., & Baum, C. M. (2022). Cognition and Daily Life Activities in Stroke: A Network Analysis. *OTJR : Occupation, Participation and Health*, 42(4), 260-268.
<https://doi.org/10.1177/15394492221111730>
- Leary, J. B., Kim, G. Y., Bradley, C. L., Hussain, U. Z., Sacco, M., Bernad, M., Collins, J., Dsurney, J., & Chan, L. (2018). The Association of Cognitive Reserve in Chronic-Phase Functional and Neuropsychological Outcomes Following Traumatic Brain Injury. *The Journal of Head Trauma Rehabilitation*, 33(1), 28-35.
<https://doi.org/10.1097/HTR.0000000000000329>
- Legg, L. A., Lewis, S. R., Schofield-Robinson, O. J., Drummond, A., & Langhorne, P. (2017). Occupational therapy for adults with problems in activities of daily living after stroke. *The Cochrane Database of Systematic Reviews*, 7(7), CD003585. <https://doi.org/10.1002/14651858.CD003585.pub3>
- Lenzoni, S., Morris, R. G., & Mograbi, D. C. (2020). The Petrified Self 10 Years After: Current Evidence for Mnemonic anosognosia. *Frontiers in Psychology*, 11, 465. <https://doi.org/10.3389/fpsyg.2020.00465>
- Levine, B., Schweizer, T. A., O'Connor, C., Turner, G., Gillingham, S., Stuss, D. T., Manly, T., & Robertson, I. H. (2011). Rehabilitation of Executive Functioning in Patients with Frontal Lobe Brain Damage with Goal

- Management Training. *Frontiers Human Neuroscience*, 5(February), 1–9.
<https://doi.org/10.3389/fnhum.2011.00009>
- Lezak, M. D., Howieson, D. B., Bigler, E. D., & Tranel, D. (2012). Neuropsychological assessment, 5th ed. In *Neuropsychological assessment, 5th ed.* Oxford University Press.
- Liddle, J., Fleming, J., McKenna, K., Turpin, M., Whitelaw, P., & Allen, S. (2012). Adjustment to loss of the driving role following traumatic brain injury: a qualitative exploration with key stakeholders. *Australian Occupational Therapy Journal*, 59(1), 79–88. <https://doi.org/10.1111/j.1440-1630.2011.00978.x>
- Lipskaya-Velikovsky, L., Zeilig, G., Weingarden, H., Rozental-Iluz, C., & Rand, D. (2018). Executive functioning and daily living of individuals with chronic stroke: Measurement and implications. *International Journal of Rehabilitation Research*, 41(2), 122–127. <https://doi.org/10.1097/MRR.0000000000000272>
- López, R. F., & Antoli, A. (2020). Computer-based cognitive interventions in acquired brain injury: A systematic review and meta-analysis of randomized controlled trials. *PLoS ONE*, 15(7 July).
<https://doi.org/10.1371/journal.pone.0235510>
- Lüdecke, D., Ben-Shachar, M. S., Patil, I., Waggoner, P., & Makowski, D. (2021). performance: An R package for assessment, comparison and testing of statistical models. *Journal of Open Source Software*, 6(60).
<https://doi.org/https://doi.org/10.21105/joss.03139>
- Luria, A. R. (1966). Higher cortical functions in man. In *Higher cortical functions in man*. Basic Books.
- Mahoney, D., Grajo, L., & Gillen, G. (2021). Content Validity of the OT Anticipatory Awareness Test: A Functional Cognitive Assessment for Adults With Neurological Conditions. *American Journal of Occupational Therapy*, 75(2). <https://doi.org/10.5014/ajot.2021.75S2-RP60>
- Mahoney, D., Gutman, S. A., & Gillen, G. (2019). A scoping review of self-awareness instruments for acquired brain injury. *The Open Journal of Occupational Therapy*, 7(2), 3.
- Mahoney, D., Kotler, J. M., Nilsen, D. M., & Gillen, G. (2023). Effectiveness of Task-Oriented Approaches and Occupation-Based Activities to Improve Performance and Participation in Instrumental Activities of Daily Living (IADL) Among Adult Stroke Survivors (2009–2019). *The American Journal of Occupational Therapy*, 77(Supplement 1). <https://doi.org/10.5014/ajot.2023.77S10008>
- Maier, M., Ballester, B. R., Leiva Bañuelos, N., Duarte Oller, E., & Verschure, P. F. M. J. (2020). Adaptive conjunctive cognitive training (ACCT) in virtual reality for chronic stroke patients: a randomized controlled pilot trial. *Journal of Neuroengineering and Rehabilitation*, 17(1), 42.
<https://doi.org/https://doi.org/10.1186/s12984-020-0652-3>
- Malouf, T., Langdon, R., & Taylor, A. (2014). The Insight Interview: A new tool for measuring deficits in

- awareness after traumatic brain injury. In *Brain Injury* (Vol. 28, Issue 12, pp. 1523-1541). Taylor & Francis. <https://doi.org/10.3109/02699052.2014.922700>
- Mamman, R., Cheng, A., Tsow, R., & Schmidt, J. (2022). Clinician reports of self-awareness after traumatic brain injury: a retrospective chart review. *BMC Health Services Research*, 22(1), 1-8. <https://doi.org/10.1186/S12913-022-08444-X/TABLES/2>
- Mammen, K., Mills, L., Deacon, R. M., Bruno, R., Dunlop, A., Holmes, J., Luksza, J., Shakeshaft, A., Farrell, M., & Lintzeris, N. (2022). Determining clinical cutoff scores for the Australian Treatment Outcomes Profile psychological health, physical health and quality of life questions. *Drug and Alcohol Review*, 41(1), 106-113. <https://doi.org/10.1111/dar.13346>
- Manolov, R. (2018). Linear trend in single-case visual and quantitative analyses. *Behavior Modification*, 42(5), 684-706.
- Manolov, R., Moeyaert, M., & Evans, J. J. (2016). *Single-case data analysis: Software resources for applied researchers*. <https://doi.org/10.13140/RG.2.1.3981.7766>
- Manolov, R., Moeyaert, M., & Fingerhut, J. E. (2021). A Priori Justification for Effect Measures in Single-Case Experimental Designs. *Perspectives on Behavior Science*, 1-34. <https://doi.org/10.1007/s40614-021-00282-2>
- Manolov, R., & Solanas, A. (2018). Analytical Options for Single-Case Experimental Designs: Review and Application to Brain Impairment. *Brain Impairment*, 19(1), 18-32. <https://doi.org/10.1017/Brlmp.2017.17>
- Marcotte, T. D., Schmitter-Edgecombe, M., & Grant, I. (2022). *Neuropsychology of everyday functioning*. Guilford Publications.
- Marks, T. S., Giles, G. M., Al-Heizan, M. O., & Edwards, D. F. (2021). Screening to Assessment Pathways in Evaluating Functional Cognition in Older Adults. *OTJR Occupation, Participation and Health*, 41(4), 275-284. <https://doi.org/10.1177/15394492211021851>
- Marks, T. S., Giles, G. M., & Edwards, D. F. (2024). Online awareness is associated with superior performance on assessments of functional cognition. *Frontiers in Aging Neuroscience*, 16, 1384812. <https://doi.org/10.3389/fnagi.2024.1384812>
- Maskill, L., & Tempest, S. (2017). Intervention for Cognitive impairments and Evaluating Outcomes. In L. Maskill & S. Tempest (Eds.), *Neuropsychology for occupational therapists: Cognition in occupational performance* (4th ed., pp. 33-49). Wiley Online Library.
- McAlister, C., & Schmitter-Edgecombe, M. (2016). Everyday functioning and cognitive correlates in healthy older adults with subjective cognitive concerns. *Clinical Neuropsychologist*, 30(7), 1087-1103.

<https://doi.org/10.1080/13854046.2016.1190404>

- McAvinue, L., O'Keeffe, F., McMackin, D., & Robertson, I. H. (2005). Impaired sustained attention and error awareness in traumatic brain injury: implications for insight. *Neuropsychological Rehabilitation*, 15(5), 569-587. <https://doi.org/10.1080/09602010443000119>
- McHugh, M. L. (2011). Multiple comparison analysis testing in ANOVA. *Biochemia Medica*, 21(3), 203-209. <https://doi.org/10.11613/bm.2011.029>
- Merchán-Baeza, J. A., Rodríguez-Bailón, M., Ricchetti, G., Navarro-Egido, A., & Funes, M. J. (2020). Awareness of cognitive abilities in the execution of activities of daily living after acquired brain injury: an evaluation protocol. *BMJ Open*, 10(10). <https://doi.org/10.1136/BMJOPEN-2020-037542>
- Middleton, E. L., & Schwartz, M. F. (2012). Errorless learning in cognitive rehabilitation: A critical review. *Neuropsychological Rehabilitation*, 22(2), 138-168. <https://doi.org/10.1080/09602011.2011.639619>
- Miyake, A., & Friedman, N. P. (2012). The Nature and Organization of Individual Differences in Executive Functions: Four General Conclusions. *Current Directions in Psychological Science*, 21(1), 8. <https://doi.org/10.1177/0963721411429458>
- Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The Unity and Diversity of Executive Functions and Their Contributions to Complex "Frontal Lobe" Tasks: A Latent Variable Analysis. *Cognitive Psychology*, 41(1), 49-100. <https://doi.org/10.1006/cogp.1999.0734>
- Mlinac, M. E., & Feng, M. C. (2016). Assessment of Activities of Daily Living, Self-Care, and Independence. *Archives of Clinical Neuropsychology: The Official Journal of the National Academy of Neuropsychologists*, 31(6), 506-516. <https://doi.org/10.1093/arclin/acw049>
- Moeyaert, M., Ugille, M., Ferron, J. M., Beretvas, S. N., & Van den Noortgate, W. (2014). The influence of the design matrix on treatment effect estimates in the quantitative analyses of single-subject experimental design research. *Behavior Modification*, 38(5), 665-704. <https://doi.org/10.1177/0145445514535243>
- Mograbi, D. C., Brown, R. G., & Morris, R. G. (2009). Anosognosia in Alzheimer's disease--the petrified self. *Consciousness and Cognition*, 18(4), 989-1003. <https://doi.org/10.1016/j.concog.2009.07.005>
- Montoro-Membila, N., Arnedo Montoro, M., Funes, M. J., & Rodríguez-Bailón, M. (2022). The Cognitive Scale of Basic and Instrumental Activities of Daily Living for Multidomain Mild Cognitive Impairment and Dementia Patients: Validation of its Extended Version. *Journal of the International Neuropsychological Society*, 28(6), 628-641. <https://doi.org/10.1017/S1355617721000758>
- Morady, K., & Humphreys, G. W. (2009). Comparing action disorganization syndrome and dual-task load on normal performance in everyday action tasks. *Neurocase*, 15(1), 1-12.

<https://doi.org/10.1080/13554790802524214>

- Morris, R. G., Nelis, S. M., Martyr, A., Markova, I., Roth, I., Woods, R. T., Whitaker, C. J., & Clare, L. (2016). Awareness of memory task impairment versus everyday memory difficulties in dementia. *Journal of Neuropsychology*, 10(1), 130-142. <https://doi.org/10.1111/jnp.12062>
- Nagelkop, N. D., Rosselló, M., Aranguren, I., Lado, V., Ron, M., & Toglia, J. (2021). Using Multicontext Approach to Improve Instrumental Activities of Daily Living Performance after a Stroke: A Case Report. *Occupational Therapy in Health Care*, 35(3), 249-267. <https://doi.org/10.1080/07380577.2021.1919954>
- Nelson, L. D., Temkin, N. R., Dikmen, S., Barber, J., Giacino, J. T., Yuh, E., Levin, H. S., McCrea, M. A., Stein, M. B., Mukherjee, P., Okonkwo, D. O., Robertson, C. S., Diaz-Arrastia, R., Manley, G. T., Adeoye, O., Badjatia, N., Boase, K., Bodien, Y., Bullock, M. R., ... Zafonte, R. (2019). Recovery After Mild Traumatic Brain Injury in Patients Presenting to US Level I Trauma Centers: A Transforming Research and Clinical Knowledge in Traumatic Brain Injury (TRACK-TBI) Study. *JAMA Neurology*, 76(9), 1049-1059. <https://doi.org/10.1001/jamaneurol.2019.1313>
- Niki, C., Maruyama, T., Muragaki, Y., & Kumada, T. (2009). Disinhibition of sequential actions following right frontal lobe damage. *Cognitive Neuropsychology*, 26(3), 266-285. <https://doi.org/10.1080/02643290903028484>
- Nir-Hadad, S. Y., Weiss, P. L., Waizman, A., Schwartz, N., & Kizony, R. (2017). A virtual shopping task for the assessment of executive functions: Validity for people with stroke. *Neuropsychological Rehabilitation*, 27(5), 808-833. <https://doi.org/10.1080/09602011.2015.1109523>
- Noé, E., Ferri, J., Caballero, M. C., Villodre, R., Sanchez, A., & Chirivella, J. (2005). Self-awareness after acquired brain injury: Predictors and rehabilitation. *Journal of Neurology*, 252(2), 168-175. <https://doi.org/10.1007/s00415-005-0625-2>
- Nott, M. T., & Chapparo, C. (2020). Cognitive strategy use in adults with acquired brain injury. *Brain Injury*, 34(4), 508-514. <https://doi.org/10.1080/02699052.2020.1725837>
- O'Connell, R. G., Dockree, P. M., Bellgrove, M. A., Kelly, S. P., Hester, R., Garavan, H., Robertson, I. H., & Foxe, J. J. (2007). The role of cingulate cortex in the detection of errors with and without awareness: a high-density electrical mapping study. *European Journal of Neuroscience*, 25(8), 2571-2579.
- O'Keefe, F., Dockree, P., Moloney, P., Carton, S., & Robertson, I. H. (2007). Awareness of deficits in traumatic brain injury: A multidimensional approach to assessing metacognitive knowledge and online-awareness. *Journal of the International Neuropsychological Society*, 13(1), 38-49. <https://doi.org/10.1017/S1355617707070075>

- O'Keeffe, F. M., Murray, B., Coen, R. F., Dockree, P. M., Bellgrove, M. A., Garavan, H., Lynch, T., & Robertson, I. H. (2007). Loss of insight in frontotemporal dementia, corticobasal degeneration and progressive supranuclear palsy. *Brain*, 130(3), 753-764. <https://doi.org/10.1093/brain/awl367>
- Onghena, P. (2020). One by one: The design and analysis of replicated randomized single-case experiments. In R. van de Schoot & M. Miočević (Eds.), *Small sample size solutions: A guide for applied researchers and practitioners*. London: Routledge.
[https://library.oapen.org/bitstream/handle/20.500.12657/22385/9780367221898_text\(1\).pdf](https://library.oapen.org/bitstream/handle/20.500.12657/22385/9780367221898_text(1).pdf)
- Overdorp, E. J., Kessels, R. P. C., Claassen, J. A., & Oosterman, J. M. (2016). The combined effect of neuropsychological and neuropathological deficits on instrumental activities of daily living in older adults: a systematic review. *Neuropsychology Review*, 26(1), 92-106. <https://doi.org/10.1007/s11065-015-9312-y>
- Owensworth, T., & Clare, L. (2006). The association between awareness deficits and rehabilitation outcome following acquired brain injury. *Clinical Psychology Review*, 26, 783-795.
<https://doi.org/10.1016/j.cpr.2006.05.003>
- Owensworth, T., Clare, L., & Morris, R. (2006). An integrated biopsychosocial approach to understanding awareness deficits in Alzheimer's disease and brain injury. *Neuropsychological Rehabilitation*, 16(4), 415-438. <https://doi.org/10.1080/09602010500505641>
- Owensworth, T., Fleming, J., Desbois, J., Strong, J., & Kuipers, P. (2006). A metacognitive contextual intervention to enhance error awareness and functional outcome following traumatic brain injury: A single-case experimental design. *Journal of the International Neuropsychological Society*, 12(1), 54-63. <https://doi.org/10.1017/S135561770606005X>
- Owensworth, T., Fleming, J., Doig, E., Shum, D. H. K., & Swan, S. (2019). Concordance between the awareness questionnaire and self-awareness of Deficits interview for identifying impaired self-awareness in individuals with traumatic brain injury in the community. *Journal of Rehabilitation Medicine*, 51(5), 376-379. <https://doi.org/10.2340/16501977-2537>
- Owensworth, T., Fleming, J., Tate, R., Beadle, E., Griffin, J., Kendall, M., Schmidt, J., Lane-Brown, A., Chevignard, M., & Shum, D. H. K. (2017). Do People With Severe Traumatic Brain Injury Benefit From Making Errors? A Randomized Controlled Trial of Error-Based and Errorless Learning. *Neurorehabilitation and Neural Repair*. <https://doi.org/10.1177/1545968317740635>
- Owensworth, T. L., McFarland, K., & Young, R. M. (2002). The investigation of factors underlying deficits in self-awareness and self-regulation. *Brain Injury*, 16(4), 291-309.
<https://doi.org/10.1080/02699050110103986>

- Owensworth, T., Quinn, H., Fleming, J., Kendall, M., & Shum, D. (2010). Error self-regulation following traumatic brain injury: A single case study evaluation of metacognitive skills training and behavioural practice interventions. *Neuropsychological Rehabilitation*, 20(1), 59-80.
<https://doi.org/10.1080/09602010902949223>
- Owensworth, T., & Shum, D. (2009). Relationship between executive functions and productivity outcomes following stroke. *Disability and Rehabilitation*, 30(7), 531-540.
<https://doi.org/10.1080/09638280701355694>
- Palacios, E. M., Sala-Llanch, R., Junque, C., Roig, T., Tormos, J. M., Bargallo, N., & Vendrell, P. (2013). Resting-state functional magnetic resonance imaging activity and connectivity and cognitive outcome in traumatic brain injury. *JAMA Neurology*, 70(7), 845-851.
<https://doi.org/10.1001/jamaneurol.2013.38>
- Palermo, S., Leotta, D., Bongioanni, M. R., & Amanzio, M. (2014). Unawareness of deficits in ischemic injury: role of the cingulate cortex. *Neurocase*, 20(5), 540-555.
<https://doi.org/10.1080/13554794.2013.826686>
- Paolo, A. M., Axelrod, B. N., & Tröster, A. I. (1996). Test-retest stability of the Wisconsin Card Sorting Test. *Assessment*, 3(2), 137-143. <https://doi.org/10.1177/107319119600300205>
- Park, H. Y., Maitra, K., & Martinez, K. M. (2015). The effect of occupation-based cognitive rehabilitation for traumatic brain injury: A meta-analysis of randomized controlled trials. *Occupational Therapy International*, 22(2), 104-116. <https://doi.org/10.1002/oti.1389>
- Parker, H. A., Rapport, L. J., Williams, M. W., Hanks, R. A., Lumley, M. A., & Bogg, T. (2018). Functional independence after acquired brain injury: Prospective effects of health self-efficacy and cognitive impairment. *Rehabilitation Psychology*, 63(4), 595-603. <https://doi.org/10.1037/rep0000243>
- Patel, M. D., Coshall, C., Rudd, A. G., & Wolfe, C. D. A. (2002). Cognitive impairment after stroke: clinical determinants and its associations with long-term stroke outcomes. *Journal of the American Geriatrics Society*, 50(4), 700-706. <https://doi.org/10.1046/j.1532-5415.2002.50165.x>
- Pedullà, L., Bricchetto, G., Tacchino, A., Vassallo, C., Zaratin, P., Battaglia, M. A., Bonzano, L., & Bove, M. (2016). Adaptive vs. non-adaptive cognitive training by means of a personalized App: a randomized trial in people with multiple sclerosis. *Journal of Neuroengineering and Rehabilitation*, 13(1), 88.
<https://doi.org/10.1186/s12984-016-0193-y>
- Pinasco, C., Oviedo, M., Goldfeder, M., Bruno, D., Lischinsky, A., Torralva, T., & Roca, M. (2021). Sensitivity and specificity of the INECO frontal screening (IFS) in the detection of patients with traumatic brain injury presenting executive deficits. *Applied Neuropsychology:Adult*, 1-8.

<https://doi.org/10.1080/23279095.2021.1937170>

Pinto, J. O., Does, A. R., Peixoto, B., & Barbosa, F. (2023). Ecological validity in neurocognitive assessment: Systematized review, content analysis, and proposal of an instrument. *Applied Neuropsychology. Adult*, 1-18. <https://doi.org/10.1080/23279095.2023.2170800>

Pinto, J. O., Peixoto, B., Does, A. R., & Barbosa, F. (2023). Proposal of a common terminology for the neuropsychological rehabilitation. *Journal of Neuropsychology*, 17(3), 431-449. <https://doi.org/10.1111/jnp.12310>

Pinto, J. O., Pontes, D., Peixoto, B., Does, A. R., & Barbosa, F. (2024). Ecological validity of neuropsychological interventions: A systematic review. *Applied Neuropsychology. Adult*, 1-20. <https://doi.org/10.1080/23279095.2024.2328694>

Polatajko, H. J., McEwen, S. E., Ryan, J. D., & Baum, C. M. (2012). Pilot randomized controlled trial investigating cognitive strategy use to improve goal performance after stroke. *American Journal of Occupational Therapy*, 66(1), 104-109. <https://doi.org/10.5014/ajot.2012.001784>

Poncet, F., Swaine, B., Dutil, E., Chevnard, M., & Pradat-Diehl, P. (2017). How do assessments of activities of daily living address executive functions: A scoping review. *Neuropsychological Rehabilitation*, 27(5), 618-666. <https://doi.org/10.1080/09602011.2016.1268171>

Poncet, F., Swaine, B., Taillefer, C., Lamoureux, J., Pradat-Diehl, P., & Chevnard, M. (2015). Reliability of the Cooking Task in adults with acquired brain injury. *Neuropsychological Rehabilitation*, 25(2), 298-317. <https://doi.org/10.1080/09602011.2014.971819>

Ponsford, J. L., Downing, M. G., Olver, J., Ponsford, M., Acher, R., Carty, M., & Spitz, G. (2014). Longitudinal follow-up of patients with traumatic brain injury: outcome at two, five, and ten years post-injury. *Journal of Neurotrauma*, 31(1), 64-77. <https://doi.org/10.1089/neu.2013.2997>

Ponsford, J., Velikonja, D., Janzen, S., Harnett, A., McIntyre, A., Wiseman-Hakes, C., Togher, L., Teasell, R., Kua, A., Patsakos, E., Welch-West, P., & Bayley, M. T. (2023). INCOG 2.0 Guidelines for Cognitive Rehabilitation Following Traumatic Brain Injury, Part II: Attention and Information Processing Speed. *The Journal of Head Trauma Rehabilitation*, 38(1), 38-51. <https://doi.org/10.1097/HTR.0000000000000839>

Poulin, V., Korner-Bitensky, N., Dawson, D. R., & Bherer, L. (2012). Efficacy of executive function interventions after stroke: a systematic review. *Topics in Stroke Rehabilitation*, 19(2), 158-171. <https://doi.org/10.1310/TSR1902-158>

Prigatano, G. P. (1999). *Principles of neuropsychological rehabilitation*. Oxford University Press.

- Prigatano, G. P. (2005). Disturbances of self-awareness and rehabilitation of patients with traumatic brain injury: a 20-year perspective. *The Journal of Head Trauma Rehabilitation*, 20(1), 19-29.
<https://doi.org/10.1097/00001199-200501000-00004>
- Prigatano, G. P. (2009). Anosognosia: Clinical and ethical considerations. *Current Opinion in Neurology*, 22(6), 606-611. <https://doi.org/10.1097/WCO.0b013e328332a1e7>
- Prigatano, G. P. (2014). Anosognosia and patterns of impaired self-awareness observed in clinical practice. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, 61, 81-92.
<https://doi.org/10.1016/j.cortex.2014.07.014>
- Prigatano, G. P., & Altman, I. M. (1990). Impaired awareness of behavioral limitations after traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, 71(13), 1058-1064.
- Prigatano, G. P., Altman, I. M., & O'Brien, K. P. (1990). Behavioral limitations that traumatic-brain-injured patients tend to underestimate. *The Clinical Neuropsychologist*, 4(2), 163-176.
<https://doi.org/10.1080/13854049008401509>
- Prigatano, G. P., Bruna, O., Mataro, M., Muñoz, J. M., Fernandez, S., & Junque, C. (1998). Initial disturbances of consciousness and resultant impaired awareness in Spanish patients with traumatic brain injury. *Journal of Head Trauma Rehabilitation*, 12, 29-38. <https://doi.org/10.1097/00001199-199810000-00005>
- Prigatano, G. P., Fordyce, D. J., Zeiner, H. K., Roueche, J. R., Pepping, M., & Wood, B. C. (1986). *Neuropsychological rehabilitation after brain injury*. Johns Hopkins University Press, Baltimore.
- Prigatano, G. P., & Schacter, D. L. (1991). *Awareness of deficit after brain injury: Clinical and theoretical issues*. Oxford University Press.
- Prigatano, G. P., & Sherer, M. (2020). Impaired Self-Awareness and Denial During the Postacute Phases After Moderate to Severe Traumatic Brain Injury. In *Frontiers in Psychology* (Vol. 11, p. 1569). Frontiers Media S.A. <https://doi.org/10.3389/fpsyg.2020.01569>
- Proffitt, R., Boone, A., Hunter, E. G., Schaffer, O., Strickland, M., Wood, L., & Wolf, T. J. (2022). Interventions to Improve Social Participation, Work, and Leisure Among Adults Poststroke: A Systematic Review. *The American Journal of Occupational Therapy : Official Publication of the American Occupational Therapy Association*, 76(5). <https://doi.org/10.5014/ajot.2022.049305>
- Quade, D. (1967). Rank Analysis of Covariance. *Journal of the American Statistical Association*, 62(320), 1187-1200. <https://doi.org/10.1080/01621459.1967.10500925>
- Rand, D., Rukan, S. B. A., Weiss, P. L., & Katz, N. (2009). Validation of the Virtual MET as an assessment tool for executive functions. *Neuropsychological Rehabilitation*, 19(4), 583-602.

<https://doi.org/10.1080/09602010802469074>

- Rapport, L. J., Bryer, R. C., & Hanks, R. A. (2008). Driving and community integration after traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, 89(5), 922-930.
<https://doi.org/10.1016/j.apmr.2008.01.009>
- RasPELLI, S., Pallavicini, F., Carelli, L., Morganti, F., Poletti, B., Corra, B., Silani, V., & Riva, G. (2011). Validation of a Neuro Virtual Reality-based version of the Multiple Errands Test for the assessment of executive functions. *Studies in Health Technology and Informatics*, 167, 92-97.
- Reid-Arndt, S. A., Nehl, C., & Hinkebein, J. (2007). The Frontal Systems Behaviour Scale (FrSBe) as a predictor of community integration following a traumatic brain injury. *Brain Injury*, 21(13-14), 1361-1369. <https://doi.org/10.1080/02699050701785062>
- Renison, B., Ponsford, J., Testa, R., Richardson, B., & Brownfield, K. (2012). The ecological and construct validity of a newly developed measure of executive function: the Virtual Library Task. *Journal of the International Neuropsychological Society: JINS*, 18(3), 440-450.
<https://doi.org/10.1017/S1355617711001883>
- Ricchetti, G., Navarro-Egido, A., Rodríguez-Bailón, M., Salazar-Frías, D., Merchán-Baeza, J. A., Ariza-Vega, P., & Funes, M. J. (2024). The breakfast and dressing conflict task: preliminary evidence of its validity to measure online self-awareness after acquired brain injury. *American Journal of Occupational Therapy*, 78(2). <https://doi.org/https://doi.org/10.5014/ajot.2024.050346>
- Ricchetti, G., Navarro-Egido, A., Rodríguez-Bailón, M., Salazar-Frías, D., Narganes-Pineda, C., & Funes, M. J. (2024). Identifying conflict monitoring as a specific executive component that contributes to impaired self-awareness in patients with acquired brain injury. *Journal of Clinical and Experimental Neuropsychology*, 1-14. <https://doi.org/10.1080/13803395.2024.2391363>
- Ridderinkhof, K. R., Van Den Wildenberg, W. P. M., Segalowitz, S. J., & Carter, C. S. (2004). Neurocognitive mechanisms of cognitive control: the role of prefrontal cortex in action selection, response inhibition, performance monitoring, and reward-based learning. *Brain and Cognition*, 56(2), 129-140.
- Rittmo, J. Ö., & McIntosh, R. D. (2021). singcar: Comparing single cases to small samples in R. *Journal of Open Source Software*, 6(68), 3887.
- Robertson, K., & Schmitter-Edgecombe, M. (2015). Self-awareness and traumatic brain injury outcome. *Brain Injury*, 29(7-8), 848-858. <https://doi.org/10.3109/02699052.2015.1005135>
- Robertson, K., & Schmitter-Edgecombe, M. (2016). Naturalistic tasks performed in realistic environments: a review with implications for neuropsychological assessment. *The Clinical Neuropsychologist*, 31(1),

16-42. <https://doi.org/10.1080/13854046.2016.1208847>

- Robin, X., Turck, N., Vutskits, L., Sanchez-Pena, P., Hainard, A., Gex-Fabry, M., Fouda, C., Bassem, H., Mueller, M., Lisacek, F., Puybasset, L., & Sanchez, J.-C. (2011). pROC: an open-source package for R and S+ to analyze and compare ROC curves. *BMC Bioinformatics*, 8, 12-77.
- Rodríguez-Bailón, M., Montoro-Membila, N., Garcia-Morán, T., Arnedo-Montoro, M. L., & Molina, M. J. F. (2015). Preliminary cognitive scale of basic and instrumental activities of daily living for dementia and mild cognitive impairment. *Journal of Clinical and Experimental Neuropsychology*, 37(4), 339-353. <https://doi.org/10.1080/13803395.2015.1013022>
- Roebers, C. M. (2017). Executive function and metacognition: Towards a unifying framework of cognitive self-regulation. *Developmental Review*, 45, 31-51. <https://doi.org/https://doi.org/10.1016/j.dr.2017.04.001>
- Romero-Ayuso, D., Castellero-Perea, Á., González, P., Navarro, E., Molina-Massó, J. P., Funes, M. J., Ariza-Vega, P., Toledano-González, A., & Triviño-Juárez, J. M. (2021). Assessment of cognitive instrumental activities of daily living: a systematic review. *Disability and Rehabilitation*, 43(10), 1342-1358. <https://doi.org/10.1080/09638288.2019.1665720>
- Rose Sin Yi, L., Jing Jing, S., Hammada, A.-O., Jonathan, B., Ladislav, B., & Jing, Q. (2024). Effects of virtual reality-based cognitive interventions on cognitive function and activity of daily living among stroke patients: Systematic review and meta-analysis. *Journal of Clinical Nursing*, 33(3), 1169-1184. <https://doi.org/10.1111/jocn.16986>
- Rotenberg-Shpigelman, S., Rosen-Shilo, L., & Maeir, A. (2014). Online awareness of functional tasks following ABI: The effect of task experience and associations with underlying mechanisms. *NeuroRehabilitation*, 35(1), 47-56. <https://doi.org/10.3233/NRE-141101>
- Royall, D. R., Lauterbach, E. C., Kaufer, D., Malloy, P., Coburn, K. L., & Black, K. J. (2007). The cognitive correlates of functional status: A review from the Committee on Research of the American Neuropsychiatric Association. In *Journal of Neuropsychiatry and Clinical Neurosciences* (Vol. 19, Issue 3, pp. 249-265). J Neuropsychiatry Clin Neurosci. <https://doi.org/10.1176/jnp.2007.19.3.249>
- Ruff, R. M. (2003). A friendly critique of neuropsychology: Facing the challenges of our future. *Archives of Clinical Neuropsychology*, 18(8), 847-864. <https://doi.org/10.1016/J.AC.N.2003.07.002>
- Rusticus, S. A., & Lovato, C. Y. (2014). Impact of Sample Size and Variability on the Power and Type I Error Rates of Equivalence Tests: A Simulation Study. *Practical Assessment, Research, and Evaluation*, 19, 11. <https://doi.org/10.7275/4s9m-4e81>
- Rycroft, S. S., Giovannetti, T., Divers, R., & Hulswit, J. (2018). Sensitive performance-based assessment of

everyday action in older and younger adults. *Aging, Neuropsychology, and Cognition*, 25(2), 259-276.
<https://doi.org/10.1080/13825585.2017.1287855>

Salazar-Frías, D., Funes, M. J., Merchán-Baeza, J. A., Ricchetti, G., Torralba-Muñoz, J. M., & Rodríguez-Bailón, M. (2023). Translation, cross-cultural adaptation and validation of the 10-item Weekly Calendar Planning Activity in Spanish-speaking ABI patients: a multicenter study. *Frontiers in Psychology*, 14, 1-17. <https://doi.org/10.3389/fpsyg.2023.1018055>

Salazar-Frías, D., Funes, M. J., & Rodríguez-Bailon, M. (2020). Valoración e intervención neuropsicológicas en las actividades de la vida diaria. In M. Triviño Mosquera, M. Arnedo Montoro, & J. Bembibre Serrano (Eds.), *Neuropsicología a través de Casos Clínicos* (2nd ed., pp. 425-436). Editorial Médica Panamericana.

Salazar-Frías, D., Funes, M. J., Szot, A. C., Gómez, L. L., Navarro-Egido, A., & Rodríguez-Bailón, M. (n.d.). The moderating role of online awareness in the association between strategy use and performance accuracy on a test of functional cognition in individuals with acquired brain injury. *Archives of Clinical Neuropsychology*.

Salazar-Frías, D., Rodríguez-Bailon, M., Ricchetti, G., Navarro-Egido, A., de los Santos, M., & Funes, M. J. (2024). Training to deal with distractions and conflicting situations in activities of daily living after traumatic brain injury (TBI): preliminary evidence from a single-case experimental design study. *Neuropsychological Rehabilitation*, 1-36. <https://doi.org/10.1080/09602011.2024.2375495>

Salazar-Frías, D., Rodríguez-Bailón, M., Ricchetti, G., Navarro-Egido, A., & Funes, M. J. (2023). The Cognitive Awareness Scale for Basic and Instrumental activities of daily living to measure self-awareness after acquired brain injury: preliminary evidence of its validity. *The Clinical Neuropsychologist*, 38(5), 1133-1155. <https://doi.org/10.1080/13854046.2023.2278822>

Sánchez-Cabeza, Á., Huertas-Hoyas, E., Máximo-Bocanegra, N., Martínez-Piédrola, R. M., Pérez-de-Heredia-Torres, M., & Alegre-Ayala, J. (2017). Spanish Transcultural Adaptation and Validity of the Behavioral Inattention Test. *Occupational Therapy International*, 2017, 1423647.
<https://doi.org/10.1155/2017/1423647>

Sansonetti, D., Fleming, J., Patterson, F., & Lannin, N. A. (2021). Conceptualization of self-awareness in adults with acquired brain injury: A qualitative systematic review. *Neuropsychological Rehabilitation*, 32(8), 1726-1773. <https://doi.org/10.1080/09602011.2021.1924794>

Sansonetti, D., Fleming, J., Patterson, F., Lannin, N. A., & Togli, J. (2024). Online awareness: a concept analysis and review of assessment approaches for adults with neurological conditions. *Disability and Rehabilitation*, 1-16. <https://doi.org/10.1080/09638288.2024.2338876>

- Scaratti, C., Leonardi, M., Sattin, D., Schiavolin, S., Willems, M., & Raggi, A. (2017). Work-related difficulties in patients with traumatic brain injury: a systematic review on predictors and associated factors. *Disability and Rehabilitation*, 39(9), 847-855. <https://doi.org/10.3109/09638288.2016.1162854>
- Schacter, D. L. (1990). Toward a cognitive neuropsychology of awareness: implicit knowledge and anosognosia. *Journal of Clinical and Experimental Neuropsychology*, 12(1), 155-178. <https://doi.org/10.1080/01688639008400962>
- Schmidt, J., Fleming, J., Ownsworth, T., & Lannin, N. A. (2013). Video feedback on functional task performance improves self-awareness after traumatic brain injury: A randomized controlled trial. *Neurorehabilitation and Neural Repair*, 27(4), 316-324. <https://doi.org/10.1177/1545968312469838>
- Schmidt, J., Fleming, J., Ownsworth, T., & Lannin, N. A. (2015a). An occupation-based video feedback intervention for improving self-awareness: Protocol and rationale. *Canadian Journal of Occupational Therapy*, 82(1), 54-63. <https://doi.org/10.1177/0008417414550999>
- Schmidt, J., Fleming, J., Ownsworth, T., & Lannin, N. A. (2015b). Maintenance of treatment effects of an occupation-based intervention with video feedback for adults with TBI. *NeuroRehabilitation*, 36(2), 175-186. <https://doi.org/10.3233/NRE-151205>
- Schmidt, J., Lannin, N., Fleming, J., & Ownsworth, T. (2011). Feedback interventions for impaired self-awareness following brain injury: A systematic review. In *Journal of Rehabilitation Medicine* (Vol. 43, Issue 8, pp. 673-680). J Rehabil Med. <https://doi.org/10.2340/16501977-0846>
- Schmidt, J., & Ownsworth, T. (2022). Neuropsychological Rehabilitation Special issue editorial: The self after brain injury. *Neuropsychological Rehabilitation*, 32(8), 1669-1675. <https://doi.org/10.1080/09602011.2022.2120504>
- Schmidt, M. (1996). *Rey Auditory verbal learning test: A handbook*. Western Psychological Services.
- Schmitter-Edgecombe, M., Cunningham, R., McAlister, C., Arrotta, K., & Weakley, A. (2021). The night out task and scoring application: an ill-structured, open-ended clinic-based test representing cognitive capacities used in everyday situations. *Archives of Clinical Neuropsychology*, 36(4), 537. <https://doi.org/10.1093/ARCLIN/ACAA080>
- Schmitter-Edgecombe, M., Parsey, C., & Lamb, R. (2014). Development and psychometric properties of the instrumental activities of daily living: compensation scale. *Archives of Clinical Neuropsychology: The Official Journal of the National Academy of Neuropsychologists*, 29(8), 776-792. <https://doi.org/10.1093/arclin/acu053>
- Schrijnemaekers, A. C., Smeets, S. M. J., Ponds, R. W. H. M., Van Heugten, C. M., & Rasquin, S. (2014). Treatment of unawareness of deficits in patients with acquired brain injury: A systematic review. In

Journal of Head Trauma Rehabilitation (Vol. 29, Issue 5, pp. E9-E30). Lippincott Williams and Wilkins.
<https://doi.org/10.1097/01.HTR.0000438117.63852.b4>

- Schwartz, M. F., Montgomery, M. W., Buxbaum, L. J., Lee, S. S., Carew, T. G., Coslett, H. B., Ferraro, M., Fitzpatrick-DeSalme, E., Hart, T., & Mayer, N. (1998). Naturalistic action impairment in closed head injury. *Neuropsychology*, 12(1), 13-28. <https://doi.org/10.1037/0894-4105.12.1.13>
- Schwartz, M. F., Reed, E. S., Montgomery, M., Palmer, C., & Mayer, N. H. (1991). The quantitative description of action disorganisation after brain damage: A case study. *Cognitive Neuropsychology*, 8(5), 381-414.
- Schwartz, M. F., Segal, M., Veramonti, T., Ferraro, M., & Buxbaum, L. J. (2002). The Naturalistic Action Test: A standardised assessment for everyday action impairment. *Neuropsychological Rehabilitation*, 12(4), 311-339. <https://doi.org/10.1080/09602010244000084>
- Shallice, T., & Burgess, P. W. (1991). Deficits in strategy application following frontal lobe damage in man. *Brain : A Journal of Neurology*, 114(2), 727-741. <https://doi.org/10.1093/BRAIN/114.2.727>
- Sherer, M., Bergloff, P., Boake, C., High, W., & Levin, E. (1998). The Awareness Questionnaire: factor structure and internal consistency. *Brain Injury*, 12(1), 63-68.
<https://doi.org/10.1080/026990598122863>
- Sherer, M., Boake, C., Levin, E., Silver, B. V., Ringholz, G., & High, W. M. (1998). Characteristics of impaired awareness after traumatic brain injury. *Journal of the International Neuropsychological Society*, 4(4), 380-387. <https://doi.org/10.1017/S1355617798003804>
- Sherer, M., & Fleming, J. (2014). Impaired self-awareness. In M. Sherer & A. M. Sander (Eds.), *Handbook on the neuropsychology of traumatic brain injury* (pp. 233-255). Springer.
- Sherer, M., Hart, T., & Nick, T. G. (2003). Measurement of impaired self-awareness after traumatic brain injury: A comparison of the patient competency rating scale and the awareness questionnaire. *Brain Injury*, 17(1), 25-37. <https://doi.org/10.1080/0269905021000010113>
- Shimamura, A. P. (2000). Toward a cognitive neuroscience of metacognition. *Consciousness and Cognition*, 9(2), 313-323. <https://doi.org/https://doi.org/10.1006/ccog.2000.0450>
- Sierra Sanjurjo, N., Saraniti, A. B., Gleichgerrcht, E., Roca, M., Manes, F., & Torralva, T. (2019). The IFS (INECO Frontal Screening) and level of education: Normative data. *Applied Neuropsychology:Adult*, 26(4), 331-339. <https://doi.org/10.1080/23279095.2018.1427096>
- Simmond, M., & Fleming, J. (2003). Reliability of the self-awareness of deficits interview for adults with traumatic brain injury. *Brain Injury*, 17(4), 325-337. <https://doi.org/10.1080/0269905021000013219>

- Sireci, S. G., Yang, Y., Harter, J., & Ehrlich, E. J. (2006). Evaluating guidelines for test adaptations: A methodological analysis of translation quality. *Journal of Cross-Cultural Psychology*, 37(5), 557-567.
- Siu, A. F. Y., & Zhou, Y. (2014). Behavioral Assessment of the Dysexecutive Syndrome for Children: an examination of clinical utility for children with attention-deficit hyperactivity disorder (ADHD). *Journal of Child Neurology*, 29(5), 608-616. <https://doi.org/10.1177/0883073813516191>
- Skidmore, E. R. (2014). Activity interventions for cognitive problems. *Pediatric Blood & Cancer*, 61(10), 1743-1746. <https://doi.org/10.1002/pbc.24781>
- Skidmore, E. R. (2017). Functional Cognition: Implications for Practice, Policy, and Research. *The American Journal of Geriatric Psychiatry : Official Journal of the American Association for Geriatric Psychiatry*, 25(5), 483-484. <https://doi.org/10.1016/j.jagp.2016.12.020>
- Skidmore, E. R., Dawson, D. R., Butters, M. A., Grattan, E. S., Juengst, S. B., Whyte, E. M., Begley, A., Holm, M. B., & Becker, J. T. (2015). Strategy Training Shows Promise for Addressing Disability in the First 6 Months After Stroke. *Neurorehabilitation and Neural Repair*, 29(7), 668-676. <https://doi.org/10.1177/1545968314562113>
- Skidmore, E. R., Holm, M. B., Whyte, E. M., Dew, M. A., Dawson, D., & Becker, J. T. (2011). The feasibility of meta-cognitive strategy training in acute inpatient stroke rehabilitation: case report. *Neuropsychological Rehabilitation*, 21(2), 208-223. <https://doi.org/10.1080/09602011.2011.552559>
- Smeets, S. M. J., Ponds, R. W. H. M., Verhey, F. R., & Van Heugten, C. M. (2012). Psychometric properties and feasibility of instruments used to assess awareness of deficits after acquired brain injury: A systematic review. *Journal of Head Trauma Rehabilitation*, 27(6), 433-442. <https://doi.org/10.1097/HTR.0b013e3182242f98>
- Sohlberg, M. M., & Mateer, C. A. (2001). Cognitive rehabilitation: An integrative neuropsychological approach. In *Cognitive rehabilitation: An integrative neuropsychological approach*. Guilford Press.
- Spooner, D. M., & Pachana, N. A. (2006). Ecological validity in neuropsychological assessment: A case for greater consideration in research with neurologically intact populations. *Archives of Clinical Neuropsychology*, 21(4), 327-337. <https://doi.org/10.1016/J.ACN.2006.04.004>
- Steinberg, C., & Zlotnik, S. (2019). The multicontext approach. In T. Wolf, E. DF, & G. GM (Eds.), *Functional Cognition and Occupational Therapy: A Practical Approach to Treating Individuals with Cognitive Loss*. (pp. 219-237). American Occupational Therapy Association, Inc.
- Stewart, G., McGeown, W. J., Shanks, M. F., & Venneri, A. (2010). Anosognosia for memory impairment in Alzheimer's disease. *Acta Neuropsychiatrica*, 22(4), 180-187. <https://doi.org/10.1111/j.1601-5215.2010.00463.x>

- Stuss, D. T. (1991). *Self, Awareness, and the Frontal Lobes: A Neuropsychological Perspective* BT - *The Self: Interdisciplinary Approaches* (J. Strauss & G. R. Goethals (eds.); pp. 255-278). Springer New York. https://doi.org/10.1007/978-1-4684-8264-5_13
- Stuss, D. T. (2011). Functions of the frontal lobes: Relation to executive functions. *Journal of the International Neuropsychological Society*, 17, 759-765. <https://doi.org/10.1017/S1355617711000695>
- Stuss, D. T., & Alexander, M. P. (2000). Executive functions and the frontal lobes: a conceptual view. *Psychological Research*, 63(3-4), 289-298. <https://doi.org/10.1007/S004269900007>
- Suchy, Y., DesRuisseaux, L. A., Gereau Mora, M., Brothers, S. L., & Niermeyer, M. A. (2024). Conceptualization of the term "ecological validity" in neuropsychological research on executive function assessment: a systematic review and call to action. *Journal of the International Neuropsychological Society : JINS*, 30(5), 499-522. <https://doi.org/10.1017/S1355617723000735>
- Suchy, Y., Gereau Mora, M., Brothers, S. L., & DesRuisseaux, L. A. (2024). Six elements test vs D-KEFS: what does "Ecological Validity" tell us? *Journal of the International Neuropsychological Society : JINS*, 30(4), 350-359. <https://doi.org/10.1017/S1355617723000723>
- Suchy, Y., Mora, M. G., DesRuisseaux, L. A., Niermeyer, M. A., & Brothers, S. L. (2024). Pitfalls in research on ecological validity of novel executive function tests: A systematic review and a call to action. *Psychological Assessment*, 36(4), 243-261. <https://doi.org/10.1037/pas0001297>
- Sunderaraman, P., Chapman, S., Barker, M. S., & Cosentino, S. (2020). Self-awareness for financial decision-making abilities in healthy adults. *PloS One*, 15(7), e0235558. <https://doi.org/10.1371/journal.pone.0235558>
- Swanton, R., Gustafsson, L., Froude, E., Hodson, T., McInerney, M., Cahill, L. S., & Lannin, N. A. (2020). Cognitive strategy training for adults with neurological conditions: a systematic review and meta-analysis exploring effect on occupational performance. *British Journal of Occupational Therapy*, 83(12), 723-740. <https://doi.org/10.1177/0308022620933095>
- Tanious, R., Manolov, R., Onghena, P., & Vlaeyen, J. W. S. (2024). Single-case experimental designs: the importance of randomization and replication. *Nature Reviews Methods Primers*, 4(1), 27.
- Tate, R. L., Kennedy, M., Ponsford, J., Douglas, J., Velikonja, D., Bayley, M., & Stergiou-Kita, M. (2014). INCOG recommendations for management of cognition following traumatic brain injury, Part III: Executive function and self-awareness. In *Journal of Head Trauma Rehabilitation* (Vol. 29, Issue 4, pp. 338-352). Lippincott Williams and Wilkins. <https://doi.org/10.1097/HTR.000000000000068>
- Tate, R. L., Lane-Brown, A. T., Myles, B. M., & Cameron, I. D. (2020). A longitudinal study of support needs

- after severe traumatic brain injury. *Brain Injury*, 34(8), 991–1000.
<https://doi.org/10.1080/02699052.2020.1764101>
- Tate, R. L., & Perdices, M. (2019). Introduction to single-case experimental designs: Historical overview and basic concepts. In *Single-Case Experimental Designs for Clinical Research and Neurorehabilitation Settings: Planning, Conduct, Analysis and Reporting*.
- Tate, R. L., Perdices, M., McDonald, S., Togher, L., & Rosenkoetter, U. (2014). The design, conduct and report of single-case research: Resources to improve the quality of the neurorehabilitation literature. *Neuropsychological Rehabilitation*, 24(3–4), 315–331. <https://doi.org/10.1080/09602011.2013.875043>
- Tate, R. L., Perdices, M., Rosenkoetter, U., Shadish, W., Vohra, S., Barlow, D. H., Horner, R., Kazdin, A., Kratochwill, T., McDonald, S., Sampson, M., Shamseer, L., Togher, L., Albin, R., Backman, C., Douglas, J., Evans, J. J., Gast, D., Manolov, R., ... Wilson, B. (2016). The Single-Case Reporting Guideline In BEhavioural Interventions (SCRIBE) 2016 Statement. *Remedial and Special Education*, 37(6), 370–380.
<https://doi.org/10.1177/0741932516652893>
- Tate, R. L., Wakim, D., Sigmundsdottir, L., & Longley, W. (2020). Evaluating an intervention to increase meaningful activity after severe traumatic brain injury: A single-case experimental design with direct inter-subject and systematic replications. *Neuropsychological Rehabilitation*, 30(4), 641–672.
<https://doi.org/10.1080/09602011.2018.1488746>
- Tempest, S., & Maskill, L. (2017). Occupation and cognitive rehabilitation. In L. Maskill & S. Tempest (Eds.), *Neuropsychology for Occupational Therapists: Cognition in Occupational Performance* (4th ed., pp. 1–16). Wiley Online Library.
- Terwee, C. B., Bot, S. D., de Boer, M. R., van der Windt, D. A., Knol, D. L., Dekker, J., Bouter, L. M., & de Vet, H. C. (2007). Quality criteria were proposed for measurement properties of health status questionnaires. *Journal of Clinical Epidemiology*, 60(1), 34–42.
<https://doi.org/10.1016/j.jclinepi.2006.03.012>
- Tilton-Bolowsky, V. E., Brock, L., Nunn, K., Evans, W. S., & Vallila-Rohter, S. (2023). Incorporating Metacognitive Strategy Training Into Semantic Treatment Promotes Restitutive and Substitutive Gains in Naming: A Single-Subject Investigation. *American Journal of Speech-Language Pathology*, 32(5), 1979–2020. https://doi.org/10.1044/2023_AJSLP-22-00230
- Tiznado, D., Clark, J. M. R., & McDowd, J. (2021). Cognitive predictors of a performance-based measure of instrumental activities of daily living following stroke. *Topics in Stroke Rehabilitation*, 28(6), 401–409.
<https://doi.org/10.1080/10749357.2020.1834269>
- Toglia, J. (2015). *Weekly calendar planning activity: A performance test of executive function*. Bethesda, MD:

AOTA Press.

- Toglia, J. (2018). The dynamic interactional model and the multicontext approach. In N. Katz & J. Toglia (Eds.), *Cognition, occupation, and participation across the lifespan: Neuroscience, neurorehabilitation, and models for intervention in occupational therapy* (4th ed., pp. 355-383). AOTA Press.
- Toglia, J., & Foster, E. R. (2022). *The multicontext approach to cognitive rehabilitation: A metacognitive strategy intervention to optimize functional cognition*. Gatekeeper Press.
- Toglia, J., & Goverover, Y. (2022). Revisiting the dynamic comprehensive model of self-awareness: a scoping review and thematic analysis of its impact 20 years later. *Neuropsychological Rehabilitation*, 1-50. <https://doi.org/10.1080/09602011.2022.2075017>
- Toglia, J., Goverover, Y., Johnston, M. V., & Dain, B. (2011). Application of the multicontextual approach in promoting learning and transfer of strategy use in an individual with TBI and executive dysfunction. *OTJR : Occupation, Participation and Health*, 31(1), 2011. <https://doi.org/10.3928/15394492-20101108-09>
- Toglia, J., Johnston, M. V., Goverover, Y., & Dain, B. (2010). A multicontext approach to promoting transfer of strategy use and self regulation after brain injury: An exploratory study. *Brain Injury*, 24(4), 664-677. <https://doi.org/10.3109/02699051003610474>
- Toglia, J., & Kirk, U. (2000). Understanding awareness deficits following brain injury. *NeuroRehabilitation*, 15(1), 57-70. <https://doi.org/10.3233/nre-2000-15104>
- Toglia, J., Lee, A., Steinberg, C., & Waldman-Levi, A. (2020). Establishing and measuring treatment fidelity of a complex cognitive rehabilitation intervention: The multicontext approach. *British Journal of Occupational Therapy*, 83(6), 363-374. <https://doi.org/10.1177/0308022619898091>
- Toglia, J., Rodger, S. A., & Polatajko, H. J. (2012). Anatomy of cognitive strategies: A therapist's primer for enabling occupational performance. *Canadian Journal of Occupational Therapy*, 79(4), 225-236. <https://doi.org/10.2182/cjot.2012.79.4.4>
- Toglia, J., & White, S. (2020). The weekly calendar planning activity. In and C. K. U. B. J. Hemphill-Pearson (Ed.), *Assessments in occupational therapy mental health: An integrative approach*. (4th ed., pp. 239-259). Slack Incorporated.
- Torralva, T., Roca, M., Gleichgerrcht, E., Bekinschtein, T., & Manes, F. (2009). A neuropsychological battery to detect specific executive and social cognitive impairments in early frontotemporal dementia. *Brain : A Journal of Neurology*, 132(Pt 5), 1299-1309. <https://doi.org/10.1093/BRAIN/AWP041>
- Torralva, T., Roca, M., Gleichgerrcht, E., López, P., & Manes, F. (2009). INECO Frontal Screening (IFS): A

- brief, sensitive, and specific tool to assess executive functions in dementia. *Journal of the International Neuropsychological Society*, 15(5), 777–786. <https://doi.org/10.1017/S1355617709990415>
- Trahan, E., Pépin, M., & Hopps, S. (2006). Impaired awareness of deficits and treatment adherence among people with traumatic brain injury or spinal cord injury. *The Journal of Head Trauma Rehabilitation*, 21(3), 226–235. <https://doi.org/10.1097/00001199-200605000-00003>
- Trevethan, R. (2017). Sensitivity, Specificity, and Predictive Values: Foundations, Plausibilities, and Pitfalls in Research and Practice. *Frontiers in Public Health*, 5, 307. <https://doi.org/10.3389/FPUH.2017.00307/BIBTEX>
- Trevorrow, S., Gustafsson, L., & Hodson, T. (2024). Leisure Engagement Among People Living With Acquired Brain Injury: A Scoping Review. *OTJR : Occupation, Participation and Health*, 44(2), 263–277. <https://doi.org/10.1177/15394492231221962>
- Tsai, Y.-C., Liu, C.-J., Huang, H.-C., Lin, J.-H., Chen, P.-Y., Su, Y.-K., Chen, C.-T., & Chiu, H.-Y. (2021). A Meta-analysis of Dynamic Prevalence of Cognitive Deficits in the Acute, Subacute, and Chronic Phases After Traumatic Brain Injury. *The Journal of Neuroscience Nursing : Journal of the American Association of Neuroscience Nurses*, 53(2), 63–68. <https://doi.org/10.1097/JNN.0000000000000570>
- Tyson, B. T., Pham, M. T., Brown, N. T., & Mayer, T. R. (2012). Patient safety considerations in the rehabilitation of the individual with cognitive impairment. *Physical Medicine and Rehabilitation Clinics*, 23(2), 315–334. <https://doi.org/doi:10.1016/j.pmr.2012.02.007>
- Van De Ven, R. M., Murre, J. M. J., Veltman, D. J., & Schmand, B. A. (2016). Computer-based cognitive training for executive functions after stroke: A systematic review. *Frontiers in Human Neuroscience*. <https://doi.org/10.3389/fnhum.2016.00150>
- van Erp, S., & Steultjens, E. (2020). Impaired awareness of deficits and cognitive strategy use in occupational performance of persons with acquired brain injury (ABI). *Irish Journal of Occupational Therapy*, 48(2), 101–115. <https://doi.org/10.1108/IJOT-10-2019-0012>
- Vanderploeg, R. D., Belanger, H. G., Duchnick, J. D., & Curtiss, G. (2007). Awareness problems following moderate to severe traumatic brain injury: Prevalence, assessment methods, and injury correlates. *Journal of Rehabilitation Research and Development*, 44(7), 937–950. <https://doi.org/10.1682/jrrd.2006.12.0163>
- Velikonja, D., Ponsford, J., Janzen, S., Harnett, A., Patsakos, E., Kennedy, M., Togher, L., Teasell, R., McIntyre, A., Welch-West, P., Kua, A., & Bayley, M. T. (2023). INCOG 2.0 Guidelines for Cognitive Rehabilitation Following Traumatic Brain Injury, Part V: Memory. *The Journal of Head Trauma Rehabilitation*, 38(1), 83–102. <https://doi.org/10.1097/HTR.0000000000000837>

- Villalobos, D., Bilbao, Á., López-Muñoz, F., & Pacios, J. (2019). Improving Self-awareness after Acquired Brain Injury Leads to Enhancements in Patients' Daily Living Functionality. *Brain Impairment*, 20(3), 268-275. <https://doi.org/10.1017/BrImp.2019.10>
- Villalobos, D., Bilbao, Á., López-Muñoz, F., & Pacios, J. (2020). Conciencia de déficit como proceso clave en la rehabilitación de pacientes con daño cerebral adquirido: revisión sistemática. *Revista de Neurología*, 70(01), 1-11. <https://doi.org/10.33588/rn.7001.2019313>
- Villalobos, D., Caperos, J. M., Bilbao, Á., Bivona, U., Formisano, R., & Pacios, J. (2020). Self-awareness moderates the association between executive dysfunction and functional independence after acquired brain injury. *Archives of Clinical Neuropsychology*, 35, 1059-1068. <https://doi.org/10.1093/arclin/acia048>
- Villalobos, D., Caperos, J. M., Bilbao, Á., López-Muñoz, F., & Pacios, J. (2021). Cognitive predictors of self-awareness in patients with acquired brain injury along neuropsychological rehabilitation. *Neuropsychological Rehabilitation*, 31(6), 983-1001. <https://doi.org/10.1080/09602011.2020.1751663>
- Vlaeyen, J. W. S., Wicksell, R. K., Simons, L. E., Gentili, C., De, T. K., Tate, R. L., Vohra, S., Punja, S., Linton, S. J., & Sniehotta, F. F. (2020). From Boulder to Stockholm in 70 years: single case experimental designs in clinical research. *The Psychological Record*, 70, 659-670.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Wallis, K., Kelly, M., McRae, S. E., McDonald, S., & Campbell, L. E. (2022). Domains and measures of social cognition in acquired brain injury: A scoping review. *Neuropsychological Rehabilitation*, 32(9), 2429-2463. <https://doi.org/10.1080/09602011.2021.1933087>
- Warrington, E. K., & James, M. (1991). The Visual Object and Space Perception Battery, Thames Valley Test Company, Bury St. Edmunds, UK.
- Watson, P. A., Gignac, G. E., Weinborn, M., Green, S., & Pestell, C. (2020). A Meta-Analysis of Neuropsychological Predictors of Outcome Following Stroke and Other Non-Traumatic Acquired Brain Injuries in Adults. *Neuropsychology Review*, 30(2), 194-223. <https://doi.org/10.1007/s11065-020-09433-9>
- Weiner, N. W., Toglia, J., & Berg, C. (2012). Weekly Calendar Planning Activity (WCPA): A performance-based assessment of executive function piloted with at-risk adolescents. *The American Journal of Occupational Therapy*, 66(6), 699-708.

- Weinstein, C. E., Acee, T. W., & Jung, J. (2011). Self-regulation and learning strategies. *New Directions for Teaching and Learning*, 2011(126), 45-53.
- Whyte, E., Skidmore, E., Aizenstein, H., Ricker, J., & Butters, M. (2011). Cognitive impairment in acquired brain injury: a predictor of rehabilitation outcomes and an opportunity for novel interventions. *PM & R: The Journal of Injury, Function, and Rehabilitation*, 3(6 Suppl 1), S45-51.
<https://doi.org/10.1016/j.pmrj.2011.05.007>
- Wilbert, J. (2023). *scplot: An R package for visualizing single-case data*. Potsdam: University of Potsdam.
<https://cran.r-project.org/package=scplot>
- Wilbert, J., Börnert-Ringleb, M., & Lüke, T. (2022). Statistical power of piecewise regression analyses of single-case experimental studies addressing behavior problems. *Frontiers in Education*, 7, 917944.
<https://doi.org/10.3389/feduc.2022.917944>
- Wilbert, J., & Lueke, T. (2023). *scan: Single-Case Data Analyses for Single and Multiple Baseline Designs. (0.60) [English]*. CRAN. <https://cran.r-project.org/package=scan>
- Wild, D., Grove, A., Martin, M., Eremenco, S., McElroy, S., Verjee-Lorenz, A., & Erikson, P. (2005). Principles of Good Practice for the Translation and Cultural Adaptation Process for Patient-Reported Outcomes (PRO) Measures: Report of the ISPOR Task Force for Translation and Cultural Adaptation. *Value in Health*, 8(2), 94-104. <https://doi.org/10.1111/J.1524-4733.2005.04054.X>
- Wilson, B. (1987). Single-case experimental designs in neuropsychological rehabilitation. *Journal of Clinical and Experimental Neuropsychology: Official Journal of the International Neuropsychological Society*, 9(5), 527-544. <https://doi.org/10.1080/01688638708410767>
- Wilson, B. A. (2008). Neuropsychological rehabilitation. *Annu. Rev. Clin. Psychol.*, 4(1), 141-162.
- Wilson, L., Stewart, W., Dams-O'Connor, K., Diaz-Arrastia, R., Horton, L., Menon, D. K., & Polinder, S. (2017). The chronic and evolving neurological consequences of traumatic brain injury. *The Lancet. Neurology*, 16(10), 813-825. [https://doi.org/10.1016/S1474-4422\(17\)30279-X](https://doi.org/10.1016/S1474-4422(17)30279-X)
- Wise, K., Ownsworth, T., & Fleming, J. (2005). Convergent validity of self-awareness measures and their association with employment outcome in adults following acquired brain injury. *Brain Injury*, 19(10), 765-775. <https://doi.org/10.1080/0269905050019977>
- Wolf, T. J., Chuh, A., Floyd, T., McInnis, K., & Williams, E. (2015). Effectiveness of occupation-based interventions to improve areas of occupation and social participation after stroke: An evidence-based review. In *American Journal of Occupational Therapy* (Vol. 69, Issue 1). American Occupational Therapy Association, Inc. <https://doi.org/10.5014/ajot.2015.012195>
- Wong, D., Pike, K., Stolwyk, R., Allott, K., Ponsford, J., McKay, A., Longley, W., Bosboom, P., Hodge, A.,

- Kinsella, G., & Mowszowski, L. (2023). Delivery of Neuropsychological Interventions for Adult and Older Adult Clinical Populations: An Australian Expert Working Group Clinical Guidance Paper. *Neuropsychology Review*. <https://doi.org/10.1007/s11065-023-09624-0>
- Woods, S. P. (2021). Introduction to the special issue on the neuropsychology of daily life. In *Neuropsychology* (Vol. 35, Issue 1, pp. 1-2). <https://doi.org/10.1037/neu0000716>
- World Health Organization. (2024). *International classification of functioning, disability and health (ICF)*. World Health Organization.
- Wulf-Andersen, C., & Mogensen, J. (2017). Family and home in cognitive rehabilitation after brain injury: The importance of family oriented interventions. *NeuroRehabilitation*, 41(2), 519-525. <https://doi.org/10.3233/NRE-162007>
- Yeo, Y. X., Pestell, C. F., Bucks, R. S., Allanson, F., & Weinborn, M. (2021). Metacognitive knowledge and functional outcomes in adults with acquired brain injury: A meta-analysis. *Neuropsychological Rehabilitation*, 31(3), 453-478. <https://doi.org/10.1080/09602011.2019.1704421>
- Yoo, C., Yong, M.-H., Chung, J., & Yang, Y. (2015). Effect of computerized cognitive rehabilitation program on cognitive function and activities of living in stroke patients. *Journal of Physical Therapy Science*, 27(8), 2487-2489. <https://doi.org/10.1589/jpts.27.2487>
- Youden, W. J. (1950). Index for rating diagnostic tests. *Cancer*, 3(1), 32-35. [https://doi.org/10.1002/1097-0142\(1950\)3:1<32::AID-CNCR2820030106>3.0.CO;2-3](https://doi.org/10.1002/1097-0142(1950)3:1<32::AID-CNCR2820030106>3.0.CO;2-3)
- Zangwill, O. L. (1947). Psychological aspects of rehabilitation in cases of brain injury. *The British Journal of Psychology. General Section*, 37(2), 60-69. <https://doi.org/10.1111/j.2044-8295.1947.tb01121.x>
- Zimmerman, B. J., & Labuhn, A. S. (2012). Self-regulation of learning: Process approaches to personal development. In *APA educational psychology handbook, Vol 1: Theories, constructs, and critical issues*. (pp. 399-425). American Psychological Association. <https://doi.org/10.1037/13273-014>
- Zimmermann, N., Mograbi, D. C., Hermes-Pereira, A., Fonseca, R. P., & Prigatano, G. P. (2017). Memory and executive functions correlates of self-awareness in traumatic brain injury. *Cognitive Neuropsychiatry*, 22(4), 346-360. <https://doi.org/10.1080/13546805.2017.1330191>
- Zlotnik, S., Schiff, A., Ravid, S., Shahar, E., & Toglia, J. (2020). A new approach for assessing executive functions in everyday life, among adolescents with Genetic Generalised Epilepsies. *Neuropsychological Rehabilitation*, 30(2), 333-345. <https://doi.org/10.1080/09602011.2018.1468272>
- Zlotnik, S., & Toglia, J. (2018). Measuring Adolescent Self-Awareness and Accuracy Using a Performance-Based Assessment and Parental Report. *Frontiers in Public Health*, 6.

<https://doi.org/10.3389/fpubh.2018.00015>