Tesis Doctoral

Actividades de la Vida Diaria y Control Cognitivo en pacientes con demencia, deterioro cognitivo leve y daño cerebral frontal.

Activities of Daily Living and cognitive control in dementia, mild cognitive impairment and frontal lobe damage patients.

MARÍA RODRÍGUEZ BAILÓN

Directoras

María Jesús Funes Molina y Marisa Arnedo Montoro

Programa Oficial de Posgrado en Psicología Experimental y Neurociencias del Comportamiento

Departamento de Psicología Experimental

Universidad de Granada

Enero 2014

Editor: Editorial de la Universidad de Granada
Autor: María Rodríguez Bailón
D.L.: GR 1840-2014
ISBN: 978-84-9083-023-9

La Doctoranda MARÍA RODRÍGUEZ BAILÓN y las directoras de la tesis MARÍA JESÚS FUNES MOLINA Y MARISA ARNEDO MONTORO, garantizamos, al firmar esta tesis doctoral, que el trabajo ha sido realizado por el doctorando bajo la dirección de los directores de la tesis y, hasta donde nuestro conocimiento alcanza, en la realización del trabajo se han respetado los derechos de otros autores a ser citados, cuando se han utilizado sus resultados o publicaciones.

Granada a 17 de Enero de 2014

Directoras de la Tesis | Doctorando

Fdo.: María Jesús Funes Molina y Marisa Arnedo Montoro | Fdo:María Rodríguez Bailón

Por aquellos que pierden de pronto sus recuerdos y

olvidan unas manos, y un rostro y una historia.

Después de todo este tiempo, debo y me gustaría agradecer a muchas personas que han contribuido a que esto tenga sentido y que, finalmente, lo haya hecho posible.

En primer lugar a mi familia, a mis padres, a mis hermanos y, por supuesto, también a mis cuñados. Ya no sólo por el apoyo técnico y de contenidos que me habéis ofrecido, sino por el apoyo constante que me habéis dado desde el primer momento. Gracias padres por cuidarme todo este tiempo. Gracias Rosa y Juan por creer en mí y empujarme a meterme en este "mundillo". Gracias Ignacio por tu diseño siempre tan exquisito. Gracias Ester porque siempre has estado disponible para todo, incluso para salir a "despejarnos".

A mi otra familia, a Antonio, Amanda y Carmencilla, porque estar con vosotros también es estar en casa.

A todas aquellas terapeutas ocupacionales, amigas y compañeras que conocen la profesión y que tienen esa sensibilidad por el trabajo con las personas. A María José Alberto, María José Pulido, Ana Bravo, Vanesa, Inma. Gracias Judit, por todo. Gracias Laura, porque seguiremos juntas y, además, con la investigación.

Gracias a aquellas personas con las que empecé este maravilloso lío de la neurociencia, a Elena y a Almudena. También a todos los compañeros del departamento y del CIMCYC, a Maryem, a Ana Pérez, a Alicia Abundis y al resto de compañeros a los que pido disculpas por no nombrarlos por razones de espacio. A mi gran compañero de estancia, Jose, por esos buenos momentos en Birmingham.

Thanks to Glyn Humphreys, Jane Riddoch and Wai-Ling Bickerton. It is a great honour to work with you.

Gracias al grupo de investigación de José Barroso en la Universidad de La Laguna, a Yaiza, Alejandra, Pedro, Rosa, Attenery y Antonieta. Gracias por enseñarme tanto y por haberme acogido como un miembro más de vuestro grupo.

Una de las mayores contribuciones que han permitido que este trabajo haya salido adelante ha sido gracias a cuatro magníficas profesionales. Gracias Tamara, Nuria, Estrella y Mónica, por todo lo que habéis "sufrido" con esta investigación. Por vuestro dulce trato con los pacientes y vuestras horas incansables de trabajo evaluando y analizando horas y horas de vídeos. No tengo palabras para expresaros mi agradecimiento.

Y, por supuesto, gracias a mis tutoras, María Jesús Funes y Marisa Arnedo. Nadie nunca hubiera podido imaginar que desde aquellas conversaciones en los pasillos comentando la necesidad de conocer qué procesos estaban implicados en las actividades de la vida diaria, iba a salir esta tesis. Os tengo que agradecer muchas cosas, vuestro trabajo, inmenso, vuestra ilusión y vuestro trato. Y especialmente, la confianza que habéis depositado en mí y la valentía de abrir una línea de investigación, cuando siempre se está más "agustico" trabajando en lo que una ya domina. Gracias y gracias. Personas como vosotras hacen que la investigación crezca, se expanda y que diferentes profesiones puedan aunar sus conocimientos en pos de un objetivo común.

A mi Alex, porque siempre, siempre me ha dado aquel anclaje necesario para saber que lo que estaba haciendo tenía sentido.

1 INTRODUCCIÓN

1.1. Definición y relevancia del estudio de las Actividades de la Vida Diaria (AVD) en la sociedad.

Las Actividades de la Vida Diaria (AVD) se definen como aquellas conductas orientadas hacia el cuidado del propio cuerpo, o a la interacción con el entorno (Moruno & Romero, 2006). Dentro de ellas, podemos distinguir dos grandes grupos: las Actividades Básicas de la Vida diaria (ABVD), dedicadas a acciones de auto mantenimiento y autocuidado, como alimentarse o realizar la higiene corporal, y, por otro lado, las Actividades Instrumentales de la Vida Diaria (AIVD), definidas como acciones más complejas orientadas a interactuar con el entorno, tales como el uso del teléfono, el manejo y control sobre la medicación o la gestión de asuntos económicos (Moruno & Romero, 2006).

La independencia personal en la ejecución de las AVD es muy importante para el ser humano por múltiples razones. Por un lado, las AVD se consideran elementos que favorecen la estructuración del tiempo, además de conformarse como mecanismos de adaptación al medio. Adicionalmente, se configuran como formas de expresión de la capacidad de acción de cada individuo en el mundo y como señas de identidad personal, sexual y social que forman parte de la propia subjetividad y favorecen el sentimiento de pertenencia a un grupo (Moruno & Romero, 2006). En consecuencia, la aparición de una enfermedad que merme la independencia en las AVD, puede afectar enormemente la percepción de control y autoeficacia que posee la persona, generándose, de este modo, expectativas de incontrolabilidad y un deterioro del autoconcepto que se traducirán en una fuerte inestabilidad emocional (depresión, ansiedad, irritabilidad) y falta de motivación (Bandura, 1977; Seligman, 1975; Seligman & Weiss, 1980). Además, la dependencia en las AVD no sólo afecta al propio enfermo, sino que también acarrea un gran desgaste físico, psicológico y económico para familiares y cuidadores. Por último, este tipo de dependencia tiene una importante repercusión social al incrementar enormemente el gasto económico para el sistema sanitario, ya que supone la necesidad de contratación de cuidadores con gran dedicación, así como la creación de instituciones donde se ofrezca una asistencia integral a este tipo de pacientes. Por tanto, uno de los grandes retos de la sanidad actual es el avance científico y tecnológico, así como la puesta en marcha de una serie de medidas evaluadoras y rehabilitadoras que promuevan la autonomía y capacitación de las personas que, por diversos motivos, han visto limitada su autonomía en las AVD.

El buen desarrollo de las AVD se incluye dentro del concepto holístico de salud. Se ha llegado a establecer como indicador de salud la capacidad del individuo para interactuar con su entorno, lograr un equilibro práctico y dirigir su propia vida (Polonio, Durante, & Noya, 2001). Son muchas las patologías de cualquier índole que causan restricciones o limitaciones en la capacidad funcional, y que, por tanto, dificultan la ejecución de las AVD. Como ejemplo de la importancia que las AVD tienen en la actualidad se puede destacar que en la demencia (o Trastorno Neurocognitivo mayor, como se denomina ahora en el DSM-V (Manual Diagnóstico y Estadístico de los Trastornos Mentales, American Psychiatric Association, 2013) el diagnóstico se establece cuando los déficits del individuo interfieren con su desempeño funcional. Más aún, hasta unos años la preservación de las AVD era el principal criterio de diagnóstico diferencial entre Deterioro Cognitivo Leve (DCL) y demencia.

La relevancia de las AVD es tal que ya no se limita a un campo de estudio de ciertas disciplinas profesionales, sino que se constituye como uno de los principales retos de la política social de los países desarrollados. Así, lo demuestra la actual Ley de Dependencia (Ley 39/2006) que asume el desafío de atender las necesidades de aquellas personas que se encuentran en situación de dependencia, entendida como un estado permanente derivado de la edad, enfermedad, discapacidad física, intelectual o mental que se puede producir en cualquier etapa de la vida. Este estado se caracteriza por la necesidad de atención personal para llevar a cabo las AVD y para mantener la autonomía, entendida como la capacidad para afrontar y decidir asuntos personales en función de los valores y preferencias propias (Alberto et al., 2009).

Por tanto, la autonomía personal en las AVD ya no es un campo del que tengan que ocuparse exclusivamente las familias de las personas en situación de dependencia o determinados profesionales, sino toda la sociedad, al entenderse como un problema social que afecta a todos, en mayor o menor medida. En definitiva, las repercusiones personales, familiares y sociales que tiene la afectación de las AVD constituyen sólidos argumentos para seguir indagando y mejorando los instrumentos de evaluación y las técnicas de intervención de la discapacidad funcional en la vida cotidiana.

La discapacidad en la realización de las AVD puede producirse tanto a causa de enfermedad física como mental. En la actualidad existe un mayor desarrollo científico y tecnológico sobre los aspectos que producen y reducen la dependencia de carácter físico en las distintas AVD, debido quizás a que tradicionalmente las disciplinas que más han estudiado las AVD se han interesado en mayor medida por los aspectos físicos implicados en su realización. Prueba de ello, es el gran desarrollo que han experimentado las técnicas restauradoras motoras y el diseño del equipamiento adaptado (ayudas externas) para rehabilitar o compensar los déficits sensoriales y motores que impactan en las AVD. Por el contrario, se conoce aún poco del impacto de los déficits cognitivos en las AVD, a pesar de haberse incrementado el número de pacientes con daño cerebral de distintas etiologías (traumatismos craneoencefálicos, accidentes cerebrovasculares, tumores, enfermedades neurodegenerativas, etc) que ven mermadas sus capacidades funcionales por las secuelas cognitivas y emocionales que presentan (déficits de memoria, de atención, apraxias, trastornos disejecutivos, etc). El grado de dependencia que llegan a manifestar excede incluso a lo que sería esperable por los problemas físicos que algunos pacientes puedan exhibir. Por ejemplo, desde los inicios de la psicología y la neuropsicología se han descrito lo que se conoce como "errores de la acción" ("*slips of action*"), donde personas sanas cometen errores de modo espontáneo, pero corrigiéndolos inmediatamente después. Sin embargo, no sucede igual en el caso de pacientes con alteraciones cerebrales o en pacientes que, sin alteraciones motoras, muestran una completa desorganización de la acción ("Síndrome de Desorganización de la Acción"). La descripción de numerosos casos de este tipo y las preguntas en relación al modo en el que esto afecta a la independencia funcional del paciente, han despertado un creciente interés desde disciplinas como la Neuropsicología Cognitiva y la Terapia Ocupacional. Dichas disciplinas recientemente han empezado a estudiar científicamente y en profundidad la relación entre los déficits cognitivos que se producen como consecuencia de diferentes patologías cerebrales y las alteraciones funcionales que interfieren en la ejecución en las AVD (Baum et al., 2008; Bettcher, Giovannetti, Macmullen, & Libon, 2008; Farias et al., 2008; Godbout, Grenier, Braun, & Gagnon, 2005; Nott, Chapparo, & Heard, 2009)

1.2. Evaluación de los procesos cognitivos en las actividades de la vida diaria.

Son muchos los procesos cognitivos que median el buen funcionamiento en las AVD. Es fácil imaginar que, para que una persona sea independiente a la hora de preparar una tostada, tiene que ser capaz de reconocer visualmente los útiles implicados, tales como el cuchillo, el pan o el tostador (gnosias visuales) o saber cómo cortar el pan e introducirlo en la tostadora (praxias ideomotoras). Igualmente es necesario que la persona recuerde la secuencia de acciones completa y así evite la omisión de pasos (memoria sobre la estructura jerárquica y organizada de la acción). Resulta imprescindible, además, que se preserven las funciones atencionales y ejecutivas, de modo que sea capaz de iniciar la acción de forma independiente, de realizar la secuencia de acciones en el orden correcto, de asociar cada utensilio a su función concreta. Es importante de la misma manera, poder inhibir la repetición de un paso ya realizado (perseveraciones) o le realización conductas automáticas hacia otros estímulos relacionados que estén al alcance (por ejemplo, la presencia del salero junto al bote de mermelada) pero que no forman parte de la actividad concreta que deseamos realizar (inhibición de conductas de utilización). Por último, se requiere que las personas tengan preservadas las funciones de tipo meta-cognitivo tales como detectar la realización de un error (monitorización del error) y corregirlo espontáneamente, o la capacidad para dar por terminado un paso o la tarea completa (recoger y alcanzar el objetivo).

El primer paso para estudiar científicamente la relación existente entre función cognitiva y actividad de la vida diaria, sería encontrar una buena herramienta de evaluación del funcionamiento cognitivo cotidiano que permita examinar a distintos grupos de pacientes con deterioro cognitivo en función de su patología o área cerebral afectada. Además, sería interesante que esta herramienta incorporara en la clínica, los avances que se han ido produciendo en la investigación sobre AVD. En este apartado se revisarán los principales instrumentos de medida que se han usado para conocer esta relación.

Escalas de evaluación del grado de deterioro global-funcional en AVD.

Tradicionalmente, las evaluaciones de las AVD se han basado en escalas que se administran a un informador fiable, generalmente el cuidador principal del paciente, como el *Índice de Barthel* de actividades básicas de la vida diaria (Mahoney & Barthel, 1965) o la *Escala de Lawton y Brody* de independencia en las actividades instrumentales de la vida diaria (Lawton, 1982). Ambos instrumentos, a través de preguntas a un informador fiable o a un profesional, indagan sobre el nivel de dependencia de las capacidades funcionales del individuo. Las puntuaciones asignadas a cada actividad se basan en el tiempo que tardan en la ejecución y la cantidad de ayuda física o verbal requerida, estableciéndose una calificación final que incluye a la persona en una categoría que va de la independencia a la dependencia (leve, moderada o grave).

Algunas de estas escalas, como la *Functional Independence Measure* (FIM) (Keith, Granger, Hamilton, & Sherwin, 1987) o *la Escala de demencia de Blessed* (Blessed, Tomlinson, & Roth, 1988) incluyen cuestiones, pocas, acerca del funcionamiento cognitivo (memoria, lenguaje), cambios en personalidad o interacción social.

El uso de este tipo de escalas se ha extendido entre los profesionales clínicos, debido a que son fáciles y rápidas de administrar, no requieren excesiva especialización para su corrección e interpretación y proporcionan información acerca del estado funcional general de un paciente. Sin embargo, resulta cuestionable su capacidad para indagar sobre el impacto de las alteraciones cognitivas en el desarrollo de las AVD. El colectivo de terapia ocupacional, profesionales que en su mayoría trabajan por la funcionalidad, destacan, entre otros aspectos, que el desuso de valoraciones estandarizadas se debe a la falta de sensibilidad para captar los resultados de los programas de intervención o los cambios que se van produciendo (Stapleton & McBrearty, 2009). Además de que contienen pocas cuestiones de cada AVD y que no en todos los casos se revisan las AVD más importantes, los posibles valores que toman con frecuencia son dicotómicos y no profundizan sobre las causas de estas disfunciones. Los motivos por los que un individuo no llega a alcanzar puntuaciones consideradas como normales en estas escalas, puede obedecer a limitaciones tan heterogéneas como discapacidad física, déficits cognitivos o alteraciones emocionales, entre otras.

Tests y valoraciones centradas en los aspectos cognitivos.

Una alternativa a las escalas funcionales ha sido la elaboración de instrumentos de medida diseñados para explorar más específicamente los déficits cognitivos, desde los cuales se pretenden inferir el nivel de capacitación para la ejecución de las AVD en diversas poblaciones (Duchek & Abreau, 1997)

Una de las autoras más conocidas en este terreno es Barbara Wilson, que ha diseñado y desarrollado baterías de evaluación de memoria, atención y funciones ejecutivas con el fin de establecer un puente de unión entre la capacidad cognitiva y la funcional. El test *Rivermead Behavioural Memory* (RBM) y su versión extendida ha demostrado poseer validez ecológica para captar las alteraciones de memoria que ocurren en el día a día de los pacientes con daño cerebral (Wilson, Cockburn, Baddeley, & Hiorns, 1989). Las principales tareas que incluye van desde la memoria verbal y la espacial hasta el recuerdo de caras y la recuperación de información autobiográfica relevante.

Con el mismo objetivo, Bárbara Wilson ha diseñado escalas de carácter más ejecutivo que exploran, de manera directa, las habilidades para planificar, cambiar de tarea y para realizar estimaciones temporales. Esta escala, denominada *Behavioural Assessment of the Dysexecutive Syndrome* (Wilson, Evans, Emslie, Alderman, & Burgess, 1998), ha demostrado que correlaciona con la capacidad para detectar los problemas en evaluaciones basadas en la ejecución, como una tarea de cocina en pacientes con daño cerebral (Frisch, Forstl, Legler, Schope, &

Goebel, 2012) además de establecerse como un predictor de las puntuaciones de una escala funcional en personas con esquizofrenia. (Katz, Tadmor, Felzen, & Hartman-Maeir, 2007).

Desde el campo de la Terapia Ocupacional también se han desarrollado otras baterías para medir, de manera general, los aspectos cognitivos que pueden están implicados en el quehacer diario, tales como la *Loewenstein Occupational Therapy Cognitive Assessment* (LOTCA) (Katz, Itzkovich, Averbuch, & Elazar, 1989) o la *Batería de Evaluación Neurológica para Terapeutas Ocupacionales de Chessington* (COTNAB) (Tyerman, Tyerman, Howard, & Hatfield, 1986). En estas baterías se exploran, con material similar a las evaluaciones neuropsicológicas, procesos como la percepción visual, en sus componentes más ejecutivos y práxicos, como los que se trabajan para la organización visuomotora o la capacidad visuoconstructiva; las capacidades ejecutivas de abstracción y categorización y, en relación con el lenguaje, la habilidad para seguir instrucciones. Se tratan de tests que presentan materiales poco ecológicos, en ningún caso familiares para los pacientes y que otorgan un índice global, que no permite distinguir entre subprocesos cognitivos a la base.

En un intento por delimitar los procesos cognitivos implicados en las AVD, también desde la Terapia Ocupacional, se diseñó la *Rivermead Perceptual Assessment Battery* (Whiting, Lincoln, Bhavnani, & Cockburn, 1985) que analiza los problemas perceptivos que pueden encontrarse en diversas poblaciones.

Sin embargo, las correlaciones entre estas medidas y la capacidad funcional no están del todo establecidas. Un estudio de rehabilitación con pacientes con daño cerebral demostró cómo diversas evaluaciones neuropsicológicas clásicas, entre ellas la RBM, no guardaban relación con los progresos funcionales en un programa de rehabilitación; debido, posiblemente a que, en el día a día, se ponen en juego más habilidades que las puramente mnésicas, que son las que principalmente evalúa el test (Quemada et al., 2003). Tampoco la valoración con el *Rivermead Perceptual Assessment Battery* ha correlacionado con resultados funcionales más allá de la propia categoría dicotómica de presentar o no una alteración visual-perceptual establecida (Donnelly, 2002).

Por todo ello, se empieza a poner en duda que este tipo de tests posean un grado de validez ecológica adecuado para hacer inferencias a la vida real, ya que, en todos los casos, se trata de tareas que carecen de material significativo para el paciente y no son similares a las que se ejecutan diariamente. Además, el entorno clínico donde se valora el funcionamiento cognitivo, a veces, es muy distinto al ambiente cotidiano, ya que, por ejemplo, en los estudios comentados en este apartado, no existen distractores, las tareas son nuevas, cortas, se realizan de una en una y se da apoyo indistintamente de si las personas obtienen éxito o fracaso (Long & Collins, 1997; Long & Kibby, 1995; Sbordone, 1996).

Valoraciones cognitivas – funcionales.

Existe una tercera categoría de valoraciones, las cuales pretenden describir los fallos cognitivos desde tareas más ecológicas. En este sentido, uno de los cuestionarios más populares ha sido el *Cuestionario de Fallos Cognitivos* (Broadbent, Cooper, Fitzgerald, & Parkes, 1982). Esta valoración, a través de 25 ítems, aborda los fallos cognitivos que pueden observarse en tareas cotidianas, como por ejemplo, si a la persona se le olvida apagar la luz, si tiene dificultades en atender a las señales de tráfico o la periodicidad con la que se enfada. Se valora su frecuencia mediante una escala tipo Likert que va desde el 1 al 5, siendo 1 una conducta que se lleva a cabo muy a menudo y 5 nunca. Se trata de una prueba auto-informe, por lo que se suele administrar a personas en estadios leves de deterioro. Aunque la potencia estadística no es muy alta, las preguntas de este cuestionario se agrupan en 3 subescalas: Memoria, Atención y Fallos de control. Otra escala muy similar al Cuestionario de Fallos Cognitivos, centrada especialmente en las funciones ejecutivas, ha sido el *Cuestionario Disejecutivo* (DEX- *"Dysexecutive Questionnaire"*) (Barker, Morton, Morrison, & McGuire, 2011). En este caso, sus 20 ítems se agrupan en 3 apartados: comportamiento, cognición y emoción. Tiene dos versiones, dependiendo de si es el propio paciente quien contesta el cuestionario o lo hace un informador fiable.

Más recientemente se ha diseñado la escala *E-Cog* (Farias et al., 2008), que pretende captar, a través de un informante externo, las habilidades o déficits que presenta el paciente en diferentes ámbitos cognitivos que se ponen en marcha en el día a día. Los ítems que se incluyen en la escala abordan seis categorías cognitivas diferentes: memoria, lenguaje, habilidades visuoespaciales, organización, planificación, y atención dividida. La escala ha resultado útil para detectar diferencias en habilidades mnésicas entre personas sanas y personas con DCL y entre esta población e individuos con demencia tipo Alzheimer en capacidades verbales. No obstante, esta escala parece ser poco sensible para la exploración de las funciones ejecutivas (organización, planificación, y atención dividida) que resultan esenciales para llevar a cabo las AVD (Aretouli & Brandt, 2010; Hughes, Chang, Bilt, Snitz, & Ganguli, 2012; Marshall et al., 2011; Pereira, Yassuda, Oliveira, & Forlenza, 2008).

Aunque estas pruebas de medición son, sin duda, interesantes aproximaciones al campo de la funcionalidad, presentan también algunos inconvenientes. Uno de los más importantes es que las preguntas sobre déficits cognitivos específicos no se circunscriben a ninguna actividad en concreto. Como ya se sabe, una simple actividad podría estar mediada por diferentes funciones cognitivas, independientemente de que estén implicadas unas más que otras, según la tarea que se trate. Una mayor contextualización de las preguntas podría contribuir a mejorar el proceso de evaluación.

Valoración de la funcionalidad a través de medidas basadas en la ejecución directa de las Actividades de la Vida Diaria.

La mayor parte de los instrumentos descritos en los apartados anteriores han recibido críticas por su falta de validez o por apoyarse casi exclusivamente en datos proporcionados por un informante. Una alternativa a estas propuestas ha surgido de las investigaciones que solicitan al paciente que realice ciertas AVD, similares a las que haría en su vida cotidiana, y posteriormente, mediante la observación y el estudio interjueces, clasificar su ejecución en diferentes categorías de respuesta.

En este sentido, una de las más validadas ha sido la *Direct Assessment of Functional Status* (DAFS) (Loewenstein et al., 1989) en la cual, a los pacientes se les pide que lleven a cabo ciertas actividades básicas tales como alimentarse o vestirse; así como actividades instrumentales, mostrando su habilidad para orientarse espacialmente y trasladarse a diferentes zonas de la ciudad, comprando y manejando asuntos económicos. Esta evaluación también incluye orientación temporal y habilidades de comunicación. La batería DAFS ha sido usada, por ejemplo, para valorar la capacidad funcional de pacientes con DCL y ha permitido detectar sus dificultades en AVD instrumentales tales como el manejo del dinero y en las compras (Pereira et al., 2010). Otras escalas como la *Structured Assessment of Independent Living Skills (SAILS)* (Mahurin, Debettignies, & Pirozzolo, 1991) o la *Occupational Therapy Evaluation of Performance and Support (OTEPS)* (Nadler, Richardson, Malloy, Marran, & Brinson, 1993) se han empleado para valorar la funcionalidad de pacientes con demencia de acuerdo al tiempo de ejecución de las tareas, la exactitud y el grado de dependencia-independencia en su realización. Sin embargo, y como sucedía en las escalas contestadas por un informador, estas medidas tampoco están exentas de críticas, ya que valoran el estado general del paciente, sin prestar suficiente atención al proceso o procesos que originan su disfuncionalidad.

El *Cognitive Performance Test* (Burns, Mortimer, & Merchak, 1994) se diseñó para analizar cualitativamente los procesos que subyacen a los problemas funcionales en pacientes con alteraciones cognitivas. Basado en la teoría de la discapacidad cognitiva de Allen, en este test se pretenden conceptualizar las consecuencias funcionales de las alteraciones cognitivas que puede presentar un paciente, desde el nivel 1, donde la persona está en coma, hasta el nivel 6, donde existe la capacidad de llevar a cabo acciones planeadas. Este test, basado en el análisis de la actividad y en los procesos de adaptación, evalúa la ejecución de seis tareas que varían según los requerimientos de procesamiento de la información que demanden, acorde con los niveles ordinales de discapacidad funcional. Bien es cierto, que este test permite delimitar, ciertas consideraciones cognitivas causantes de los problemas funcionales, ya que analiza si la persona es capaz de integrar estímulos internos, propioceptivos, puede realizar acciones rutinarias o es capaz de planificar acciones motoras. Sin embargo, dentro de estas categorías, tampoco profundiza en el proceso cognitivo específico subyacente a estos problemas.

De esta forma, el test *Executive Function Performance Test*, ha sido una de las valoraciones, dentro de esta categoría, que se ha centrado en estudiar específicamente las funciones ejecutivas necesarias para llevar a cabo diversas AVD. Este test, basado en la observación de la ejecución de cuatro tareas: cocinar, usar el teléfono, gestión de medicamentos y pago de facturas, pretende analizar las capacidades ejecutivas para iniciar, organizar, secuenciar, estimar la seguridad y terminar de modo apropiado una tarea. Las puntuaciones que se pueden otorgar van en una escala desde 0 a 5, donde la puntuación "0" indica una total independencia para ese ítem dentro de una tarea y la puntuación "5" una dependencia total. Esta escala ha sido sensible, por ejemplo, para detectar problemas ejecutivos cotidianos en diversas poblaciones, como pacientes con daño cerebral leve y moderado (Baum et al., 2008), esclerosis (Goverover et al., 2005) o esquizofrenia (Katz, Todmor, Felzen, & Hartman-Moeir, 2007).

Otra de las pruebas que se puede incluir dentro de esta categoría, diseñada por terapeutas ocupacionales, es la *Assessment of Motor and Process Skills (AMPS)* (Fisher, 2006a, 2006b). Esta valoración funcional estandarizada diseñada para medirla calidad de desempeño en las AVD, evalúa habilidades motoras y de procesamiento cognitivo que impactan en el desarrollo de diversas actividades cotidianas. El *AMPS* se basa en la observación rigurosa de la realización de dos actividades significativas, que son elegidas por la propia persona, de entre un conjunto de actividades previamente seleccionadas por el evaluador. Para la medición, el *AMPS* ofrece un amplio abanico de actividades posibles a realizar, que se va ampliando a medida que investigadores y clínicos van validando nuevas tareas, con el objetivo de usarlas en sus propios contextos culturales. El procedimiento de evaluación consiste en la observación y el registro, mientras se está realizando la actividad, de 16 ítems relacionados con las habilidades motoras y 20 con las de procesamiento cognitivo según cuatro criterios: nivel de esfuerzo, eficiencia, seguridad e independencia al realizar la actividad. En relación con las habilidades de procesamiento, esta herramienta distingue varias cuestiones a tener en cuenta en la ejecución de una tarea, como son la aplicación del conocimiento, organización temporal, organización de los espacios y de los objetos, habilidades relacionadas con la resolución de problemas, así como la capacidad para aprender y adaptarse a la ejecución. El conocimiento de la evaluación en sí y de lo que se valora en cada item, permite darnos cuenta de que la terminología usada para describir estas habilidades de procesamiento guarda poca relación con los términos usados por la Psicología para referirse a ciertas capacidades cognitivas. Así, por ejemplo, el item en el *AMPS* denominado "Aplicación del conocimiento" combina procesos tanto de memoria semántica como práxicos, así como otras cuestiones que pueden deberse a problemas atencionales o incluso de seguridad personal, al penalizar si pregunta al examinador por algo que debía haberse quedado claro antes de comenzar la actividad. Este hecho genera una falta de comunicación entre los profesionales e investigadores que trabajan con personas que presentan alteraciones funcionales, lo cual es una merma para avanzar de manera multidisciplinar.

Tanto las puntuaciones motoras como las de procesamiento son registradas de manera independiente mediante una aplicación informática particular del *AMPS*, proporcionando un informe de evaluación en relación con las capacidades de la persona. Si bien es una herramienta de evaluación que tiene como centro de interés la propia AVD y profundiza, mejor que las escalas y los tests mencionados, en los procesos que subyacen a la disfuncionalidad, también presenta inconvenientes. Entre los más importantes están 1) requiere de una costosa y extensa formación para su administración, 2) emplea términos que no son compartidos por otras disciplinas que se interesan también por el estudio de las AVD, con lo que dificulta el intercambio de información con otros profesionales, 3) los materiales varían en cada caso, según la persona evaluada. 4) no existe un control sobre la presencia de objetos en las diversas actividades, y ni siquiera de los contextos en los que las AVD se realizan.

En resumen de todo lo expuesto, se puede concluir que la delimitación de los procesos cognitivos que subyacen a las AVD resulta complicada porque los instrumentos de evaluación que se emplean con frecuencia, principalmente, se centran en procesos determinados o bien calculan índices globales que no permiten delimitar los procesos cognitivos alterados. Además, en muchas ocasiones no tienen suficiente validez ecológica, no utilizan términos comunes a otras disciplinas interesadas en las AVD, o bien no controlan experimentalmente la selección de la muestra, los materiales y distractores que se presentan o, en definitiva, los contextos en donde las AVD se realizan. Como una alternativa a estos procedimientos clásicos, hemos elaborado la creación de una escala cognitiva de ABVD y AIVD que describiremos en detalle en la serie experimental 5 de esta tesis. La escala se basa, en una línea de investigación que recientemente está cobrando especial relevancia en el estudio de las AVD y que se encuadra dentro de el *Naturalistic Action Test,* así como de la propuesta del grupo de investigación de Glyn Humphreys sobre los procesos cognitivos que intervienen en las AVD.

Dentro del campo de la Neuropsicología, el *Naturalistic Action Test* (Schwartz, Segal, Veramonti, Ferraro, & Buxbaum, 2002), basado en los estudios de Myrna Schwartz (Schwartz et al., 1999; Schwartz, Reed, Montgomery, Palmer, & Mayer, 1991), comienza a ganar protagonismo como una valoración útil, tanto para el ámbito clínico como para la investigación. Este test mide, a través de la observación de la conducta en tareas cotidianas con objetivo, los errores producidos por pacientes con diversas etiologías. Al paciente se le solicita que lleve a cabo tres tareas: 1) hacer un café y una tostada de mantequilla y mermelada, 2) envolver un regalo y 3) preparar la merienda y la cartera a un niño. Mientras que en la primera actividad sólo se ofrecen los útiles para realizar la tarea, en los otros dos casos se incluyen objetos distractores para que la persona tenga que hacer un proceso de selección del objeto correcto. Esta herramienta de evaluación, disponible de manera gratuita a través de internet, detecta el tipo de errores que se realizan en cada tarea, de acuerdo con la siguiente clasificación expuesta en la tabla 1.

Tabla 1. Clasificación de errores propuesta por el *Naturalistic Action Test*

- *Errores semánticos o de sustitución de objeto:* un objeto semánticamente relacionado se usa en el lugar del objeto apropiado (target) para esa tarea.
- *Errores de omisión*: omitir un paso necesario para completar la acción.
- *Error de secuencia*: una acción se realiza en un orden de pasos equivocado.
- *Errores de adición*: se añade una acción innecesaria para completar la acción.
- *Errores de calidad*: se juzga erróneamente la cantidad (espacial o en volumen) apropiada para una acción.
- *Sustitución gestual*: un objeto que es correctamente usado se utiliza con un gesto inapropiado.
- *Desorientación espacial o de agarre*: se orienta de manera errónea un objeto en relación con la mano o con otro objeto.
- *No-estimación espacial*: la relación espacial entre dos o más objetos es incorrecta.
- *Omisión de objeto*: no se usa un objeto que debería usarse y se realiza la acción con una parte del cuerpo.
- *Errores de perseveración*: una acción se repite después de haberla terminado.

De igual manera, los estudios de Humprheys y Forde (1998) han contribuido a ofrecer herramientas para la observación de las actividades de la vida diaria con fines de investigación, principalmente. Aunque los códigos de observación se han basado en los trabajos de Schwartz y cols., estos autores han introducido algunos matices en la clasificación de errores. Así, Humprheys y Forde diferencian entre repetir un paso, intercalando otros, como por ejemplo echar azúcar al café, calentar la leche y volver a echar azúcar y las perseveraciones que se producirían cuando una persona insiste y repite en un paso que actualmente se está llevando a cabo, aunque el objetivo se haya completado, como por ejemplo no parar de echar azúcar a la taza de café. Esta diferenciación no es arbitraria y está basada en mecanismos cognitivos diferenciados que se revisarán en próximos apartados.

Además, la investigación en este campo también está introduciendo nuevas categorías de errores más sutiles, que pueden observarse en individuos que presentan déficits leves, pero que son autónomos en la vida diaria, como ocurre en las personas diagnosticadas de DCL (Seligman, Giovannetti, Sestito, & Libon, 2013).

1.3. Análisis de los patrones de error en la realización de las AVD. Una aproximación al estudio de los procesos cognitivos implicados en AVD.

La evidencia científica ha demostrado que los procesos cognitivos son necesarios para llevar a cabo las AVD, sin embargo, todavía no se conoce en profundidad qué peso tiene cada una de las funciones cognitivas en la ejecución de cada tarea. Una de las estrategias utilizadas para investigar sobre las relaciones entre función cognitiva, función cerebral y capacidad funcional ha consistido en seleccionar distintos grupos de pacientes en función de su alteración cerebral, a los que se les administran una serie de tests clásicos de corte neuropsicológico que miden distintos procesos cognitivos de manera aislada, tales como atención, memoria o reconocimiento de objetos. Por otro lado, se les realizan valoraciones de corte funcional que evalúan la ejecución en diferentes AVDs. Finalmente, se analiza el patrón de correlaciones existente entre estos dos tipos de medidas para los distintos grupos de pacientes (Baum et al., 2008; Bettcher et al., 2008; Farias et al., 2008; Godbout et al., 2005). Correlacionar el tipo de error funcional con los procesos cognitivos que normalmente median las estructuras cerebrales afectadas constituye una estrategia para conocer los circuitos neuroanatómicos y los procesos cognitivos subyacentes, de cuya integridad depende la correcta ejecución de una determinada AVD.

En este sentido, una de las aproximaciones de investigación más prolíficas y prometedoras, está siendo el análisis de los diferentes patrones de errores que distintas poblaciones con daño cerebral adquirido o procesos neurodegenerativos, cometen en diferentes actividades de la vida diaria medidos de modo directo, tal y como hemos descrito en el apartado anterior.

Las primeras investigaciones realizadas con esta última estrategia de investigación se centraron en la evidencia encontrada en sus estudios de un patrón de error muy similar en pacientes con diversas patologías cerebrales. Así, pacientes con traumatismo craneoencefálico (Schwartz et al., 1998) pacientes con lesión en el hemisferio izquierdo (Buxbaum, Schwartz, & Montgomery, 1998) o derecho (Schwartz et al., 1999) pacientes con lesiones frontales bilaterales (Humphreys & Forde, 1998) o pacientes con demencia (Giovannetti, Libon, Buxbaum, & Schwartz, 2002) presentaron un patrón de error muy similar, caracterizado por una gran cantidad de errores de omisión y errores de secuenciación frente a otro tipo de errores. Además, algunos de estos estudios encontraron una relación directa entre el deterioro cognitivo global y el número de omisiones. La falta de especificidad y la fuerte relación entre deterioro cognitivo global y la presencia de omisiones, fue determinante para establecer la **"teoría de los recursos globales"** según la cual, las funciones cotidianas consumen recursos, de modo que cuando éstos son limitados, debido a la presencia de cualquier alteración cerebral, afectan por igual a todas las funciones cognitivas y a la posibilidad de producir cualquier tipo de error en las AVD (Schwartz et al., 1998). De este modo, aunque los pacientes muestren un perfil neuropsicológico diferencial con respecto a las funciones afectadas, el responsable último de los fallos en AVD es una falta global de recursos.

Aunque esta teoría ha supuesto un esfuerzo por explicar con datos empíricos el origen cognitivo de los errores funcionales, estudios recientes han criticado el modelo debido a fallos en el control experimental. Una de las cuestiones principales podría ser la selección de pacientes. La muestra de pacientes no se agrupaba en función de la lesión que presentaban y, en su mayoría, tenían lesiones muy extensas que afectaban a múltiples funciones cognitivas. Tampoco se controlaba la lateralidad ni la variabilidad de las lesiones dentro de cada grupo. Se requiere, por tanto, un mayor rigor en la selección de la muestra y en la manipulación de las condiciones experimentales a las que van a ser sometidos los pacientes. Y, por supuesto, se necesita un grupo control con el que comparar la ejecución de los pacientes en cada tarea.

Es aquí donde la Neurociencia Cognitiva está realizando una gran aportación al estudio experimental de las AVD, ya que además de introducir un mayor rigor metodológico en la selección de la muestra y en el diseño experimental, dispone de modelos teóricos apropiados que pueden ayudar a integrar mejor los datos que se han descrito y a avanzar en nuevas hipótesis para seguir delimitando los procesos que subyacen a la realización de las AVD. Sin embargo, los métodos y diseños de la neurociencia cognitiva tradicionalmente han estado alejados del estudio de tareas cotidianas.

No obstante, el modelo de control de la acción propuesto por Norman y Shallice (1983) enmarca de manera sucinta el control cognitivo en relación con las actividades de la vida diaria. Este modelo, que se mediatiza por ciertos esquemas mentales que especifican la interpretación de las entradas o inputs externos y la subsiguiente acción o respuesta, está compuesto por dos partes fundamentales. Por un lado, el Dirimidor de conflictos (DC) ("*Contention Scheduling*", *CS*) encargado de poner en marcha actividades rutinarias a través de esquemas de acción. Los esquemas de acción representan las estructuras abstractas de unas secuencias de acción aprendidas, independientemente de los objetos con los que se realicen dichas secuencias, como por ejemplo, hacer un café. A su vez, estos esquemas contienen componentes o subesquemas, que pueden compartirse entre diversos esquemas de acción (Cooper, 2002). Los esquemas de tareas rutinarias almacenados se activan gracias a estímulos ambientales desencadenantes, los cuales se mantienen activos hasta que el objetivo se haya cumplido o hasta que otro esquema de tarea lo inhiba de manera recíproca. La activación de este esquema debe ser lo suficientemente alta como para superar el umbral necesario para llevar a cabo la acción. Sin embargo, con este sistema únicamente seríamos capaces de llevar a cabo acciones gracias a disposiciones ambientales, pero en ausencia de estas señales, no realizaríamos ninguna acción o perseveraríamos repetidamente. Por este motivo, Norman y Shallice proponen la otra parte de su modelo, el Sistema Atencional Supervisor (SAS), el cual está implicado en el control de acciones intencionales, voluntarias, que requieren un control cognitivo de alto nivel, por lo que regula la actividad de DC. De esta forma, el SAS modula la selección rutinaria de operaciones, cuando ésta no resulta apropiada. Ante situaciones novedosas, que requieren planificación o donde es necesaria la inhibición de esquemas competidores, el SAS actuaría resolviendo.

Ya en el contexto de las AVD y basándose en varios estudios llevados a cabo con pacientes con demencia y DCL, ha surgido un modelo reciente apuntando una distinción clara, similar a la que plantean Norman y Shallice en su modelo, entre dos tipos de errores comunes en las AVD con diferentes relaciones cognitivas. Giovannetti y colaboradores (2008), en contra de la teoría de los recursos globales, postulan una clara diferenciación entre los errores de tipo de omisión, frente a los errores de comisión (Giovannetti, Bettcher, Brennan, Libon, Kessler, et al., 2008; Seidel et al., 2013). Dentro de los errores de comisión, se incluirían todas aquellas conductas realizadas de manera incorrecta, esto es, fallos de secuenciación, sustitución de objeto, perseveraciones, así como adiciones. Giovannetti y cols (2008), introducen además en esta categoría errores relacionados con alteraciones práxicas, como la desorientación espacial o de agarre, la no-estimación espacial y la sustitución gestual. Además, añade errores de calidad y omisiones de objetos. Mientras que los errores de omisión se han relacionado y han sido predichos por medidas globales cognitivas, así como por valoraciones de memoria episódica, los errores de comisión han sido predichos por medidas ejecutivas.

Aunque en ocasiones se incluyan todos estos tipos de errores en la categoría de comisión, también se ha hecho diferenciación dentro de esta categoría, debido a los resultados obtenidos y los correlatos neurales que se han hallado. De esta forma, se diferenciaría entre comisión dentro de la tarea y fuera de la tarea. Las comisiones dentro de la tarea incluirían todos los errores explicados, a excepción de los errores de adición que formarían parte de las comisiones fuera de la tarea. Los errores de adición, por tanto, harían referencia a aquellas conductas que se ejecutan fuera del esquema de la tarea, tales como comerse el alimento preparado o usar un utensilio que no es el objetivo. Dichos errores se han relacionado con el volumen en la sustancia blanca profunda, en la corteza gris y en el hipocampo (Seidel et al., 2013). Por sus correlatos neurales, se plantea que estas acciones podrían responder a una combinación de procesos de memoria con procesos de control cognitivo.

En esta misma línea, el grupo liderado por Glyn Humphreys también ha contribuido a delimitar los procesos cognitivos implicados en las AVD, distinguiendo entre procesos relacionados con los procesos mnésicos y los que implican el control ejecutivo (Ver Figura 1).

Siguiendo este esquema, se irán describiendo las investigaciones que han abordado el estudio de estos procesos, con el objetivo de conocer el peso y las características de su contribución al campo de las Actividades de la Vida Diaria. De acuerdo con los resultados obtenidos, se podrá comprobar que muchos de los procesos implicados en los errores que se observan en las AVD pueden explicarse por déficits en el sistema de control cognitivo.

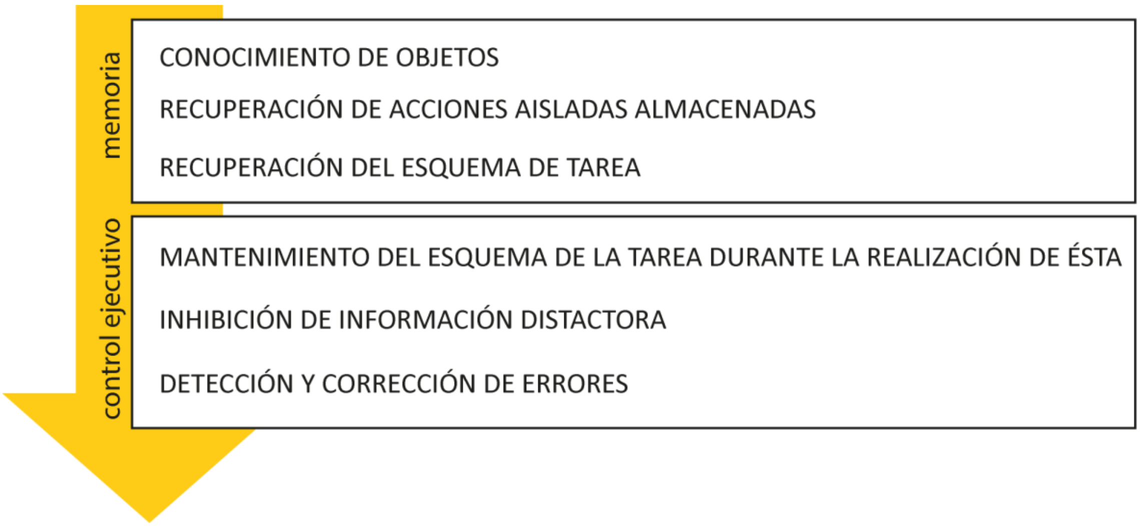


Figura 1. Procesos cognitivos implicados en la ejecución de las AVD.

Memoria

Déficit en el conocimiento de los objetos. Problemas de memoria semántica ¿Suficiente para generar errores en las AVD?

Con el objetivo de conocer específicamente la contribución de un proceso cognitivo concreto, como la memoria semántica, a la ejecución de las AVD, diversos estudios han seleccionado de manera cuidadosa pacientes con determinadas alteraciones cognitivas. Los déficits en memoria semántica generan dificultades en el acceso al conocimiento semántico de los objetos con los que se trabajan (qué son, para qué se usan, con qué objetos están relacionados, etc), por lo que, podría pensarse que su afectación pudiera originar diversos tipos de errores funcionales. Sin embargo, pacientes que presentan alteraciones en estas funciones no parecen mostrar problemas a la hora de llevar a cabo tareas cotidianas. Apoyando esta idea, Buxbaum y cols (1997) así como Riddoch y cols (2002) y Bier y cols (2013) mostraron que no es suficiente un déficit en la memoria semántica para acarrear errores en el encadenamiento de las AVD en pacientes con patologías neurodegenerativas. Un paciente con demencia semántica, aún a pesar de sus problemas para acceder al significado de los objetos, llevó a cabo una ejecución de AVD dentro de la normalidad (Buxbaum et al., 1997). Sin embargo, otro paciente con demencia y sin problemas semánticos, pero sí ejecutivos, hizo un buen uso de los objetos, aisladamente, pero presentó graves problemas al realizar tareas secuenciales con varios de ellos. Riddoch (2002) plantea que la ausencia de problemas funcionales ante déficits semánticos puede deberse a que las tareas rutinarias estén basadas en relaciones de visión-acción, desde la consolidación de la información a través de un aprendizaje asociativo, lo cual genera una representación de cadenas secuencialmente ordenadas. En este sentido, un estudio ha disociado el conocimiento conceptual semántico de los objetos (la llamada vía del "qué") y la capacidad para usarlo (la vía del "cómo"), incluso en la resolución de problemas a la hora de usar objetos nuevos (Hodges, Spatt, & Patterson, 1999).

Adicionalmente también puede deberse a esa capacidad que tienen los objetos para su potencial uso, debido a su propia configuración *("affordance")*.

En daño cerebral adquirido, también se ha demostrado que pacientes con buena memoria semántica generan graves errores a la hora de usar el conocimiento para llevar a cabo tareas que implicaban varios objetos (Forde & Humphreys, 2000). Los errores funcionales, parecen, por tanto, no tener relaciones tan directas con el buen o mal funcionamiento de la memoria semántica, sino más bien con problemas ejecutivos.

Recuperación de acciones individuales y Esquema de tarea

Una medida objetiva para evaluar la capacidad de recuperar acciones individuales y el esquema de la tarea ha sido el análisis y estudio de las omisiones de pasos. De manera general, a la hora de hacer un café, los pasos de servir café, leche, calentar la leche, poner azúcar y remover, se deben llevar a cabo para alcanzar el objetivo de preparar un café "al uso". Obviar algún paso y saltárselo conllevaría, por tanto, contabilizar una omisión. Las omisiones de pasos esenciales a la hora de realizar una tarea se han constituido como uno de los errores más documentados en los estudios con tareas basadas en la ejecución. Sin embargo, aún se discuten los mecanismos cognitivos que están a la base de este tipo de error. Investigaciones en pacientes con demencia tipo Alzheimer, mostraron cómo las **omisiones** de pasos esenciales para llevar a cabo la tarea pueden deberse a un fallo en la recuperación de los objetivos de la tarea, así como de las acciones necesarias para completarla (Giovannetti et al., 2008). De hecho, los autores plantean que estos fallos funcionales fueron predichos por la realización de pruebas de memoria episódica, pero también por medidas de cognición global como el Mini-Mental. Apoyando la diferenciación entre tipos de errores, Giovannetti y colaboradores destacaron las formas por las cuales personas sanas, pacientes con DCL y demencia cometen diversos errores. Frente a los pacientes con demencia que generan tanto errores de omisión como de comisión (errores que implican generar una acción incorrecta) en igual proporción, los participantes sanos y los pacientes con DCL presentaron una distribución asimétrica, donde prevalecieron los errores de comisión frente a los de omisión que eran menos frecuentes (Giovannetti, Bettcher, Brennan, Libon, Burke, et al., 2008). Desde este planteamiento, las omisiones podrían producirse por fallos en la selección adecuada de un esquema de acción, de entre muchos competidores, por lo que ninguno de los esquemas de acción candidatos alcanzaría un nivel de activación tal que permitiera superar el umbral necesario para ejecutarse.

No obstante, aunque parece clara la contribución del recuerdo y la recuperación de las acciones individuales y el esquema de la tarea en la correcta ejecución de las AVD con objetivo, todavía no se conocen con exactitud a qué déficits cognitivos concretos se puede atribuir la generación de la categoría más frecuente de error en todos los grupos de pacientes estudiados, la omisión de pasos. Aunque en ciertos pacientes, como los que presentan demencia tipo Alzheimer, este déficit se podría explicar por los graves fallos de memoria que presentan, otras poblaciones con alteraciones ejecutivas añadidas, también han cometido este tipo de error. En este sentido, la contribución de los estudios con pacientes con "Síndrome de Desorganización de la Acción" ha sido esencial. El término del "Síndrome de Desorganización de la Acción" viene dado por una serie de estudios de investigación donde se pusieron de manifiesto errores de acción a la hora de llevar a cabo diversas actividades de la vida diaria en pacientes con distintas lesiones cerebrales. Según Humphreys y Forde (1998), el mecanismo de esta disfunción conlleva, por un lado, un déficit en el control automático de esquemas de actividades cotidianas en memoria y en el conocimiento secuencial, esto es, en el Dirimidor de Conflictos (DC), y por otro lado, debe manifestarse un fallo atencional en el Sistema Atencional Supervisor (SAS), por el cual haya una dificultad en desarrollar estrategias para alcanzar el objetivo de la tarea. El SAS también se encargaría de inhibir respuestas automáticas y comunes con los objetos no necesarios para llevar la acción propuesta. Estas alteraciones funcionales presentadas, por tanto, son de diferente índole de las que pudiera llevar a cabo un paciente con alteraciones exclusivas en las funciones ejecutivas.

Investigaciones con estos pacientes han profundizado, a través de manipulaciones experimentales muy precisas, en el origen de las omisiones de los pasos. Así, por ejemplo, a un paciente con Síndrome de Desorganización de la Acción que presentaba un número importante de omisiones en diversas actividades y bajo diferentes condiciones, se le pidió que guiara a un experimentador en la realización de una tarea, mediante la verbalización de los pasos que debía dar (Morady & Humphreys, 2011). El número de omisiones y de fallos de secuenciación se redujo considerablemente bajo esta condición, lo cual pone de manifiesto que la capacidad para recuperar las acciones de manera secuenciada al menos en este paciente, no estaba afectada. Este hecho parece demostrar que las omisiones no se deben exclusivamente a un fallo en la recuperación de los pasos de la tarea, sino que, una vez más, se entrevé que la alteración, además, puede estar relacionada con las funciones ejecutivas o, más específicamente con el control cognitivo.

Investigaciones neuropsicológicas parecen apoyar también este hecho, desde estudios con pacientes con DCL multidominio (Seligman et al., 2013). Cuarenta y cinco personas con DCL multidominio fueron evaluados con dos pruebas neuropsicológicas, una de memoria episódica verbal y otra abordando diversas funciones ejecutivas. Los análisis de regresión mostraron que ninguna de las medidas predecía, en ningún caso, la omisión de pasos esenciales para la tarea. Por lo cual, según este estudio en población con DCL, no se corroboró la relación previamente encontrada entre fallos de memoria y omisiones de pasos.

Los estudios de neuroimagen con este tipo de tareas también muestran resultados contradictorios. Aunque desde el campo de la memoria, con tareas experimentales, los errores en omisión en tareas de adquisición de información, consolidación y recuerdo se han relacionado con la sustancia gris cortical del hipocampo, en la investigación sobre AVD, las omisiones de pasos esenciales de tareas cotidianas no han mostrado relaciones tan estrechas con estas zonas cerebrales. En este sentido, un reciente estudio en pacientes con demencia que realizaban la tarea NAT encontraron que este tipo de error se asociaba a un decremento en el volumen hipocampal, aunque la correlación no alcanzó niveles significativos (Seidel et al.,

2013) y, por tanto, no tuvo la suficiente potencia estadística para inferir una capacidad predictiva. Otros estudios, sin embargo, sí han hallado correlaciones y predicciones significativas entre los errores de omisión en la tarea NAT, igualmente evaluados en pacientes con demencia, con el volumen en zonas de la corteza entorrinal, hipocampo y giro parahipocampal, (Bailey, Kurby, Giovannetti, & Zacks, 2013), áreas cerebrales implicadas en la memoria declarativa. No obstante, cabe destacar que este último estudio también aparecía una correlación positiva y significativa entre el volumen de la corteza cingulada anterior y los errores de omisión, aunque no llegó a alcanzar capacidad predictiva.

En resumen, la mayoría de las investigaciones en este tema apuntan a una contribución importante de la memoria a la hora de recuperar las acciones individuales y el esquema de una tarea cotidiana. Sin embargo, del mismo modo, otros estudios no encuentran esta relación de manera tan clara. Un aspecto a tener en cuenta, es que ninguno de estas investigaciones disocia entre la recuperación de pasos y el mantenimiento del esquema en la tarea. Por tanto, y puesto que el mantenimiento del esquema de la tarea durante la ejecución se ha relacionado con aspectos ejecutivos, bajo este error podrían intervenir también procesos relacionados con el control cognitivo.

Control cognitivo

El sistema de control cognitivo, encargado de la regulación de la atención, actúa cuando las rutinas establecidas son insuficientes o cuando es necesario obviar parte de la información que se está procesando para alcanzar la tarea objetivo. Sería el eje central dentro del sistema de redes neurales de la atención propuesto por Michael I. Posner (Posner & Petersen, 1990). Este sistema modula y guía la activación de las otras redes atencionales: la red de alerta, que mantiene un estado de "arousal" necesario para la detección de estímulos y la red de orientación, que dirige la atención hacia un estímulo potencialmente relevante.

Los estudios con Resonancia Magnética Funcional, han puesto de manifiesto la activación de zonas frontales en participantes sanos cuando el sistema de control cognitivo se pone en juego. Asimismo, son numerosos los estudios que constatan alteraciones en este sistema en pacientes con daño cerebral frontal. El tipo de problema que pueden presentar estos pacientes son de diversa índole, pero todos ellos tienen un común denominador: un déficit del control del comportamiento y un fallo para alcanzar objetivos. Los déficits que manifiestan están relacionados con la incapacidad para generar respuestas auto-iniciadas (Burgess & Shallice, 1996), para controlar respuestas automáticas especialmente con lesiones frontales ventrolaterales izquierdas (Alexander, Stuss, Picton, Shallice, & Gillingham, 2007) y en zonas bilateriales superiores mediales (Stuss, Floden, Alexander, Levine, & Katz, 2001) o para inhibir el comportamiento en determinadas circunstancias cuando existe un daño en la corteza orbitofrontal medial (Szatkowska, Szymanska, Bojarski, & Grabowska, 2007).

No sólo ante lesiones específicas del lóbulo frontal se han encontrado problemas ejecutivos, también en otro tipo de patologías se han evidenciado este tipo de déficits. En este sentido, los pacientes con demencia tipo alzheimer en las fases iniciales, además de mostrar problemas de memoria episódica o de lenguaje, también suelen comenzar a tener fallos en las funciones ejecutivas, como demuestran los tests neuropsicológicos de atención dividida, abstracción, o fluidez semántica (Baudic et al., 2006). Estudios experimentales, recientemente también han corroborado estos resultados a través de tareas Simon, Stroop y tareas de cambio, mediante el análisis de la distribución de los TR (Tse, Balota, Yap, Duchek, & McCabe, 2010). Los pacientes con demencia fronto-temporal (variante de conducta), asimismo, han demostrado alteraciones ejecutivas puramente cognitivas o conductuales (Piquard, Lacomblez, Derouesne, & Sieroff, 2009; Rascovsky et al., 2011), y de hecho la presencia de éstas son requisito imprescindible para su correcto diagnóstico.

Incluso, estos déficits podrían aparecer en estadios previos a la demencia, como por ejemplo en algunas personas con DCL que posteriormente evolucionan a demencia.

Aunque existen varios subtipos, las alteraciones en múltiples procesos cognitivos son comunes dentro de este diagnóstico. Un consenso reciente establece que, al igual que en la demencia, no sólo es la memoria episódica la que empieza a estar fallando en estas personas, si no que las alteraciones pudieran estar mediadas por otros procesos, entre los que se incluyen las funciones ejecutivas (Albert et al., 2011). La importancia de estos procesos es tal que los déficits a este nivel, en pacientes con DCL multidominio, se han convertido en potentes predictores del desarrollo de una posible demencia tipo alzheimer (Backman, Jones, Berger, Laukka, & Small, 2005; Rozzini et al., 2007).

A continuación, exponemos los aspectos del control cognitivo que se han demostrado necesarios para la ejecución de tareas cotidianas.

Mantenimiento del esquema de la tarea

Una de las funciones de la red de control sería la de **mantener disponible la información para llevar a cabo las tareas requeridas** (Posner & Dehaene, 1994), lo cual se relaciona estrechamente con el ejecutivo central de la memoria de trabajo propuesto por Baddeley en 1986. Los estudios de neuroimagen han demostrado que los correlatos neuroanatómicos que mediarían estas funciones se sitúan en zonas de la corteza prefrontal dorsolateral y ventromedial (Stuss & Levine, 2002).

Como hemos analizado anteriormente para realizar una tarea, además de recuperar los pasos y el esquema general, se requiere mantener "online" este esquema durante su realización para poder completarla. Estudios con pacientes con lesiones frontales han planteado una disociación entre la generación de unidades de recuerdo de las acciones (en inglés *script generation*) y las unidades de acción que se pueden llevar a cabo realmente cuando realizan una acción (en inglés *script execution*) (Boelen, Allain, Spikman, & Fasotti, 2011). En ambos casos, debe existir un control de arriba abajo (en inglés *top-down*) que permita guiar la conducta hacia el objetivo y evoque las acciones necesarias para completar la tarea. Sin embargo, en el caso de la ejecución de unidades de acción, es necesario, además, tener en cuenta un control de abajo a arriba (en inglés *bottom-up*) que permita mantener controladas las acciones y los pasos que pueden elicitar los objetos que están presentes a la hora de realizar la tarea. Al parecer, esta segunda medida es más sensible a los problemas que presentan los pacientes con lesiones frontales (Boelen et al., 2011; Chevignard et al., 2000).

La recuperación de las acciones en las tareas cotidianas es guiada por una activación temporal de los pasos de la tarea en la memoria de trabajo, necesarios para ejecutarlos todos y en un orden correcto (Burgess & Hitch, 1992; Humphreys & Forde, 1998; Partiot, Grafman, Sadato, Flitman, & Wild, 1996). El orden de las acciones en las actividades de la vida diaria, es generado a través de un perfil de activación en las unidades de representación que evocan el orden de los pasos. De esta forma, si existe una alteración en esta representación en la memoria de trabajo y el gradiente de activación está menos activo o existe ruido dentro de él, se generará un problema a la hora de recuperar los pasos y se podrán omitir o realizar en orden incorrecto. En consecuencia, las omisiones podrían ser fruto no sólo de un déficit en la recuperación de la acción o del esquema *per se*, sino también de una alteración en el mantenimiento de esta información mientras estamos realizando la tarea. Desde el modelo de Norman y Shallice (Norman & Shallice, 1983) se plantea que el Dirimidor de Conflictos, es el encargado de controlar estas acciones rutinarias. Este sistema consiste en una red jerárquicamente estructurada de esquemas de acción. Un esquema de acción puede activar los componentes de una secuencia de acción en términos de otras acciones a bajo nivel. Sin embargo, cuando se produce una situación inesperada, o las condiciones, donde y como se realiza la acción, son adversas, el Dirimidor de Conflictos no es suficiente y es necesario activar el Sistema Atencional Supervisor. En estos casos, introducir ruido en la activación del esquema en memoria podría generar errores similares a cuando el gradiente de activación de la tarea no está lo suficientemente activo o aisladamente no se han podido recuperar las acciones individuales y el esquema de la tarea.

Perseveraciones y repeticiones

Como comentábamos anteriormente, diversos estudios han descrito y analizado de manera más exhaustiva la conducta observable en muchos pacientes con lesiones frontales, en la que repiten incesablemente acciones que ya han sido completadas (Forde & Humphreys, 2002; Humphreys & Forde, 1998). Cuando los pasos de las tareas se completan, las personas generan una inhibición *de rebote* para prevenir la competición con los pasos siguientes. De esta manera, decae la activación de la representación de las acciones ya realizadas y las acciones posteriores ganan la competición en la selección. Esto previene que las acciones se repitan inmediatamente después de realizarlas. Por tanto, este tipo de error hace referencia a la categoría "perseveraciones", las cuales se definen como aquellas respuestas recurrentes una vez que el objetivo se ha completado.

Por otro lado, repetir pasos intercalando otras acciones puede tener un origen diferente al de las "perseveraciones". La secuenciación de pasos correcta para completar una tarea debe mantenerse en el tiempo mediante mecanismos de competición en cola y la imposición de un gradiente de activación sobre el conjunto de las acciones en la secuencia. Este gradiente de activación podría ser parte de un esquema almacenado de acciones para las tareas de la vida diaria, y en tanto en cuanto este gradiente de activación se mantenga, las acciones se producirán en una secuencia temporal correcta. En el caso de las repeticiones, la degradación del gradiente de activación provoca que las acciones anteriormente realizadas puedan ser reiniciadas. Añadido a este mecanismo, la no repetición de acciones ya completadas se lleva a cabo por un proceso de monitorización de alto nivel, que requiere de la recuperación de las acciones ya completadas mantenidas en la memoria de trabajo.

Inhibición de información distractora y automática.

La pregunta, entonces, que cabe hacerse es la de ¿bajo qué circunstancias se puede manipular el gradiente de activación? O lo que es lo mismo ¿cuándo se introduce ruido en el esquema en memoria? Cuando llevamos a cabo una tarea cotidiana, a menudo, la solemos realizar en contextos donde existen muchos objetos distractores que debemos ignorar para completar correctamente la acción objetivo, pero con los cuales se activa automática una acción.

Nuevamente, la neurociencia cognitiva puede arrojarnos luz en este sentido. Además de mantener el esquema en memoria de la tarea durante su ejecución, el sistema de control cognitivo se encarga de **controlar de manera voluntaria nuestro comportamiento e inhibir conductas automáticas no necesarias para nuestro objetivo**. Este sistema se pone en marcha cuando es necesario resolver situaciones novedosas o que requieren de una planificación para su ejecución. Cuando no opera esta red, los distintos estímulos activan sus correspondientes esquemas de respuesta basados en la práctica con ellos. Ante situaciones novedosas, difíciles, de corrección de errores o en las que se necesita una planificación o toma de decisiones, se requiere un sistema "*top-down*" para superar las respuestas automáticas, por lo que se activa dicha red controlando otras operaciones necesarias para alcanzar el objetivo planteado (Norman & Shallice, 1983).

Según esta propuesta, en el proceso de control se distinguen dos fases asociadas a dos áreas cerebrales diferenciadas, la función de la corteza del cíngulo anterior que consistiría en detectar el conflicto mientras y la corteza dorsolateral prefrontal, que tendría la función de implementar los procesos necesarios para su resolución (Botvinick, Cohen, & Carter, 2004; Carter et al., 1998; MacDonald, Cohen, Stenger, & Carter, 2000). Por tanto, en este modelo se hace explícito una subdivisión de funciones dentro del control atencional. Recientemente, además, se ha relacionado la corteza orbitofrontal con el proceso de inhibición de actividad neural que pueda ser irrelevante (Szatkowska, Szymanska, Bojarski, & Grabowska, 2007).

Desde el punto de vista experimental, existen varias tareas que han medido la capacidad para controlar el comportamiento, inhibiendo aspectos de la realidad irrelevantes para el objetivo final. Una de las más ampliamente usadas ha sido la ya mencionada tarea **Stroop**. En esta tarea, se presentan a los participantes una lista de nombres de colores impresos en distintos colores, y la tarea consiste en nombrar el color de la tinta en la que están escritas las palabras, obviando la respuesta dominante, que en este caso es la lectura automática. El resultado que se suele obtener es una peor ejecución (mayor número de errores e incremento de tiempo de reacción) para aquellos ensayos en los que la palabra de color no es congruente con el color de la tinta (ensayos incongruentes) en comparación con los ensayos en los que el significado de la palabra corresponde con el color de la tinta (ensayos congruentes), resultado conocido como efecto de Interferencia. Esta versión es la más extendida, pero han aparecido muchísimas variantes de ella: stroop numérico, stroop emocional, etc. (para una revisión, ver Macleod, 1991). Una de las variantes más usadas ha sido tareas de **Stroop Espacial,** donde la dirección de una flecha (dimensión relevante) puede apuntar hacia el mismo u opuesto lugar donde aparece (dimensión distractora). Este paradigma también supone conflicto entre dos dimensiones del estímulo: su dirección y su localización.

Otro tipo de conflicto igualmente utilizado es la tarea de **Flancos**, donde la fuente del conflicto proviene de otros estímulos distractores que flanquean a un estímulo central al que hay que responder, ya que estos pueden evocar la misma respuesta requerida por el estimulo central u objetivo (ensayo compatible) o la respuesta opuesta (ensayo incompatible) (Eriksen, 1995).

Finalmente, la tarea **Simon**, refleja el conflicto entre una dimensión estimular (lugar de aparición del estímulo) y una dimensión de respuesta (lugar de la respuesta) (Lu & Proctor, 1995).

En relación con el ámbito de las AVD, diversos estudios han profundizado en esta cuestión diseñando manipulaciones donde incluían objetos distractores que se debían ignorar para completar la tarea *target*[1] correctamente. Un estudio con un paciente con ADS, mostró cómo se incrementaban los errores de omisión bajo circunstancias donde se presentan objetos distractores relacionados semánticamente (Morady & Humphreys, 2009). La competición entre objetos distractores y objetos necesarios para realizar la tarea objetivo se vio incrementada y provocó que este paciente no pudiera mantener en activo todos los pasos requeridos para hacer la tarea. De hecho, este ruido en el esquema podría desaparecer cuando se ofrecen instrucciones para realizar las tareas, pero de una en una y alternando los pasos entre las diferentes tareas a realizar, para que el contexto compartido no genere más conflicto (Morady & Humphreys, 2011).

Una conclusión similar proviene del trabajo de Cooper et al (2005) sobre la simulación de los déficit en AVD generando lesiones virtuales en su modelo computacional. En este estudio se demostró que la lesión virtual que producía un patrón de error más parecido al encontrado en los pacientes reales de los estudios anteriores fue la introducción de ruido en el esquema de representación de los objetos y acciones dentro del Dirimidor de conflictos.

Asimismo, cabe destacar que no sólo la información distractora puede generar ruido en el esquema de la tarea, en relación con los objetos necesarios para hacer la tarea, y por tanto, provocar omisiones, sino que, también, se ha demostrado que otro tipo de errores, relacionados con los objetos distractores puede generarse cuando se presentan en la realización de una tarea. La literatura experimental con tareas simples en personas sanas ha mostrado que aquellos objetos distractores que requieren acciones parecidas a la de los objetos target (e.j. Castiello, 1996; Craighero, Bello, Fadiga, & Rizzolatti, 2002; Craighero, Fadiga, Rizzolatti, & Umilta, 1998; Tipper, Howard, & Jackson, 1997; Tipper, Lortie, & Baylis, 1992; Tipper,

[1] A lo largo de este trabajo, utilizaremos el término inglés "target" para referirnos a la tarea o estímulos a los que los participantes deben responder.

Paul, & Hayes, 2006), pueden incluso preactivar acciones hacia ellos de modo automático y consecuentemente enlentecer la acción hacia el objetivo.

Sustituciones de objeto

Giovannetti y colaboradores (2010) realizaron un estudio en el que compararon una condición con distractores con fuerte similitud física y de acción (affordance) con los objetos target, frente a una condición con distractores no relacionados con los objetos target. Esta manipulación aumentó el número de errores de sustitución de objeto en un grupo homogéneo de pacientes con demencia, es decir, los distractores relacionados eran usados como si fueran los objetos target en mayor medida que los distractores no relacionados (por ejemplo, usaban el cucharón (objeto distractor) en sustitución a la cuchara (target) en mayor medida que un salero). Además, los distractores relacionados se manipularon sin ningún objetivo en mayor medida, produciendo así un aumento en el tiempo de ejecución total en comparación al que se registraba con los distractores no relacionados.

Los autores han interpretado este efecto de los distractores relacionados a nivel físico y de *affordance* como evidencia de que los pacientes con demencia sufren un déficit ejecutivo o de control cognitivo, al no ser capaces de inhibir el uso de los distractores. Esto es congruente con los déficits en control cognitivo que se detectan con medidas neuropsicológicas y pruebas experimentales en este tipo de pacientes (aunque en el presente estudio no se informa de este tipo de medidas). No obstante, con la manipulación en este estudio presentada, no podemos descartar que se existan algunos déficits semánticos a la base de estas sustituciones de objetos.

Acciones tangenciales y manipulaciones sin objetivo

Uno de los déficits de control cognitivo mejor documentado tras daño cerebral frontal en relación con la presencia de distractores, ha sido la llamada "conducta de utilización" (Archibald, Mateer, & Kerns, 2001; Lhermitte, 1983). Estas alteraciones en el control cognitivo generan una captura atencional o preactivación hacia los objetos distractores impidiendo que se pongan en marcha procesos inhibitorios. Este tipo de error consiste en atender, tocar y usar objetos presentes en su entorno de modo correcto, pero sin que estos formen parte de una acción coordinada y con una finalidad determinada. La observación de esta conducta, que claramente refleja un problema de control cognitivo, ha sido generalmente observada en condiciones en las que los pacientes no estaban realizando otra tarea.

Partiendo del conocimiento de estos errores, Niki y colaboradores (2009) manipularon condiciones en las que se le presentaban a los pacientes objetos distractores que podían estar o no relacionados semánticamente con los objetos target, y además, entre ellos, conformaban tareas (tareas distractores) cuyos esquemas debían inhibir. La muestra de pacientes en este estudio estuvo limitada a tres pacientes, por lo que los resultados no pudieron ser muy generalizables. Frente a dos pacientes que no se vieron afectados por la manipulación experimental sobre la relación entre objetos target y distractores, sólo uno obtuvo un nivel significativamente más alto de errores en la condición de objetos relacionados, aunque especialmente circunscrito a una tarea de las cuatro que se presentaban. Añadido a estos resultados, e independientemente de las condiciones experimentales por las que pasaron los pacientes, éstos no mostraron errores de omisión ni de secuenciación, sino más bien errores que incorporaban los objetos distractores, como manipulaciones del objeto sin propósito predeterminado, sustituciones de objeto o la realización de acciones parciales o completas de la tarea distractora (con los objetos distractores), que fueron interpretados como conductas de utilización. A la luz de los resultados concluyeron que este incremento de errores con los objetos distractores, podría deberse a la falta de inhibición del esquema de la tarea distractora activada por la presencia de los objetos distractores.

Según varios estudios del ámbito de la percepción y la acción motora, la mera presencia de objetos activa automáticamente e implícitamente la acción asociada a ellos, incluso cuando el objetivo de la tarea no está directamente relacionado con los propios objetos (Grezes, Tucker, Armony, Ellis, & Passingham, 2003; Tucker &

Ellis, 1998). Recientemente se ha demostrado que esta activación es mayor si presentan varios objetos que son compatibles funcionalmente, como una botella llena y un vaso vacío (De Stefani, Innocenti, Bernardi, Campione, & Gentilucci, 2012). Es por esta razón por la que Niki y colaboradores plantean la existencia de una activación de abajo a arriba incontrolada hacia los objetos distractores, describiendo, por tanto, un nuevo síndrome denominado "Síndrome de Desinhibición de la Acción". En este sentido, y contrario al "Síndrome de Desorganización de la Acción", estos pacientes sustituyen un objeto por otro, reinterpretando la acción del distractor, sin perder el objetivo a alcanzar. Esta capacidad preservada pone de manifiesto, en estos pacientes, el mantenimiento del esquema de la acción target y la existencia de suficientes recursos cognitivos para llevar a cabo la tarea sin omisiones o fallos de secuenciación.

Las conductas de utilización que evidencia Niki y cols., en su estudio con pacientes frontales son interpretadas dentro del modelo de Cooper (2005) como el producto del desequilibrio entre la representación de los objetos y el esquema de la tarea preestablecida. Tanto la activación del esquema de abajo-arriba, como de arriba-abajo deben coordinarse para que la activación de uno conlleve y arrastre la activación del otro. Sin embargo, cuando se produce un descenso en la activación del esquema de la tarea, los objetos pueden "controlar" la conducta a realizar. A excepción del estudio de Niki y colaboradores, los estudios anteriores siempre han acentuado la competición a nivel de la representación de los objetos, manipulando que los distractores fueran parecidos visual y funcionalmente a los objetos targets (Giovannetti et al., 2010; Humphreys & Forde, 1998). De esta forma, se introduce ruido a nivel de representación de los objetos, por lo cual la selección del objeto puede ser incorrecta. Por el contrario, introducir objetos que pueden elicitar una acción paralela también incrementa la dificultad en el esquema de la tarea, lo cual incrementa considerablemente esta competición, generando una serie de errores hasta entonces no estudiados. No obstante, en el estudio de Niki y cols., no se compararon condiciones con objetos distractores que elicitaran una acción y condiciones donde los objetos distractores no conformaran entre sí ninguna tarea. De esta forma, todavía no podemos conocer en profundidad la influencia de este tipo de manipulaciones con los objetos distractores en la realización de AVD.

Actualmente también se está analizando un tipo de error más sutil, que podría asimismo evidenciar un fallo en el control cognitivo. Este tipo de error denominado "manipulaciones sin objetivo" o "jugueteo con objetos" hace referencia a tocar de cualquier forma un objeto, sin tener la pretensión de usarlo para la tarea objetivo. Tanto el estudio de Niki y cols. (2009) como una reciente investigación en el campo del deterioro cognitivo (Seligman et al., 2013) ponen de manifiesto la importancia de este tipo de error, que puede verse incrementando ante la presencia de objetos distractores.

Detección y Corrección de Errores

Otra función del sistema de control cognitivo es la de **añadir el carácter consciente a la información procesada y utilizar la retroalimentación para modificar la conducta** (Posner & Rothbart, 1992). En este sentido, uno de los aspectos más ampliamente estudiados ha sido la detección de errores. Las respuestas erróneas parecen producirse por una falta de control en la emisión de una respuesta, ya que se generan más rápidamente que las respuestas correctas (Pailing, Segalowitz, Dywan, & Davies, 2002). Los mecanismos neuronales asociados a esta función parecen estar mediados por la Corteza Cingulada Anterior (*ACC* = *"Anterior Cingulate Cortex"*). De manera general, el *ACC* actúa como unión entre las zonas prefrontales laterales (control cognitivo) y las zonas motoras frontales (control motor) (Paus, 2001). Por ello, se le asigna un papel importante en la selección de programas alternativos motores, además de en la resolución de conflictos atencionales, inhibición de conductas automáticas y corrección de errores (Botvinick et al., 2004). Además, a través de sus conexiones con estructuras motoras (área motora suplementaria y ganglios de la base) accede a los esquemas musculoesqueléticos, sistemas de salida oculomotores y vocalización (Paus, 2001).

La capacidad para detectar y corregir errores, o tomar las medidas para evitar que se repitan en el futuro, se ha estudiado en el laboratorio con tareas experimentales de interferencia tipo Stroop. Así, se ha observado que, en personas sanas, tras la comisión de un error se produce un enlentecimiento de la respuesta (Gehring, Goss, Coles, Meyer, & Donchin, 1993) y una reducción del efecto de interferencia.

En ocasiones, en el día a día, las personas sanas cometemos errores cotidianos, tales como echar los calcetines sucios a la basura, en vez de al cesto de la ropa sucia, o ponerle sal al café. Estos errores, denominados en términos anglosajones como *"Action slips"* (Norman, 1981) se caracterizan por una corrección inmediata de la acción, al comparar nuestro comportamiento con una representación del estado ideal, por lo que el error no llega a realizarse completamente (Giovannetti, Schwartz, & Buxbaum, 2007).

Sin embargo, no ocurre igual ante alteraciones en el sistema de control cognitivo. Pacientes con daño cerebral frontal no exhiben, tras la comisión de un error, el patrón electrofisiológico típico que se suele encontrar en personas sanas (Stemmer, Segalowitz, Witzke, & Schonle, 2004) ni tampoco el enlentecimiento de la respuesta siguiente al error (di Pellegrino, Ciaramelli, & Ladavas, 2007), lo que les ha llevado a concluir que estos pacientes tienen problemas en el ajuste dinámico del control cognitivo.

Del mismo modo, en tareas cotidianas, los pacientes con Síndrome de Desorganización de la Acción o las personas con demencia no presentan el mecanismo típico para la detección y corrección de estos errores cotidianos.

En la literatura experimental, incluyendo la que aborda el estudio de las AVD, se ha demostrado una clara diferenciación entre el proceso de detección y el de corrección de errores (Zapf & Reason, 1994). Los estudios de neuroimagen sugieren que el cíngulo anterior se encargaría de evaluar y detectar el conflicto existente, mientras que la corteza prefrontal dorsolateral o los ganglios basales serían los encargados de implementar una respuesta para corregir la situación. (Botvinick et al., 2004; Gehring & Knight, 2000)

El análisis de estos mecanismos de detección y corrección de errores se ha abordado especialmente con estudios en los que se perseguía rehabilitar estos componentes. Los intentos de rehabilitación en ADS apuntan a que no basta con poner énfasis simplemente en la pérdida del objetivo a alcanzar, sino que es necesario también tener en cuenta un componente ejecutivo que organice y planifique la acción, a la vez que active esquemas inhibiendo otros competidores. Uno de los programas de intervención que ha tenido mayor éxito en un paciente con "Síndrome de Desorganización de la Acción" ha sido el uso de estrategias de verbalización (Bickerton, Humphreys, & Riddoch, 2006). La intervención se basó en el aprendizaje, la memorización y el posterior uso de un poema donde se exponían los pasos esenciales para realizar un té. El mantenimiento verbal del poema a lo largo de la tarea permitía la activación de un bucle fonológico que, en el caso del paciente que se estaba rehabilitando, permanecía intacto, y que actuaba como una forma de memoria de trabajo, lo cual le permitía guiar los pasos de la tarea.

Los pacientes con demencia tipo Alzheimer también han mostrado patrones de errores análogos en las actividades de la vida diaria. Estas similitudes pueden deberse a que, en fases moderadas, tanto las funciones ejecutivas como las de memoria ya se ven alteradas. Esta población parece no detectar la mayoría de los errores que cometen, aunque sí corrigen un gran porcentaje de los errores que detectan (Bettcher et al., 2008). La detección podría compensar, por tanto, los fallos en otras esferas cognitivas como la memoria.

Un reciente estudio en pacientes con demencia tipo Alzheimer evidenció una mejoría en el número de errores detectados, a través de un breve entrenamiento previo a la tarea (Bettcher et al., 2011). La detección de errores podría evidenciarse a través de tres formas: (1) verbalizando el error cometido, (2) intentando corregir el error, aunque de una manera no adecuada o (3) llevando a cabo una conducta que lo corrija de manera adecuada. El entrenamiento pretendía mejorar los esquemas del conocimiento de la tarea, reduciendo la carga en el funcionamiento lingüístico y el contenido semántico. De esta forma, a los pacientes se le mostró un vídeo donde se podía observar a una persona llevando a cabo la tarea (desde la perspectiva del paciente), así como una presentación de las acciones y de los objetos con los que, posteriormente, se iba a trabajar. Aunque la detección de errores se incrementó, no lo hizo la corrección de éstos, no hallándose diferencias significativas con el grupo que no llevó a cabo este entrenamiento.

En este estudio se comprobó que la detección de errores fue predicha por una medida de evocación fonológica, por el test de fluidez "FAS". Además, la proporción de errores detectados-corregidos fue predicha por una el test "*Clock Drawing*", donde además de capacidades visuoespaciales, de construcción y de organización, se pusieron en marcha procesos de ejecutivos de corrección (Bettcher et al., 2008)

Resolución de problemas

Partiendo de la base de los estudios relacionados con la detección y corrección de errores, un proceso más complejo es el denominado "Resolución de problemas". Esta función hace referencia a la capacidad para dar solución a errores propios, pero más aún, a situaciones inesperadas que pueden ocurrir y que requieren de respuestas más elaboradas que las habituales. Desde el campo de la Neuropsicología algunos tests han sido sensibles para detectar los déficits a este nivel como por ejemplo el *D-KEFS* (Delis, Kaplan, & Kramer, 2001) o el *Wisconsin Card Sorting Test* en pacientes con daño cerebral (Gouveia, Brucki, Malheiros, & Bueno, 2007; Heled, Hoofien, Margalit, Natovich, & Agranov, 2012). No obstante, estas valoraciones usan materiales muy artificiales que, en ningún caso, pueden acercarse a lo que ocurre en el día a día, por ejemplo, a la hora de resolver qué hacer cuando se nos acaba la pasta de dientes. Desde aquí, planteamos la dificultad de observar este tipo de error en evaluaciones de observación directa, puesto que es complicado controlar situaciones inesperadas o provocar que el paciente cometa un error ante una determinada condición. Sin embargo, consideramos imprescindible un abordaje funcional de este tipo de problemas tan frecuentes en pacientes con daño cerebral frontal y procesos neurodegenerativos.

La capacidad de iniciar actividades.

Por último, y no menos importante, queremos introducir la imprescindible capacidad para iniciar los comportamiento necesarios para nuestro quehacer diario. Esto es, la habilidad de, por ejemplo, empezar a cocinar cuando los estándares culturales y las necesidades fisiológicas lo demandan. Déficits en este sentido han sido informados en pacientes con demencia y DCL (Boyle et al., 2003) provocando graves alteraciones en su día a día. Aunque, bien es cierto que este comportamiento debe estar relacionado con los niveles motivacionales de la persona, estudios recientes también han destacado sus correlatos ejecutivos, específicamente relacionándolos con tareas de fluidez verbal (Drijgers, Verhey, Leentjens, Kohler, & Aalten, 2011). Algunos tests, mediante tareas de ejecución en directo, han pretendido observar estas conductas, como lo es el AMPS (Fisher, 2006a, 2006b), sin embargo, esta capacidad no puede ser analizada en un contexto de laboratorio o medida en un momento concreto, sino que requiere de la información provista por una persona que conviva día a día con el paciente.

2 AIMS OF THE RESEARCH

The general aim of this thesis is to further understand the role of Cognitive Control processes in the Execution of Activities of Daily Living (ADL), that is, to analyse under which conditions these executive processes are put into play in everyday life and how they might get compromised after frontal lobe damage or neurodegenerative disease like dementia or Mild Cognitive Impairment (MCI). More specifically, the goals in this research are:

1. One main question is to specify which kind inhibitory control deficits are mostly affected after frontal brain damage. More specifically, we are interested to see whether all forms of irrelevant information are equally difficult to suppress in normal participants and especially after frontal lobe damage in simple experimental computer based tasks manipulating the nature of the irrelevant information.
2. Similarly to experimental computer based conflict tasks where relevant and irrelevant stimuli compete for behaviour (i.e. Stroop or Simon tasks), deficits in executive inhibition are also observed in the context of everyday activities when patients commit perseverations of actions, touch objects without purpose or use distractor objects (commission errors). In addition, in everyday life situations like preparing a coffee, we might also encounter other stimuli not necessary for the coffee relevant task but that might be surrounding the coffee items. The second aim of the present thesis is to see until what extend the same kind of explanations derived from research with simple experimental interference tasks could help to better understand how distracting objects might impact on in everyday life performance and how they can explain ADL alteration after brain disease. As a first step to know that, we will test which of these different forms of distractor interference measured with computer based experimental tasks is mostly related to interference effects produced by irrelevant related objects in ecological performance-based ADL situations.
3. The third aim the present research is to isolate which kind of real life distractor objects interfere more on ADL execution after frontal lobe damage but also in other neurological diseases like dementia and MCI. We were interested in comparing the effect of distractors, depending on the nature of

the relationship that they have with the target items in ecological situations with real objects. Are semantically related distractors more distracting than action related ones? Do they produce the same kind of alterations in ADL performance? Are there differences of the effect of distractors between patient groups? Responding to these questions constitutes the third objective of the present thesis.

4. The last objective of this thesis is to demonstrate how research on the relations between cognitive deficits and ADL execution might have important applications, like, for example, to develop new diagnostic tools more sensitive to distinguish different types of diseases like MCI and dementia from healthy ageing. In this regard, we will design a preliminary informant-based task to help to distinguish executive deficits from deficits in task memory schema that might be mostly responsible of different pattern of errors observed by a patient in their usual ADL execution. As these two kinds of deficits (executive vs. task schema) might co-occur in some patients with dementia or MCI and in different degrees, the present tool might help to isolate which processes are mostly altered depending on the consequences that they have on ADL behavior. The novelty of this diagnostic tool compared to previous proposals is that it will take into account both levels of analysis, that is, to measure different cognitive processes contextualized in different ADL activities differing in complexity.

2.1. Overview of the research

Experimental series 1. Executive attention and personality variables in patients with frontal lobe damage

In experimental series 1 we will use the ANT- I task, a well known task that allow to simultaneously measure exogenous orienting effects towards irrelevant spatial cues, alertness effects towards irrelevant auditory signals, and conflict effects towards incompatible flankers. We will compare these three indexes of attentional effects between a group of frontal brain damage patients with healthy aged matched participants. This task will help to test whether these patients present a general attentional deficit, so that their lesions might alter these three forms of attention, or whether they might exhibit a more specific pattern of alteration.

Experimental series 2. Relations between experimental measures of control cognitive and everyday errors after frontal lobe damage

In this experimental serie we present two experiments. In **experiment 2.1.** we will design a new cognitive control task in which three additional types of conflicting situations (Distractor Filtering, Spatial Stroop or S-S and Simon or S-R conflict) apart from the ones measured in the experimental series 1, will be combined in a orthogonal manner. The interference index on these three types conflicting situations obtained for frontal patients will be compared to healthy aged matched participants. The results of this experiment will provide a better understanding on what kind of irrelevant information (that conflicting at the physical level or at the response level) is more harmful after frontal lesions.

In **experiment 2.2**., we will design a performance-based ADL task where a subset of the same participants from experiment 2.1. will be asked to make a cup of coffee or a toast with butter and jam in the presence of related distractor objects that could be used in a joint action, conforming an alternative but not required Distractor Task. We will analyse everyday errors according to error criteria based on Humphreys and Schwartz. Next, we will analyse the pattern of relations between participants performance on the computer based interference task in experiment 2.1.and the pattern of errors in the ADL task in experiment 2.2 These data will provide further understanding about the type of cognitive control process that are mostly related to different error patterns in ADL behaviour.

Experimental series 3. Making coffee in the presence of objects to make a toast vs. a soup: The influence of the relationship between distractor and target items in ADL execution after frontal lobe damage.

The main aim in the experimental series 3 is to study the influence of the type of relationship between the target and distractor objects (that elicit a whole distractor task) in frontal and non-frontal damaged patients, in ADL performance. On the one side, we will compare conditions in which target and distractor tasks share action steps and objects. On the other side, the semantic relationship between target and distractor tasks will be manipulated. By these experimental manipulations we will be able to compare within participants, the impact of these two forms of distractor relationship o different error patterns of ADL performance. This will catch more light about the kind of cognitive control deficits that most impact in ADL.

Experimental series 4. Different patterns of everyday errors in Mild Cognitive and Dementia patients.

Similarly to experimental series 3, in the fourth study we will investigate the impact of different conditions in ADL performance. In this case, we were interested to investigate a different group of patients, Dementia, Mild Cognitive Impairment and healthy participants, given that these populations usually suffer both executive deficits but also some degree of task memory schema degradation that might co-occur even on the same patient. We have designed a task similar to the Task distractor context related condition used in experimental series two and three. We will ask twice to each participant for the same ADL under two conditions. In one of them, distractor objects could be used in a joint task (i.e oranges and orange juice maker) and moreover these distractor tasks (i.e to make an orange juice) could be part of a higher level category ("breakfast") in which the target task (i.e to make a cup of coffee) could be also included. In another condition, we will show isolated semantically related distractor objects, but that altogether cannot constitute an alternative related task. In this study we will separately measure the impact of these two conditions errors toward distracting objects vs. Errors related to the target items. This might help to isolate under what conditions cognitive control is more required, and thus, what type of distractors are more harmful for dementia and mild cognitive impairment patients.

Experimental series 5. Preliminary Cognitive Scale of Basic and Instrumental Activities of Daily Living, for Dementia and Mild Cognitive Impairment.

In the last experimental series, we design a preliminary new informant-based assessment tool, "The Cognitive Scale for Basic and Instrumental Activities of Daily Living" in order to analyze cognitive aspects in different everyday activities. This scale will be answered by direct patients caregivers and will allow to measure cognitive alterations in different everyday activities in familiar settings over time. We focus on four key cognitive abilities: Task Memory Schema, and three executive measures: Error Detection, Problem Solving and task Self-Initiation along a range of basic (BADL) and instrumental (IADL) activities. Data from this study will provide information of the cognitive failures that impact in ADL performance in a larger range of activities than performance-based measures and by controlling familiar contexts.

3 EXPERIMENTAL STUDIES

Experimental series 1

Executive attention and personality variables in patients with frontal lobe damage

Manuscript published in Spanish Journal of Psychology as Rodriguez-Bailon, M., Trivino, M., & Lupianez, J. (2012). Executive Attention and Personality Variables in Patients with Frontal Lobe Damage. *Spanish Journal of Psychology, 15*(3), 967-977. doi: 10.5209/rev_SJOP.2012.v15.n3.39388

Executive attention and personality variables in patients with frontal lobe damage

Rodríguez-Bailón, María[1], Triviño, Mónica[2], Lupiáñez, Juan[1]

1. Department of Experimental Psychology. University of Granada, Spain.
2. Neuropsychology Service. San Rafael University Hospital. Granada, Spain.

Abstract

Executive Control is required to deal with novel situations or when an action plan is needed. This study aimed to highlight the executive attention deficits of patients with frontal lobe damage. To do so, the ANT-I task (Attention Network Test-Interactions) was administered for the first time to a group of 9 patients with frontal damage caused by traumatic brain injury (TBI) and a matched control group. This task made it possible to measure the three attentional networks proposed by Posner et al. (1994) and their interactions. Results on the alerting and orienting networks did not show any significant differences between the groups. However, a significant effect of group on the executive control network was observed. In addition, participants' personality was assessed with a clinical inventory (the Millon Personality Inventory) that showed a significant positive correlation between borderline personality disorder and the conflict index. These results suggest that frontal lobe damage causes an exclusive impairment in the conflict resolution network that is related to personality traits characterized by a lack of behavioral control. More research will be necessary to study this causal relationship.

Keywords

Cognitive control, Attention, Frontal, Neuropsychology, Personality

Introduction

The aim of the present study was to explore the attentional networks proposed by Michael Posner in 1994 by administering the ANT-I task for the first time to a group of patients with prefrontal damage. The cognitive control system, known as the *anterior attentional network* or *executive control network* in that theory, is in charge of the central control of attention and influences the other attentional networks, i.e. the *posterior or attentional orienting network* and the *alerting network*. This complex control system, which is considered part of the so-called executive functions (Tirapu-Ustarroz, Garcia-Molina, Luna-Lario, Roig-Rovira, & Pelegrin-Valero, 2008), allows individuals not only to organize and coordinate various cognitive functions but also to anticipate and plan goal-oriented actions (Sohlberg & Mateer, 1989).

This cognitive control system is believed to keep goal-oriented information available to perform tasks (Posner & Dehaene, 1994). Researchers argue that it selects relevant information and suppresses irrelevant information, which is related to the central executive of working memory (Baddeley, 1986; Stuss & Levine, 2002). Moreover, it is consider to bring processed information into consciousness and use feedback to modify behavior (Posner & Rothbart, 1992).

This cognitive control system allows individuals to deal with situations that are new or require planning. In other words, the various stimuli activate their corresponding response schemes based on the individual's experience with them; yet, in the face of situations that are new or difficult and require error correction, planning or decision-making, a "top-down" system is required to overcome automatic responses; in these cases, this network becomes activated and controls other necessary operations to reach the objective (Norman & Shallice, 1983).

Executive control and the prefrontal cortex

The areas of the brain associated with cognitive control are the anterior cingulate cortex, which monitors conflict, and the dorsolateral prefrontal cortex (DLPF), which implements mechanisms to resolve conflict by controlling the activation of other areas of the brain (Botvinick et al., 2004). The orbitofrontal cortex has recently been related to the inhibition of neural activity that may be irrelevant, unwanted or uncomfortable for reaching the objective set (Hooker & Knight, 2008; Szatkowska et al., 2007). Therefore, there is no doubt that the prefrontal cortex plays a role in the various aspects of cognitive control and that damage to this cortex affects the brain's ability to inhibit dominant and automatic responses.

In fact, patients with frontal lobe damage can have a broad range of alterations in their executive functions whose common denominator is an impairment in behavioral control and difficulties planning to reach goals. Many experimental studies have analyzed the nature of the executive deficits of patients with various frontal lesions in relation to impaired conflict resolution (Alexander, Stuss, Picton, Shallice, & Gillingham, 2007; P. W. Burgess & Shallice, 1996; Stuss, Floden, Alexander, Levine, & Katz, 2001; Szatkowska et al., 2007). The deficits they have shown are related to the inability to generate automatic responses (Burgess & Shallice, 1996), to control automatic responses, particularly in lesions of the left ventrolateral prefrontal cortex (Alexander et al., 2007) and in upper medial bilateral areas (Stuss et al., 2001), or to inhibit behavior in specific circumstances when there is damage to the medial orbitofrontal cortex (Szatkowska et al., 2007). Recently, prefrontal damage has also been related to a deficit in voluntary temporal preparation (Trivino, Correa, Arnedo, & Lupianez, 2010).

Executive control and personality variables

Executive control has been related to the concept of self-regulation, that is, controlling the flow of information from the environment to avoid conflicting responses in behavior (Posner, Rothbart, Sheese, & Tang, 2007). Posner et al. (2007) showed that the concept of self-regulation, particularly what they called "effortful control" – the ability to control responses, inhibiting a dominant response while performing a subdominant response – is correlated with the activation of the anterior cingulate and the medial frontal cortex as well as the executive control index.

Difficulties self-regulating or controlling one's impulses are present in diseases such as borderline personality disorder, antisocial disorder and bipolar disorders. Numerous studies have found a relationship between such diseases and frontal dysfunctions, mainly related to fronto-limbic connections (Blair, 2004; Lin, Weng, Xie, Wu, & Lei, 2011; Schmahl & Bremner, 2006; Soloff et al., 2003). In addition, frontal lobe damage causes a distinctive alteration of personality characterized by increased borderline personality, mania, anxiety and antisocial traits (Pizzi, Chapin, Tesar, & Busch, 2009) as well as high impulsivity (Alexander et al., 2007). Frontal lobe lesions can also lead to difficulties in realizing the consequences of one's actions or assessing risk (dos Santos Assef, Seabra Capovilla, & Capovilla, 2007).

Executive control and the ANT-I

For several years, various tasks have been proposed to measure the performance and efficiency of the three attentional networks proposed by Posner. The original task – the Attention Network Test, also known as ANT (Fan, McCandliss, Sommer, Raz, & Posner, 2002) – yields behavioral measures of the efficiency of the three networks using one simple task. It is based on measuring reaction times (RTs) in a flanker task in which participants must discriminate the direction of a central arrow flanked by two arrows on either sideg.

Callejas et al. (Callejas, Lupianez, Funes, & Tudela, 2005; Callejas, Lupianez, & Tudela, 2004) introduced a new variable – a tone – to measure alerting in order to quantify the effect of the three networks independently as well as the effect of each of them on the other two. This modified version, known as the Attention Network Test-Interactions (ANT-I), has shown clear interactions between the three attentional networks (Callejas et al., 2005).

Despite the relationship between the prefrontal lobe and deficits in cognitive control and self-regulation, the authors are not aware of the existence of any studies measuring the three attentional networks in patients with a prefrontal lesion or exploring their relationship with personality variables related to impulsivity.

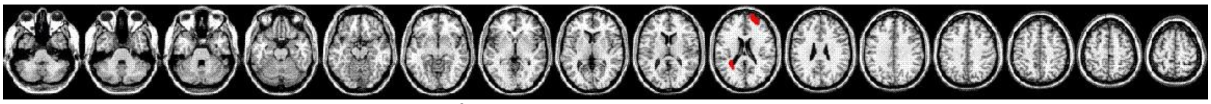
Objectives

The main objective of the present study was to determine which attentional networks are altered as a consequence of prefrontal lesions. This was done by administering for the first time the ANT-I, an experimental task designed to assess the three attentional networks, to patients with a prefrontal brain lesion secondary to traumatic brain injury (TBI). The authors expected such patients to have slower reaction times when solving incongruent trials. Moreover, as shown by the literature, frontal areas seem to be key structures not only for cognitive control but also for self-regulation. Therefore, patients with frontal lobe lesions were expected to show a marked deficit in the executive control network associated to behavioral alterations (i.e., impulsivity, borderline personality disorder, mania, etc.). Therefore, the second objective was to study for the first time the relationship between certain personality variables (related to lower self-regulation) and the attentional data provided by the ANT-I.

Method

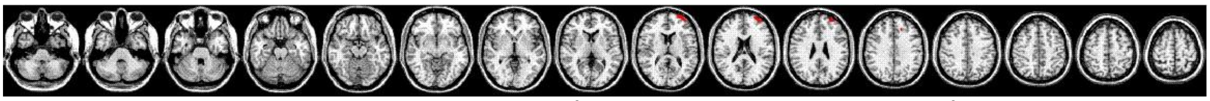
Participants

The study groups were composed of 9 patients with prefrontal brain damage (7 men and 2 women) secondary to traumatic brain injury (TBI) and nine neurologically intact individuals (6 men and 3 women). The inclusion criterion for the frontal group was the presence of damage in the prefrontal lobe confirmed by neuroimaging and the neuropsychological assessment performed. The most relevant information on the location of the lesions of patients in the frontal group are shown in Table 1 and Figure 1. All the patients had impairment in the dorsolateral prefrontal cortex, the orbital prefrontal cortex or the anterior cingulate cortex. Exclusion criteria were the presence of dementia, aphasia or spatial hemineglience or having performed any version of the ANT-I or ANT in the past.

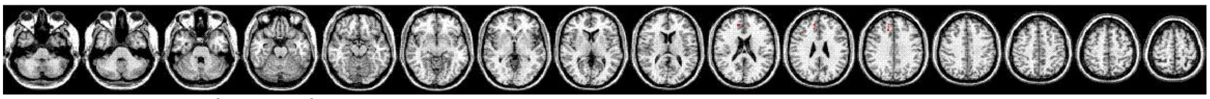


1. Lesion location: Right anterior-basal and left temporal regions.

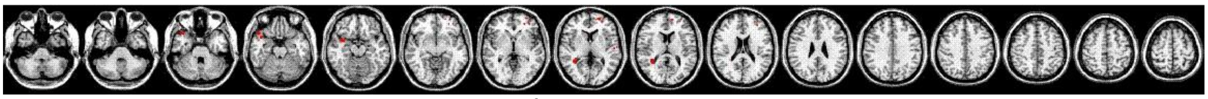
2. Lesion location: Left frontoparietal and right occipital (contrecoup) regions.



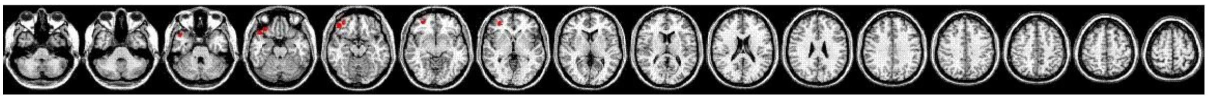
3. Lesion location: Bilateral subdural hygroma in the frontal convexity with a small right frontal subcortical hyperdense image that suggests diffuse axonal injury.



4. Lesion location: Left medial frontal region.



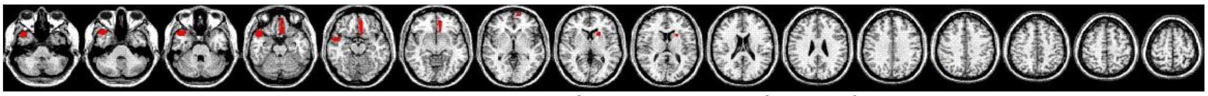
5. Lesion location: Ventricular dilation, hypodensity of the internal capsule and thalamus. Point-shaped images in the white matter of the right frontal cortex and edema in the white matter of the left frontal cortex (Diffuse Axonal Injury).



6. Lesion location: Left frontal lesions.

7. Neuroimage eliminated from the hospital records: CT report of January 2004: The image shows a left temporal and left frontal area of encephalomalacia associated to a large craniotomy with evident pressure from the surgery, a moderate displacement of the structures of the midline towards the right side and a discrete partial collapse of the left lateral ventricle. It also shows an effacement of the left hemispheric sulci, which suggests expansive and lateral phenomena.

8. Neuroimage eliminated from the hospital records: CT report of August 2005: Image compatible with a right occipital concussion. Image compatible with a small chronic infarction adjacent to the right border of the opening of the tentorium. Small hypodense image at the center of the ridge that may also show a former trauma. Thin layer of right upper frontal subdural fluid.



9. Lesion location: Hematoma in basal ganglia and right frontal concussion focus. Left temporal lesion.

Figure 1. Neuroimage of participants with frontal damage. Lesions were drawn with MRICron software on a brain model with 7 mm axial sections. It was not possible to obtain the pathological neuroimage of participants 7 and 8 so the text describes the radiological report of the neuroimaging test performed.

Table 1. Brain areas injured and their correspondence in Brodmann areas for each patient (P) and lateralization of lesions (left vs. right). As shown in the table, the patient with the largest lesion was patient 2 (P2). The remaining patients showed lesions that were more restricted to the prefrontal lobe.

Brain area injured		Patients (P) with these lesions and lateralization of the lesion	
Prefrontal cortex	Brodmann areas	Left	Right
Dorsolateral prefrontal cortex	8, 9, 46, 47	P3, P5	P1, P2, P4, P6
Orbitofrontal cortex	10, 11	P3, P5, P9	P1, P6
Anterior cingulate cortex	32	P3	P2, P4
Other areas			
Temporal lobe	20, 21, 37, 38, 48	P1, P2, P5, P9	P5, P6, P9
Angular gyrus (temporoparietal junction)	39	P2	P2
Occipital lobe	19	P2	P2

Control participants and patients were matched for sex (with one exception), age and educational level. Mean age was 30.89 years (SD=8.07) in the control group and 29.4 years (SD=6.97) in the frontal group. Participants in the control group had 14 years of education (SD=2.92) while those in the frontal group had 13 years of education (SD=3.46).

Patients and control subjects participated voluntarily after giving their informed consent. The study was approved by the Ethics Committee for Clinical Research of Virgen de las Nieves Hospital (Granada, Spain). The experiment was conducted according to the ethical standards laid down in the Declaration of Helsinki.

Neuropsychological assessment

Patients with frontal lesions underwent neuropsychological tests to determine the characteristic symptoms related to the location of their lesions. The neurological assessment protocol used is shown in Table 2. This protocol was used to define the prefrontal deficit of patients and set the inclusion criteria for the study.

The Millon Multiaxial Clinical Inventory (MMCI-II) (Millon, 1987) was also administered to assess the personality disorders described in the Diagnostic and Statistical Manual of Mental Disorders or DSM-IV-TR (American Psychiatric Association, 2003) and other psychological disorders. This psychometric test is mainly used for the diagnosis or clinical evaluation of adults with emotional, social or interpersonal problems and therefore seems to be a good measure to detect personality disorders.

Table 2. Protocol of neuropsychological assessments administered to patients and controls and data obtained in both groups

FUNCTION Test and subtest	RESULTS		
	Mean and SD Frontal Group	Mean and SD Control Group	Level of significance
Intellectual quotient *Premorbid intellectual functioning* *Bilbao and Seisdedos formula (2004)*	115.48 (21.31)	113.00 (11.03)	p = .761
Current intellectual quotient (IQ)			
Verbal IQ	92.33 (19.33)	115.78 (10.75)	**p = .006**
Manipulative IQ	76.33(12.60)	109.67(13.33)	**p = .000**
Total IQ	84.33(18.92)	113.11(11.00)	**p = .001**
Language			
Comprehension			
Token Test	34.44 (1.42)	35.25 (0.43)	p=.124
Denomination			
Boston Naming Test	48.89(11.26)	56.25 (2.38)	P=.073
Premotor functions			
Premotor functions (Barcelona Test)			
Rhythm (Errors)	0.63 (1.32)	0 (0)	p = .17
Reciprocal inhibition (Errors)	0.25 (0.43)	0.22 (0,67)	p = .92
Graphic alternances	1.63 (0.48)	2.00 (0)	p = .063
Motor alternances	1.75 (0.43)	2.00 (0)	p = .102
Bimanual coordination	1,75 (0,43)	2.00 (0)	p = .102
Verbal memory			
Test Aprendizaje Verbal España Complutense (TAVEC)			

Learning	41.66 (11.43)	56 (8.81)	**p = .009**
Short term free recall	8 (4.58)	12.55 (3)	**p = .024**
Long term free recall	8.11 (4.22)	13.44 (2.83)	**p = .006**
Intrusions	15(13.17)	5.89 (9.6)	p = .113
Perseverations	5.55 (5.31)	4.55 (7.99)	p = .759
Semantic strategies in learning (Lists A+B)	10.33 (7.86)	24.11 (13.26)	**p = .016**
Semantic strategies in recall (Short term+long term)	5.11(3.69)	14 (9.39)	**p = .018**
Serial strategies in learning (Lists A+B)	6.55 (4.61)	5.22 (2.11)	p = .442
Serial strategies in recall (Short term+long term)	2.11(2.31)	1.22 (2.33)	p = .429
Recognition	10.89 (5.44)	15.67 (0.71)	**p = .019**
False positives	1.33 (1.6)	1.67 (3.32)	p = .789
Visual memory			
Rey-Osterrieth Complex Figure Test			
Immediate Recall PC	34.11 (32.12)	68.11 (34.92)	**p = .042**
Working memory			
Phonological loop			
Digit span subtest of WAIS-III	8.67 (2.64)	10.89 (3.10)	p = .121
Visuospatial sketchpad			
Spatial span subtest of WMS-III	9 (3.94)	10.33 (5.07)	p =.542
Central executive			
Letter-number sequencing subtest of WAIS-III	8.44 (4.19)	11.33 (2.06)	p = .082
Attention			
Sustained attention			
Trail Making Test – Part A - Errors	0	0.11	p =.332
Divided attention			
Part B - Errors	3.11 (3.18)	0.22 (0.44)	**p = .016**
Interference			
Stroop Colour and Word Test	40.44 (10.76)	51 (8.42)	**p = .034**
Stroop Interference	52.44 (9.31)	51.78 (3.87)	p = .895
Executive functions			
Verbal abstraction			
Similarities subtest of WAIS-III	10.78 (3.86)	14.33 (2.91)	**p = .043**
Visual abstraction			
Matrix reasoning subtest of WAIS-III	7.67 (2.83)	11.89 (2.67)	**p = .005**
Temporal sequencing			
Picture arrangement subtest of WAIS-III	7.33 (2.34)	11.11 (2.93)	**p = .008**
Constructive praxia			
Block design subtest of WAIS-III	6.56 (3.71)	10.33 (3.71)	**p = .046**
Copy of Rey-Osterrieth Complex Figure Test (PC)	79.11 (18.03)	90.67 (10.12)	p = .113
Fluency			
FAS fluency test	23.78 (9.23)	39.67 (12.79)	**p = .008**
Animal fluency test	15.78 (4.21)	23.67 (5.12)	**p = .003**
Mental flexibility and categorization (Wisconsin Card Sorting Test, WCST)			
No. trials	103.22 (25.35)	99.00 (20.87)	p = .705
% Errors (PC)	29.89 (22.40)	44.67 (26.95)	p = .224

% Perseverative responses (PC)	27,33 (28,84)	64.11 (36.87)	**p = .031**
% Perseverative errors (PC)	26.22 (27.56)	63.67 (38.17)	**p = .030**
% Non-perseverative errors (PC)	43.89(21.13)	33.44 (20.43)	p = .302
No. of categories completed (PD)	4.56 (2.13)	5.67 (0.71)	p = .157

SD= Standard deviation; PC= Percentile; WAIS III: Weschler Adult Intelligence Scale, 3rd Edition; WMS: Weschler Memory Scale, 3rd Edition

Experimental task

The experimental task used in this study was the Attentional Network Test-Interactions or ANT-I (Callejas et al., 2004).

The task involved measuring reaction times (RTs) in a flanker task in which participants had to respond to a central arrow that was flanked by two other arrows on either side. Participants were seated in front of a computer screen and instructed to indicate in which direction the arrow was pointing by pressing one of two possible keys of a computer keyboard (key "C" if left and key "M" if right). Participants were given feedback on their performance (reaction times and correct trials) in practice trials. Stimuli were preceded by a visual spatial signal (to measure the orienting network) and an auditory alerting signal (to measure the alerting network).

Procedure

A fixation point (+) of a variable duration (400-1600 ms) appeared at the start of each trial, followed by an auditory alerting signal (50 ms duration) in half of the trials (Alerting signal, 2 levels: Presence or Absence of sound). After 400 ms, the orienting visual signal appeared for 50 ms above or below the fixation point in two thirds of the trials. The orienting signal did not appear in the remaining third of the trials. The target and its flanks appeared 50 ms after the orienting signal, either in the same position as the orienting signal (valid trials) or in the opposite position (invalid trials) for 3000 ms or until the participant responded (Orienting signal, 3 levels: Valid trials, Invalid trials or Trials with no signal). The Executive control network was established with 2 levels: Congruent Trials, in which the target was flanked by arrows pointing in the same direction, and Incongruent Trials, in which the arrows pointed in the opposite direction.

After the response, the fixation point appeared again with a variable duration until the 4450 ms of each trial were completed. No stimuli appeared between trials. Figure 2 shows a diagram of the procedure used.

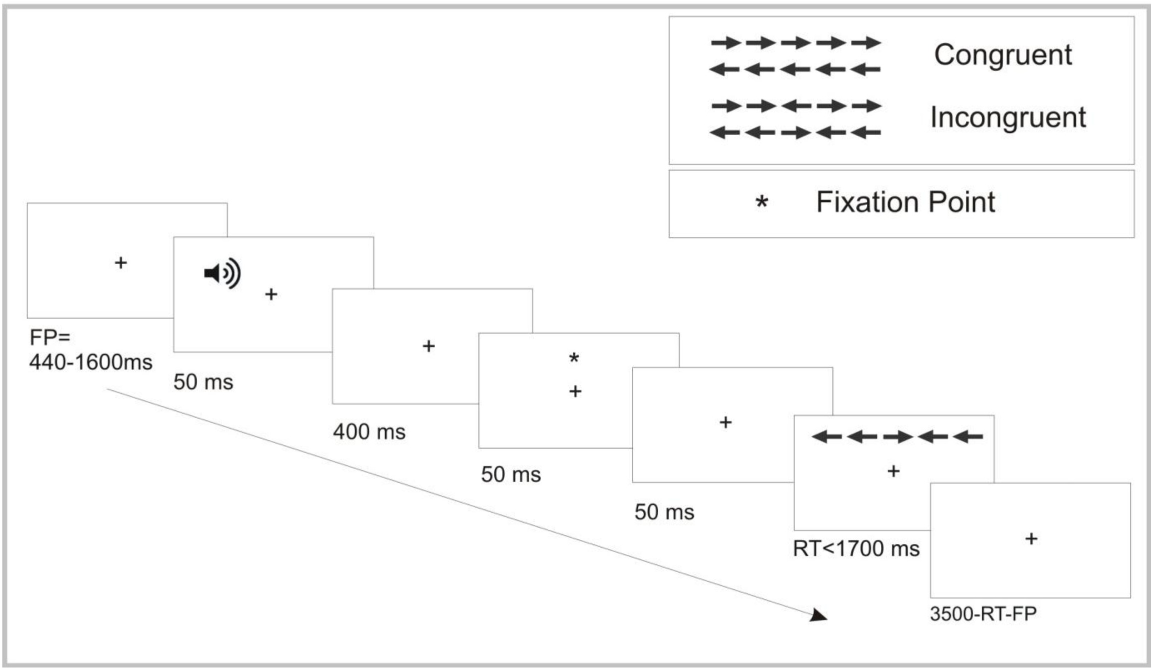


Figure 2. Diagram of the ANT-I task, procedure and stimuli used in the experiment. The duration of the whole trial was 4450 ms. RT=Reaction Time. FP=Fixation Point

The practice block included 2 trials. The task was composed of 6 blocks of 48 trials each, that is, a total of 288 trials (24 trials per experimental condition). Trials were randomly presented in each block.

Design

The experiment had a 2 (Auditory alerting signal: present vs. absent) x 3 (Visual orienting signal: no signal, valid or invalid trials) x 2 (Executive control: congruent vs. incongruent trials) x 2 (Group: frontal vs. control) mixed factor design. The first three variables were manipulated within subjects.

Results

Neuropsychological assessment

To explore which demographic and neuropsychological assessment variables differed significantly between the control group and the frontal damage group, a single factor ANOVA was conducted for each of these variables. No differences were found between groups regarding age, $F(1,16) = .130$; $p = .723$, or education, $F(1,16) = .439$; $p = .517$. However, significant differences were found regarding neuropsychological assessment. More specifically, the frontal group showed a clear dysexecutive deficit with the following impairments in several subscales of the WAIS-III: impaired abstraction capacity in the similarities subtest, $F(1,16) = 4.85$; $p = .043$, impaired planning in the picture arrangement subtest, $F(1,16) = 9.10$; $p = .008$, and impaired motor programming and visual construction abilities in the block design subtest, $F(1,16) = 4.66$; $p = .046$, as well as a significantly higher percentage of perseverative errors in the Wisconsin Card Sorting Test, $F(1,16) = 5.69$; $p = .030$. Significant differences were also found in the errors made by patients with frontal lesions in the B part of the Trail Making Test compared to the control group, $F(1,16) = 7.29$; $p = .016$. Yet, no differences were found between the groups in tests assessing cognitive functions that do not depend on prefrontal circuits (i.e., language). The neuropsychological assessment and the neuroimaging confirmed that the patients' damage was prefrontal, since there were no significant differences between groups in premotor functions. Neuropsychological results are shown in greater detail in Table 2.

Experimental task

Mean RTs for each experimental condition were analyzed with a 2 (Group) x 2 (Alerting signal) x 3 (Orienting signal) x 2 (Executive control) mixed factor ANOVA. The standard deviations were calculated for each participant and RTs with 2.5 standard deviations above the mean were eliminated. The mean of each condition was calculated in the remaining trials. Error percentages were not subjected to statistical analysis, as there was no variability in some experimental conditions (the mean was equal to 0).

The main effect of Group was significant, $F(1,16) = 9.00$, $p = .008$, with higher RTs in the frontal group than the control group. The analysis also showed significant effects of the three within-subject variables measuring the functioning of each attentional network, thus replicating the results obtained by Callejas et al. (2005; 2004). As regards the **alerting** network, responses were faster in trials with a signal than in those with no signal, $F(1,16) = 27.05$, $p < .001$. The main effect of **orienting** was also significant, $F(2,32) = 121.94$, $p < .001$, with faster RTs when there was a signal that indicated the subsequent location of the target (valid trials) than when no signal was presented, $F(1,16) = 61.69$, $p < .001$. As regards the **executive control** network, significant differences were found between the incongruent and the congruent condition, $F(1,16) = 390.52$, $p < .001$. However, the most relevant result was that, as expected, the only main effect significantly modulated by the group was the effect of conflict, as indicated by the Executive control x Group interaction, $F(1,16) = 11.73$, $p = .003$. The frontal group showed greater interference in the flanker task than the control group.

Interactions found in the studies undertaken by Callejas et al. (2005; 2004) were not modulated by the group, although the Congruence x Alerting interaction was marginally modulated by the group factor, $F(1,16) = 3.15$, $p = .095$. Although both groups showed a greater effect of conflict in the presence of an auditory signal compared to the condition with no signal, patients showed a 35.28% increase whereas controls only showed a 16.71% increase.

To conduct a more detailed analysis of attentional networks, the indices of functioning of each network were calculated. The alerting index was obtained by subtracting RTs of trials with an alerting signal from those of trials with no alerting signal (but only considering trials with no visual signal). The orienting index was obtained by subtracting the RTs of valid trials from those of invalid trials. Finally, the executive control index was obtained by subtracting the RTs of incongruent trails from those of congruent trials. A single factor ANOVA was conducted between the Group factor and each of the three indices obtained (Alerting, Orienting and Executive control). The Group effect was only significant with the executive control index, $F(1,16) = 11.73$, $p = .003$, as the patient group showed a greater interference effect. By contrast, the effect of the other indices was independent of the group (Orienting, $F(1,16) = 1.29$, $p = .272$; Alerting, $F < 1$). This dissociation is clearly shown in Figure 3.

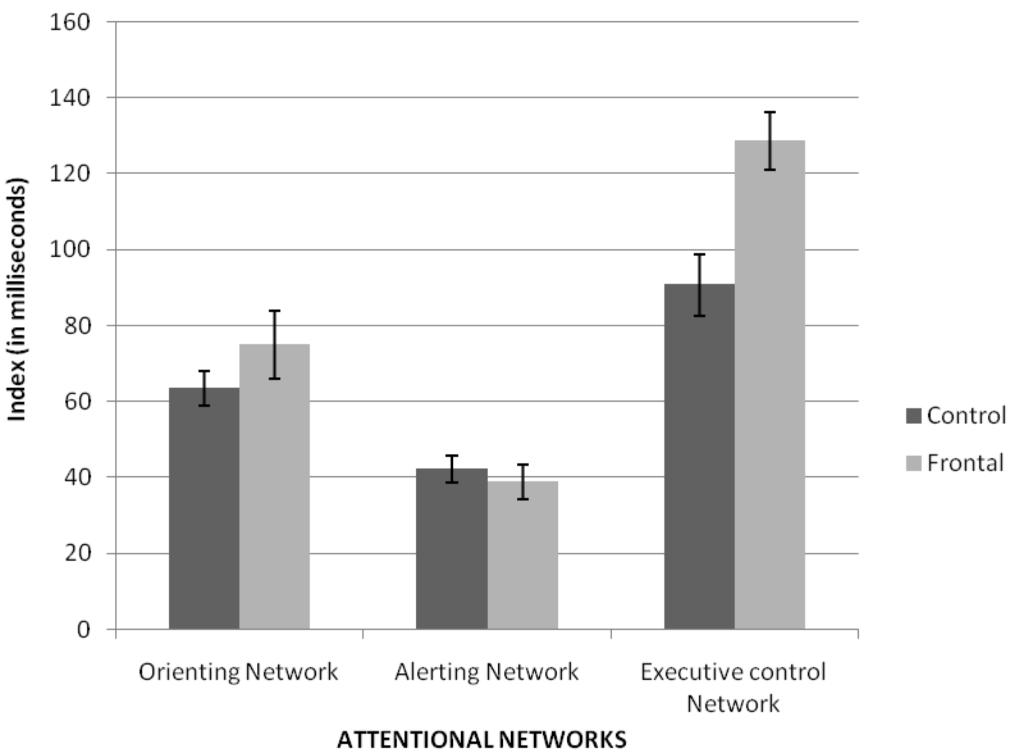
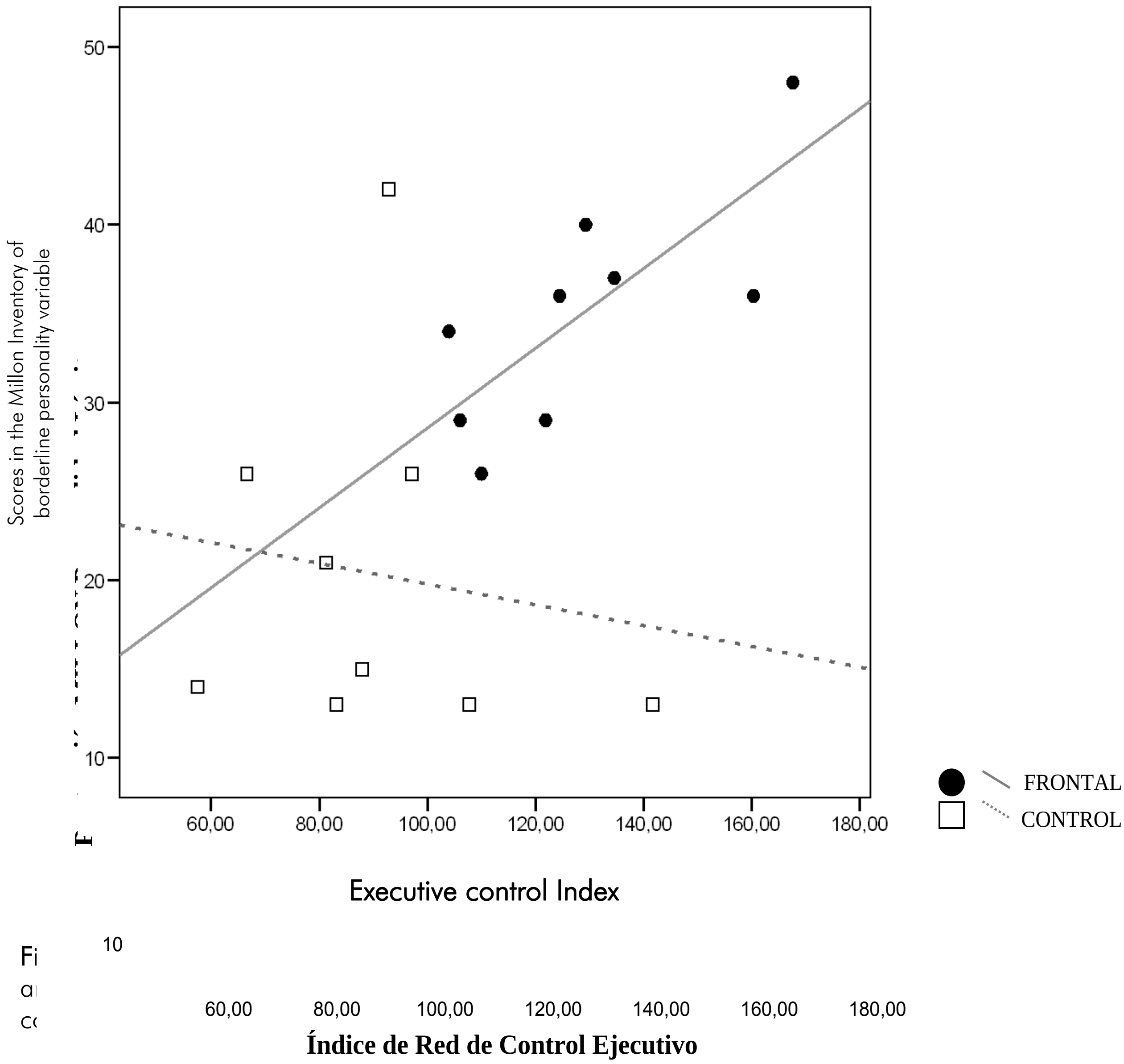


Figure 3. Differences between the indices of reaction times (RTs) of the Orienting, Alerting and Conflict variables in each group.

Personality and cognitive control

A bivariate correlation analysis was performed between the index of conflict and the aspects assessed by the Millon Clinical Multiaxial Inventory (MCMI-II) in the results obtained by the 9 patients. It was not possible to administer the inventory to one of the participants of the frontal group. Therefore, the sample used in this analysis was composed of 8 participants. From the MCMI, the authors chose personality disorders and related serious alterations associated to impulsivity and lack of self-regulation in the literature, such as antisocial, compulsive and borderline personality disorders and hypomania. Results showed that only borderline personality, $R = .863$, $p = .006$, was correlated with the conflict index with a level of significance of $p = .0.01$; the correlation was marginal in the case of antisocial personality, $R = .672$, $p = .068$. However, the correlation was not significant for compulsive personality, $R = -.096$, $p = .822$, or hypomania, $R = -.365$, $p = .373$. A correlation analysis was also conducted in the control group but no correlations between these variables and the executive control index were significant (all the $ps > .230$). The spread diagram of the correlations with borderline personality is shown in Figure 4.



Fi
a
c(

Conclusions

The present study is the first to show a greater interference (deficit in the executive control network) in a group of patients with prefrontal damage than in a control group. This deficit was related to measures of personality associated to cognitive and behavioral impulsivity and inflexibility.

The executive control network, the main target of this study, is responsible for solving non-automated or conflicting situations and is located in prefrontal areas. Studying alterations of this network in patients with frontal lesions is key to support experimental data and learn more about attentional functioning under normal conditions and after a brain injury (Posner & Petersen, 1990). The present study suggests that lesions in the prefrontal cortex interfere in conflict resolution. This confirms the results of previous studies conducted with functional neuroimaging that have found that control effort activated the anterior cingulate, the left prefrontal cortex (Bush, Luu, & Posner, 2000; Duncan & Owen, 2000; Fan, Flombaum, McCandliss, Thomas, & Posner, 2003), the right prefrontal cortex and the fusiform gyrus (Fan et al., 2003).

The study also showed the conflict effect in three patients whose lesion was practically restricted to the orbitofrontal cortex. This cortex has recently been related to the ability to inhibit irrelevant information in tasks of the Stroop Test and the Trail Making Test (Fu et al., 2001; Harrison et al., 2005; Mitchell, 2005). For this reason, the fact that the present study found a relationship for the first time between this area of the brain and conflict resolution is considered relevant. Yet, conclusions should be drawn with caution due to the size of the sample. Future studies with larger samples will make it possible to divide the prefrontal lesion group into subgroups and thus analyze the involvement of each circuit and prefrontal area in conflict resolution and executive control. A larger sample would also allow exploring the various types of control mechanisms, since a recent study has shown the existence of different conflict adaptation effects in different tasks that activate the attentional executive control network, such as Stroop or Simon tasks (Funes, Rodriguez Bailon, Ruiz Perez, & Lupianez, 2009). For all these reasons, future studies should aim at discovering the cognitive mechanisms and neural correlates of the various executive control tasks.

Regarding the interactions between networks, no group effects were found in any of the interactions. However, a marginal effect of group was observed in the interaction between alerting and cognitive control. This seems to indicate an additional impairment in conflict resolution caused by the alerting signal in patients with frontal lobe damage. This finding could have an important application in clinical neuropsychology. In fact, it may suggest the need to rehabilitate the executive control network in patients with prefrontal lesions in the absence of any “activating” stimulus, since its presence seems to generate more confusion than preparing to solve the conflicting situation. However, it is key to consider the population in which interventions on the executive control network are to be conducted, given that beneficial effects of the alerting network on cognitive control have been found in other groups such as schizophrenic patients or patients with spatial hemineglicence (Amado et al., 2011; Chica et al., 2012).

The findings of this study and therefore those obtained in other studies with clinical populations (Amado et al., 2011; Miro et al., 2011; Mullane, Corkum, Klein, McLaughlin, & Lawrence, In press; Wang et al., 2005) show that the ANT-I task has amply proven its sensitivity to specific deficits in each attentional network and also reflects alterations in interactions between networks, which is of major scientific and applied interest.

Personality and cognitive control

Another of the main results found was the relationship between the conflict effect and personality variables. The main trait that the conflict effect correlated with was borderline personality. Borderline personality disorder is described in the DSM-IV-TR as a pervasive pattern of instability of interpersonal relations, self-image and affects and marked impulsivity (American Psychiatric Association, 2003). These data support other studies that have conducted experiments with the ANT in patients diagnosed with Borderline Personality Disorder. Results have shown that these patients show low indices of effortful control, associated to a greater interference in the flanker task (Posner et al., 2002). Similar results showing a greater conflict effect have been observed in participants with high trait anxiety (Pacheco-Unguetti, Acosta, Callejas, & Lupianez, 2010). The results of the present study show that the relationship between these variables depends on the existence of a borderline personality disorder secondary to a brain injury, given that the correlation was not significant in control participants.

Personality alterations secondary to prefrontal damage characterized by behavioral disinhibition and impulsivity are well known. They may also generate a deficit in cognitive control and conflict resolution. To explore this possible relationship, the conflict network was analyzed by introducing the scores in the borderline personality variable of the Millon Inventory as a covariate. However, the difference between groups remained significant so this result cannot be explained by differences in borderline personality between patients and controls. Therefore, these results seem to reflect the existence of a common mechanism that lies at the basis of cognitive and behavioral control. Future studies could design clinical interventions on this kind of patients to discover whether a transfer of improvement occurs in cognitive conflict resolution tasks.

Acknowledgements

The authors wish to thank neuropsychologist Carmen Sáez and neurologist Cristóbal Carnero for their cooperation, as they made it possible to collect data in the Fydian Neurocenter clinic in Granada.

Experimental Series 2

Relations between experimental measures of control cognitive and everyday errors after frontal lobe damage.

Relations between experimental measures of control cognitive and everyday errors after frontal lobe damage.

Rodríguez-Bailón, María[1], Lupiáñez, Juan[1,2], Ródenas-García, Estrella[1], García-Morán, Tamara[1,3], Triviño, Mónica[1,4]and Funes, María Jesús[1,2].

1. Centro de Investigación Mente, Cerebro y Comportamiento. Campus de Cartuja s/n. Granada, Spain.

2. Departamento de Psicología Experimental. Universidad de Granada, Granada, Spain

3. Asociación Granadina de Familias para la Rehabilitación del Daño Cerebral Adquirido "AGREDACE", Granada, Spain.

4. Servicio de Neuropsicología, Hospital Universitario San Rafael, Granada, Spain

Abstract

After frontal lobe damaged patients usually fail on cognitive control tasks, where a controlled response is required while inhibiting automatic behaviour. Many computer-generated tasks based on Stimulus-Stimulus (S-S) or Stimulus-Response (S-R) conflict have been designed in order to assess this executive process. However, deficits inexecutive inhibition are also observed in the context of everyday activities when patients commit perseverations of actions, touch objects without purpose or use distractor objects (commission errors). The aim in this paper was to test differences between a group of frontal lobe damage and aged control participants in a computer based task where different types of conflict (Distractor Filtering, Spatial Stroop or S-S and Simon or S-R conflict) were included and on a performance-based everyday life task under the presence of semantically related distractors. Most importantly, we analyzed the relationship between participants scores in both the experimental and ADL task. Frontal patients showed larger interference in the three conflict types and more commission errors in everyday activity in comparison to controls. However only S-R (Simon) conflict rather than on S-S (stroop) interference was related to commission errors in ADL execution. We conclude that the interfering effect produced by distractors in ADL performance could be mainly due to deficits in the mechanisms to inhibit irrelevant actions triggered by semanticaly associated irrelevant objects in the scene.

Keywords

Cognitive Control, Executive Functions, Frontal lobe damaged, Activities of Daily Living,

Introduction

Executive functions refer to a number of cognitive mechanisms that mainly involve three processes: working memory, flexibility, an inhibitory process by which we can control our behaviour and override prepotent and automatic responses (Miyake et al., 2000). From these processes more complex processes arise, such as reasoning, problem solving or planification (Diamond, 2013).

Through more basic processes, cognitive control or inhibitory processes enables control over our behaviour in a top-down manner, instead of being automatically driven by previous experience with stimuli or habits. These mechanisms allow us to select stimuli we want to attend and suppress attention to other irrelevant stimuli, which leads to goal driven behaviour.

Some tests and tasks have been designed in order to evaluate and measure this cognitive control system. One of the most used tasks has been the Stroop task, in which experimenters show to participants a list of names of colours written in different colour inks. Participants are asked to say the ink colour in which words are written, while ignoring the dominant and automatic response, which in this case is the reading of the word. Participants use to exhibit a poor performance (inaccurate and slow responses) when the meaning of the word is incongruent with the ink colour (e.g., the word “RED” written in green ink colour) in comparison to when the meaning of the word is congruent with the ink colour in which this word is written (e.g., the word “RED” written in red ink colour). This effect is called interference effect. The colour version is the most popular since first reported in 1935 by John Ridley Stroop, but there are many other versions: number-size stroop, emotional stroop, etc (Macleod, 1991).

Another widely used version has been Spatial Stroop in which the direction of an arrow (or the spatial meaning of a word), which is the relevant dimension for the task, can point to (or mean) the same or opposite place where the arrow appears (Lu

& Proctor, 1995). From the Dimensional Overlap Model (DO) (Kornblum, Hasbroucq, & Osman, 1990), this paradigm involves a conflict between two intrinsic dimension of the own stimuli: direction and localization. For this reason this type of conflict is considered Stimulus-Stimulus (S-S) interference.

Other task created to assess cognitive control has been the Simon Task (Simon & Craft, 1972). In this task participants must attend to a non-spatial dimension of one specific dimension of a stimulus (e.g., its colour, or its shape) in order to generate a lateralized response (left-right), which can be compatible or incompatible with the localization of the shown target stimulus. For example, participants might have to response by hitting either a left or right key in response to the colour of a square, which also appears either to the left or to the right of the fixation point. The location of the stimulus would be the irrelevant information in this case, and thus participants should ignore it, in order to focus on the relevant information, specifically the feature specifying the correct response. Thus, in this case conflict arises between a stimulus dimension (localization in which stimuli appears) and a response dimension (the location of the response key) (Lu & Proctor, 1995b), and therefore is named Stimulus-Response (S-R) interference.

Flanker tasks, have also been a widely measure to assessed cognitive control (Eriksen, 1995). In this task, the target (for example, an arrow) is flanked by non-target stimuli, which correspond either with the same directional response as the target (congruent flankers), or with the opposite response (incongruent flankers). Participants are instructed to indicate the direction of the target by pressing one of two response keys, while ignoring the distractors. In contrast to Stroop or Simon, which might index pure measures of S-S o S-R interference, respectively, the conflict measured in a flanker task might be a combination S-S and S-R conflicts.

Neural correlates of these difference conflict effects are located in dorsolateral prefrontal cortex and anterior cingulate (Carter et al., 1998; MacDonald et al., 2000). Studies with frontal damaged patients demonstrated that patients used to have more problems in the resolution of Stroop (Alexander et al., 2007; Balani, Soto, & Humphreys, 2012; Stuss et al., 2001) or Simon interference (Kumada &

Humphreys, 2002). Thus, they used to make more errors and take more time to resolve incongruent trials of these conflict types in comparison to a control group (Kumada & Humphreys, 2002) or a group of non-frontal patients (Funes, Lupianez, & Humphreys, 2010b).

Besides the overall measures of interference in these tasks, other ways to assess cognitive control have been proposed, for example, evaluating on-line reactive adjustments in control after situations when control is needed (e.g., after an incongruent trial). In fact, in healthy population, congruency effects (the different between congruent and incongruent trials) are smaller on a current trial when preceded by an incongruent trial than when preceded by a congruent trial incongruent (Gratton, Coles, & Donchin, 1992). In these situations, an increased top-down control is thought to be active as the result of the resolution of conflict on the previous trial, even when stimulus characteristics change across trials (Ullsperger, Bylsma, & Botvinick, 2005). This effect, which is called conflict adaptation, was absent however in frontal patients when perceptual features of stimuli changed on consecutive trials (Funes et al., 2010b). A recent study with frontal damaged patients also revealed specific impairments in cognitive control evaluated by a flanker task (Rodriguez-Bailon, Trivino, & Lupianez, 2012), which, as stated above might involve both S-S and S-R conflict.

In order to distinguish between the different types of conflict and analyse whether different processes are involved in solving these types of conflict operates in parallel or otherwise different type of conflict are solved by the same general cognitive control mechanisms, diverse studies have been carried out. For this purpose, researches have designed tasks in which the different conflict types are assessed in the same context and with the same stimuli. Several studies have produced evidence suggesting the existence of specific mechanisms involved in the resolution of different conflict situations (Egner, 2008; Wendt, Kluwe, & Peters, 2006). Some of this evidence come from studies showing that conflict adaptation effects are specific of each conflict type (Funes, Lupianez, & Humphreys, 2010a). Thus, for example, Stroop congruency does depend on Stroop congruency on the previous trial, but does not depend on Simon congruency. Neuroimage data also corroborated these findings (Bunge, Hazeltine, Scanlon, Rosen, & Gabrieli, 2002; Egner, Delano, & Hirsch, 2007). Whereas parietal cortex was activated in S-S monitoring, neural correlates of S-R monitoring were rather frontal premotor areas. Nevertheless, a recent study have suggested a new hybrid model of cognitive control in which it has included specific-domains to resolve specific conflict situations, and a global cognitive control domain which neural correlates were more variable between subjects (Jiang & Egner, 2013).

Although, conflict effects depend on endogenous attentional control, these effects could be also modulated by external aspects of cognitive control. Thus, exogenous stimulus such as adding distractor stimulus around the target stimuli, could interfere with performance of the cognitive tasks. Nevertheless, a high cognitive control process could increase distractor processing and, consequently, it could cause interference effects (Lavie, 2005). A study with a frontal and temporal damaged patient demonstrated that the presence of distractor stimuli in a Simon Task increased interference effects, when irrelevant information that the patient should ignore was the automatic information (Kumada & Humphreys, 2002).

In the same way that is has been investigated with experimental tasks, cognitive control has also been investigated in everyday behaviour. In fact, executive control processes are essential to predict job and academic success (Bailey, 2007; Borella, Carretti, & Pelegrina, 2010). In clinical settings, these processes are very potent predictors of impairment decline from mild cognitive impairment (MCI) to dementia disease (Aretouli, Tsilidis, & Brandt, 2013). Currently, many studies are being dedicated to study executive functions involved in the performance of Activities of Daily Living (ADL) (Aretouli & Brandt, 2010; Aretouli et al., 2013; Hughes et al., 2012; Morady & Humphreys, 2009; Perneczky et al., 2006; Reid-Arndt, Nehl, & Hinkebein, 2007; Tan, Hultsch, & Strauss, 2009). The online maintenance of task schema in memory when we are doing a specific task, a functional aspect related to executive processes on memory, is very important to avoid sequence failures or to stop repetitive perseverations of a completed action. So, when we are carrying out an ADL, it is necessary to maintain task schema and also activate inhibitory process, with which we can focus on target actions in a correct sequence, and target objects, inhibiting actions that could be evoked from distractor objects (Niki et al., 2009).

In this sense, a meta-analysis with dementia and MCI patients has highlighted the important contribution of these processes to the functional status of patients (Martyr & Clare, 2012). Different tests ranging from attentional selection, inhibition, abstraction to flexibility have been found to significantly correlate with different functional measures obtained from informant questionnaires or performance based tasks (Martyr & Clare, 2012).

One of the current issues about functional domains that different studies are studying is the knowledge of the influence from distractor objects on performance in ADL. Typically, we are exposed to different contexts where there are multiple objects that we should ignore in order to achieve our goal. After frontal brain damage, several case studies have been documented in which patients used to attend, touch and use present objects in a properly way, but out of a coordinate action and without any purpose. This type of behaviour called "Utilization Behaviour" (Archibald et al., 2001; Lhermitte, 1983) provides evidence of attentional endogenous control deficit that provokes an attentional capture or preactivation to unnecessary distracting objects, which is not counteracted by the activation of inhibitory processes. Thus, under situations where many distractor objects are shown, the executive control that is exerted will be higher in order to inhibit actions towards these distractor objects than in situations in which only target objects were present. Moreover, distractor interference could be even higher depending on the relationship between target and distractor objects.

Although previous studies reported the absence of distractor effects in everyday tasks after frontal lobe damage (Humphreys & Forde, 1998) perhaps due to weak links between distractor and target objects, recent studies have found significant differences between conditions with vs. without distractors (Giovannetti et al., 2010; Morady & Humphreys, 2009; Niki et al., 2009). One study has focused on the relation in terms of physical and functional similarity (e.g. salt and sugar), showing that dementia patients produce more errors with physically and functionally similar to target objects (Giovannetti et al., 2010). More concretely they made more substitutions errors, replacing distractor objects by target objects, and touched without any purpose these distractor objects in the related compared to the unrelated condition. However, this type of error could be due interpreted, to not only due control or inhibitory deficits, but also to semantic impairments like degraded task schema and object knowledge due to their disease.

Niki et al (2009) carried out a study with frontal patients to dissociate between these two explanations and hey designed a new distractor condition which consisted on the presence of distractors that altogether constituted a set of objects to complete a competing not required task. They compared two conditions, one where the whole distractor task was semantically related (e.g. all items to make a Japanese tea when asked to make coffee) or unrelated (drawing a picture–preparing an envelope for presenting a gift of money). They selected three brain damage patients with exclusive lesions in the right prefrontal lobe who had previously shown no ADL alterations in the absence of distractors. Independently of conditions, the authors found that these patients produced a large proportion of errors with the distractors under these conditions; however they didn't observe systematic differences across semantically related vs. unrelated conditions due to the small size of the sample. Experimental studies supported the idea about the facilitation of object processing when these objects were part of a common action with other linked object (such as a bottle with a glass) (Humphreys et al., 2013; Humphreys & Riddoch, 2007). In this way, Niki et al (2009) proposed that under conditions in which distractors could be used in a join action could provoke more interference, and, thus, executive control could be more active in order to inhibit actions towards distractor objects. Consequently, the relationship between target and distractor objects could influence the kind of ADL performance errors showed.

Therefore, our principal aim with this study was to establish a bridge between experimental tasks of cognitive control and functional measures of performance in the presence of distracting objects. Thus, we designed an experiment in which the direction of an up/down-pointing arrow was to be discriminated by pressing a left or right key, which made it possible to measure two types of conflict (Simon or Stimulus-Response conflict, and Stroop, or Stimulus-Stimulus conflict). This was combined with a visual search task in which we compared conditions with and without distractors, which allowed the measurement of a further control mechanism: distractor filtering. The three factors were fully crossed in an orthogonal design. We analysed execution in a group of frontal damaged patients and a control group in order to know the specific cognitive control mechanism that was mosltly impaired after frontal damage. In particular, we were interested in the analysis of the modulation of the presence of distractors on task performance in both groups.

In relation to functional domains, a subset of participants carried out an everyday task in the presence of distracting objects evoking a different task, which participants should ignore. This way, we increased the need for control that participants should activate, which we expected would reveal functional differences between groups. An important goal of this study was to correlate both measures (experimental and functional measures) in order to investigate the relationship between these different assessment measures of cognitive control.

Experiment 1. Cognitive control Task

Method

Participants

The study groups were composed of 19 patients with prefrontal brain damage (10 men and 9 women) secondary to brain injury and 54 neurologically intact individuals (16 men and 38 women). The inclusion criterion for the frontal group was the presence of damage in the prefrontal lobe confirmed by neuroimaging and neuropsychological assessment. The most relevant information regarding the location of the lesions of patients in the frontal group are shown in Table 1. Exclusion criteria were the presence of spatial heminegligence and altered comprehension.

Patient	Lateralization	Type of injury	Date of injury Month/Year	Structural imaging (CT and MRI reports)
1	Right	Stroke	June/1998	CT (October-1998): Hemorrhage in right frontobasal region with pronounced mass effect, as well as intraventricular hemorrhage, subfalcial herniation and blood in the basal cistern with diffuse cerebral edema.
2	Bilateral	TBI	July-1990	CT (July-1990): Discrete global atrophy with bifrontal predominance and bilateral frontobasal demyelination mainly in the left hemisphere.
3	Right	Tumour	August-2011	CT (August-2011): Dense image in right frontal region with mild signs of edema. MRI (September-2011): Intracraneal expansive process in right frontal lobe with mild mass effect on adjacent structures without contrast enhancement, compatible with a gemistocytic diffuse astrocytoma (grade II). MRI (January-2012): Postsurgical changes with a malacic cavity in right frontal region with retraction of the frontal horn. Areas with T2 altered signal in posterolateral parenchyma adjacent to the surgical bed.
4	Bilateral	Stroke	June-2012	MRI (June-2012): Chronic ischemic lesions in the territory of both anterior cerebral arteries, more extensive on the right hemisphere.
5	Right	Stroke	June-2007	CT (June-2007): Subdural hematoma with right fronto-temporo-parietal extension. Focal hemorrhage in right frontal region. Mild midline shift.
6	Left	Stroke	January-2010	CT (January-2010): Left sylvian hematoma and subarachnoid hemorrhage extending to the basal cisterns, interhemispheric fissure and contralateral sylvian region with intraventricular hemorrhagic component in ventricles III and IV. Aneurysm in the left middle cerebral artery (16,2 x 14,4 mm in diameter). A surgical intervention with clipping of the aneurysm was performed, as well as a descrompessive craniotomy due to an increase of the left sylvian hematoma with mass effect.

				CT (February-2010): Left frontal craniotomy and malacic frontotemporal changes underlying the craniotomy. Chronic ischemic stroke in left temporo-parietal-occipital region.
7	Bilateral	TBI	January-2012	**CT** (January-2012): Right paramedian occipital fracture and bilateral frontobasal hemorrhagic contusions. Small subdural bleed at the falx cerebri. Bifrontal craniotomy due to increasing intracraneal presion.
8	Bilateral	Herpetic meningoencephalitis	January-2006	**CT** (May-2010): Extensive hypodensity area in both right frontal and temporal lobes as well as the left external capsule, and in the territory of both middle and anterior cerebral arteries. Retraction of the lateral ventricles mainly in the left one.
9	Bilateral	TBI	January-2007	**CT** (January-2007): Small subarachnoid hemorrhage close to the anterior sulci in the interhemispheric fissure. Cerebral cortical atrophy of frontal predominance. **MRI** (October-2008): Pronounced cerebral atrophy, leukoaraiosis and ependymitis. This patient was also examinated by functional imaging (SPECT –CT) **SPECT-CT** (February-2009): Cortical distribution of the radiotracer markedly homogeneous, highlighting the existence of a marked hypocaptation at bilateral frontal lobe in its mediobasal portion and in both anterior temporal poles. Significant reducing uptake in the left parietal lobe and relative hypocaptation of left somatosensory cortex. **SPECT-CT** (February-2011): Identical observations as in 2009.
10	Bilateral	Stroke	April-2010	**CT** (April 2010): Extensive intracerebral hematoma at the base of the frontal lobes and right caudate nucleus extending to the entire ventricular system. Extensive subarachnoid hemorrhage. An aneurysm in the anterior communicating artery (AcoA). **CT** (May 2010): Mild decrease of the intraventricular, interhemispheric and bilateral frontobasal hemorrhage. A slight increase in ventricular size is appreciated.

				MRI (June 2011): Frontobasal bilateral encephalomalacia of post-hemorrhagic nature. Vast leukoencephalopathy in the white matter of both cerebral hemispheres. Ventricular derivation entering through the right frontal lobe. Ventricular system of normal size.
11	Bilateral	Stroke	November-2011	CT (November 2011): Subarachnoid hemorrhage occupying supra-and infratentorial cisterns, interhemispheric fissure and the anterior corpus callosum. Mild hemorrhagic component in the third ventricle and foramen of Monro. Greater hemorrhagic accumulation in posterior frontobasal midline with a large aneurysm (8mm x 8mm) in the anterior communicating artery (AcoA). No signs of hypertensive hydrocephalus.
12	Left	TBI	December-2009	CT: Blood in tentorium cerebelli and left ventrolateral occipital horn. Supratentorial hemorrhagic foci. Millimetric hemorrhagic contusions in left frontal region. Two small hemorrhagic lesions in the right cerebellar peduncle.
13	Bilateral	Postanoxic encephalopathy	November-2005	MRI: Discrete atrophy predominantly frontal
14	Right	Tumour	May-2011	MRI: DP, T2 and Flair hyperintense punctiform areas in frontal white matter mainly on the right side, consistent with focal gliosis with nonspecific significance. Incidentally, image compatible with meningioma in the right olfactory bulb (cribriform plate) of 18 x 21 x 22 mm, which slightly compresses the basal surface of the frontal lobe with discrete edema in adjacent subcortical white matter.
15	Left	TBI	December-2003	CT (Dec-2003): Left frontal contusive focus. MRI (Apr-2007): Diffuse alteration of yuxtacortical bifrontal white matter signal suggestive of diffuse axonal injury (DAI).

16	Right	TBI	June-2006	CT (Jun-2006): Right frontal hemorrhagic contusive focus, intraventricular hemorrhage with occupation of third ventricle and haematic fluid in lateral ventricles, subarachnoid hemorrhage en convexity sulci more intensive in left sylvian sulcus.
17	Left	TBI	June-2002	CT (Jun-2002): Small hemorrhagic contusion in left frontobasal region. MRI (Apr-2005): Two small foci of scar tissue in left frontal lobe.
18	Right	TBI	February-2005	CT (Feb-2005): Small hyperdense images in the right frontoparietal region compatible with contusive or hemorrhagic foci. MRI (Apr-2007): Glyosis area with segmentary atrophy in lateral and basal portion of right frontal pole and superior portion of right temporal pole.
19	Right	TBI	March-2008	CT (Mar-2008): Discrete subdural hematoma at the falx cerebri with a small left parietal-occipital contusive focus without mass effect and signs of diffuse axonal injury. MRI (Mar-2008): White matter hyperdense foci in both cerebral hemispheres predominantly on right frontal lobe, and compatible with hemorrhagic axonal lesion foci. Small bifrontal subdural hygroma. Hemorrhagic remains persist in cortical sulci in middle line of anterior frontal region but isolated of parietal convexities.

No significant differences were found in age between groups. Mean age was 34.31 years (SD = 15.11) in the Control group and 40.90 years (SD = 14.81) in the Frontal group. Although a larger percentage of women participated in the Control (73%) than in the Patients group (47%), the differences did not reach significance (χ^2=3.24; *p*=.07). Patients and Control subjects participated voluntarily after giving their informed consent. The study was approved by the Ethics Committee of the different stroke associations (AGREDACE, ADACEA Jaén, ADACEMA) and San Rafael University Hospital in Granada (Spain). The experiment was conducted according to the ethical standards laid down in the Declaration of Helsinki.

Stimuli and apparatus

Participants were tested on a Pentium computer running E-prime software (Schneider, Eschman, & Zuccolotto, 2002) and sat in front of the computer screen at a viewing distance of about 53 cm. Stimuli were presented on a 15-inch color Lenovo monitor. All the stimuli consisted of black arrows pointing either up or down. The target (an up or down-pointing arrow) could appear in one of four possible locations, either in the in top-left, top-right, bottom-left or bottom-right corners of an imaginary square (see Figure 1). Responses were made by pressing either the “v” key (left response) on the keyboard with the index finger of the left hand or the “m” key (right response) with the index finger of the right hand.

Procedure

Participants were instructed to make left/right key presses in response to the up/down direction of the target as quickly as possible while avoiding making errors. In half of the trials, the target appeared alone, while in the other half of the trials it was accompanied by a double head arrow in each of the other three locations. Half of the participants responded to the “up” direction by pressing the letter “v” (left response) with the index finger of their left hand and to the “down” direction by pressing the letter “m” (right response) with the index finger of their right hand. The opposite mapping was used for the other half of participants.

The sequence of events on each trial was as follows (see Figure 1). The fixation point was displayed for 750 ms, after which the target was displayed on the screen until participants' response or for 2000 ms if there was no response. Auditory feedback (a 500 Hz, 50 ms computer-generated tone) was given on error trials, or on trials in which no response was made within 2000 ms.

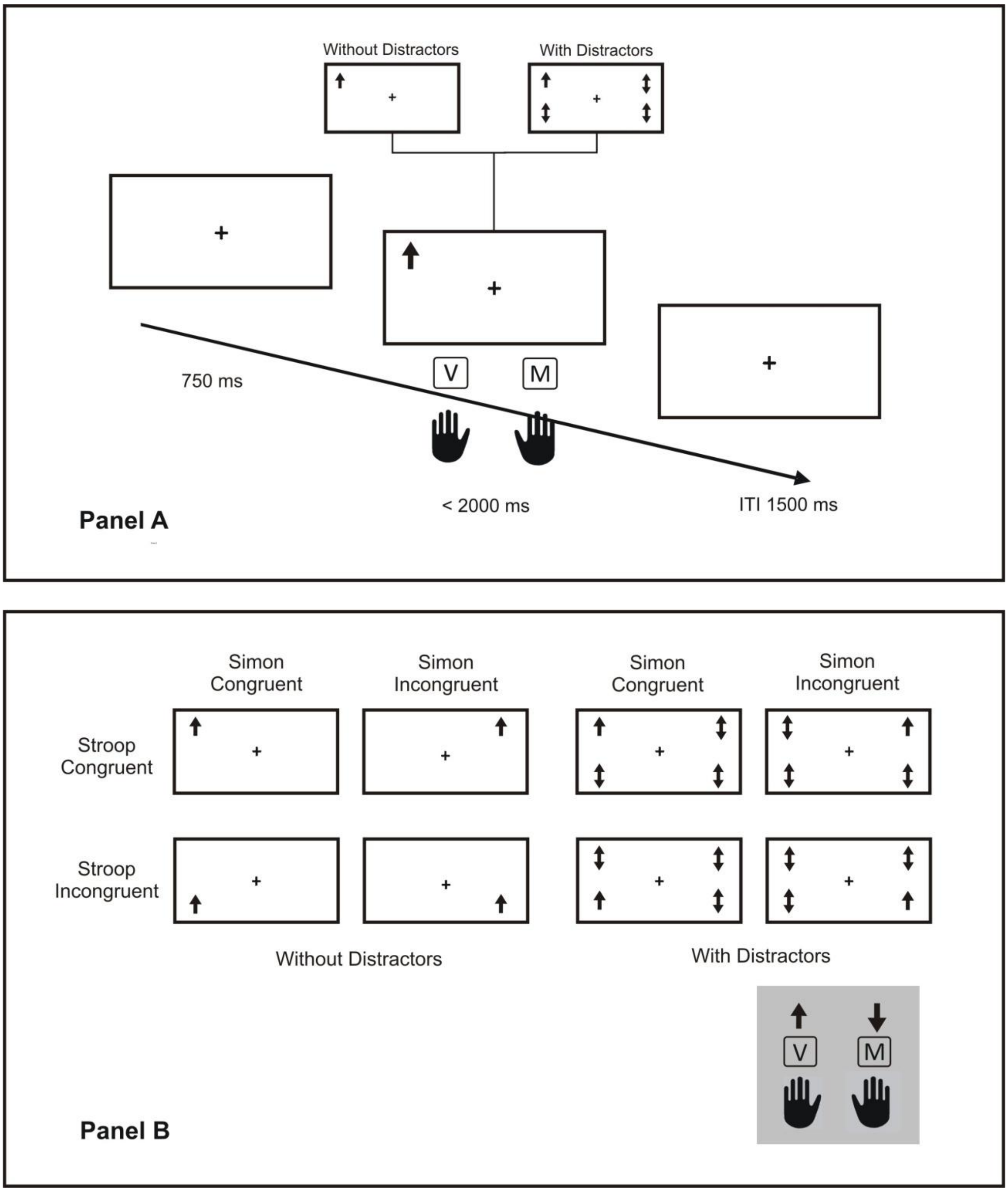


Figure 1. Panel A. Sequence of events in a trial. The example illustrates a trial with distractor present and absent, Stroop Congruent and Simon Congruent. Panel B. Examples of the eight experimental conditions.

Design

This task was designed to measure three mechanisms underlying cognitive control at the same time: Stimulus-Response (Simon) conflict, Stimulus-Stimulus (Spatial Stroop) conflict and Distractors filtering (presence vs. absence of distractors) in an orthogonal way. Therefore, a 2 (Distractors) x 2 (Spatial Stroop) x 2 (Simon) x 2 (Group: Control vs. Frontal patients) mixed factorial design was used.

On Simon congruent trials the correct response was ipsilateral to the target location, whereas on incongruent trials it was contralateral to the target location. On Stroop congruent trials the direction of the target arrow coincided with its location (e.g., an up-pointing arrow appearing in the upper locations), whereas on incongruent trial the direction of the target did not coincide with its location. Double head arrows appeared in the other three locations in the distractors conditions.

The experiment consisted of 32 practice trials (not included in the statistical analysis), followed by 8 blocks of 64 experimental trials each, with all experimental conditions randomly mixed within each block. The experiment stopped between blocks, allowing participants to rest.

Median Reaction Time (RT) and percentage of errors were analysed as dependent variables.

Results

A 2 (Distractors) x 2 (Spatial Stroop) x 2 (Simon) x 2 (Group) mixed analysis of variance (ANOVA) were performed for each dependent variable (median RTs, and proportions of errors), with the first three variables as within-participants factors and Group (Control vs.Frontal patients) as a between-participants factor.

For the RTs analyses one patient (Patient 2) was excluded due to a high proportions of errors (32%). The first block was considered as practice and was removed from the analysis.

The main effect of Group was significant, F(1, 70) = 52.71, $p<.001, \eta p^2=.43$, with longer RTs in the Frontal (878 ms) than in the Control group (620 ms). The analysis also showed as significant the main effects of each of the three within-participants variables measuring each subtype of cognitive control. Regarding distractors filtering, responses were faster in trials in which the target arrow appeared alone (618 ms) than in those with distracting arrows (751ms), F(1, 70) = 282.07, $p< .001$, $\eta p^2=.80$. The main effect of Spatial Stroop was also significant, F(1, 70) = 68.56, $p< .001, \eta p^2=.49$, with faster RTs for Stroop-congruent (674 ms) than for Stroop-incongruent (695ms) trials. Finally, the main effect of Simon was also significant, F(1, 70) = 158.19, $p< .001, \eta p^2=.69$, RTs being faster for Simon-congruent (661 ms) than for Simon-incongruent(707 ms) trials.

Each of these main effects was significantly modulated by Group. Thus, the Frontal group showed greater interference from distractors, F(1, 70) = 19.62, $p< .00$, $\eta p^2=.21$, and larger Spatial Stroop, F(1, 70) = 5.77 , p = .019, $\eta p^2=.07$, and Simon effectsF(1, 70) = 10.08 , p = .002, $\eta p^2=.12$.

A three-way interaction between Distractors, Spatial Stroop and Group was found, F(1, 70) = 8.14, p =.006. Similarly, we found a three way interaction between Distractors, Simon and Group, F(1, 70) = 6.06, p =.016. A partial ANOVA conducted on the conditions with distractors revealed significant Stroop x Group and Simon x Group interactions, F(1, 70) = 10.04, p =.002, and F(1, 70) = 12.82, $p<.001$, respectively. However, in the conditions without distractors this interaction disappear Spatial Stroop, F<1, and much reduced for Simon, F(1, 70) = 3.65, $p=.060$.

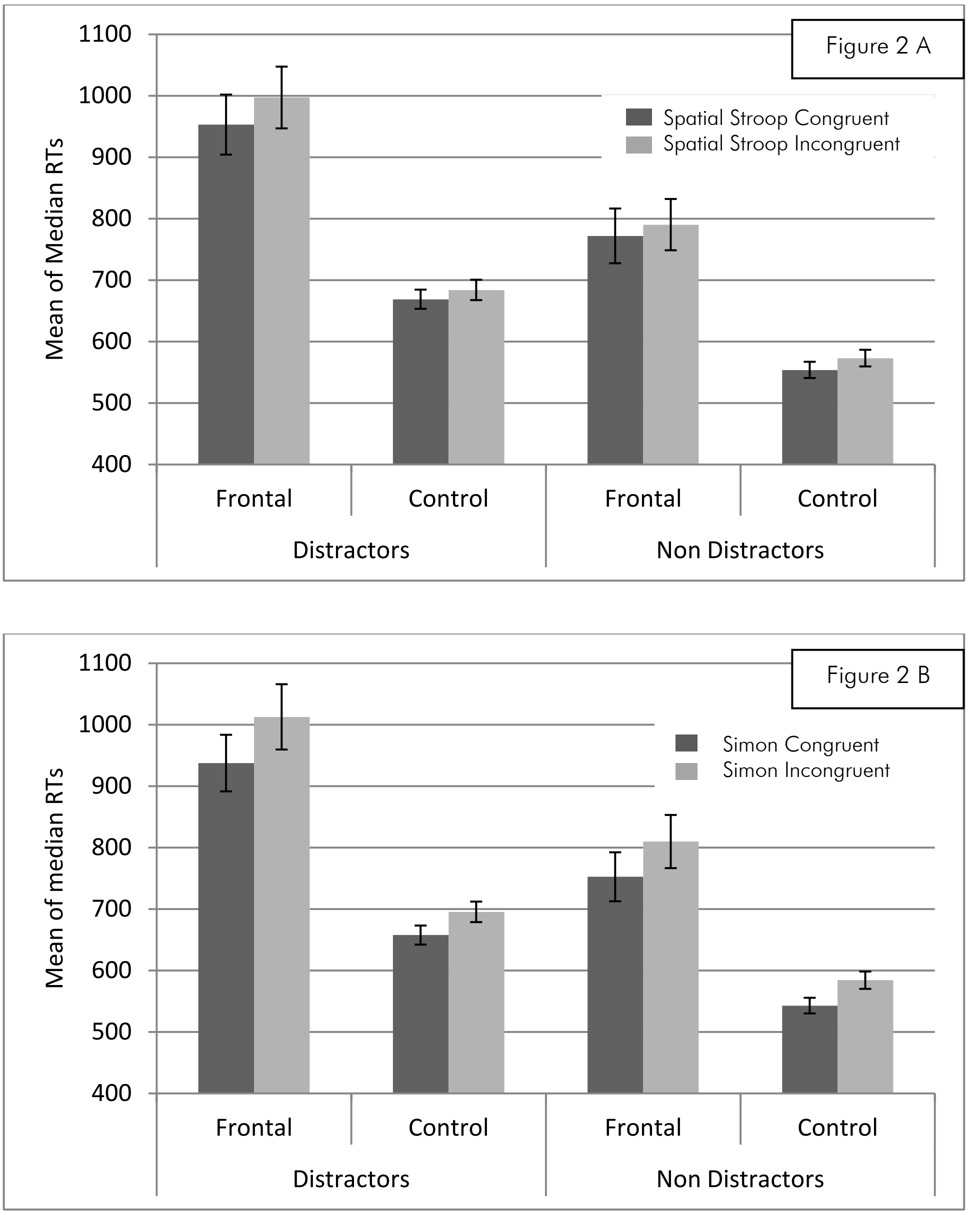


Figure 2. Figure 2A. Mean of median RTs for each group (Frontal and Control) with and without distractors in Spatial Stroop Congruent and Incongruent conditions. Figure 2B. Mean of median RTs for each group (Frontal and Control) with and without distractors in Simon Congruent and Incongruent conditions. Error bars represent the standard error of the mean.

In relation with error percentages, we also found significant main effects of Group, $F(1, 71) = 17{,}19$, $p < .001$, $\eta p^2 = .19$, Spatial Stroop,$F(1, 71) = 5.52$, $p = .022$, $\eta p^2 = .07$, and Simon, $F(1, 71) = 47.38$, $p < .001$, $\eta p^2 = .40$.In both Stroop and Simon conflict types, lower error percentages, were observed on congruent than on incongruent trials. No significant differences were found for error percentages as a function of Distractors, $F(1, 71) = 1.74$, $p=.19$, $\eta p^2=.02$. Distractor Filtering was nevertheless marginally modulated by Group, $F(1, 71) = 3.83$, $p=.054$, $\eta p^2=.05$, while Simon congruency was indeed significantly modulated by Group, $F(1, 71) = 4.23$, $p=.043$, $\eta p^2=.05$. We did not find any three way interaction between Group, Distractor Filtering and Spatial Stroop, $F(1, 71) = 1.28$, $p=.262$, or Group, Distractor Filtering and Simon ($F>1$).

Discussion

Our task allowed us to measure three types of conflict: Spatial Stroop (S-S interference), Simon (S-R interference) and distractor filtering. These conflict types were measured in the same task context without varying any relevant information for measuring each conflict type. Importantly, results showed that our task with this orthogonal design was appropriate to measure each conflict type, as responses were slower and less accurate in conditions where distractors were displayed, and on Simon- or Stroop-incongruent trials.

The task probed to be also suitable to detect group differences in cognitive control, as Frontal patients showed larger interference in the three conflict types than the Control group. Regarding the presence of distractors, is has been shown that the Frontal Eye Field is more activated during conjunction search tasks than during feature search tasks (Donner et al., 2000). As our double-head distracting arrows shared similarities in several visual features with the target arrow, the display was configured like a conjunction search task when the distractors were presented. This explains why group differences were larger in the presence of distractors than when a single target was presented.

Furthermore, we found differences between Control and Frontal group regarding Stroop and Simon interference, which is consistent with several previous studies that demonstrated difficulties in controlling automatic behaviour after frontal lobe damaged (Alexander et al., 2007; Burgess & Shallice, 1996). Different frontal areas (ventral, medial and orbital) have been related to the deficit to stop automatic responses by applying top-down control (Alexander et al., 2007; Stuss et al., 2001; Szatkowska et al., 2007). The orbitofrontal cortex has been related to the inhibition of neural activity that may be irrelevant, unwanted or uncomfortable for reaching the established goals (Picton et al., 2007; Szatkowska et al., 2007).

However, one of our aims was to design an experimental task in order to separate these two conflict types (i.e., S-R and S-S interference). Indeed there are several pieces of evidence showing that these two conflict types are different in nature. Thus, according to Egner et al.(2007), Stroop conflict adaptation was related to parietal areas, Simon conflict adaptation was rather related to ventral premotor neural correlates. Deficits in both tasks in the frontal group in comparison to the Control group could be due to the heterogeneity of our sample, and the extended lesion of some frontal patients, who also exhibited lesions in posterior areas, such as temporal and parietal cortices. Although the resolution of cognitive control tasks might depend on the type of conflict that needed, in both S-S and S-R conflict, it is necessary to activate the control system in order to avoid automatic responses, which demands the involvement of the frontal lobe.

It is important to note that we observed a critical modulation of the presence of distractors in the between group differences observed for both Spatial Stroop and Simon conflict types. When distracting stimuli were shown, patients had especially more difficulties to solve conflict situation in the Spatial Stroop and Simon tasks, whereas the two groups performed similarly when no distractors were presented. Our study corroborated a previous research with a patient with frontal and temporal damaged in which the presence of distractors increased the processing of automatic irrelevant information in a Simon Task (Kumada & Humphreys, 2002). However, in a Simon-reverse task in which non-automatic information has to be ignored (i.e., in a semantic Simon task, when participants responded to the location of the target – LEFT or RIGHT- instead of responding to the meaning of the word - LEFT or RIGHT-), an opposite pattern was found. In this case, interference was reduced in size when distractors were added.

Our results might seem inconsistent with Lavie's Perceptual Load theory (Lavie, 2005), which predict that a high perceptual load (as in our case with the distracting double head arrows) can eliminate processing of distracting information (arrow location in our case). According to Lavie theory, under high perceptual load, with collapsed attentional resources, irrelevant stimulus could not be processed and early attentional selection would takes place. However, the theory also predicts an opposite effect of working memory (WM) load. In this case when WM load is increased the set for maintaining target selection against distractors is impaired, thus distractor processing being enhanced, leading to larger interference (Lavie, 2005). Given that patients with frontal lesions should have working memory deficits, they might have WM problems especially in the presence of distractors. In this case they might have special difficulties maintaining the task set (i.e., target direction is relevant, whereas target location is irrelevant), which will might lead to larger interference. Control participants would not have their WM capacity compromised by the presence of distractors, and therefore would have similar interference with and without distractors. Unfortunately, we did not assess WM capacity of participants, so further research is necessary in order to know the relation between these two processes.

Another possibility is that the, due to their similarity, target and distractors are grouped together, so that when the target is selected against the other three distractor its location is more strongly coded as in this case it would be left-right or up-down coded not only in relation to the fixation point but also in relation to the whole grouped display. The stronger coding of the irrelevant target location would lead to larger interference effects especially in patients who have deficient inhibitory control mechanism.

Nevertheless, a perhaps more plausible explanation could be that interference effects in frontal patients were a reflexion of their difficulty to extract relevant information in cluttered scenes, as it has been shown for the elderly. The effects making more complex the scene have been studied in older people, showing that the ability to select relevant information from a cluttered scene is degraded by age (Sekuler, Bennett, & Mamelak, 2000).

Experiment 2. ADL performance-based task

Once we found deficits in cognitive control in Frontal damaged patients with our experimental task, the next aim was to analyse whether these executive control impairments transferred to everyday settings. In order to do so, we designed an ADL task with the presence of distracting objects in order to observe how task performance was affected the presence of distractors and the type of errors that were committed with them.

Method

Participants

Some participants of the first experiment (11 frontal patients and 11 control participants) were also evaluated with the ADL measure we developed. Control participants and patients were matched for sex, age and educational level (Table 2). The inclusion criterion for the frontal group was the presence of damage in the prefrontal lobe confirmed by neuroimaging and neuropsychological assessment. The most relevant information on the location of the lesions of patients in the frontal group is shown in Table 1. Exclusion criteria were the presence of spatial heminegligence and not having preserved comprehension.

Table 2. Demographic data for the subset of Controls and Frontal patients who participated in Experiment 2.

	Control		Frontal		Group differences	
	Mean	SD	Mean	SD	F	p-value
Age	42.82	5.15	44.18	5.21	.44	.51
Years of Education	12.45	0.99	11.18	0.76	.07	.79
Sex (%women)	63.6 %		63.6 %		$\chi^2 = 0$	

ADL measures

Participants were individually tested in a room conveniently prepared for the experiment. Patients were placed in front of a table with the different objects, and we made sure they could grasp every object in the table. At the beginning of each task, participants were asked to denominate all objects and say aloud their use in order to detect any possible perception and/or semantic memory alterations of participants. Then, participants were instructed to perform one ADL task. Performance of each participant was videotaped for later analysis. In addition to the target items, distractor objects were intermixed with the target items. See Table 3 for a description of the target and distractor objects for each task.

Table 3. Target and Distractor Objects of each functional task (coffee and toast).

Target Objects Task	Distractor objects	
Coffee with milk	Tomato toast	Orangejuice
Coffee bag	Tomato	Orange
Milk	Olive oil	Juice maker
Cup	Slices of bread	Glass
Sugar	Toaster	
Hotplate	Plate	
Pan	Knife	
Teaspoon		
Toast with butter and jam	Coffee with milk	Orange juice
Butter	Coffee bag	Orange
Jam	Milk	Juice maker
Slices of bread	Cup	Glass
Toaster	Sugar	
Plate	Hotplate	
Knife	Pan	
	Teaspoon	

Design

Each patient had to carry out one of the cooking task. Half of the participants made a cup of coffee whereas the other half made a toast with butter and jam. All distractor objects constituted the object set necessary to complete an additional but not required ADL task, which we called the distractor tasks. These distractor tasks were always a "cooking" task, specifically a "breakfast" task in Spanish culture (tomato toast and orange juice, or coffee with milk and orange juice).There were a total of sixteen objects in each task. Objects location was changed randomly across sessions and participants.

Errors made by patients were classified according to Humprheys and Forde (1998) and Schwartz et al. (1991) criteria. Descriptions of each error category are explained in Table 4. In order to test our hypothesis, we followed the distinction made by Giovannetti (2008) between omissions and commission errors. We analysed omissions in proportions, dividing the number of steps omitted between the total number of steps of the target task (and then turned these proportions into percentages). Commission errors included substitutions, perseverations, repetitions, manipulations, action additions and tangential steps. For commission errors, instead, there were not a limited number of errors, because participants could make the same errors incessantly, and therefore we coded number of errors instead of proportion. Although Giovannetti (2008) proposed that actions performed out of the task context, like additions or tangential steps, could be included in a separate category, some studies considered that off-tasks steps would be within commission errors (Buxbaum et al., 1998; Seligman et al., 2013).

Table 4. Descriptions of errors in the performance-based task.

Omissions: Necessary steps to complete target task were omitted. Omissions score was transformed to percentage depending on number of steps that each participant made.

Commissions

- Perseverations: Some steps of actions were inappropriately repeated immediately.
- Repetitions: Inappropriate repetition of a step later in the sequence.
- Failures in Sequence: Failure to follow the conventional order of actions. Normative task sequences are shown in Appendix 1.
- Substitutions: An incorrect object was used instead of a correct target object in order to complete the target action.
- Manipulations/Toyings: The participant only lifted an object and then set it down or fiddled with it.
- Action Additions: The participant added an action that cannot be interpreted as a task step. (For example when participants wanted to eat what they had prepared).
- Tangential Actions: When the participant performed an action sequence correctly but from the distractor task. For example, when doing correct actions to make a toast when asked to make a coffee.

Neuropsychological Assessment

Participants were evaluated with an ample neuropsychological protocol. Cognitive processes such as language, memory, attention and executive functions were evaluated in order to assess the cognitive state of all participants, both patients and controls. MiniMental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975) was used to assess global cognitive status of participants. In order to evaluate short and long term memory, participants were assessed by Rey´s Auditory Verbal-Learning Test (Rey, 1964). Two measures were used of this test: number of words recalled after the first time in a free recall test and number of words recalled at long term in a free recall test. The INECO Frontal Screnning was used to evaluate executive functions (Torralva, Roca, Gleichgerrcht, Lopez, & Manes, 2009). Ideomotorpraxias was assessed by Barcelona Test (Peña Casanova, 1990). Semantic fluency was evaluated by asking the participant to say aloud as many animals as possible within 60 seconds (Ardila, Ostrosky-Solis, & Bernal, 2006).

Some patients could not complete the whole evaluation battery because of fatigue, and lack of motivation. To analyse the data, we chose neuropsychological tests that were completed for at least, 90 percent of participants.

Results

Neuropsychological tests revealed differences between groups in all the tests, with the exception of praxias and comprehension measures. See Table 5 for a more specific description of these differences.

Table 5. Protocol of neuropsychological assessments administered to Patients and Controls and data obtained in both groups.

Tests	Control		Frontal		Group differences	
	Mean	SD	Mean	SD	z	p-value
MMSE (n=21)	29.64	0.15	26.20	1.12	-2.81	.005*
Praxias (n=21)	4.00	0	3.60	0.84	-1.52	.128
Comprehension (n=20)	13.90	0.30	13.89	0.33	-.146	.884
R-AVLT STFRecall (n=21)	6.36	2.29	3.10	1.79	-3.05	.002*
R-AVLT LTFRecall (n=21)	11.64	3.29	2.40	2.45	-3.82	<.001*
INECO Frontal Screnning (n=22)	29.25	11.55	16.77	5.02	-3.56	<.001*
Semantic Fluency (n=21)	25.00	6.84	14.40	6.99	-2.83	.005*

*p<.05. Note: MMSE= Mini Mental State Examination, R-AVLT STF Recall=Number of words recalled after the first time in a free recall test in Rey´s Auditory Verbal-Learning Test (Short Term Free Recall), R-AVLT LTF = Recall number of words recalled in long term in a free recall test Rey´s Auditory Verbal-Learning Test (Long Term Free Recall).

ADL Scores

In order to analyse differences between groups in relation with ADL measures, we carried out the statistical comparisons by using non-parametric measures, because variables were not normally distributed. SPSS software was used for statistical analyses (IBM Corporation, 2011). Following Giovannetti´s proposal (2008), we analysed omissions and commissions separately. Significant differences between groups were found for commissions (z=-2.27, p=.023).The Frontal group made more errors in relation to the Control group, as show in Figure 2. Regarding omissions, although frontal group seem to exhibit more this type of errors, perhaps due to a higher variability (see error bars in figure 2), between groups differences were not significant (z=-1.23, p=.332).

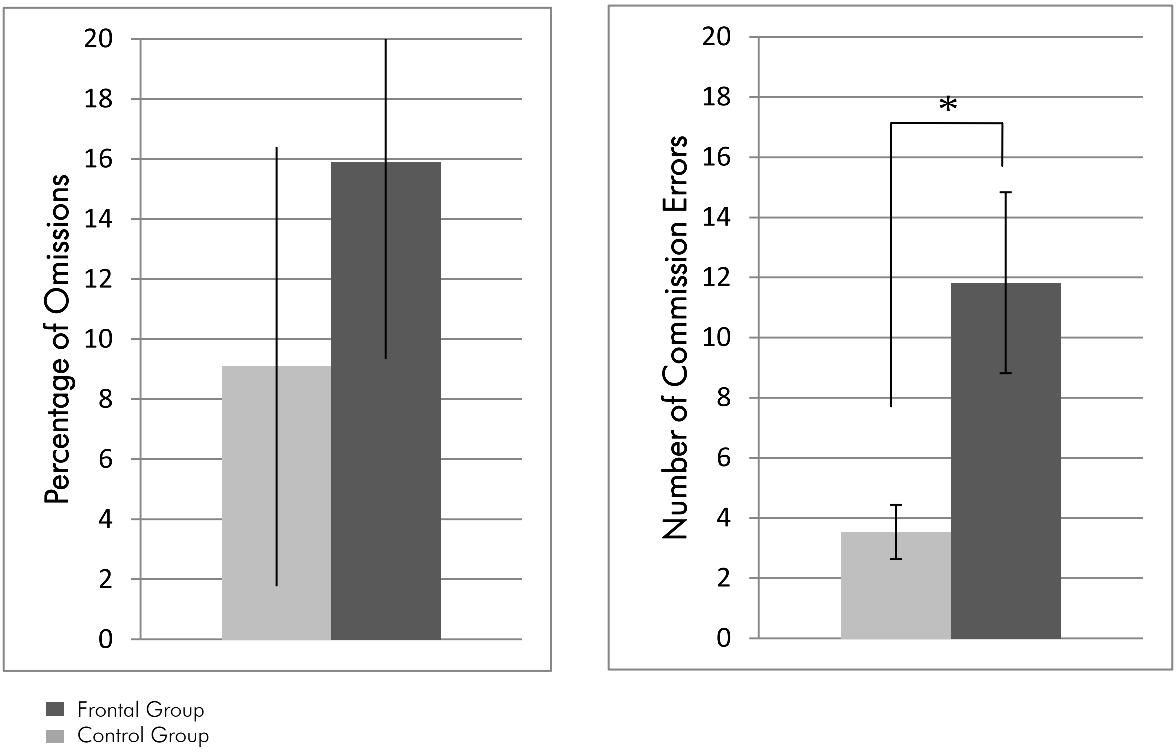


Figure 2. Mean of omissions percentage and commissions for both groups.
Error bars represent the standard error of the mean. *=p<.05

Relations between experimental cognitive measures and ADL variables.

Once we analysed ADL and cognitive control experimental measures, we wanted to know how they relate to each other.

For the experimental measures (Experiment 1), we computed six indexes, two (one with RT and the other with the percentage of errors) for each conflict type for which patients showed deteriorated performance (Distractor Filtering, S-S or Spatial Stroop interference, S-R or Simon interference). Distractor Filtering was computed by subtracting the RTs/% Errors of trails with distractors from those without distractors, S-S interference was computed by subtracting the RTs/% Errors of Stroop-congruent trails from those of Stroop-incongruent trials and, finally, S-R interference was computed by subtracting the RTs/% Errors of Simon-congruent trails from those of

Simon-incongruent trials. For the ADL measures we used percentage of omissions, and number of commission errors.

Table 5 shows the correlation between cognitive control measures and commissions and omission errors in ADL tasks in the subsample of Controls and Patients who completed Experiments 1 and 2 (for the analysis of RTs data from the patient 2 were excluded). Commission errors were positively correlated with the Cognitive Control Index of Simon interference. The positive correlation was significant for the error index (r=.403, p=.046), and was in the same direction for RT (r=.400) although did not reach significance (p=.072). Percentage of omissions was significantly correlated with the RT Index of the Distractor effect measured in the experimental task (r=.492, p=.023).

Table 5. Correlations between commissions and omissions percentage and experimental control task indexes.

	RT Index Cog.Control Task			Error Index Cog.Control Task		
ADL variables	Distractor	Stroop	Simon	Distractor	Stroop	Simon
Commissions	.186	.164	.400	-.149	-.407	.403*
Omission (%)	.492*	-.043	-.031	-.059	.328	-.082

*p<.05

In relation to neuropsychological tests, commissions errors were marginally correlated to executive control test INECO frontal Screenning (r=-.314, p=.15). On the other hand, percentage of ommisions was significant correlated to MMSE scores (r=-.453, p=04). Other neuropsychological measures did not reach statistically significant correlations.

Discussion

Our principal aim with the Experiment 2 was to discover the characteristic pattern of everyday errors in frontal damaged patients. By an "eliciting" task, we found significant differences in commissions errors between frontal and control participants. The commission errors category grouped all the errors in which participants made an incorrect action, such as i.e perseverations, tangential steps or substitutions of errors. In the study by Niki, (2009), after right frontal damaged patients used to exhibit an Action Deshinibition Syndrome, in which participants incorporated distractor objects to the actions, touching objects without any purpose and committing tangential steps and objects substitutions. This type of behaviour could be related to a deficit in the top-down and bottom-up balance that takes place when we usually do every day actions. In the same way that in the experimental task of Experiment 1, in the everyday task of Experiment 2 distractors have also been able to influence the need to exert more cognitive control, in order to avoid actions associated to distractor objects. Moreover, in our task we incorporated distractor objects which usually are used in a join action (for example a toast maker and a slice of bread). The representations of these objects are part of a perceptual unit and therefore will be activated in a major extent because they share semantic (Moores, Laiti, & Chelazzi, 2003) spatial relations, and also because they tend to co-occur in the same temporal moments (Humphreys & Riddoch, 2007). Thus, the representation of one these grouped objects will activate the representations of the others objects with which they are related to (Humphreys et al., 2013). Therefore, showing objects that grouped lead an action could provoke more interference that isolated objects and, thus, it would be more sensitive to cognitive control alterations.

With the exception of Niki et al. (2009) study, previous studies by performance-based tasks have used semantic and physically related distractors, finding either no differences between performance with or without distractors (Humphreys & Forde, 1998), or an increase in the number of substitutions (Giovannetti et al., 2010) or omissions under related distractors (Schwartz et al., 1999). We suggest that the absence of errors related to the cognitive control deficits in these studies, could be due to the fact that the relationship between target and distractor objects were based only in semantic or physical features. Unfortunately, in our study we could not compare the patients execution in everyday task with "eliciting" distractors with other condition with distractors unrelated, or without distractors. Further research will need to clarify this issue.

Similarly to Niki et al (2009), we did not find significant differences between Control participants and Frontal Patients in omissions errors. Although, this type of error has been broadly investigated, little is known specifically about the underlying cognitive processes in different populations. In dementia patients, cognitive global measures (MMSE) and specific episodic memory test (Philadelphia Verbal Learning Discriminality) have predicted the number of omissions committed in three everyday activities (Giovannetti et al., 2008). Thus, Giovanneti et al (2008) proposed that this type of error could be due to cognitive deficits in episodic memory, having problems to recall the task goals. However, she pointed out that this interpretation should be treated with caution, because, although omissions were predicted by this test, correlations did not reach significant values. Neither neuroimaging studies have revealed conclusive findings, because hippocampal volume –cerebral region related to episodic memory- did not correlate significantly with omissions (Seidel et al., 2013). On the other hand, studies with frontotemporal damaged patients who exhibit Action Desorganization Syndrome (ADS), have also shown errors of this category. After this syndrome, patients used to make many errors in activities of daily living, such as sequence failures, omissions and perseverations, etc. According to Humphreys and Forde (1998) ADS syndrome involves a double cognitive dysfunction, on one level, deficits in retrieving action schema, in managerial knowledge and, on another level, difficulties in monitoring and resolving unfamiliar situations. Thus, this syndrome involves the actuation of frontal and temporal lobes (Forde & Humphreys, 2002). In our study, although we have observed significant differences between groups in global cognitive measures, memory tests and also in executive functions, the deficits seem not to be enough to trigger failures to omit essential steps of the task.

General Discussion

To our knowledge, our study is the first one to analyse the relationship between experimental cognitive control tasks and ecological measures assessed by ADL performance tasks. Previous above mentioned works have used classical neuropsychological tests in order to know relations between cognition and everyday life; however, none of them have related them with such specific RT and Accuracy measures of inhibitory classical, simple conflict interfering tasks. In the first experiment, we created a cognitive control task in which we could distinguish three types of cognitive conflicts. Distractor filtering, in which we analysed target detection under conditions with and without similar distractor stimulus. We also incorporated a Spatial Stroop conflict, comparing the congruency between the direction of the arrow and its localication (S-S conflict), and finally, a stimulus-response (S-R) conflict or Simon, examining differences between conditions in which the correct response is ipsilateral/contralateral to target localization. We found significant differences for all the conflicts between groups, showing a greater interference in frontal damaged patients in RTs. Moreover, even a higher Stroop and Simon interference was found in frontal patients under conflict conditions where distractor stimulus appeared. In relation to errors, we found an effect of group marginally in Distractors Filtering, and significant in Simon conflict. According to many previous studies, these data demonstrated the presence of control cognitive deficit after frontal lobe damaged.

On the other hand, we designed an ADL performance-based task in which we asked participants to make a cup of coffee or a toast with butter and jam. Based on previous studies (Niki et al., 2009), we incorporated very "eliciting" distractor objects in order to analyse the ability to inhibit them. Similarly to the experimental task, we found a significant difference between groups in commission errors, that included perseverations, repetitions, failures in sequence, substitutions, manipulations/toying, action additions and tangential steps. Consistent with our results, this type of errors has been associated to executive measures (Giovannetti et al., 2008) and some of these problems have been also observed in frontal damaged patients (Luria, 1966;

Niki et al., 2009). No significant differences between omissions errors were found between groups, as described Niki et al in their study.

In order to know the linkage between these two measures of inhibitory deficits, we carried out correlation analyses. We found a positive and significant correlation between the error index of Simon conflict and Commissions errors in ADL task. The RTs index of Stroop interference was also positively associated to ADL commissions, although this correlation did not reach significance. However, none of the other control measures demonstrated a significant relation with this type of everyday error. As described in the introduction, Simon conflict has been considered to be stimulus-response conflict (Lu & Proctor, 1995), and consequently, has demonstrated to activate premotor frontal areas (Egner et al., 2007). It seems reasonable that the possibilities for actions offered by objects, that is “Affordance”, depends on S-R conflict more than S-S stimuli, in fact, affordance is described by over learned stimulus-response associations. Several studies have showed a relationship between “affordance” and S-R paradigms, suggesting that affordance could be considered like a S-R conflict type (McBride, Sumner, & Husain, 2012). When patients must inhibit to use o to lift an object with any voluntary purpose, they have to control their motor actions in response of a triggering stimuli. In these sense, different studies with patients who exhibit unvoluntary behaviours, have corroborated these findings, like Utilization Behaviour and Alien hand syndrome. Patients with Alien hand syndrome used to grasp and use objects from the environment involuntarily with alien limb (Scepkowski & Cronin-Golomb, 2003). In one study with this syndrome demonstrated how increased automatic motor actions by objects which afford actions with alien hand than the other hand. Moreover, by a backwards masked priming task, alien hand did not show automatic inhibition of primed responses (McBride, Sumner, Jackson, Bajaj, & Husain, 2013). Consistent with these findings, a recent neuroimage study have showed neural activations in the right inferior frontal gyrus, a cerebral area implicated in response inhibition in Simon or Go/no Go tasks (Chikazoe, 2010; Forstmann et al., 2008), uniquely during alien movements (Schaefer, Heinze, & Galazky, 2010). According to McBride, Husain and Sumner (2012) this activation could be a reflection of a failure attempt to inhibit motor movements. Similar findings have been observed in Utilization behaviour syndrome, in which patients cannot control their behaviour, and they used to grasp and use objects out of the main task (Boccardi, Della Sala, Motto, & Spinnler, 2002). In addition, Humphreys and Riddoch (2000) reported that activations from distractors which could be used in a joint action with target objects, needed a greater inhibition.

Therefore, our results highlight the relations between control cognitive deficits at the level of response, more than at level of stimulus-stimulus conflict, and commissions, that is, actions that incorrectly are included in the task performance.

Surprisingly, ommisions errors were also correlated with the Distractor main effect. Omission errors have been previously associated with global measures of cognitive impairment (Giovannetti et al., 2008) and this was also replicated in our study, with a significant correlation between omissions and MMSE. Similarly to Sekuler (2000) results, the difficulties to extract relevant information from situations in which many stimulus are presented is degraded by age. Moreover, it seems that the "Useful Field of View", a measure of visual processing speed, is also positively correlated with more time to complete different activities of daily living (Owsley, Sloane, McGwin, & Ball, 2002). Thus, we suggest that general cognitive impairment could be responsible of both, omissions as well as problems in select relevant information especially under cluttered scenes. Of course, the exact causes between these two phenomena need to be addressed in future studies.

To conclude in this study we have found a novel linkage between two measures of inhibitory deficits from very different research traditions. The fact that commission like errors produced on ADL performance under the presence of highly related distractors are especially linked to errors in conflict tasks requiring inhibition of an irrelevant but higly automatized response, is promising, as it might indicate that commission errors are especially due to deficits to inhibit object activations at the level of their response representation. Again more research in this line is still needed to fully understand this pattern of relations. On the other side, a larger sample of participants might help to elucidate whether S-S congruency effects (Stroop) are also related to commission errors, or even if more specific relations emerge, for example between these interference indexes specific error subtypes within the commission category.

Acknowledgements

We thank to Jose Barroso, professor at the University of La Laguna (Spain) for patients recruitment. We also thank the Stroke Associations AGREDACE (Granada), ADACEA (Jaén) and ADACEMA (Málaga) and San Rafael University Hospital in Granada. The present research was funded by the Spanish Ministry of Science and Innovation through a PhD research fellowship to the first author (FPI BES-2009-020741), a research project to the first and the last authors (Junta de Andalucía SEJ-6351) and a research project to the last author (PSI 2011-22416)

Experimental series 3

Distraction in multi-step tasks: The influence of target-distractor relations on everyday tasks after frontal lobe damage.

Distraction in multi-step tasks: The influence of target-distractor relations on everyday tasks after frontal lobe damage.

Rodríguez-Bailón, María[1], Funes Molina, María Jesús[1, 3] and Humphreys, Glyn[2]

1. Centro de Investigación Mente, Cerebro y Comportamiento. Campus de Cartuja s/n. Granada, Spain.

2. Departament of Experimental Psychology University of Oxford.

3. Departamento de Psicología Experimental. Universidad de Granada, Granada, Spain

Abstract

After damage to the frontal lobe patients have been reported as having problems in everyday tasks, and these problems can be increased under conditions in which distractor objects are present. The main aim of this study was to evaluate the influence of target-distractor relations in brain lesioned patients with and without damage to the frontal cortex. We compared conditions in which the target and distractor tasks shared action steps and objects, and conditions in which the semantic relationships between the target and distractor tasks were manipulated. Independent of the conditions, frontal patients exhibited more repetitions of task steps and more manipulations of objects without any purpose than non-frontal patients. In addition, frontal damaged patients carried out significantly more manipulations of objects without any purpose, when the tasks shared objects and action steps. Omission errors showed opposite effects across the groups. While frontal patients increased their omission errors in the presence of semantically related distractors, non-frontal patients committed fewer omissions in this case. These findings show that the effect of distractor interference after frontal damage depends on the competition from motor actions triggered by distractor objects when they share actions. Moreover, unlike the non-frontal patients, the frontal patients did not benefit from semantic-based contextual cueing to retrieve the task memory schema and so reduce omission errors.

Keywords

Activities of Daily Living, Frontal damage, Distractors.

Introduction

Following damage to the frontal lobes of the brain patients can have problems in inhibiting pre-potent orienting responses to distractors (Alexander et al., 2007; Picton et al., 2007). This involuntary bottom-up attentional orienting might lead to patients touching, grasping or using distractor objects that are outside the current task goal. This is known as 'utilisation behaviour' (Archibald et al., 2001; Lhermitte, 1983). In addition, patients with frontal lobe damage may repeat and perseverate their actions even when the target task or a given task step is already completed (Rodriguez-Bailon et al., 2012; Stuss & Levine, 2002). These utilization and dysexecutive errors can be incorporated within a broader dysexecutive syndrome in patients.

There is a large research literature demonstrating that the mere presence of a salient distractor can interfere with the selection of a target (e.g. reflected in increased reaction times, error rates, saccades and hand movements towards distractors), especially when these distractors share some critical features with the target (Folk, Remington, & Johnston, 1992; Welsh, 2011) or are semantically related to the target (Belke, Humphreys, Watson, Meyer, & Telling, 2008; Grezes, Tucker, Armony, Ellis, & Passingham, 2003; Moores, Laiti, & Chelazzi, 2003; Tucker & Ellis, 1998). This kind of interference seems especially important in patients with dysexecutive deficits due to frontal brain damage (Balani et al., 2012; Kumada & Hayashi, 2006; Morady & Humphreys, 2011; Zihl & Hebel, 1997) consistent with executive control processes (that would normally modulate such responses) being located within frontal cortex.

There is also a growing body of literature examining the effects of different kinds of distraction on behavior in naturalistic everyday life situations where routine tasks require the use of several familiar objects in a correct sequence of actions. Of particular interest here is whether frontal brain damaged patients with dysexecutive problems (Alexander et al., 2007; Stuss et al., 2001; Stuss & Levine, 2002) exhibit a larger impairment in ADL execution when distractors are present, and whether this depends on the type of distractor.

The influence of distractors on ADL tasks

In order to isolate the impact of distractors in the execution of ADL tasks, some recent studies have manipulated the type of relationship between the distractors and the target objects. For example in a study of dementia patients, Giovannetti and colleagues (2010) manipulated two conditions in which target items were mixed with either visually and functionally similar distractors or visually and functionally unrelated items. There were more errors in task performance when related compared to unrelated distractors were present. More concretely, dementia patients touched and committed object substitutions with the distractor items, especially when the distractors were visually and functionally similar to target items (Giovannetti et al., 2010). Giovannetti et al. suggested that these results could be due to executive failures rather than semantic deficits. However, a degraded task schema could also explain the high occurrence of distractor manipulation and object substitutions when distractors were visually and functionally similar to targets, given the typical memory impairments in dementia. Moreover, distractors visually similar to targets have not been shown to produce larger numbers of errors in patients with frontal lobe damage and dysexecutive symptoms (Humphreys & Forde, 1998), indicating that visual similarity may not be a critical factor for such patients.

Other studies have focused on interference effects from semantically distractors. For example, Giovannetti et al. (2002), in a study with dementia patients, reported that there were more object substitutions errors (using a distractor object as a target item) under conditions in which semantically related distractors were present (Giovannetti et al., 2002). However, since the presence of semantic distractors also correlated with the complexity of the displays, it is difficult to differentiate the distractor effects from the effects of task complexity.

In a single case study with a patient with bilateral frontal lobe damage and substantial executive deficits, FK, Morady and Humphreys (2009) found that the presence of semantically related distractors led to a larger number of errors - specifically omissions- compared with conditions without distractor, or where there were distractors but they were not semantically related (Morady & Humphreys, 2009). In a similar study, Niki, Maruyama, Muragaki, & Kumada (2009) manipulated the semantic context of an ADL task by including a condition in which the distractors that were present could elicit an alternative but not required task. They compared two conditions, one where the distractor and target tasks were **semantically** related (e.g. all distractors were related to making Japanese tea when the task was to make coffee) and one where they were unrelated (task 1: drawing a picture; task 2: preparing an envelope for a gift of money). They tested three brain damage patients with exclusive lesions in the right prefrontal lobe who had previously shown few omission and sequence errors in the absence of distractors. The authors reported that these patients produced a large proportion of errors with the distractors under these semantic related conditions; however, only one of the three patients exhibited more errors for the semantically related vs. the unrelated conditions. The distractor manipulation conducted by Niki et al. (2009) is interesting for several reasons. First, the presence of a set of distractors that together link to a complete alternative related task might introduce competition not only at the level of selecting individual objects but also at the level of selecting the task goal. Indeed, this situation might increase the need to recruit the executive system in order to bias the competition in favor of the target task and against the distractor task, thus, increasing its sensitivity to the presence of executive deficits such as "goal neglect", also associated with frontal lobe lesions (Duncan, Emslie, Williams, Johnson, & Freer, 1996).

Finally, there is another potential relationship between targets and distractors in everyday life situations whenever different tasks **share the same step actions and objects**. For example, to prepare a cup of instant coffee and an instant powder soup there are some steps actions like heating the water and/or using common objects (e.g., the kettle). Consequently, even if ADL tasks with common steps may be less semantically related than tasks such as making coffee and toast (both belonging to the "breakfast category"), they are related at the level of actions towards several common objects. In addition this kind of relationship is not the same as distractor-target relations based on physical similarity, like sugar and salt, because the actions associated to the objects are very different.

There is a body of evidence showing that processing can be facilitated when participants are asked to identify single objects that share a motor action with other irrelevant items. For example, Helbig et al. (2006) displayed pairs of pictures objects that were both congruent (such as pliers and nutcracker) or incongruent (a pan and a special guitar) in terms of their motor actions. Target naming was facilitated in the congruent motor action condition compared with when the stimuli had incongruent actions, consistent with there being an action priming effect (Helbig et al., 2006)

A very recent study has established the term "working affordance" to describe the capacity that has two linked objects to perform an action based on their functional compatibility (De Stefani et al., 2012). Under the presence of distractor objects that were functionally compatible with the target, motor actions (such as grasp and lift) were faster than in the presence of other objects. Thus, if the motor actions from distractor objects are compatible with those to the target, the action to the target might be primed. However, it would also possible that under these conditions, participants might find it difficult to inhibit actions towards the action related distractors, and this might be especially relevant for frontal lobe patients with inhibitory deficits. For example, in one study, Humphreys and Riddoch (2000) carried out an experiment with the frontal lobe patient FK, in which they asked him to pick up the target object (a cup) with the hand compatible with the position of the handle of the cup (left-right). Distractor objects were presented which could have a functional affordance between them (i.e a jug with a cup) with a distractor placed in the reach trajectory to the target. These distractor objects also had their handles positioned on the left or right and these could be compatible or not with the position of the cup handle (the target object).Humphreys and Riddoch found that FK used often the hand incompatible to pick up the target object under the condition where the related distractor was compatible with the incorrect (target-incompatibl) hand. The authors suggested that FK was sensitive to the action afforded by the distractor (the compatibility of its handle to a hand response), and this triggered selection of the incorrect hand for the target.

These data suggest that several properties of distractors might mediate performance in everyday life tasks, including the semantic relation of distractor objects to individual targets, whether different distractors together evoke a separate task, and whether the distractor afford an action. To date, however, no studies have attempted to investigate the relations between these different factors. This was the aim here.

The present study

In this study we aimed to investigate how the presence of different types of distractors influences ADL performance in patients with frontal brain lesions and dysexecutive disorders. Performance of a small group of patients with frontal lesions was compared to a control group of 5 patients with lesions outside the frontal lobe and free of executive alterations. The comparison of frontal to non-frontal 'control' patients is critical to test the hypothesis that lesions in prefrontal areas and not brain damage in general, are responsible for the changes in ADL performance observed in the frontal population.

Second, in this study we directly compared the interference effect produced by semantically related distractors with the effects produced by action-related distractors. This last form of target-distractor relationship has never been tested in the context of ADL tasks before. Furthermore, in both cases, all distractors constituted a set of objects that would be used in an alternative but irrelevant task, rather than constituting isolated objects. As stated above, when all distractors are linked to an alternative task, it is possible that there can be competition between the tasks and the incorrect distractor task (as opposed to isolated distractor objects) might be used.

Finally, the two main manipulations, whether the distractor task was related or unrelated to the target task, and the type of distractor presented (semantically related vs. steps/objects related to targets) were manipulated within participants, so that all participants were asked to do a given target task under four distractor conditions, which can be seen in figure 1.

Method

Participants

11 participants were recruited from the Behavioural Brain Centre at the University of Birmingham. Participants were divided into two groups based on their lesion localization, as can be seen in Table 1, patients from the pre-frontal group (n = 6, mean age = 57.1 years, SD = 17.3) had damage that included prefrontal regions. All the frontal lesioned patients failed the rule finding and switching test of executive function in the BCoS battery (Humphreys, Bickerton, Samson, & Riddoch, 2012) . The lesioned control group included patients with focal damage sparing the frontal cortex (See Figure 1). (n = 5, mean age = 62.8 years, SD = 6.6). All participants had either normal or corrected-to-normal vision or normal or near to normal arm and hand mobility in at least one limb (DS, MP, TM, PH and JB all had a hemiplegia and MH showed signs of apraxia)[2].

[2] In all the tasks patients could ask the experimenter to support an object while it was used by the patient using one arm. This meant that the presence of a hemiplegia itself should not have had an impact on the scoring of task performance which was based on whether actions were made or omitted and if particular types of action error occurred.

Table 1. Patient list, including lesion site and clinical details

Patient	Sex	Age	Hand Laterality	Lesion site	Clinical deficit	Aetiology
FRONTAL PATIENTS						
F.K.	M	37	Right	Bilateral superior and medial temporal gyri, bilateral lateral occipital gyri, bilateral rostral and polar frontal regions. Some disseminated damage bilaterally to dorsolateralprefrontal cortex	Agnosia, aphasia, dysexecutive syndrome.	Anoxia
D.S.	M	72	Right	Left inferior, middle and frontal gyri	Non-fluent aphasia, impaired verbal short term memory.	Stroke
P.H.	M	34	Right	Left medial and superior temporal lobe, left interior and middle frontal gyri	Non-fluent aphasia, deep dyslexia, impaired verbal short term memory	Stroke
M.P	M	60	Right	Right inferior frontal, inferior parietal and superior temporal	Neglect, acalculia	Aneurysm
T.M	M	70	Right	Right fronto-temporal-parietal	Neglect	Stroke
J. B	F	70	Right	Right inferior parietal plus a silent left occipital lesion	Left extinction plus left neglect (most pronounced in reading)	Stroke
LESIONED CONTROL PATIENTS						
D.T	M	66	Left	Left occipital	Right extinction	Stroke
M.MD	M	68	Right	Sub-cortical (right internal capsule, thalamus, superior longitudinal fasciculus)	Poor short-term memory	Stroke
M.H	M	53	Right	Left parietal (angular gyrus), lentiform nucleus. (bilateral).	Right extinction, optic ataxia.	Anoxia
P.M	M	68	B.	Left and right inferior parietal regions	Aspects of simultanagnosia, left extinction	Strokes
P.F	F	59	B.	Superior parietal extending to inferior regions	Aspects of simultanagnosia, left extinction	Strokes

Note. B.=Bilateral

Experimental procedure and design

Participants were individually tested in a kitchen room. They were placed in front of a table with different objects, and we made sure they could grasp every object in the table. At the beginning of each task, participants were asked to name all objects in order to reject perception and semantic memory deficits. All participants were able to name all objects. Participants were instructed to perform the target task. The behavior of each participant was videotaped for later analysis. In addition to the target items, distractor objects were placed on the table, intermixed with the target items. All distractor objects constituted the object set necessary to complete an additional but not required ADL task, which we called the distractor task. All ADL target and distractor tasks were "cooking" tasks that are usually done within a kitchen. All objects were presented in front of the participant and their location varied randomly across sessions and participants

We manipulated the relationship between the target tasks and the distractor tasks in two ways: (1) we manipulated whether the target and distractor tasks shared the same semantic context or category, and (2) whether the target and distractor tasks shared a subset of common object steps and/or objects.

These manipulations led to four conditions. For the Shared Context - Shared Steps/Objects condition, both the target and the distractor tasks were semantically related and both belonged to the same cooking preparation context (e.g. making tea and coffee are both part of breakfast preparation), but also shared some steps and/or objects (making tea and coffee are both done in cups and required water to be boiled in a kettle). For the Shared Context - non Shared Steps/Objects condition, the target and the distractor task belonged to the same cooking context (e.g making toast and making coffee are part of breakfast preparation), but the tasks did not share steps or objects. For the non Shared Context - Shared Steps/Objects condition, the target and the distractor task did not belong to the same cooking context (e.g making a cup of tea and a bowl of soup from soup powder are part of different daily meals), however the tasks did share some steps and/or objects (in order to make both a cup of tea or a bowl of soup it was necessary to boil water in a kettle). Finally, for the non Shared Context – Non Shared Steps/Objects condition, the target and the distractor tasks did not belong to the same cooking context (e.g making a cup of tea and making soup from a tin, are part of different daily meals) and neither shared steps and/or objects. For each condition several task target and task distractor combinations were included. See the task set for each experimental conditions in table 2, and an example of each of them in Figure 1.

Table 2. Tasks in each experimental condition

	SHARED CONTEXT				NON SHARED CONTEXT			
	Shared Steps/Objects		non Shared Steps/objects		Shared Steps/Objects		Non Shared Steps/object	
	Target Task	*Distractor Task*	*Target Task*	*Distractor Task*	*Target Task*	*Distractor Task*	*Target Task*	*Distractor Task*
1A	Tea	Coffee	Tea	Toast	Tea	Soup	Tea	Tin of Beans
1B	Coffee	Tea	Coffee	Toast	Coffee	Soup	Coffee	Tin of Beans
2A	Croissant	Toast	Croissant	Coffee			Croissant	Stock*
2B	Toast	Croissant	Toast	Coffee			Toast	Stock*
3A	Soup powder	Stock*	Soup powder	Tin of Beans			Soup powder	Toast
3B	Stock*	Soup powder	Stock	Tin of Beans			Stock*	Toast
4A	Tin of soup	Beans	Tin of soup	Stock*			Tin of soup	Coffee
4B	Tin of Beans	Tin of soup	Tin of Beans	Stock*			Tin of Beans	Coffee
5A					Coffee	Stock*		

*Stock for a gravy

Coffee - Tea. Shared Context - Shared Steps/Objects

Coffee - Toast. Shared Context – non Shared Steps/Objects

Coffee – Soup powder. Non Shared Context - Shared Steps/Objects

Coffee – Tin of Beans. Non Shared Context – non Shared Steps/Objects

Figure 1. Examples of the objects presented in each experimental condition with making a cup of coffee as the target task.

Each patient carried out 4 cooking tasks for each experimental condition, except for the condition with the "non Shared Context - Shared Steps/Objects", in which only two tasks were performed (it was not possible to create another cooking task combination compatible with the condition requirements). Thus, only the coffee and tea target tasks (types 1A, 1B, 5A) were included for this condition. Each patient performed either version A or B of each condition. This meant that each patient performed 14 tasks distributed across 4-6 sessions depending on the state of fatigue and alertness of the patient (with a duration of approximately one hour each). The only exception to this was patient MP, who, due to availability, performed only 10 tasks, although he carried out all the task combinations for all the experimental conditions. The target tasks were counterbalanced across patients. The order of tasks was randomly presented. Objects for each condition and are shown in Appendix 1.

Data Analysis

Errors made by patients were classified based on the criteria set out by Humprheys and Forde (1998) and Schwartz et al, (1991). Descriptions of each error category are provided below:

<u>Commisions</u>

- Perseverations: Some steps of target or distractor actions were inappropriately repeated immediately.
- Repetitions: The participant repeated a target or distractor step inappropriately later in the sequence.
- Failures in Sequence: A participant failed to follow the conventional order of actions.
- Sustitutions: A target object was used instead of a correct target object in order to complete the target action.
- Manipulations/Toyings: A participant only lifted an object and then set it down or fiddled with it.
- Action Additions: We included in this category several kind of situations where a participant added an action that cannot be interpreted as a task step. In that category we included errors when using a target object or doing an action that was outside the range of action criteria, for example, when participants wanted to eat what they had prepared.
- Tangential Actions: When the patient performed an action sequence correctly but from the distractor task, for example, when carrying out correct actions to make a toast when asked to make coffee.
- Added step with a distractor object in the target task, when patients added a step in the target action by using a distractors object, for example when a participant prepared a cup of coffee, but he added a tea bag, too.

<u>Omisions</u>: Necessary steps were omitted.

Results

Analyzing patterns of errors by Group. General analysis

In order to analyze differences in the number and type of errors committed by each group (Frontal and Non-Frontal group), we compared the pattern of error of both groups with a non-parametric test: the Mann–Whitney U test as the data were not normally distributed.

Consistent with our prediction, frontal patients committed more **total** errors (the sum of all error types across tasks and conditions) than non-frontal patients ($z = 2.46$, $p<.05$). Regarding group differences on specific error categories, we found that frontal patients committed more object **manipulations**/toying errors than the non-frontal group ($z = 2.74$, $p < .05$). Moreover, the number of step **repetitions** was significantly larger for the frontal group compared to the non-frontal one ($z = 2.10$, $p < .05$). We did not found statistically differences between the groups for other errors.

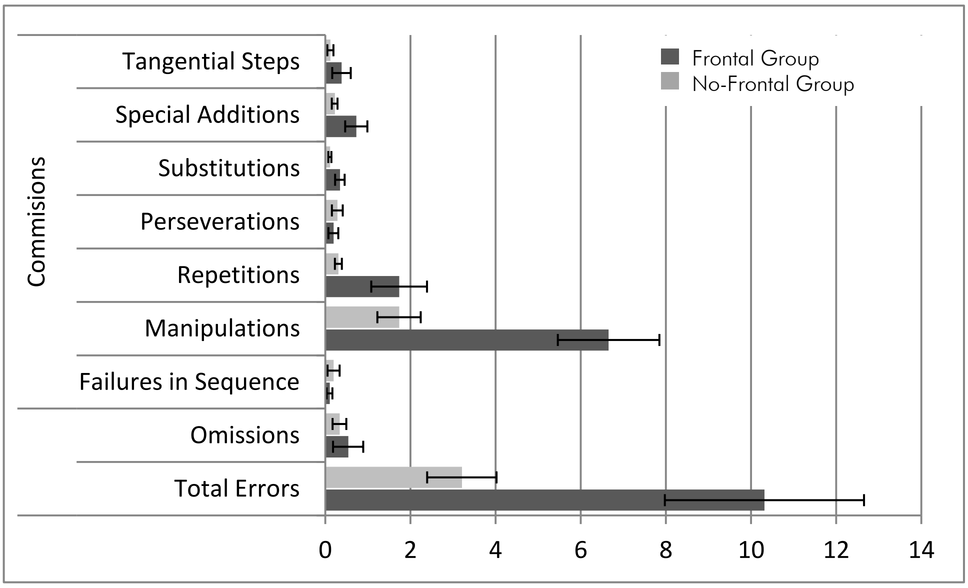


Figure 2. Number of errors for each error category summed across all the tasks. Error bars represent the standard error of the mean.

Analyzing the Effect of Task Distractor type (Action/object sharing vs. Context sharing)

Having analyzed the differences between the groups for the Total error score and for the different categories of error, the next step was to see whether there were differences in the pattern of errors depending on the type of relationship between the target objects and the distractors; in particular we assessed the influence of Task distractors sharing actions/objects with the target task, and the influence of Task distractors that shared the semantic context with the target objects and to see if these two variables produce different effects on the two groups of participant. In order to analyze together the effect of action/object sharing between the target and distractor tasks, the effect of context sharing and the variable Group, we were obliged to use parametric tests, in order to include within and between subjects variables in the same analysis. Thus, we performed a mixed repeated measures ANOVA where we included the variables action/object sharing and context sharing as within subject variables and the variable group as a between subject variable.

As we described in the method section, the sub-set of tasks that were included for the "non Shared Context - Shared Steps/Objects" conditions was smaller and restricted to those of making a cup of tea or making coffee. Because these tasks were highly practiced by these patients we decided to restrict the number of tasks included in this analysis and equates the four conditions in terms of practice with the task. This restriction would avoid potential improvements in performance due to practice for the "non Shared Context - Shared Steps/Objects" conditions compared to the other ones that also included less practiced tasks such as making a soup, a stock or preparing beans (these tasks had never being practiced in the lab before by any participant). Thus, in order to avoid confounding by practice, we restricted this analysis to highly practiced tasks across conditions: the target task was to make a cup of coffee, tea, a toast or a croissant. The other tasks (make soup, stock or cook beans) were excluded from this analysis. Total errors were higher for the frontal group than for the damaged non-frontal control group, with a borderline statistical difference between the groups. ($F(1,9)=4.47$ $p=.06$). In addition, frontal patients made significantly more toying /manipulations than the Non-frontal control group ($F(1,9)= 6.61$, $p < .05$) and they committed more steps repetitions ($F(1,9)=5.99$, $p < .05$).

The total errors made by the patients were higher in conditions where the objects and task steps were shared, indicated by a marginal main effect of Shared Steps/Objects on total errors ($F(1,9)= 5.03$, $p=.052$). The same action sharing effect was found for the manipulation/toying error category ($F(1,9)=8.91$, $p <.05$) – there were more manipulation/toying errors for the Steps/Objects shared than for the non-shared condition. In addition, a significant Action Sharing by Group interaction was obtained for the manipulation/toying error category ($F(1,9)=5.09$, $p=.051$). Planned comparisons revealed that while manipulation/toying errors by the non-frontal group were not affected by action sharing between the target and distractor tasks ($F<1$), frontal patients made significantly more manipulation errors in the Steps/Objects sharing condition ($F(1,9)= 15.11$, $p <.005$) (See Figure 3).

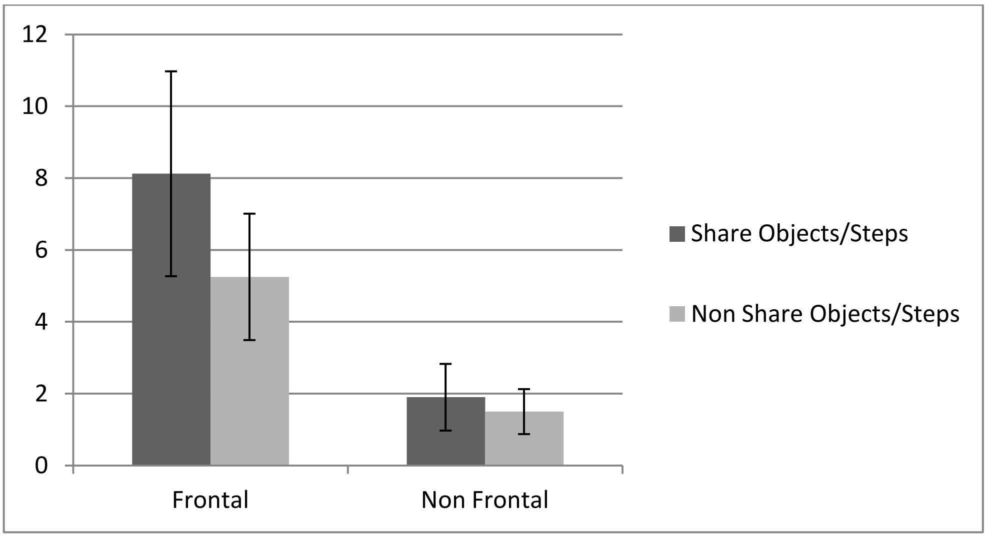


Figure 3. Manipulation error scores as a function of Group and action/object sharing condition. Error bars represent the standard error of the mean.

Regarding the effect of the Context sharing distractor, we did not found a main effect of Context sharing for any error category (F<1 for all the variables, except to action additions, p=.199). However, there was a context shared by Group interaction for the step omissions error category ($F(1,9)=6.49$, $p<.05$). As shown in figure 4, Frontal patients made more omissions when the distractors and target objects belonged to the same context. In contrast, non frontal patients showed a tendency in the opposite direction, that is, they made fewer omissions when the task context was shared. As suggested by Figure 4, separate ANOVAs for each group revealed facilitation for the non-frontal group, and interference for the frontal one, although these effects did not reach significance ($F(1,4) = 2.67$, $p = .18$ and $F(1,5) = 4$, $p = .10$, respectively).

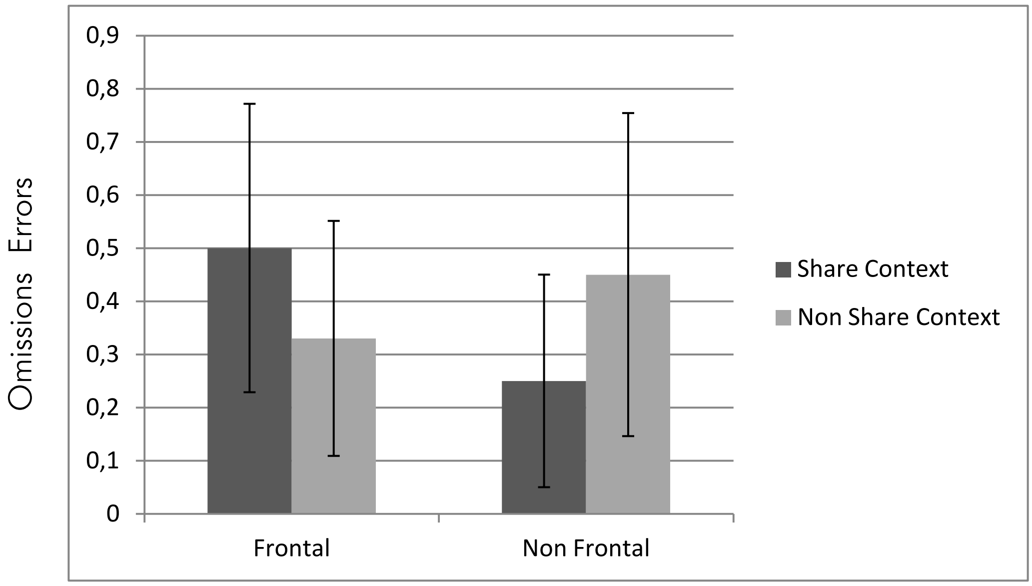


Figure 4 .Step omission scores as a function of the Group and the Semantic Task distractor sharing condition. Error bars represent the standard error of the mean.

Discussion

The primary aim of this study was to investigate how different relations between target and distractor objects could influence ADL performance in frontal lobe patients suffering dysexecutive behaviour.

First, our results showed that the frontal damaged group made more errors, especially, manipulations and repetitions, than the non frontal group when using a paradigm were target objects were intermixed with distractor objects that altogether constituted an additional but irrelevant competing task. This group effects constitute a valuable piece of evidence that might help to isolate the especial contribution of Frontal lobe functions for the correct execution of ADL tasks. This is important because previous ADL group studies have not found group differences dependent on the brain lesion (Buxbaum et al., 1998; Schwartz et al., 1999; Schwartz et al., 1998) This has led some authors (e.g., Schwartz, 2006) which made the authors to conclude that ADL performing depends on global cognitive resources rather than specific cognitive patterns. According to this theory, ADL tasks recruit general cognitive resources, and, when these resources are limited by brain damage, all cognitive functions necessary to perform everyday activities are affected irrespective of the lesion.

However, here we used a more controlled selection of patient groups. In addition, we manipulated task difficulty through the presence of different types of distractor. Our findings that the number of errors (specially toying and step repetitions) increased for the frontal group can be more confidently linked to the fact that their lesions affected the frontal lobe.

Another critical aspect that might have helped to find a larger ADL impairment for the frontal group here is the fact that we included distractors that altogether constituted an alternative non-required task. As stated in the Introduction, this kind of distractor manipulation may add an additional source of competition between target and distractor items, at the level of tasks rather than objects. This might have produced a general larger task load on performance and greater problems in selecting which actions to perform and with which objects – generating a form of 'goal neglect' where patients lost track of the action they were asked to do, allowing toying and repetition behaviors to emerge. According to the Niki et al. study (2009) errors in ADL performance in their patients were not due to the degradation of task schema in memory, but rather to inhibition deficits. In agreement with this, their main pattern of errors involved errors with distractor objects, but not with target objects. For this reason, they proposed that prefrontal patients might have a general functional disinhibition problem (Action Disinhibition Syndrome; Niki et al., 2009)). Differently to this, however, we found more manipulations errors for both distractors and targets. This suggests that the presence of distractors might not only tap executive deficits but also problems in the memory task schema in our frontal patients. Nevertheless, functional disinhibition behaviour could be observed not only with distractors, but rather also with target objects when the target objects were attended and selected at incorrect times (i.e to use the coffee pot, when coffee has already been added to the cup) so that a target object used or touched in an incorrect moment. Thus, objects might be selected as a "target" or "source distractor", depending on the dynamic changes occurring in the task (Cooper et al., 2005). Thus, when the step is to add sugar to the coffee, it is necessary to know that the sugar bowl is the "source" but not a target object any more. The finding of an increase in repetition error for the frontal relative to the non-frontal group could be an index of problems in 'activation recovery' for the first group. According to the 'Gradient Activation' model (Burgess & Hitch, 1992), when a task step is completed, for of 'rebound inhibition' is elicited in order to avoid competition between objects and actions required for the next steps. Thus the activation of the representation of already accomplished actions should decay allowing the following steps to win the competition. So, the gradient activation should return to the baseline. However, after frontal lobe damage this may not be the case so that previously made actions continue to compete for selection (Humphreys & Forde, 1998).

Regarding the nature of the relationship between Task distractors and targets, we found that both semantic and action relations produce stronger interference effects for the frontal patients than for the non-frontal ones. However, these interfering effects were evident in different aspects of the ADL tasks, depending on the nature of the target-distractor relationships.

Regarding the effect of Steps/Objects sharing, we found that all participants showed more errors in general, and toying errors (manipulations) in particular, when task distractors shared steps and objects with the target task compared with when they did not. However, this interference effect was larger and only reached significance for the frontal group. Under these conditions, the step of "Boiling water in the kettle" might have activated the two tasks: To make a cup of coffee and (the irrelevant) "to make a cup of tea". The fact that all necessary objects to complete the distractor task were present might have enhanced the activation towards the distractor task. Thus, in our example, a strong inhibitory process might be required in order to suppress actions towards the distractors that elicit tea-making actions. In the absence of this (after frontal lobe damage) actions may be directed to the distractors (generating toying errors) or there may be just more general confusion between the two tasks. Some previous studies have reported a facilitation effect when the motor actions required to use an object and to use a distractor were similar(Helbig et al., 2006).

Alongside this, strong distractor interference effects were also obtained when distractor tasks were semantically related to the target objects but again in the frontal damaged patients. The semantic relations we used here tried to simulate real life common situations where, apart from the particular items needed for a given task, we may find other objects present that share a similar context with the target objects (e.g., both sets of objects might be sued at the same time of the day, for the same meal and so forth). In contrast the unrelated distractors will typically not co-occur with the targets and they may reflect tasks performed at a different time of day. Thus, we hypothesized that distractors belonging to the same compared to different semantic categories to targets would interfere more on ADL execution, especially for the frontal group.

The results were consistent with this. The effect of semantic distractors interacted with the group, with a trend towards interference was observed for the frontal group. Moreover, the non-frontal group exhibited the opposite pattern – in this case there was a trend towards facilitation instead of interference for the semantically related condition compared to the unrelated one. In addition, and also differently from what was obtained for the Steps/Objects sharing manipulation, the semantic manipulation had an effect on the accomplishment of the target task, by altering the number of step omissions to fully complete the target task.

The finding of more omission errors when semantically related task distractors are present in frontal patients replicates a previous single case study. Morady and Humphreys (2009) reported that FK (also one of the patients tested here) showed more omissions under conditions in which distractor objects were semantically related to the target object than when distractors were semantically unrelated. The present study extends these earlier findings to a larger group of frontal patients and a larger number of tasks. This finding is also in agreement with other studies within the context of a visual search and working memory tasks. For example, studies have shown that normal participants can show interference effects (in RT and saccades) when distractors are semantically related to the target compared with when the distractors are unrelated (Telling, Meyer, & Humphreys, 2010). According to these authors, semantically related distractors produce an increased of noise within a task schema, especially under such competitive conditions in which distractor objects are typically used in the same semantic context. The increase of noise within the task schema could provoke a decrease of activation of the target tasks steps, so they are no longer selected (Cooper et al., 2005). On the other hand, the present findings are also consistent with previous findings that omission errors in the context of ADL performance are usually is associated to global measures of cognitive impairment and to episodic memory alterations (Giovannetti et al., 2008), more than executive measures in dementia patients. Thus, it is possible that our frontal patients might be suffering both executive and degraded memory for ADL task schemas (see Humphreys & Forde, 1998). This joint alteration might result in more task omissions under the presence of highly related objects. Further research is required to fully detail the relationship between omissions and frontal lobe damage.

In contrast to the frontal patients, the non-frontal patients here exhibited a benefit instead of interference when they encountered distractors that were semantically congruent with the target task. This facilitation effect is congruent with a large body of evidence from the perception, categorization and memory fields showing that normal people typically identify single objects much faster and more accurately when the objects are embedded in semantically related contexts or environments (Biederman, Mezzanotte, & Rabinowitz, 1982; Boyce & Pollatsek, 1992; Boyce, Pollatsek, & Rayner, 1989; Palmer, 1975). In our study, we might hypothesize that performing an ADL task like making coffee under the presence of semantically related task distractors could provide a coherent familiar context, let say, the context of a “breakfast”.

Non-frontal patients might benefit from this contextual information, with the presence of related distractors helping to retrieve the general context (the breakfast) and consequently produce a larger activation of the target task schema, thus reducing the number of omissions. This is also congruent with a similar finding in our laboratory where in a group of healthy older participants, MCI and dementia patients as a whole are facilitated by semantically related task distractors (evident as a reduction in the number of errors committed towards target items; Rodríguez-Bailón, M, in preparation).

The knowledge derived from this research might have important consequences for patient diagnosis and for intervention. The fact that the same kind of distractors (i.e. semantically related) might produce benefits on some patients but interference on others might help to guide the design of individualized compensatory strategies depending on the brain lesions and/neuropsychological profile of a given patient.

Appendix 1

Objects for each task

Coffee: Coffee jar, bottle of milk, kettle, sugar, teaspoon, cup.

Tea: Tea jar, bottle of milk, kettle, sugar, teaspoon, cup.

Toast: Slice of bread, jam, butter, knife, plate.

Croissant: Croissant, jam, butter, knife, plate.

Soup Powder: Soup powder pack, kettle, bowl, scissors, spoon.

Stock (for a gravy): Stock pack, kettle, bowl, spoon.

Beans: Tin of beans, pan, hotplate, bowl, spoon.

Tin of soup: Tin of soup, pan, hotplate, bowl, spoon.

Experimental series 4

Different patterns of everyday errors in Mild Cognitive and Dementia patients

Different patterns of everyday errors in Mild Cognitive and Dementia patients.

Rodríguez-Bailón, María[1], Montoro-Membila, Nuria[2], García-Morán, Tamara[3], Ródenas-García, Estrella[1] and Funes Molina, María Jesús[1,4].

1. Centro de Investigación Mente, Cerebro y Comportamiento. Granada, Spain
2. Servicio de Neurología. Hospital Universitario San Cecilio. Granada, Spain.
3. Asociación Granadina de Familias para la Rehabilitación del Daño Cerebral Adquirido "AGREDACE", Granada, Spain.
4. Departamento de Psicología Experimental .Granada, Spain.

Abstract

Previous studies have reported errors in Activities of Daily Living (ADL) in the presence of distractor objects in dementia and brain injury patients. However, little is known about what type relation between distractor and target objects might be more harmful to performance this population. We compared the ADL execution in Mild Cognitive Impairment (MCI), dementia and control participants under two conditions: One in which target objects we mixed with distractor objects that could constituted an alternative semantically related but non-required task, as distractor items could be used in a joint action (i.e presence of oranges and an orange juice maker). This Task-Distractor condition was compared to another where related but isolated distractors were present, which could not be used in a joint action to form a distractor task, then so called Objects-Distractor condition. We separately analyzed ADL errors associated to the target task and target items and errors associated to distractor items. We found that errors committed with Task distractor objects, produced a larger interference in MCI and dementia patients. However, the presence of Task distractor objects produced a benefit instead on interference on errors related with the target task. These opposite effects helped to isolate the distractor properties might ameliorate task schema memory impairments from executive deficits, both present in MCI and dementia patients.

Keywords

Activities of Daily Living (ADL), Dementia, Mild Cognitive Impairment (MCI), Executive functions, Memory.

Introduction

Dementia and multi-domain Mild Cognitive Impairment (MCI) patients often show functional deficits when they have to complete simple everyday activities like meal preparation (American Psychiatric Association, 2000; Giovannetti et al., 2002). Many studies have demonstrated that their decline in everyday functioning increase as the patients get worse in their cognitive abilities (Arrighi, Gelinas, McLaughlin, Buchanan, & Gauthier, 2013; Mioshi, Hodges, & Hornberger, 2013; Padilla, 2011; Suh, Ju, Yeon, & Shah, 2004). A main research challenge is to further understand what cognitive deficits present in dementia and MCI are mainly responsible of these functional limitations, in order to propose specific intervention programs that may ameliorate the degree of independence in simple ADL (van Hoof, Kort, van Waarde, & Blom, 2010).

One critical aspect still not fully understood regarding the relations between cognition and function is how the presence of other objects not necessary for the task at hand might influence the correct execution of ADL. This seems to be a crucial issue, as everyday environments are typically composed by both target items necessary for the task at hand but also by irrelevant objects, sometimes with high semantic and/or physical relations with the target items.

A large research tradition from the “Visual Search” and “Attentional Capture” fields have consistently found that the mere presence of visually presented distractors interfere with the target selection even in normal participants (e.g. increase in reaction times, error rates, number and time of saccades or hand movement towards distractors), especially when these distractors share some critical features with the target (Folk, Remington, & Johnston, 1992; Welsh, 2011) or are semantically related (Belke, Humphreys, Watson, Meyer, & Telling, 2008; Grezes et al., 2003; Moores et al., 2003; Tucker & Ellis, 1998). This kind of interference seems especially important in patients with disexecutive deficits due to brain damage (Balani et al., 2012; Kumada & Hayashi, 2006; Morady & Humphreys, 2011; Zihl & Hebel, 1997).

Altogether, these studies point towards automatic bottom-up attentional distraction towards related irrelevant distractors, that can be observed on normal participants and seem to be clearly disruptive in neuropsychological patients suffering top-down executive inhibition.

The kind of target stimuli used in these experimental studies were usually isolated objects requiring a single response towards them, and consequently were far from everyday life situations where routine tasks require the use of several familiar objects in a correct sequence of actions. However, one plausible prediction that can been made from them is that dementia and MCI, because of typically suffering executive/inhibition deficits (Rainville, Lepage, Gauthier, Kergoat, & Belleville, 2012; Torralva et al., 2009; Traykov et al., 2007), might also exhibit a larger impairment in ADL execution under the presence of related distractors compared with conditions without distractors or non-related ones. However, as far as we know, only one previous study has systematically tested the presence of related distractors in the execution of ADL in dementia participants. This study focused on the relation in terms of physical and functional similarity (Giovannetti et al., 2010). Dementia patients were tested with the Naturalistic Action Test (NAT; Schwartz et al., 2002) and asked to make coffee with milk, wrapping a gift or preparing a packed lunch. Participants were tested under two conditions, one with the presence of distractors functionally and physically similar to target items (e.g., salt for sugar) compared to a condition where distractors were neither visually nor functionally similar to targets (e.g., glue for sugar). Results revealed that dementia patients made more errors involving the distractors (i.e. touching and using distractors) and took longer to complete the task for the target related condition. Interestingly, this distractor effect did not affect the ability to accomplish the task (no differences in the proportion of step omissions) and did not increase the number of commission errors related with the target items. However this study did not include a healthy control group, nor was compared with a MCI group, thus, it is still unknown whether the distractor interference they found was exclusive for dementia patients or could be similarly observed for multi-domain MCI or even for healthy participants.

In another recent study (Niki et al., 2009) three prefrontal brain damage patients tested on a new distractor condition which consisted on the presence of distractors that altogether constituted a set of objects to complete a competing task (e.g. all items to make a Japanese tea when asked to make coffee). The authors found that similarly to dementia patients in Giovannetti et al. (2010) study, these frontal patients produced a large proportion of errors with this kind of "Task distractors". Interestingly, these authors described a new type of error present in at least one of their three participants, which consisted in adding "correct" but tangential actions and even completing the whole distractor task, in addition to the target task. One coherent interpretation of the presence of this kind of error is that the presence of the whole set of objects to perform a competing task might elicit the automatic pre-activation of a whole alternative task goal or action schema, and consequently might require the executive system to bias the competition in favor of the target task and against the distractor task, that is, a process of task goal selection, (e.g. recruitment of the Supervisory Atentional System, SAS, to bias the Contention Scheduling System competition between the two task schemas, in terms of the model of Norman and Shallice, (1980). In other words, this kind of Task related distractor manipulation might increase the sensitivity to detect "Goal Neglect", a kind of executive deficit usually reported in different groups of neuropsychological patients (Duncan et al., 1996). Altogether we propose that the kind of distractor manipulation introduced by Niki and colleagues (2009) might be especially relevant to detect executive/inhibitory deficits, as it constitutes a double source of competition, one at the level of object selection and another at the level of task or goal selection.

Based on the research revised so far, we might conclude that given the typical presence of executive deficits in dementia and multi-domain MCI patients, the presence of task related distractors, as the ones present in Niki et al. study (2009), might impair ADL execution by increasing the interference effects produced by Task distractors.

On the other side, there is an important body of research showing semantic context facilitation effects on object recognition. For example, it is well known that healthy participants are better at recognizing objects when they appear embedded in semantically consistent backgrounds (Biederman, Mezzanotte, & Rabinowitz, 1982; Boyce & Pollatsek, 1992; Boyce, Pollatsek, & Rayner, 1989; Palmer, 1975). Even further, several studies have found that dementia patients with semantic problems usually show a benefit for object use when these objects appear on coherent contexts or locations based on their previous experience towards them (Snowden, Griffiths, & Neary, 1994). Within the context of ADL execution, a recent study has also showed that healthy old participants exhibited a clear advantage in ADL execution when they were performed on familiar environments compared to unfamiliar ones (Geusgens, van Heugten, Hagedoren, Jolles, & van den Heuvel, 2010). Going back to the Niki et al., Task distractor manipulation (2009), we might hypothesized that performing an ADL task like making coffee under the presence of semantically related task distractors like for example, all the items necessary to make a toast, could constitute a source of facilitation (instead of a source of competition) as they might provide a coherent familiar context, let say, the context of a “breakfast”. This benefit might be most evident on those patients exhibiting some degradation on their semantic memory about ADL tasks. Consequently a second alternative prediction that could be made is that dementia and may be also MCI, because of showing some degree of task schema degradation, might show a benefit instead of interference on related Task distractor situations, where distractors might provide a coherent context for the target task, thus, facilitating target object recognition, and/or the step actions required to complete the target task. A third possibility could be that because dementia and multi-domain MCI patients usually exhibit both types of cognitive deficits, that is, inhibitory deficits and degraded task knowledge, the presence of highly related distractors that altogether constitutes a coherent context for the target task could produce both opposing effects, that is, distractor interference but also context facilitation. Thus, it is possible that both effects might co-occur but being reflected in different aspects of behavior or error categories. More concretely, we propose that the presence of related task distractors might increase the number of errors towards the them, like touching or even using distractors, meanwhile the same condition might reduce errors related to the target task, like step omissions and errors in sequence.

However, in Niki et al. study (2009) the authors did not compare the distractor task condition with a condition where the competing distractors were isolated objects that did not constitute a competing task. Second, and similarly to the previous distractor study described above (Giovannetti et al., 2010) they did not include a healthy control group, thus, it is difficult to know whether the presence of distractors constituting an alternative task, could lead to the same kind of errors even on healthy participants. Finally, any study has tested before the effect of this kind of "Task distractors" on dementia and MCI patients.

The present study

The general aim of the present study was to further isolate the cognitive mechanisms by which distractor items impact ADL performance in dementia and multi-domain MCI.

We based on the general paradigm introduced by Niki et al. (2009) where the whole set of distractors constitutes an alternative task. We selected this manipulation because it seems especially sensitive to executive deficits as it provides two levels of competition, one at the level of object selection but also at the level of task goal selection. Second, it might be also sensitive to task memory schema degradation, given that task related distractors might also constitute a coherent context for the target task execution. In order to isolate the effect of ADL performance under the presence of Task related distractors, we directly compared this *Task-distractor condition* with another were related distractors were present but did not constituted an alternative task, what we called the *Objects-distractor condition*.

Given the typical finding that dementia and multi-domain MCI usually present executive deficits but also different degrees of task memory degradation, the present paradigm might let us to test three alternative hypothesis. One that due to their executive disorders, dementia and MCI might show a large interference effect compared to healthy participants, especially on the *Task-Distractor* condition , as task distractors compete not only at the level of object selection buy also at the level of task goal selection. We were especially interested in a specific type of distractor error, the presence tangential steps errors, that is, correct action steps towards the consecution of the distractor task. Analyzing the distribution of this form of error between groups, might be a key reflection of executive or "Goal Neglect" deficits which might help to further distinguish dementia and MCI patients from healthy old people.

The second possibility to be tested was that Task distractors because of providing a coherent context for the target task might instead produce a benefit on dementia and MCI performance and somehow compensate for their task memory degradation. Third, we wonder whether both effects, Task distractor interference but also Task distractor facilitation might co-occur in this population, but being observed in different aspects of performance, let say to produce more errors with the distractors, but at the same time to facilitate actions related with target task items.

Method

Participants

Twenty nine multi domain MCI patients and 31 dementia patients (18 Alzheimer, 2 Vascular dementia, 2 Mixta dementia and 9 Frontotemporal dementia) patients were recruited from the dementia outpatient program at San Cecilio Hospital (Granada, Spain). Diagnoses were made at an interdisciplinary team conference based on clinical data and following standardized criteria. For MCI, the diagnostic criteria (Albert et al., 2011) were: (1) Concern regarding a change in cognition, obtained from the patient and/or from the informant, (2) Objective evidence of impairment in one or more cognitive domains according to patient´s age and educational level, (3) Preservation of independence in functional abilities, although they have usually mild problems in complex activities and (4) did not met criteria for dementia. Dementia participants –alzheimer, vascular and frontotemporal dementia- met criteria for dementia according to DSM-IV (Association, 2000). A healthy aged-matched Control group (N = 27) was recruited from the community. All control elderly participants had neither cognitive nor functional deficits evaluated by an extensive neuropsychological protocol. All of them lived independently.

Exclusion criteria were absence of long-standing psychiatric illness and motor/sensitive deficits. Moreover, participants had to be able to maintain their attention over time and to understand and follow different spoken instructions (preserved language comprehension).

Procedure and design

Participants were tested individually in a room. Patients were placed in front of a table with a set of cooking objects on it. We ensured that they could grasp every object in the table. At the beginning of each task, participants were asked to name all objects present in the table and to explain their use in order to reject perceptive and semantic memory alterations. Then, participants were instructed to perform the same ADL task under two conditions, one under the "*Task-Distractor*" and one under the "*Objects-Distractor*" conditions. We ensured that participants had understood what they have to do (i.e. which was their target task) by asking them to repeat the instructions. The order of the two conditions was counterbalanced across participants on each group. Performance of each participant was videotaped for later analysis. In addition to target items, distractor objects were intermixed with the target items. The objects were randomly positioned on the table at the beginning of each session for each participant.

The required target task (either to prepare a cup of coffee with milk and sugar or to make a toast with butter and jam) was counterbalanced among participants. For the *Task-Distractor* Condition, all distractor objects constituted the object set necessary to complete two additional but not required ADL tasks. These two distractor tasks were also "cooking" tasks semantically related with the target task, so that altogether they were part of the semantic category "breakfast". More concretely, for the target task "To make a cup of coffee with milk" the distractor tasks were making an orange juice and an olive oil and tomato toast.

For the target task "To prepare a toast with butter and jam" the distractor tasks were a cup of coffee with milk and objects to make an orange juice.

For the Objects-Distractor condition, distractor items were also "cooking" related objects, but in this case, they were isolated items, in the sense that they never constituted a whole set to complete an alternative ADL task. The number of objects in both conditions was equated (sixteen for both the Task-Distractor and the Object-Distractor conditions). For details about the whole set of objects per experimental condition, see Table 1.

Table 1. Tasks and objects in each experimental condition.

"Task-Distractor" Condition		"Objects-Distractor" Condition	
Target Objects Task	Distractor objects	Target Objects Task	Distractor objects
Target Task A: Coffee with milk Objects: Coffee bag, Milk, Cup, Sugar, Hotplate, Saucepan and Teaspoon.	Distractor task: Tomato toast Objects: Tomato, Olive oil, Slices of bread, Toaster, Plate and Knife. Distractor task: Orangejuice Objects: Orange, Juice maker and Glass.	Target Task A: Coffee with milk Objects: Coffee bag, Milk, Cup, Sugar, Hotplate, Saucepan and Teaspoon.	Objects: Whisk, Apple, Bowl, Banana Salt, Pâté, Grater, Platter and Knife.
Target Task B: Toast with butter and jam Objects: Butter, Jam, Slices of bread, Toaster, Plate and Knife.	Distractor task: Coffee with milk Objects: Coffee bag, Milk, Cup, Sugar, Hotplate, Saucepan and Teaspoon. Distractor task Orangejuice Objects: Orange, Juice maker and Glass.	Target Task B: Toast with butter and jam Objects: Butter, Jam, Slices of bread, Toaster, Plate and Knife.	Objects: Tea bag, Juice pack, Salt, Fork, Ladle, Grater, Little jug, Whisk, Apple and Bowl.

ADL Scoring Procedures

Errors made by patients were classified based on Humphreys and Forde, (1998) and Schwartz et al. (1991) criteria. Descriptions of each error category are explained in Table 2. In order to test our hypothesis, we made the distinction used by Niki et al (2009) and Giovannetti et al. (2010) between errors associated to the target items vs. errors associated to the distractors. Finally, we calculated the "Total error" score, which was the result of summing up Target errors and Distractor errors.

Table 2. Descriptions of errors in performance-based task.

Errors associated with the target objects

- Perseverations: Some steps of target actions were inappropriately repeated immediately.
- Repetitions: The participant repeated a target or distractor step inappropriately later in the sequence.
- Failures in Sequence: A participant failed to follow the conventional order of actions. Given the variability in the task performance order across participants, we included only errors of this type in those cases where they were aberrant and prevented the accomplishment of the task. These errors are fully described in Appendix 1
- Action Additions: A participant added an action that cannot be interpreted as a task step. (For example when participants wanted to eat what they had prepared).
- Substitutions: A target object was used instead of a correct target object in order to complete the target action.
- Manipulations/Toyings: A participant only lifted a target object and then set it down or fiddled with it.
- Tool omissions: A properly use of tool was omitted. When patients fail in this category, usually they use any part of their body instead of the correct tool.
- Omissions: Necessary steps to complete target task were omitted. Omissions score was transformed to percentage depending on number of steps that each participant had did.

Errors associated with Distractors

- Substitutions: A distractor object was used instead of a correct target object in order to complete the target action.
- Manipulations/Toyings: A participant only lifted a distractor object and then set it down or fiddled with it.
- Tangential Actions: When the patient performed an action sequence correctly but from the distractor task. For example, when doing correct actions to make a toast when asked to make a coffee. We included in this category whether participants ate distractor object.
- Perseverations: Some steps of distractor actions were inappropriately repeated immediately.
- Repetitions: The participant repeated a distractor step inappropriately later in the sequence.

Inter-rater reliability

Two raters independently coded video recordings on different error categories. Disagreements between the coders were resolved through discussion and re-review of videotapes. Inter-rater reliability was assessed for 20 percent of the sample selected randomly. Raters demonstrated that the ICC coefficient for test reliability was very high, with a reliability estimate of more than 0.90 in all scoring measures.

Neuropsychological Assessment

Participants were evaluated with a neuropsychological protocol. A broad measure of different cognitive processes such as language, memory, attention and executive functions was used in order to assess the cognitive state of all participants. For denomination we used 15-Item Boston Naming Test (Fastenau, Denburg, & Mauer, 1998; Mack, Freed, Williams, & Henderson, 1992). In order to evaluate short and long term memory, participants were assessed by the Rey´s Auditory Verbal-Learning Test (Rey, 1964). Four measures were used of this test: The number of words recalled after the first time in a free recall test (Short Term Memory), the number of words recalled in long term in a free recall test, the number of omissions and false alarms in a recognition test. The INECO Frontal Screening was used to evaluate executive functions (Torralva et al., 2009). Ideomotor praxias was assessed by the Barcelona Test (Peña Casanova, 1990).

Semantic fluency was evaluated by asking to the participants as many words as possible from an animal category in 60 seconds (Ardila et al., 2006).

A small group of patients could not complete the whole evaluation battery because of low education level, fatigue, and lack of motivation. All these tests were performed by at least 80% of participants.

Results

Demographic and neuropsychological results

One way ANOVA and a Chi Square Test revealed that the groups did not differ in age or gender. Groups differed in years of education, but only in relation to MCI group, who had less years of education than controls and dementia participants. However, previous studies have demonstrated that these kind of everyday tasks are not affected by this factor (Buxbaum et al., 1998; Schwartz et al., 1999; Schwartz et al., 1998; Schwartz et al., 2002). As can see in Table 3, dementia patients showed poorer execution in all neuropsychological variables in comparison with Control group, and MCI patients were placed at intermediate levels of impairment in almost all the neuropsychological tests, with exception of denomination and praxias test, where MCI patients didn't differed from control participants.

Table 3. Demographic and neuropsychological results for the three groups

	Control		MCI		Dementia		ANOVA		Group differences
	Mean	SD	Mean	SD	Mean	SD	F	d.f	
Age	66.33	8.90	70.97	6.13	67.71	8.10	2.65	2,84	n.s
Years of Education	10.27	3.54	8.24	3.45	9.48	3.11	3.74*	2,84	(Control=Dementia) >MCI
Sex (%women)	59 %		45%		48%		χ^2 =1.26		n.s
Neuropsychological Scores									
MMSE	29.67	.62	26.43	.52	21.61	4.42	49.11**	2,83	Control > MCI > Dementia
Denomination	13.63	1.57	13.97	1.12	13.20	2.07	1.61	2,83	n.s
Praxias	3.96	0.19	3.79	0.49	3.33	0.92	7.86	2,83	(Control=MCI) > Dementia
R-AVLT ST FRecall	4.44	1.42	2.90	1.50	2.35	1.62	14.38**	2,84	Control > (MCI = Dementia)
R-AVLT LTFRecall	8.07	3.35	3.21	2.74	1.42	1.69	48.00**	2,84	Control > MCI > Dementia
R-AVLT Omissions	1.15	1.56	2.69	2.89	3.66	3.28	6.08*	2,82	Control > Dementia
R-AVLT False alarms	1.33	1.41	5.90	6.64	11.03	9.73	13.74**	2,82	Control > MCI > Dementia
INECO	24.22	2.57	15.36	5.89	10.36	6.44	48.49**	2,80	Control > MCI > Dementia
Semantic Fluency	21.00	6.58	12.76	4.16	9.58	4.50	36.64**	2,83	Control > MCI > Dementia

n.s = Nonsignificant; *p<.005; ** p<.001Note. MMSE = Mini Mental-State Examination; R-AVLT STFRecall = Short Term Memory of Rey Auditory Verbal Learning Test. R-AVLT LTFRecall = Long Term Memory of Rey Auditory Verbal Learning Test. INECO = INECO Frontal Screnning.

Denomination and Semantic action knowledge of isolated objects presented in the task.

First, we analyzed differences among groups. In relation with denomination, we summed correct responses to name objects (for target and for distractor objects) in the two distractor conditions, as well as we asked participants for the use of each object. Two different analysis of variance were conducted, one for the naming of the objects and one for the knowing of the object use, with the variable Group as between subjects. For the analysis of naming objects, we found significant differences among groups, given the main effect of the Group variable (F (2,84) = 5.96, p <. 005). Dementia patients showed a significant impairment in this domain in comparisons with the control ($p < .05$), and MCI groups ($p < .01$). However, MCI and Control group did not differed between them ($p = .1$). In relation to the knowledge about the object use, no group differences were obtained (F (2, 84) = 1.40, $p = .25$).

Analysis on the performance based ADL task.

Data from one participant from the control group were not available for the *Task-Distractor* condition, due to technical problems at the time of recording. Similarly, one participant from the dementia group performed a previous non-comparable version of the *Objects-Distractor* condition. Consequently, these two set of data for this two participants were replaced by the mean of each group on the corresponding conditions.

In order to analyze the differences among groups and conditions in different categories of ADL errors, separated mixed repeated measures ANOVAs were carried out, one for the total errors score, another for the score error related with distractors and a third one for the target related error score. Each analysis included the variable distractor type (*Task-Distractor* vs. *Objects-Distractor*) manipulated within subjects and the variable Group (control, MCI and dementia) as between participants.

Analysis on the Total Error score

Regarding the analysis on total errors, we found a main effect of group, (F (2, 84) = 12.4, $p < .001$, $\eta p^2 = .23$). Post hoc comparisons revealed significant differences after Bonferroni correction between the control and dementia groups ($p < .001$), while the differences between the dementia and MCI ($p = .05$), and between control and MCI groups ($p = .062$) did not reach significance. Finally, differences between the experimental distractor conditions were not significant ($F < 1$).

Analysis on the Distractor Error Score

Regarding the analysis on errors involving distractor items, we also found a main effect of group (F (2, 84) = 4.55, $p < .05$, $\eta p^2 = .10$). As predicted, such group effect was modulated by the Distractor type manipulation, as indicated by the significant two-way interaction between Group x Distractor type (F (2, 84) = 3.29, $p < .05$, $\eta p^2 = .07$). Separate analysis were consequently conducted, one for each Group, with the variable type of distractor as within participants. The analysis conducted on the Control group showed no differences between distractor conditions, although as can be observed in Figure 1 and Table 5, they still made numerically less distractor errors for the *Task-Distractor* condition than for the *Objects-Distractor* one. Interestingly, the pattern of distractor errors made by the two patient groups was opposite, as they made more distractor errors for the *Task-Distractor* condition than for the *Objects-Distractor* one. Such an interference effect for the *Task-Distractor* condition did not reach significance for the MCI group, $F(1, 28) = 1.83$, $p = .19$, but it was significant for the Dementia group $F(1, 30) = 6.3$, $p < .05$ $\eta p^2 = .17$.

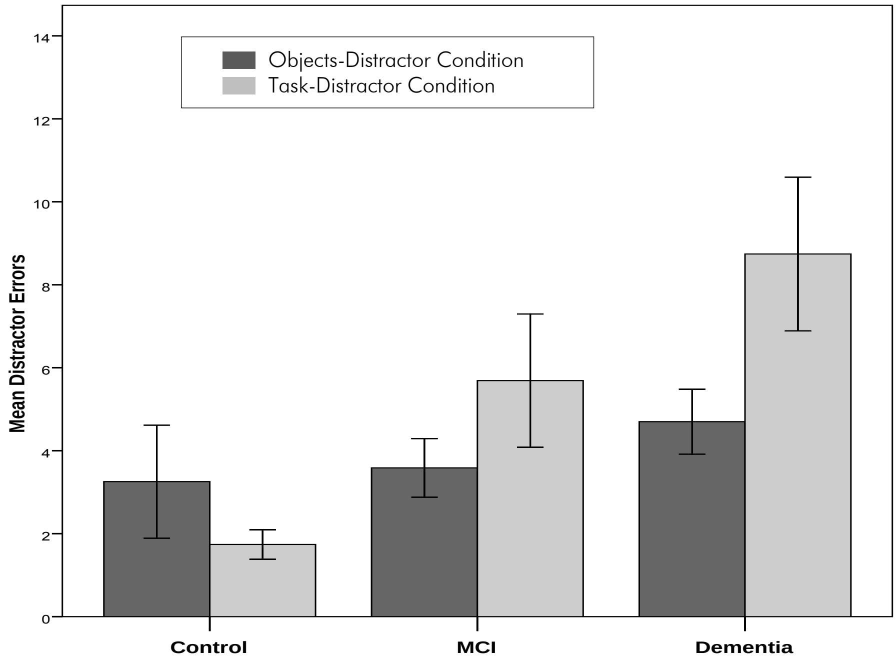


Figure 1. Mean Distractor Errors for each group in the two conditions. Bars reflects Error bars reflect +/-1 standard error.

Analysis of Tangential Distractor steps Errors

As described in the introduction we were especially interested in analyzing group differences regarding Tangential steps, that is, steps correctly done with distractor objects, as we assumed that the presence of this kind of error might be a pure reflection of deficits on executive task goal. Table 4 shows the proportion of participants that exhibit this type of error, independently of the number of them. Meanwhile, for the *Objects-Distractor* condition the presence of this kind of error was rare and groups did not differ among them (χ^2 (2) =1.37, p = .50), for the *Task-Distractor* condition, group differences were statistically significant (χ^2 (2) =10.13, p < .005). Interestingly, in this distractor condition, any healthy participant produced Tangential steps, meanwhile a large proportion of MCI and dementia group did produce this type of errors on the *Task-Distractor* condition.

Table 4. Percentage of participants that exhibit tangential steps in each group and distractor condition.

	Control	MCI	Dementia
Task-Distractor Condition	0 %	24.1 %	32.3 %
Objects-Distractor Condition	3.7%	3.4 %	9.7%

Analysis on the Target Error score

Regarding the analysis restricted to errors related with the target task, we found a main effect of Group (F (2, 84) = 15.5, $p < .0001$ $\eta p^2 = .27$). Bonferroni corrected post hoc comparisons revealed that groups made an increasing number of target errors with increasing levels of cognitive impairment. Thus, dementia patients made significantly more errors than MCI patients ($p = .01$) and Controls ($p < .001$), and MCI made more errors than the control ($p = .04$).

Differently to the previous analysis on total errors, the difference between the two distractor conditions was significant ($F(1, 84) = 5.68$, $p < .05$, $\eta p^2 = .06$), indicating a reduction of target errors for the *Task-Distractor* condition compared to the *Objects-Distractor* condition. Importantly, this facilitation effect for the *Task-Distractor* condition did not interact by group ($F < 1$). As can be seen in Figure 2 and Table 5, all groups produced less errors for the *Task-Distractor* condition than for the *Objects-Distractor* condition.

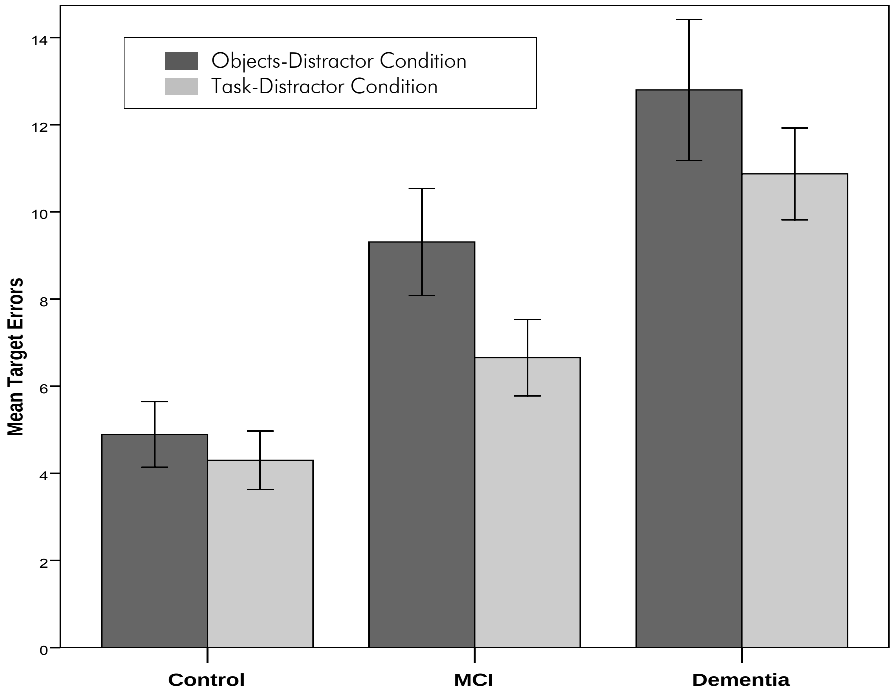


Figure 2. Median Target Errors for each group in the two conditions. Bars reflects Error bars reflect +/-1 standard error

Table 5. Target and Distractor Errors for each group in two conditions.

		Objects-Distractor Condition		Task-Distractor Condition	
		Mean	SD	Mean	SD
Target Errors (Total)	Control	4.89	3.90	4.30	3.48
	MCI	9.31	6.62	6.66	4.73
	Dementia	12.80	9.01	10.87	5.87
Perseverations	Control	0.04	0.19	0.00	0.00
	MCI	0.07	0.26	0.07	0.26
	Dementia	0.13	0.56	0.10	0.30
Repetitions	Control	0.11	0.42	0.23	0.58
	MCI	1.00	1.90	0.31	0.71
	Dementia	0.63	1.01	0.61	1.14
Failures Sequence	Control	0.00	0.00	0.00	0.00
	MCI	0.14	0.44	0.07	0.26
	Dementia	0.20	0.40	0.16	0.37
Action Additions	Control	0.41	0.69	0.38	0.79
	MCI	0.59	0.95	0.52	0.78
	Dementia	0.67	1.04	0.65	0.80
Substitutions	Control	0.04	0.19	0.04	0.19
	MCI	0.21	0.49	0.03	0.19
	Dementia	0.27	0.44	0.26	0.44
Man/Toyings	Control	4.12	3.92	3.19	3.30
	MCI	6.21	5.32	4.59	4.40
	Dementia	9.13	8.53	7.32	5.41
Tool Ommisions	Control	0.00	0.00	0.00	0.00
	MCI	0.21	0.41	0.28	0.45
	Dementia	0.13	0.43	0.13	0.34
Omissions (%)	Control	2.31	9.28	6.60	15.20
	MCI	14.40	17.37	12.93	19.50
	Dementia	27.16	22.19	27.82	24.13
Distractor Errors (Total)	Control	3.25	7.07	1.74	1.85
	MCI	3.59	3.80	5.69	8.65
	Dementia	4.70	4.35	8.74	10.31
Substitutions	Control	0.07	0.27	0.08	0.27
	MCI	0.14	0.35	0.07	0.26
	Dementia	0.50	0.76	0.42	0.72

Man/Toyings	Control	2.85	5.42	1.65	1.84
	MCI	3.38	3.83	3.93	5.48
	Dementia	4.00	3.88	6.03	6.43
Tangential Steps	Control	0.30	1.54	0.00	0.00
	MCI	0.07	0.37	1.55	3.40
	Dementia	0.20	0.75	1.84	3.30
Perseverations	Control	0.00	0.00	0.00	0.00
	MCI	0.00	0.00	0.00	0.00
	Dementia	0.00	0.00	0.03	0.18
Repetitions	Control	0.04	0.19	0.00	0.00
	MCI	0.00	0.00	0.14	0.52
	Dementia	0.00	0.00	0.42	1.06

Regarding the results with the distractor objects, we calculated the "Distractor Interference Index", by subtracting the numbers of errors in the Object-Distractor condition from the Task-Distractor condition. In addition, we calculated the "Target Facilitation Index", but oppositely to the pattern of distractor objects, that is, by subtracting the numbers of errors in the Task-Distractor condition from the Object-Distractor condition. In order to analyse the relations beween these indexes and neuropsychological measures, we carried out Pearson correlations. As describe in Table 6, the Distractor interference Index correlated with MMSE and INECO Frontal Screening. Target Index did not reach significant values.

A stepwise multiple regression analysis with the Distractor interference Index as a dependent variable was performed. Predictor variables were the neuropsychological variables for which we found significant correlations, that is MMSE and INECO. The best model accounted for 9.3 % of the variance, $F\ (1,82)=8.26$, $p<.01$, with INECO $\beta=-.304$ $p<.01$ as the only significant predictor variable.

Table 6. Correlations between neuropsychological measures and Distractor interference and and Target facilitation Indexes.

	MMSE (*n*=86)	Denomination (*n*=86)	Praxias (*n*=86)	R-AVLT ST FRecall (*n*=87)	R-AVLT LT FRecall (*n*=87)	INECO (*n*=83)	Semantic Fluency (*n*=86)
Distractor Index	-.252*	-.093	-.153	-.116	-.183	-.304**	-.140
Target Index	-.099	.057	.011	-.053	-.109	-.077	-.024

Note. MMSE=MiniMental State Examination; R-AVLT ST FRecall = Short Term Free Recall Rey Auditory Verbal Learning Test; R-AVLT LT FRecall = Long Term Free Recall Rey Auditory Verbal Learning Test; INECO=INECO Frontal Screnning

Discussion

The general aim of the present study was to further isolate the cognitive mechanisms by which distractor items impact ADL performance in dementia and multi-domain MCI. Advances in isolating which are the distractor properties that mostly interfere with everyday functioning in this population might have important practical consequences for both diagnostic and intervention purposes. We designed an ADL task where participants had to either prepare a cup of coffee with milk and sugar or a toast with butter and jam. Items necessary to complete the target task where intermixed with semantically related items. We manipulated the nature of the distracting items. On the *Objects-Distractor* condition, distractors were isolated semantically related cooking items. On the *Task-Distractor* condition, these cooking items constituted the whole set to complete two alternative but semantically related tasks, so that altogether (the target and the distractor tasks) were congruent with the coherent context of a “breakfast”.

First, we found that the present ADL task was sensitive to discriminate important differences among diagnostic groups in a Spanish population, as the Total Error score fully discriminated dementia from healthy control and MCI participants. Even further, when focusing on errors related with the correct accomplishment of target task, we additionally found that the present ADL task helped to discriminate MCI from healthy old participants.

Meanwhile the distinction between dementia and healthy control participants found here is in agreement with several previous performance based studies using related tasks (Cooke, Fisher, Mayberry, & Oakley, 2000; Giovannetti et al., 2008; Giovannetti et al., 2002), the finding of ADL performance-based differences between MCI and healthy participants seems more compelling, given that differences in functional performing between these two groups are very subtle (Seligman et al., 2013) and has only been found when using more complex tasks, like when performing difficult finances (Griffith et al., 2003) or tasks with multitasking requirements (Schmitter-Edgecombe, McAlister, & Weakley, 2012). Our study has helped to isolate a new condition that might help to discriminate MCI everyday deficits even on a very simple and common ADL task like coffee preparation, which is, when asking patients to do that under the presence of semantically related distractors. The presence of related distractors might constitute a situation more sensitive to the executive or inhibitory deficits usually present in dementia but also in MCI patients.

Even further, when looking for errors associated to distractor items, we found that contrary to healthy participants, MCI and dementia patients showed more distractor errors (e.g. they touched or even used them) on those situations where distractors, as a whole, constituted alternative ADL tasks sharing the same semantic category with the target task (breakfast), compared to when related distractors did not conform a related task (i.e. isolated kitchen utensiles). We propose that Task distractors might capture attention and action in a stronger and more automatic manner than isolated related objects because of activating a higher order semantic category, thus, these object representations might be more activated that those of objects that do not retrieve a highter order sementic category. Therefore, these distractors conforming other tasks might compete with target items not only at the level of object selection but also at the level of task selection (task goal). This high activation of the distractors together with the extra source of task competition produced by them might had led to the exhibition of a high proportion of errors with the distractors in MCI and dementia patients. This kind of distractor errors could be considered as a direct measure of an exacerbated bottom-up and/or a lack of action inhibition towards highly activated irrelevant items present in the scene in these groups of patients. Especially relevant was the presence of "correct" but tangential actions towards the task distractors that were frecuently produced by MCI and dementia patients. Interestingly, old healthy adults never produced this kind of behaviour on the task distractor condition, thus, the presence of this kind of correct but tangential actions might constitute a cualitative distinction between healthy vs. impaired ageing even on early stages. However, a large proportion of MCI and dementia patients never exibit this kind of behaviour. Consequently, more research is still needed to furhter understand if different subtypes of MCI and dementia might be more prone to produce this kind of behavior with distractor.

Nevertheless, apart from the intefering effects produced under the Task distractor condition, we observed that this kind of Task distractors produced some benefits (instead of inteference) on participants when looking at how well they performed the target task, given the observation of a reduction on errors related with the target compared to when performing the task under the presence of isolated objects. This facilitation effect for the Task distractor condition didn't interact with group, and was similarly spread for the three groups. One potential explanation for this facilitation effect is that the presence of task distractors might provide a coherent (or congruent) contextual environment for the target task, which might somehow help to retrive the correct task schema from memory. This finding is fully in agreement with previous studies showing that both healthy but also dementia patients with semantic problems might improve object recognition when an object is embedded on semantically coherent contexts (e.g. Palmer, 1975). Moreover, a recent study has found context congruent facilitation effects on an object categorization task along a range of different age groups. Interestingly, they found that the group of healthy participants over 75 years made more errors in categorization task under incongruent contexts than younger ones (Remy et al., 2013). This might indicate that even on normal ageing, the memory schema of the task might start to deteriorate and consequently might be especially sensitive to the level of context congruency. That might explain the general facilitation effect found in the present study in our old population as a whole group.

To conclude, the finding of opposItte effects due to the presence of Task distractors in MCI and dementia ADL performace found in the present study has helped to dissociate two main cognitive deficits present in this population that might alter their everyday functioning in a different extent. With the presence of Task related distractors participants might have activated a coherent context for the target task, which might had led to a better retrieval of the task schema from memory, thus compesating for the initial deterioration of this kind of knowledge. However, this high semantic activation produced by this kind of Task distractors might have had some side effects restricted to MCI and dementia participants. Because of their executive deficits, they might have been unable to avoid distraction by distractors thus leading to a large proportion of errors with them.

Future research might elucidate whether different subtypes of MCI and dementia patients suffering different brain progressive pattern of deterioration might also be differently affected by the presence of Task distractors. Consequently, we might predict that if a patient alteration is mostly defined by the presence of semantic memory deficits with spared executive processes, then we might recommend to perform ADL under the presence of Task related distractors, as he/she might have a contex benefit without the side effects on being distracted. On the othe side, if we encounter a patient showing a large deficit in executive funcioning but still preserving their semantic memory schema, an useful compensatory recomentation might be to avoid ADL execution under the presence of hightly related task distractors as the ones used in present study.

Appendix 1. Failures in Sequence for each task

Coffee task

- To pour milk in the cup before pouring it into the pan.
- To stir milk before heating the milk
- To heat the cup before pouring milk into the cup.
- To stir sugar and coffee before adding milk.

Toast task

- To put lower the buttonhole lever before putting the slice of bread.
- To spread butter before toasting the slice of bread.
- To add jam before spreading butter.
- To put jam and butter before to take the slice of bread.

Experimental series 5

Preliminary Cognitive Scale of Basic and Instrumental Activities of Daily Living, for Dementia and Mild Cognitive Impairment.

Manuscript submmited to Journal of Gerontology: Psychological Sciences

Preliminary Cognitive Scale of Basic and Instrumental Activities of Daily Living, for Dementia and Mild Cognitive Impairment.

Rodríguez-Bailón, María[1], Arnedo-Montoro, María Luisa[2], Montoro-Membila, Nuria[3], Garcia-Morán, Tamara[4], Funes Molina, María Jesús[1,5].

1. Centro de Investigación Mente, Cerebro y Comportamiento. Granada, Spain
2. Departamento de Psicobiología. Universidad de Granada. Granada, Spain.
3. Servicio de Neurología. Hospital Universitario San Cecilio. Granada, Spain.
4. Asociación Granadina de Familias para la Rehabilitación del Daño Cerebral Adquirido "AGREDACE", Granada, Spain.
5. Departamento de Psicología Experimental .Granada, Spain.

Abstract

The present study evaluated cognitive and functional deficits in multi-domain Mild Cognitive Impairment (MCI), dementia and healthy aged matched control participants with a preliminary new informant-based assessment tool, "The Cognitive Scale for Basic and Instrumental Activities of Daily Living ". This tool allowed us to evaluate four key cognitive abilities: Task Memory Schema, Error Detection, Problem Solving and task Self-Initiation along a range of basic (BADL) and instrumental (IADL) activities. The results showed that Task Memory Schema alterations were dependent of task complexity, while the other three cognitive items were independent of ADL type. Dementia patients were impaired in all cognitive abilities for both basic and instrumental activities. On the other side, MCI patients task schema was preserved for both ADL types, however, they exhibited a generalized Problem Solving deficit, and this kind of errors were present even for BADL. Finally, MCI patients also showed deficits on Error Detection, and Self Initiation but for instrumental ADL. The combination of different cognitive processes instantiated in different ADL differing in complexity measured by this new assessment tool, seems promising to further understand the specific relations between cognition and function in this and other cognitively impaired population.

Keywords

Activities of Daily Living (ADL), Mild Cognitive Impairment, Dementia, Assessment, Neuropsychology.

Introduction

Diagnoses for dementia and multi-domain Mild Cognitive Impairment can be distinguished for the severity of cognitive deficits and the impact of them in labour and social life. Meanwhile, dementia patients exhibit moderate to severe cognitive alterations that affect to their everyday functioning, MCI patients are diagnosed on the basis of milder cognitive deficits with small impact on their daily activities (Albert et al., 2011; McKhann et al., 2011; Petersen, 2004).

Many studies, have demonstrated that dementia patients produce numerous errors when they are making different activities of daily living (ADL) and their decline in everyday functioning increase as the patients get worse in their cognitive abilities (Arrighi et al., 2013; Mioshi et al., 2013).. A moderate dependence, on even simple or basic (BADL) as well as on more complex or instrumental (IADL) has become a critical diagnostic criteria for dementia (Mioshi et al., 2007; Reisberg et al., 2001; Zanetti, Frisoni, Rozzini, Bianchetti, & Trabucchi, 1998).

However, the degree of functional alterations in MCI constitutes a more controversial issue (e.g. Gold, 2012; Petersen et al., 2001; Petersen et al., 1999; Winblad et al., 2004).While early diagnostic criteria (Petersen et al., 1999) established that MCI patients had preserved ADL performance, the same authors reformulated later their diagnostic criteria to the expression "relatively intact", to accommodate critical findings pointing to alterations in ADL functioning in this population (Petersen, 2004). Continuing with this line of evidence, recent studies have shown that MCI patients are relatively independent in BADL, but they show some impairments in IADL (Gure, Langa, Fisher, Piette, & Plassman, 2013; Weston, Barton, Lesselyong, & Yaffe, 2011). Importantly, several studies are showing that the degree of complexity of ADL tasks is a critical aspect that increases MCI functional alterations (Griffith et al., 2003; Reppermund et al., 2011). Consequently, we can conclude that the distinction between which kind of daily activities are mostly altered in each patient group (e.g. basic vs. instrumental tasks) seem to be a critical factor for diagnostic purposes, specially to distinguish between MCI and healthy participants.

Even if these two critical aspects, cognitive and functional deficits, are usually measured by different tools for clinical and diagnostic purposes, research is mostly interested in elucidating the specific relations between these two impaired aspects of behavior in dementia and MCI patients, trying to further understand which kind of cognitive deficits are mostly responsible of the pattern of errors in different types of ADL.

Several studies using correlation and regression analyses between cognitive measures after neuropsychological screening and global measures of functional impairment, have found important relationships between executive deficits and ADL functioning in dementia and/or MCI (Aretouli & Brandt, 2010; Hughes et al., 2012). A similar conclusion is raised by performance based studies. For example, a recent study using a novel ADL situation requiring multitasking found that MCI had more difficulties than healthy old participants to complete this kind of executive task (Schmitter-Edgecombe, McAlister, & Weakley, 2012).

Especially relevant for the analysis of the relations between cognition and function in dementia and MCI are those studies based on the standardized Naturalistic Action Test (NAT) (Schwartz et al., 2002) who proposes an exhaustive error coding system for the execution of three ADL tasks, preparing coffee, preparing a packed lunch and wrapping a gift. Within this methodology, these authors have dissociated two broad kinds of errors (Giovannetti et al., 2008). On the one side, step omissions, that seem to be associated to deficits in the hardwired or memory stored knowledge about the task. On the other side, commission like errors, that is, errors related with the online execution of the task, like object substitutions, toying or repetitions, might be reflections of executive alterations. Such a distinction has proved to be useful to differentiate specific patterns of impairment between dementia and MCI. Thus, meanwhile dementia patients produce an even proportion of both error categories, as a reflection of cognitive deficits in both, the memory schema of the task and on the online executive regulation of performance, the pattern of errors of MCI patients is characterized specifically for commission like errors, which were interpreted as reflections of executive deficits (Giovannetti et al., 2008). Even further, a more sophisticated error coding system recently proposed with the NAT, have shown that dementia (Bettcher et al., 2008) but also MCI patients (Seligman et al., 2013) miss to detect a large proportion of their own errors, which is again consistent with the idea that executive deficits are a key source of everyday action impairment in dementia and MCI.

However, the specific relationship between cognition and function in MCI and dementia is still not completely understood and it need further testing. One problematic aspect of the studies cited above regarding the relation between executive deficits and function impairment is that the authors didn't report evidence of differences between MCI or dementia groups from healthy old participants. Consequently, it is not clear yet whether these patterns of errors are exclusive to MCI patients or are more broadly present in normal aged participants. Similarly, a recent influential study using an informant based cognitive everyday scale called " E-Cog" (Farias et al., 2008) failed to detect differences between MCI and healthy control groups in any of the three executive functions measured in the scale, organization, planning or divided attention. This opens the possibility that other subtype of cognitive errors, especially those tapping executive deficits need to be codified to better discriminate MCI from healthy ageing.

Second and more important, the design of the most performance-based and informant-based tools proposed in the past don´t allowed to fully address the broad pattern of possible relations between different cognitive processes on different types of ADL. Thus, even if most cognitive processes might be necessary for the correct execution of most ADL, it is possible that some asymmetries in the degree of involvement of these processes occur, depending on the complex nature of a given ADL. This possibility cannot be addressed on previous performance based studies that focused on a small subset of ADL tasks similar in task complexity (e.g. the NAT test focused on only three IADL) or in others focusing on a unique cognitive process (e.g. the Day Out Task that only focus on executive-multitasking alterations). A similar problem is present on previous informant based tools, as most of them are designed to measure a given cognitive alteration (Barker et al., 2011; Grace, Stout, & Malloy, 1999; Jorm & Korten, 1988; Wilson et al., 1998). Even when measuring a whole range of cognitive processes, like the E-cog does (Farias et al., 2008), these scales don't allow to measure the impact of these cognitive deficits on different ADL differing in difficulty. Thus, the kind of cognitive items used on them are either too broad (not instantiated in any given ADL, e.g. "Thinking ahead") or are exclusive for a given ADL (e.g. the "Repeating stories or questions" item would be only part of the memory factor or the item "Thinking things through before acting" would only be part of the executive-planning factor").

Description of the Preliminary Cognitive Scale of Basic and Instrumental Activities of Daily Living

The main aim of the present study is to provide some new insights to increase the understanding of the specific relations between cognitive deficits and everyday life impairments in dementia and MCI. We designed a direct informant-caregiver tool sensitive to both levels of analysis, that is, able to measure these key cognitive processes, (memory schema about the task as well as different executive processes), instantiated along a range of several ADL differing in the degree of complexity.

In order to measure these key cognitive processes, we transfer a subset of the error coding system usually used in performance-based research studies and convert them into concrete items or questions easily recognizable by a patient informant caregiver within the context of a whole range of ADL differing on the degree of complexity. Consequently, we created a design where most cognitive items were asked for every ADL activity, so that we could have a measure of each cognitive aspect within the context of each ADL task.

To isolate critical cognitive errors able to improve the discriminability between dementia, MCI and healthy ageing, we did an empirically and theoretically based selection. In this sense, some items were selected based on some of the critical findings obtained in previous studies that haveproved to be potentially relevant to further dissociate between healthy old participants, MCI and dementia. In this regard we first selected the category **Memory schema of the task** (presence of omissions and/or sequence alterations). As described above, this process has proved to be more altered in dementia than in MCI, however, it still unknown whether this cognitive aspect is differently altered depending on the complexity of the task. Second, we decided to include the category: **Error detection** for two reasons. First, because previous studies have consider it a key aspect of executive impairments (e.g. Bettcher et al., 2008) and second, because, as far as we know, any study has directly compared yet the impairments of this ability between dementia, MCI and healthy participants.

Third, we included a new cognitive category: **Problem solving**, concretized as the ability to find a solution for their own errors or more broadly, for any unexpected situation occurring during the execution of the current ADL task. As far as we know, this item has never been included in previous diagnostic cognitive or functional tools for dementia and MCI. This executive ability has proved to be highly impaired in many neurological syndromes when measured with neuropsychological tests like the Wisconsin, the D-KEFS Tower Test (Delis et al., 2001) or D-KEFS Sorting Test (Delis et al., 2001), but all of them use artificial material which are far from ADL realistic situations. However, one common appreciation, at least in dementia or frontal lobe patients, is that when they are asked to make a simple ADL out of their familiar or expected environment, they commit more errors compared to when tested in their familiar environments (Bickerton, Humphreys, & Riddoch, 2007; Geusgens et al., 2010). Following further this argument, we predicted that dementia and may be also MCI patients might encounter difficulties any time their expected or routine set of objects or required actions are unexpectedly altered in any form. Interestingly, we expect that this ability, when impaired, might be observed even for simple abilities.

Finally, the fourth cognitive category we decided to include was **Task Self-initiation when necessary**. This has been previously described as a common problem in dementia and MCI (Boyle et al., 2003; Drijgers et al., 2011) but the processes implicated on it are still not fully understood. Thus, some authors have related this ability with motivational alterations (Drijgers et al., 2011), however we believe that additional cognitive executive factors, like prospective memory, organization or updating, could also have a large contribution and according to our main prediction, once altered, it might affect the self initiation of even simple tasks like tooth brushing.

Regarding the selection of ADL activities to be included in the scale, we based on some of the BADL and IADL proposed on the Occupational Therapy field (Youngstrom et al., 2002) and included in traditional scales of everyday functioning as these are commonly used for the clinical diagnosis of dementia or MCI.

Method

Participants

Twenty-eight multi-domain MCI patients and 23 dementia patients were recruited from the Dementia outpatient program in San Cecilio Hospital (Granada). Diagnoses were made by an neurologist specialized in dementia and MCI. The dementia group was heterogeneous, with 47% of participants with diagnoses of probable Alzheimer, 35 % with frontotemporal, and 17% of vascular dementia. The old match Control group (N=20) was recruited from the community. All these healthy old control participants had neither cognitive nor functional deficits.

Exclusion criteria were the presence of psychiatric illness and motor/sensitive deficits. The participants had to be able to maintenance their attention over time, and to preserve language comprehension.

Medical reports of the patients were obtained after informed consent from both the patients and the Ethics Committee of the hospital in compliance with the national legislation on the protection of personal data, Ley Orgánica de Protección de Datos de Carácter Personal (Ley 15/1999, 1999). The investigation was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki.

Age and years of education did not differ among groups, as revealed by One-way ANOVAs, $F(2, 67)=1.56$, $p=.22$ and $F<1$, for the analysis of age and years of education respectively. Details about the relevant sociodemographic and clinical data can be seen in table 1.

Table 1. Sociodemographic data of participants.

Group	N	Months Evolution (Sd)	Mean Age (Sd)	Years of education (Sd)	Gender
Control	20	---	68.35(8.40)	9.00 (3.31)	8 men 12 women
MCI	28	21.85 (13.58)	72.07 (7.99)	8.11 (3.11)	11 men 17 women
Dementia	23	26.09 (17.78)	68.78 (7.96)	8.87 (2.68)	10 men 13 women

ADL activities

The set of ADL included in the protocol were: Brushing teeth, Having a shower, Making up/Shaving, Getting dressed, Cooking, Home Care: cleaning, washing and hanging the clothes, setting the table and Economical Finances/ Shopping.

Cognitive items

For each ADL, a set of cognitive questions were included. These questions were equivalent for each ADL and referred to: (1) Knowledge about the necessary steps and about the step order of the task (Task Memory Schema), (2) Ability to detect their own errors (Error Detection), (3) Ability to solve their own errors or other unexpected situations occurring during task execution (Problem Solving), (4) Ability to self initiate a required task when necessary (Self-Initiation). Table 2 shows the whole tool, where it can be observed how these different cognitive items were instantiated in every ADL. As can be observed, the four cognitive categories were included in every ADL, with the exception of the task Economical Finances/Shopping for which we could only measure the Error Detection and Self-Initiation items. One more question was included in Cooking and Home Care activities about the knowledge of steps in more complex tasks.

Table 2. Cognitive ADL questions

Frequency questions common for all of them

How often did he/she use to do this activity throught his/her life?
How often does he/she currently do this activity ?

BRUSHING TEETH

1. Does he/she know the steps to brush his/her teeth and does he/she perform them in the right order (first putting the toothpaste on the toothbrush, then rubbing the teeth and finally, rinsing out?
2. He/she is able to notice if he/she has got toothpaste on him/her, if he/she has got wet, if he/she has put too much or toolittle toothpaste or has rinsed out little. (ability to detect that there has been an error).
3. He/she is able to find a solution if there isn´t any toothpaste left, if he/she has not taken the towel or if a problem arises.(For example, looking for other toothpaste tube.
4. He/she remembers to brush when necessary. (for example, after meals or before going to bed).

HAVING A SHOWER

1. He/she knows the steps to shower and performs them in the right order (undressing, getting into the shower, soaking, soaping (body and head), rinsing, drying).
2. He/she is able to notice if he/she is not soaping, rising or drying any part of body (ability to detect that there has been an error).
3. He/she is able to find solutions when there is no soap or shampoo left, or if he/she has not taken a towel or if a problem has occurred.
4. He/she remembers he has to have a shower when necessary.

MAKE UP/SHAVING. CHOOSE DEPENDING ON THE GENDER.

1. He/she knows the steps for applying makeup or shaving and performs them in the correct order (makeup: If he/she pours cream, this must always be done before makeup or rouge. Shaving: applying shaving cream, shaving, rinsing, drying the face).
2. He/she is able to tell if he/she has bad makeup or shaving (such as areas left without makeup/shaving or does it only on one part of the face).
3. He/she is able to find a solution if there is not any foam or makeup left or if he/she encounters other problems.
4. He/she remembers to make up/shave when it is necessary.

GETTING DRESSED

1. He/she knows the steps to get dressed and performs them in the correct order (First, underwear, second interior garments and then coat; first putting socks before shoes).
2. He/she is able to notice if he/she has put on the right clothes.
3. He/she corrects it if he/she detects an error
4. He/she remembers to get dressed when it is necessary.

COOKING

1. He/she knows the steps to cook simple meals and performs them in the correct order (Omelettes, salads, toasts, sandwiches, coffee, etc).
2. He/she knows the steps to cook complex meals and performs them in the correct order (Stews, casseroles, meat dishes, rice, pasta, etc).
3. He/she is able to notice if he/she has skipped an essential step, or if he/she is wrong in the correct order of steps or he/she has put an ingredient which should not be used for this meal (ability to detect that there has been an error).
4. He/she is able to find solutions for the errors that he/she made. (For example: Adding the missing food or species)
5. He/she remembers to start cooking when it is necessary.

HOME CARE: CLEANING, WASHING AND HANGING THE CLOTHES, SETTING THE TABLE.

1. He/she remembers the steps to load the washer and performs them in the right order (put the clothes, put the detergent and softener, put a drying program)
2. He/she knows the steps to cleaning up, washing up, sweeping, mopping and laying the table and performs them in the correct order.
3. He/she is able to realize that he/she has not done the cleaning properly or if he/she has missed a step when putting the washing machine or laying the table (capacity to detect that there has been an error)
4. He/she is able to find solutions to the mistakes he/she has made (for example, cleaning more)
5. He/she remembers to begin the house cleaning or to load the washing machine or to lay the table when it is necessary.

ECONOMICAL FINANCES/SHOPPING

1. He/she is able to notice whether the change given is correct.
2. He/she remembers to do the shopping when it is necessary.

A direct caregiver participant was asked whether each cognitive ability was present/absent in the patient behaviour and how often occurred. Four answer choices were possible for each question (item): Never(1) - Sometimes(2) – Frequently(3) - Always(4), so that lower responses were associated with a larger impairment. A trained professional guided or resolved doubts to informants about the items. At the beginning of each ADL, we asked informants about how often did the participant performed that activity at present and in the past (before having established a diagnosis, or at least two years ago). Those cognitive items associated to an activity for which the informant answered the option "never" at present, were not required to be completed and consequently were not included on further analysis. See table 3 to see the percentage of patients per group and ADL type that kept doing a given ADL at present.

Table 3. Number (N) and Percentage of patients per group and ADL type that kept performing them at the moment of testing.

Group	B-ADL	I-ADL
Control	100% (20)	100% (20)
MCI	100% (28)	82.14 % (23)
Dementia	100% (23)	56.52 % (13)

Design and data Analyses

Regarding the analysis of ADL complexity, we first performed an Exploratory Principal Analysis Component (PCA) to verify that the set of ADL activities we included in the scale were in fact grouped in our sample within the two classical categories of BADL and IADL. For this analysis, we incorporated the variables as a result of the mean of all items in each activity of the scale. The PCA was performed with the eigenvalue criterion (>1) to determine the number of factors extracted and varimax rotation to simplify the interpretation of factors. As described above, the four cognitive items were included in every ADL, with the exception of the task Economical Finances/Shopping for which we could only measure the Error Detection and Self-Initiate items. Consequently the analysis with this ADL didn't included the score on the memory schema and the problem solving items.

Second, in order to ensure that each cognitive item of the same type across ADL activities was actually measuring the same cognitive process, we calculated the fiability - with Cronbach´s alpha- of the mean of each cognitive item asked in the scale across ADL activities. The measure related with the cognitive items Problem solving and Task schema didn't include the score on the Economical/shopping ADL.

Third, in order to obtain independent evidence of the convergent validity of the cognitive items proposed here, a neuropsychological standardized screening was administered to the participants. It included an exhaustive assessment of different cognitive deficits such as language, memory, attention and executive functions. A few patients could not complete the whole evaluation due to a low education level, fatigue, or lack of motivation. The statistical analysis included the neuropsychological tests that were completed by at least 80 percent of the participants. Table 4 shows the cognitive processes assessed. Then, we carried out correlations (Spearman) between neuropsychological variables and the four cognitive items asked in the protocol. Moreover, stepwise regression analyses were done to detect the best neuropsychological variables that predicted the specific cognitive process implicated in ADL. SPSS software was used for statistical analyses (IBM Corporation, 2011).

Finally and more important, we were interested in determining any differences among our three groups in these four cognitive items for both basic vs. Instrumental ADL activities

As a subset of participants had stop doing more IADl than BADL ones due their illness, separated analysis were driven for each of the two ADL categories obtained on the PCA analysis. Group differences on each cognitive process were investigated with non-parametric tests (Multiple between-groups Kruskal-Wallis analyses and later, Mann-Whitney U Test for group two by two comparisons) due to the fact that scores were not normally distributed. Effect sizes were estimated using Cohen´s d calculations.

Results

ADL PCA analysis

We first calculated the mean of all items asked on each ADL. Preliminary analyses showed that the data were appropriate for PCA (Kaiser-Meyer-Olkin measure of sampling adequacy = 0.73; Bartlett's test of Sphericity, x2 (21) = 185.19, $p<$ .001). PCA were yielded a two component solutions, accounting 81.60 % of the variance. PCA revealed that the items were grouped in two principal categories. The mean of "Brushing teeth", "Having a shower", "Making up/Shaving" and "Get dressed" loaded on the first component, congruent with the traditional "BADL category", while the mean of "Cooking", "Home Care" and "Economical Finances and shopping" loaded on the second component, congruent with the traditional "IADL distinction".

Cognitive processes internal consistency

In order to test the internal consistency of the four cognitive variables, that is for Sequence/Memory Schema, Error Detection, Problem Solving and Self Initiation, we calculated the fiability - with Cronbach´s alpha- of the mean of each cognitive item asked in the scale across all ADL activities. We found a high internal consistency for Task Memory Schema (α=.78), for Error Detection,(α=.83), for Problem Solving (α=.87) and for Self-Initiation (α=.83).

Neuropsychological Assessment and its relationship with the cognitive items included in the scale (Convergent Validity)

We found significant differences among groups in the neuropsychological screening. As can be seen in Table 4, Executive functions and Memory tests were performed progressively worst with increasing levels of impairment. As expected, MCI patients' scores were significantly lower than that for the control group, but significantly higher than dementia participants.

Table 4. Mean of scores in Neuropsychological tests in Control, MCI and dementia groups. Standard desviation (in parenthesis) was also included.

	Control	MCI	Dementia	Sig. Differences
Mini Mental State Examination	29.57 (0.7)	24.81 (4.41)	19.71 (4.17)	Control-MCI MCI-Dementia Control-Dementia
Rey AVLT				
Short-term free recall Total	39.63 (7.20)	24.5 (9.65)	16.27 (8.12)	Control-MCI MCI-Dementia Control-Dementia
Long term free recall	8.05 (2.46)	3.61 (2.88)	0.95 (1.29)	Control-MCI MCI-Dementia Control-Dementia
False alarms in recognition	1.26 (1.19)	5.04 (8.74)	6.9 (8.94)	Control-Dementia
Omissions in recognition	0.89 (1.24)	2.48 (2.36)	5.30 (3.69)	Control-MCI MCI-Dementia Control-Dementia
INECO Frontal Screnning	24.07 (2.29)	14.27 (7.80)	8.52 (5.96)	Control-MCI MCI-Dementia Control-Dementia
Semantic Fluency	20.16 (5.54)	11.48 (4.88)	8.87 (4.01)	Control-MCI Control-Dementia

Note. Rey AVLT = Rey Auditory Verbal Learning Test.

In order to know the relation between the four cognitive categories included in the present assessment tool with neuropsychological variables, we carried out Spearman Correlations restricted to MCI and dementia patients. Correlations matrices can be seen in Table 5.

Table 5. Spearman Correlations between Cognitive Domains in the present ADL Scale and Neuropsychological Variables in MCI and dementia Patients.

	Memory Schema	Detection	Solution	Self-Initiate
MMSE (*n*=50)	.383**	.364*	.432**	.327*
Rey AVLT Total (*n*=48) Short-term free recall	.246	.145	.393**	.289*
Rey AVLT(*n*=48) Long-term free recall	.407**	.281	.400**	.399**
INECO (*n*=40)	.270	.346*	.498**	.343*
Semantic Fluency (*n*=50)	.115	.166	.292*	.308*

Note. MMSE = Mini Mental-State Examination; INECO = INECO Frontal Screnning; Rey AVLT = Rey Auditory Verbal Learning Test; Detection = Error Detection, Solution = Problem Solving. * $p < .05$. ** $p < .01$.

Four stepwise multiple regression analyses were performed including the neuropsychological variables for which we found significant correlations. In the first regression analysis the mean of Task Memory Schema was introduced as dependent variable. The best model accounted for 17.2 % of the variance, F (1,45)=10.55, $p<.01$, with AVLT Long term free recall $\beta=.436$ $p<.01$ as the only significant predictor variable.

In the second regression analysis the mean of the Error Detection variable was introduced as the dependent variable. The best model accounted for 10,4 % of the variance, F (1,37)=5.40, $p<.05$, with MiniMental $\beta=.357, p<.05$ as the only significant predictor.

In the third regression analysis the mean of Problem Solving variable was introduced as dependent variable. The best model accounted for 21.9 % of the variance, F (1,37)=10.36, $p<.01$, with INECO Frontal Screenning, $\beta=.468$, $p<.01$ as the only significant predictor.

In the forth regression analysis the mean of the Self-Initiation factor was introduced as dependent variable. The best model accounted for 15.5 % of the variance, $F(1,37)=6.79$, $p=.013$, with Long term Memory $\beta=.394$, $p=.013$ as the only significant predictor variable.

Relationship to Clinical Diagnosis (External Validity) and task complexity

Analysis on Basic ADL

Results showed significant Diagnosis group effects for the four Cognitive factors (Memory Schema factor, $\chi2(2, N=71)=13.76$, $p<.001$, for Error Detection $\chi2(2, N=71)=12.50$, $p<.001$, for Problem Solving $\chi2(2, N=71)=23.96$, $p<.001$ and for Self-Initiation $\chi2(2, N=71)=16.66$, $p<.001$).

Comparisons between the dementia and the Control groups revealed significant differences after Bonferroni correction for the four types of cognitive items, (Task Memory Schema ($Z = -3.31$, $p<.001$;d=1.07), Error Detection ($Z = -3.40$, $p<.001$;d=1.29), Problem Solving ($Z = -4.77$, $p<.001$;d=1.84) and Self-Initiation ($Z = -3.93$, $p<.001$;d=1.43).

MCI and dementia patients differed in Task Memory schema ($Z = -2.52$, $p=.012$;d=0.60) and Self-Initiation ($Z = -2.43$, $p=.015$;d=0.77). However, in Error Detection ($Z = -2.01$, $p=.044$), Problem Solving ($Z = -1.96$,$p=.050$) they did not find significantly differed after Bonferroni correction.

Comparisons between the Control group and MCI patients revealed significant differences in Problem Solving($Z = -3.60$, $p<.001$;d=1.20). A similar pattern was obtained for Error Detection ($Z = -1.96$, $p=.050$), and Self-Initiation ($Z = -2.13$, $p=.033$), although these differences didn't reached significance after Bonferroni correction. No significant differences were obtained between these two groups for the Memory Schema ($Z = -1.33$, $p=.184$).

Analysis on Instrumental ADL

We also found a significant Diagnosis group effect for each cognitive item (Task Memory Schema, $\chi 2(2, N=56)=8.37$, $p=.015$, Error Detection, $\chi 2(2, N=56)=19.84$, $p<.001$, Problem Solving, $\chi 2(2, N=56)=17.45$, $p<.001$ and Self-Initiation, $\chi 2(2, N=56)=13.77$, $p=.001$.

For the comparisons between control participants and dementia patients, we found significant differences for all cognitive conditions, that is, for Task Memory Schema ($Z = -2.64$, $p=.008$;d=0.98), Error Detection ($Z = -4.13$, $p<.001$;d=1.84), Problem Solving ($Z = -3.81$, $p<.001$;d=1.57) and Self-Initiation ($Z = -3.47$, $p<.005$;d=1.26).

Comparisons between MCI and dementia patients we found significant differences in Error Detection ($Z = -2.64$, $p=.008$d=1.07). The comparison on the other variables did not reach significance (p=.075, $p=.190$ and p=.10, for Task Memory schema scores, Problem Solving and Self-Initiation, respectively). Comparisons between the control and MCI patients revealed a significant difference between the two groups for the three executive conditions after Bonferroni correction Error Detection ($Z = -2.73$, $p=.006$;d=0.26), Problem Solving ($Z = -3.55$, $p<.001$;d=1.06) and Self-Initiation ($Z = -2.84$, $p=.005$; d=0.73). Similar to the previous analysis on the BADL, control and MCI patients didn't differ significantly for the Memory Schema condition ($Z = -1.73$, $p=.084$).

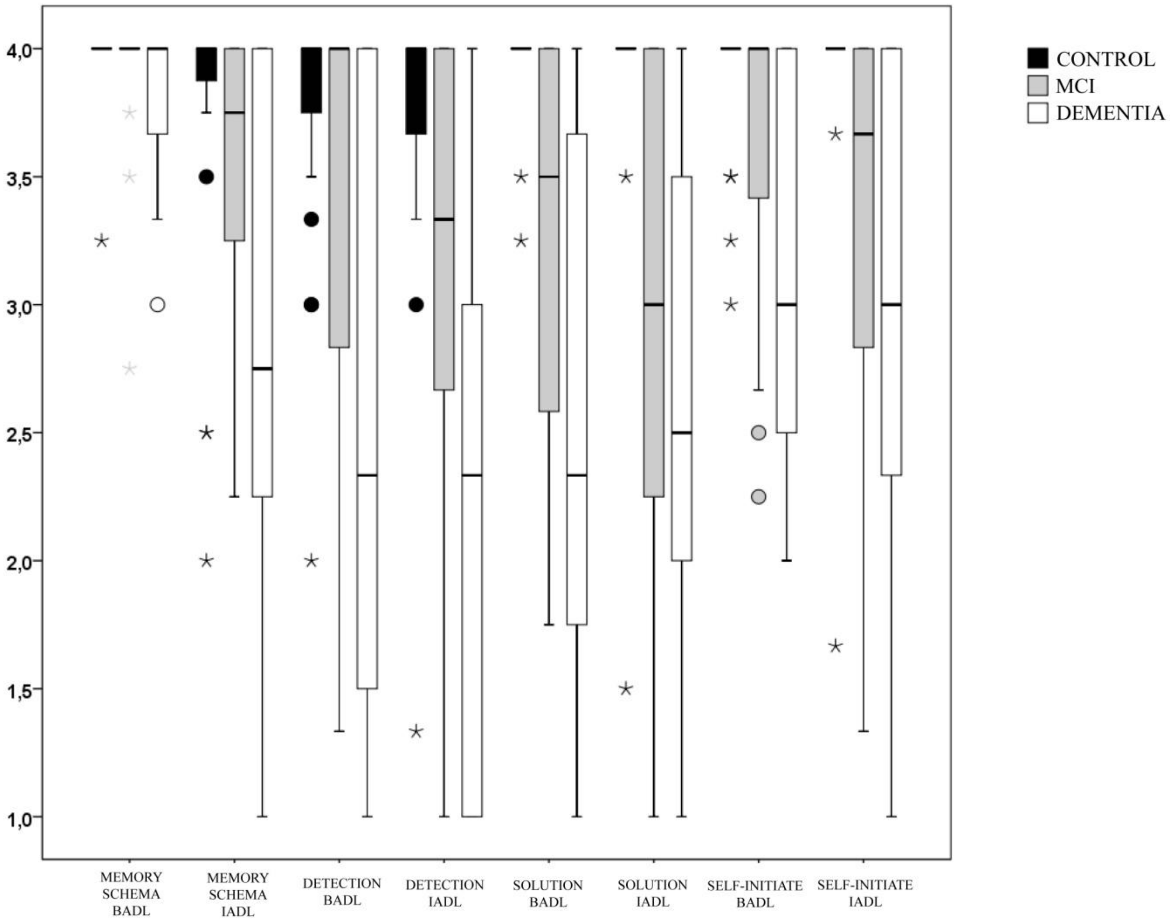


Figure 1. Boxplot with cognitive process in BADL and IADL in Control, MCI and dementia groups. Higher punctuactions reflects better functioning. Note. Detection = Error Detection; Solution = Problem Solving.

Discussion

In this study we proposed a new caregiver informant based tool to further understand the functional cognitive deficits that distinguish MCI, dementia patients and healthy old participants. The novelty of the present proposal is that it allows dissociating among critical cognitive process within a range of ADL activities differing in complexity. Although there had been several proposals to detect these alterations in the past, in most cases, the designs were not sufficiently exhaustive to capture different cognitive failures contextualized within a whole range of ADL differing in complexity. We propose that such a distinction is important to further understand the specific relations between cognition and function. In addition, very few studies with performance based or informant based tools have systematically included comparisons between dementia, MCI with an healthy old control group, to differentiate which deficit are due to normal ageing from those which are specific to the dementia or MCI disease. The present study compared the caregiver informant based reports of participants of these three groups.

A second key aspect of the present tool was to include some critical cognitive items still not fully understood or completely tested in previous ADL studies. First, we included the item "hardwired knowledge about the task schema" (Task Memory Schema), to fully testits impairment in dementia, MCI and healthy controls across a whole range of BADL vs. IADL. Second, we included the ability to detect their own errors. This aspect, even if already in dementia (Bettcher et al., 2008) and MCI (Seligman et al., 2013) as far as we know, it has not yet compared with healthy participants, thus it is still unclear whether previous findings of deficits in this regards might constitute a diagnostic criteria for dementia and MCI. Even further, it was not known whether such a problem might be present even for BADL, as previous studies only used IADL. Finally, we decided to include two additional cognitive categories, Problem solving and Self-Initiation, that even if previously described as altered in dementia and MCI they have not usually included in performance based or informant based cognitive ADL tools.

The third additional novelty of the scale was that of converting part of the error coding system usually used in performance-based studies into informant-based items. This allowed us to ask for very concrete and easily observable behavior, contextualized in a given ADL, which might have increased the fiability of caregiver reports. This might constitute an additional important improvement from previous cognitive scales where they usually include items that often require an overgeneralization and abstraction of the patient behaviour (e.g. the item "Thinking ahead" from the E-cog, compared to the item "He/she is able to notice if he/she has put on the right clothes." from the present tool).

A first PCA analysis corroborated in our sample, the classical division between basic and instrumental activities (Youngstrom et al., 2002). Second, a fiability analysis confirmed a high internal consistency for all of these cognitive variables (Memory Schema, Error Detection, Problem Solving and Self Initiation) across basic and instrumental ADL.

In order to further understand the cognitive processes that we were measuring with our four cognitive items, a group of neuropsychological tests were also administrated to our sample. Then, correlation and multiple regression analysis were conducted on the results obtained with MCI and dementia patients, to see the specific relations between them. Consistent with our prediction, the variable “Task Memory Schema” was predicted by AVLT Long term free recall, a valid test to measure episodic memory. This is also consistent with what has previously found when measuring memory schema with performance based tasks, like those studies using the NAT, that have systematically found important relations between omission errors with memory measures similar to the ones used here (e.g. Giovannetti, et al., 2008). Second, we found the variable “Error Detection” to be best predicted by a global cognitive measure, that is, the Mini-Mental State Examination- MMSE- (Folstein et al., 1975). This finding was surprising as we had the prediction that the ability to detect their own errors would be related with more specific and complex executive functions. In a previous study with dementia population, detection errors in performance-based tasks were predicted by a word generation task based on phonetic cues (FAS) (Bettcher et al., 2008). In our case, we used a fluency test more related to memory retrieval (semantic fluency), and perhaps for this reason, we didn’t find any relation with Error Detection. One possibility that needs further testing could be that undetected errors might be a reflection of both executive deficits but also to degraded task memory, that is, patients wouldn’t detect their own errors in part because they start to “forget” how it was the correct task (Reason, 1990; Seligman et al., 2013). This could explain why this cognitive item was best predicted by a global cognitive measure like the MMSE in our study. More exhaustive memory test in combination with executive measures will be necessary to further clarify the underlying processes of Error Detection. Third, consistent with our predictions, the variable "Problem Solving" was highly predicted by the INECO Frontal Screening test, a specific tool to assess a broad range of executive functions in dementia population (Torralva et al., 2009). Thus, we could be more confident that the ability to solve infrequently problems in everyday life constitutes a clear measure of executive functions like the ones measured with artificial, standardized tests (Godefroy, 2003). Finally, the variable "Self Initiation" was highly correlated with Semantic Fluency. Interestingly, this finding is consistent with a recent study where verbal fluency has been associated to apathy (George, Whitfield, & Walker, 2013). Thus, the ability to generate different words within one category seems to be a good predictor of how a patient will initiate the necessary everyday activities. However, we found that the main predictor of our "Self-Initiation" item was long- term memory. It is possible that this item is a reflection of several processes, thus, it might be a consequence of low motivational states, but also due to executive aspects of memory as it is prospective memory. In fact, the concrete ADL questions present in our study emphasized the ability to remember to initiate different ADL when necessary. Thus, it is congruent to find a relation with memory measures, as a necessary condition to self initiate a given task in the future. Of course more research is still need to further delimitate the cognitive and motivational processes implicated in this aspect of behavior.

In relation with differences between groups, the present study helped us to isolate the specific alterations that dementia and MCI patients might have compared with aged-matched healthy participants. Thus, taking into account both level of analysis, that is, different cognitive aspects and different ADL helped us to reveal the following diagnostic results:

A first general observation from Figure 1, was a consistent stepwise pattern where healthy participants showed the best performance, followed by the multi-domain MCI group and dementia patients showing the worst performance, for each cognitive item for both BADL and IADL.

Regarding dementia patients, we found that the present assessment tool discriminated dementia patients from healthy participants in all four cognitive aspects for both BADL and IADL tasks. This finding is in agreement with previous diagnostic proposals indicating that this group of patients typically shows cognitive alterations in several cognitive domains and on both basic and instrumental ADL (Mioshi et al., 2007; Reisberg et al., 2001; Zanetti et al., 1998)

The separate analysis of the four cognitive items for BADL and IADL also reveals specific diagnostic alterations for the multi-domain MCI group. First, this group shows evidence of preserved task schema, for both ADL tasks when compared with healthy participants. One future direction to further study this relation might include more complex ADL to see whether a higher level of task complexity might be more sensitive to differences between MCI and old participants in task knowledge. Finally, this result is also consistent with previous performance based studies showing that MCI produce a small proportion of step omissions (Giovannettiet al., 2008). These studies have usually associated the presence of omissions to deficits in episodic memory (Giovannetti et al., 2008). However, given that multi-domain MCI patients usually show deficits in this domain, we wonder whether their preserved ability to maintain task memory schema, at least in this scale, would be more a reflection of semantic or procedural memory. Future research including additional neuropsychological test that dissociate between different memory systems might help to further understand the nature of this cognitive item included in the present scale.

By contrary, MCI patients presented important problems compared to healthy participants for all other cognitive factors included in the scale, that is, for "Error Detection", "Problem Solving" or "Self-Initiation". However, for Error detection and Self-Initiation, group differences only reached significance for the complex instrumental activities. On the other side, deficits in Problem Solving for MCI were similar for BADL and IADL.

Altogether, the pattern of alterations found for MCI patients in this study might indicate that these patients might usually report small problems on BADL, probably due to the fact that their hardwired stored memory schema about the task is still well preserved. However, when an unexpected situation don't allow the retrieval of this memory schema, like, for example, if we find out that the kettle is not working properly, or it is not located where typically should be, then they might show difficulties to find out a novel or alternative solution to finish the task, like for example to heat water on the microwave. Importantly, this kind of unexpected situations might occur for any kind of activity, that is, even for basic ADL ones. Nevertheless, this kind of problem solving situations were described long time ago as one of the five key situations pointed by traditional dual models line the one proposed by (Norman & Shallice, 1983), where a Supervisory Atentional System is required to modulate the Contention Scheduling. The Problem Solving item included in the present scale might constitute a direct measure of such a situation. Of course, many other neuropsychological tests have been proposed since then to isolate alterations on this executive ability. However, as far as we know this is the first time that such ability is contextualized in real everyday situations to measure MCI and dementia alterations.

To conclude, our results support previous studies in which executive functions have shown to be a core problem in multi-domain MCI patients (Traykov et al., 2007; Zheng et al., 2012). Moreover, many studies have related these cognitive impairments with functional problems that MCI used to have (Aretouli & Brandt, 2010; Hughes et al., 2012). On the other side, the present pattern of results is also consistent with those studies showing that MCI have special difficulties in instrumental activities (Farias et al., 2006; Gure et al., 2013; Perneczky et al., 2006; Weston et al., 2011). However, in our study we have found that these previous findings can be further specified, as not all everyday cognitive factors involved in instrumental activities are altered (i.e. Task memory schema), while some others (i.e. problem solving) might be already altered even for BADL. Consequently, we believe that the present pattern of results might have important consequences to better specify the diagnostic criteria especially for MCI.

One drawback of the present study is its small sample, especially for the dementia group, given the high proportion of them that had stop performing IADL activities. This finding might indicate that the present scale will be more appropriate to evaluate MCI and initial dementia patients who might still keep functionally active, even if presenting some difficulties. Future versions of this scale might include other cognitive error items, that help to better understand the relations between cognition and function in this population.

Funding

This work was supported by the Spanish Ministry of Science and Innovation through a PhD research fellowship awarded to the first author (FPI BES-2009-020741) and a research project to the first and the last authors (Junta de Andalucía SEJ-6351).

Acknowledgments

We acknowledge Estrella Ródenas and María Torres Rivas for assistance with data collection. We thank Juan Montes, Neurologist in charge of the Neurology Division at San Cecilio Hospital (Granada).

4 DISCUSIÓN GENERAL

El principal objetivo de esta tesis ha sido analizar el papel de los procesos de control cognitivo implicados en la realización de las actividades de la vida diaria en diversas poblaciones clínicas como pacientes con demencia, DCL multidominio y daño cerebral frontal. Para su estudio, hemos llevado a cabo una serie de tareas experimentales y actividades de la vida diaria, donde hemos introducido manipulaciones experimentales para poner en juego al sistema de control cognitivo y así poder medir su impacto en tareas de funcionamiento cotidiano.

En nuestra primera investigación, seleccionamos una tarea experimental que, desde la Neurociencia Cognitiva, ha demostrado medir las tres funciones atencionales, propuestas por el modelo de Posner (Posner & Dehaene, 1994) y la administramos a una muestra de pacientes con lesión en regiones prefrontales. La tarea atencional ANT-I consiste en una tarea que combina una medida para la red de control, la red de vigilancia y la red de orientación. Los resultados mostraron que sólo el sistema de control ejecutivo (capacidad de resolución de conflicto producido por la presencia de flancos), encargado de la resolución de conflicto es el que se encuentra alterado en estos pacientes. Además, los resultados correlacionaron de manera significativa con medidas comportamentales de personalidad. Este estudio, por tanto, demostró que tras daño cerebral frontal existe un déficit específico del sistema de control cognitivo.

En un segundo estudio quisimos profundizar en la relación entre el sistema de control cognitivo y las AVD. Una de las funciones que este sistema puede tener en las AVD es el filtraje y la inhibición hacia objetos distractores que interfieran con la realización de la tarea objetivo (target). Para ello, diseñamos una tarea experimental de ordenador con estímulos simples, incorporando tres fuentes diferentes de conflicto. Por un lado, un ensayo podía presentar conflicto entre dos dimensiones estimulares del estímulo (e.j. una flecha apuntando hacia la arriba pero localizada en la parte de debajo de la pantalla, conflicto tipo Stroop), conflicto entre una dimensión estimular y la respuesta (e.j. una flecha que requiere una respuesta con la mano izquierda pero que aparece localizada a la derecha, conflicto tipo Simon) o la presencia de otros estímulos distractores alrededor del estímulo target (e.j. la aparición de flechas doble acompañando a la aparición de la flecha target).

Posteriormente, se pidió a los pacientes con lesión frontal que realizaran una AVD en la que se introdujeron objetos reales distractores que conformaban entre sí una tarea semánticamente relacionada con la tarea que les solicitábamos. De esta manera, se incrementaba la necesidad de actuación del control inhibitorio.

Los resultados mostraron un efecto de interferencia en los dos tipos de conflicto y en el filtraje de distractores, tanto en medidas de Tiempo de Reacción (TR) como en el porcentaje de errores para los conflictos tipo Simon y Stroop. Asimismo, encontramos un efecto de los distractores en la resolución del conflicto modulado por el grupo. Ante la presencia de estímulos distractores, los pacientes frontales mostraron un incremento en el TR para los efectos de Simon y Stroop.

En la tarea funcional, los resultados mostraron que los pacientes con lesión frontal realizaron más errores de comisión (errores que implicaban llevar a cabo acciones incorrectas, como perseverar, sustituir un objeto por otro o usar los objetos distractores) en comparación con el grupo control. Además, los datos experimentales y funcionales revelaron una correlación positiva y significativa entre el número de errores en el conflicto tipo Simon y las comisiones realizadas en la tarea cotidiana de hacer un café o una tostada.

Una vez demostrada la implicación del sistema de control cognitivo y las AVD, nos propusimos, en el tercer estudio, estudiar la influencia de los distractores en este tipo de relación, en función de que éstos estuvieran o no relacionados con la tarea target. Con el objetivo de comprobar si el daño específico en la región frontal era el responsable del tipo de errores que se habían detectado en los dos primeros estudios, seleccionamos dos muestras de pacientes, una con lesiones en regiones frontales y otra con daño en zonas cerebrales que no implicaban la región frontal. De esta manera, elaboramos un diseño factorial con cuatro condiciones en las cuales se combinaba la posibilidad de compartir semánticamente el contexto o la posibilidad de compartir pasos u objetos entre los objetos distractores y los target. Todo ello, contando con objetos que entre sí elicitaban tareas. En primer lugar, e independientemente de las condiciones, encontramos que los pacientes con lesiones frontales cometieron más repeticiones de pasos ya completados y más manipulaciones de los objetos sin un propósito. Un dato sorprendente con respecto a las condiciones, fue que encontramos una tendencia a la facilitación del contexto para los pacientes con lesiones que no implicaban áreas frontales. Estos pacientes realizaron menos omisiones en las condiciones donde el contexto era congruente con la tarea a realizar. Por el contrario, el grupo de pacientes frontales pareció no solo no beneficiarse de estas claves a la hora de realizar todos los pasos esenciales de la tarea, sino que la presencia de objetos relacionados semánticamente produjo el efecto contrario, es decir, un mayor número de omisiones. Asimismo, bajo las condiciones donde los objetos target y distractores compartieron pasos y objetos, encontramos que los pacientes frontales cometieron más manipulaciones de los objetos sin objetivo, mientras que los pacientes no frontales no se vieron afectados por esta condición.

Tras comprobar las repercusiones que el daño frontal tiene en las AVD debido, probablemente, a los déficits que produce en el sistema de control cognitivo, decidimos realizar un cuarto estudio con otro tipo de población clínica, las demencias, que se sabe presentan un gran deterioro en la ejecución de las AVD y muestran déficits tanto de memoria como ejecutivos en las pruebas de evaluación neuropsicológica. Introdujimos, además un grupo de pacientes con DCL multidominio. Esta población suele presentar déficits ejecutivos, aunque aún no se ha podido dilucidar si consiguen o no interferir en sus AVD. Mientras que para el diagnóstico de demencia es fundamental la presencia de alteraciones en la ejecución de las actividades de la vida diaria, en pacientes con DCL los fallos son más sutiles y se relacionan especialmente con déficits en la precisión, agilidad o eficacia en tareas más complejas, como las AIVD. Siguiendo con la lógica de los estudios con objetos distractores planteados previamente con pacientes con lesión frontal, en esta investigación quisimos diferenciar claramente la interferencia añadida de los distractores cuando éstos entre sí elicitaban una tarea distractora que, a su vez, estuviera relacionada y ocurriera en el mismo contexto espacio-temporal que la tarea target. Para ello, comparamos dos condiciones donde los distractores elicitaban tareas (Condición Distractores-Tarea) y condiciones en las que los distractores no podrían ser usados en una acción común (Condición Distractores-Objetos). Observamos los resultados dependiendo de si los errores eran cometidos con los objetos target o con los distractores. En este sentido, encontramos un patrón de influencia opuesto, dependiendo del tipo de error observado. Los errores con los objetos target fueron significativamente menores bajo la condición de Distractores-Tarea para todos los grupos, mientras que esta misma condición produjo un mayor número de errores con los distractores aunque sólo para los grupos de demencia y DCL.

Finalmente, en nuestro quinto y último estudio, nos planteamos la necesidad de incorporar los resultados que habíamos obtenido en estos experimentos, junto con algunos de investigaciones previas, para diseñar un instrumento de evaluación de AVD. Nuestro objetivo fue la creación de una escala que fuera fácil y rápida de administrar y, a la vez, que se basara en contextos más ecológicos, en cuanto a la medición de los diferentes tipos de AVD que los que hay disponibles actualmente. Para ello, diseñamos y administramos a familiares/cuidadores la "Escala Preliminar Cognitiva de las Actividades Básicas e Instrumentales", donde incluimos tres preguntas relacionadas con el sistema de control cognitivo, como fueron: la capacidad para detectar errores, la capacidad para resolver problemas y la capacidad para iniciar por uno/a mismo/a una cierta actividad, como podría ser lavarse los dientes o cocinar. Por otro lado, medimos la capacidad para acordarse de los pasos de la tarea y secuenciarlos correctamente. Los resultados mostraron que, mientras que los pacientes con demencia obtuvieron puntuaciones significativamente más bajas para todos los ítems en las actividades básicas e instrumentales, los pacientes con DCL alcanzaron puntuaciones similares a los controles a la hora de recordar y secuenciar los pasos de la tarea, independientemente del tipo de actividad. Sin embargo, a diferencia de lo que se ha comunicado en la mayoría de las investigaciones sobre esta población, sí encontramos problemas a la hora de solucionar problemas en comparación con los participantes controles incluso en las ABVD. El resto de ítems (Detección de errores e

Iniciar actividades) también se vieron afectados en los pacientes con DCL pero solo en las AIVD.

Con el objetivo de discutir e integrar todos estos resultados dentro de la literatura previa sobre funciones cognitivas y AVD, vamos ir abordándolos en distintos apartados. Por tanto, la estructura básica de las conclusiones finales es la siguiente.

(1) La influencia de los distractores en la realización de tareas experimentales y de la vida diaria ante fallos ejecutivos, (1.1) El efecto de los distractores en tareas experimentales, (1.2) El efecto de los distractores en la conducta hacia los objetos distractores y target de manera inapropiada en las AVD, (1.3) Medidas clásicas y experimentales de control cognitivo y su relación con las comisiones y errores con los distractores en las AVD, (1.4) El efecto de los distractores semánticamente relacionados en el esquema de la tarea. (2) Evaluando actividades básicas e instrumentales en contextos familiares: Esquema de tarea en memoria, Detección de Errores, Solución de Problemas e Iniciación.

4.1. La influencia de los distractores en la realización de tareas experimentales y de la vida diaria ante fallos ejecutivos

El estudio del impacto de los distractores en la realización de tareas, tanto de ordenador como en la vida cotidiana, ha generado una serie de resultados a menudo contradictorios. A continuación, exponemos los datos obtenidos en esta tesis discutiéndolos con la literatura previa.

El efecto de los distractores en tareas experimentales.

En relación con las tareas atencionales, diversos estudios con población sana han demostrado un incremento en el TR debido a la interferencia generada por la presencia de distractores semánticamente relacionados (Moores et al., 2003). Del mismo modo, en pacientes con lesiones frontales la presencia de distractores semánticos ha interferido en la correcta selección del target. En este estudio usaban una tarea de memoria de trabajo en la que los pacientes debían indicar si una palabra aparecía posteriormente en forma de dibujo en una lámina donde, además, se incluían dibujos distractores. Los pacientes frontales cometieron significativamente más errores en las condiciones en las que se presentaron distractores semánticamente relacionados y especialmente cuando el target no aparecía (Telling et al., 2010). Nuestros datos experimentales obtenidos con la tarea de control cognitivo apoyan estos estudios en pacientes con lesiones frontales. Aunque en nuestro caso, los estímulos distractores no fueron específicamente manipulados por la categoría semántica (distractores como flechas bidireccionales), sí que guardaban una fuerte relación física con el estímulo target (flecha unidireccional). Bajo estas circunstancias, los pacientes con lesiones frontales obtuvieron una peor ejecución en TR en la resolución del conflicto tipo Stroop y Simon. Resultados muy similares con tareas semejantes a las diseñadas en este trabajo se han encontrado en un caso con un paciente con Síndrome de Desorganización de la Acción, mostrando un incremento de TR y errores cuando presentaron distractores en la realización de una tarea Simon (Kumada & Humphreys, 2002). Todos estos datos apuntan a que el efecto de la interferencia de los distractores está íntimamente relacionada con funciones mediadas por el lóbulo frontal, y que, tras la lesión, la interferencia puede incrementarse significativamente, empeorando la realización de tareas que impliquen, a su vez algún tipo de control cognitivo. Por un lado podríamos pensar que la presencia de los distractores puede incrementar la necesidad de mantener los requerimientos de la tarea y puesto que los estímulos distractores, en este caso, son estímulos muy parecidos visualmente a los estímulos target, los pacientes perderían el "set" de tarea. Sin embargo, no podemos descartar la idea de que la complejidad de la tarea per se pueda incrementar la dificultad en la resolución de conflicto cuando existen déficits ejecutivos.

Puesto que este trabajo está principalmente orientado a la capacidad funcional, la siguiente pregunta que cabría hacerse, entonces, sería ¿qué ocurre, bajo la presencia de objetos distractores, cuando realizamos una actividad de la vida diaria? ¿observaremos resultados similares a los encontrados con las tareas de ordenador de control cognitivo con estímulos simples?

El efecto de los distractores en la conducta hacia los objetos distractores y target de manera inapropiada en las AVD.

De acuerdo con lo planteado por Niki y colaboradores (2009), en nuestro estudio 2, tras lesión del lóbulo frontal, encontramos una cantidad de comisiones significativamente mayor que la que muestra el grupo control. Los pacientes realizan más perseveraciones, repeticiones, manipulaciones sin objetivo, sustituciones, acciones adicionales e incluso usan en mayor medida los objetos distractores. Más aún, resultados muy similares aparecen en el estudio 3, comparando la ejecución de pacientes frontales frente a pacientes con lesiones localizadas en otras zonas cerebrales. En dicho estudio, y de manera independiente a las manipulaciones experimentales, que se comentarán posteriormente, encontramos que los pacientes frontales cometen más repeticiones y manipulaciones sin objetivo que el grupo no frontal. En ambos casos, el diseño experimental empleado permitió incrementar la necesidad de activar el sistema de control cognitivo al mostrar objetos distractores que entre sí elicitaban acciones y tareas que debía inhibir. En este sentido, un reciente estudio ha puesto de manifiesto la capacidad que tienen dos objetos juntos para evocar una acción basada en su compatibilidad funcional, como por ejemplo una botella llena y un vaso vacío (De Stefani et al., 2012). Así, el término "*affordance de trabajo*" (*working affordance* en su término en inglés) genera un efecto de "*priming*" hacia el otro objeto con el que se relaciona y la activación de un objeto desencadena la activación del otro. Por tanto, bajo estas circunstancias la complejidad para inhibir el uso de esos objetos podría verse incrementada.

¿Qué ocurriría entonces si mostramos en vez de uno, dos objetos que pueden ser compatibles funcionalmente con otro objeto mostrado? Con el objetivo de contestar esta pregunta, desarrollamos el diseño experimental del estudio 3. Ante condiciones en las que los objetos distractores competían por la acción con otro objeto target, además de que junto con otros objetos distractores podían conformar una tarea distractora, los pacientes con lesiones frontales cometieron más manipulaciones sin objetivo que el grupo no frontal. Todo apunta a que ese efecto de "*priming*" de acción es redundante. Ante la petición de realizar un café, la activación de un objeto común como el hervidor eléctrico activaría el tarro del café, que sería el target, pero también el bote del té, que sería el objeto distractor. La activación de estos objetos podría derivar en un incremento de manipulaciones sin objetivo de estos objetos en los pacientes con problemas específicos de inhibición.

Congruentes con los datos obtenidos por pacientes con lesiones focales, un patrón de error similar ha sido encontrado en pacientes con patologías neurodegenerativas (demencia y DCL multidominio) que presentan, asimismo, fallos ejecutivos. Bajo circunstancias en las que los objetos distractores formaron parte de una acción, que a su vez pertenecía a una categoría en la que estaba incluida la tarea target, cometieron más errores con los objetos distractores que cuando se presentaron objetos distractores de manera aislada. Aunque en el caso de los pacientes con DCL estas diferencias no alcanzaron niveles de significatividad, se observa una marcada tendencia ascendente, en comparación con el grupo control. De hecho, encontramos un patrón de error sorprendente, los pasos tangenciales, que aunque no se mostraron en todos los pacientes con DCL y demencia, el porcentaje de casos sí fue significativo en relación con los participantes controles, que no los cometieron en ninguno de los casos. Llevar a cabo acciones en relación con preparar un zumo de naranja, cuando la tarea target es preparar una tostada, puede interpretarse como un problema de “Goal Neglect”, por el cual se pierde el “set” de la tarea, a pesar de que las instrucciones se han entendido y se han repetido verbalmente por el paciente. Este tipo de errores se ha relacionado con el mantenimiento de los requerimientos de la tarea y se han observado en pacientes con lesión frontal (Duncan, Emslie, Williams, Johnson, & Freer, 1996), por lo que, todo apunta a que, desde el DCL ya pueden observarse alteraciones ejecutivas que darían lugar a este tipo de problemas. El hecho de que no se cometan errores en los participantes controles sugiere que esta conducta podría ser un indicador de deterioro cognitivo. En conclusión todos estos datos sugieren, que a medida que el control cognitivo falla, especialmente la capacidad que tienen las personas para evitar la interferencia de estímulos distractores, los errores en la vida cotidiana a la hora de realizar acciones inapropiadas, incluso hacia objetos distractores, también aumentan.

Medidas clásicas y experimentales de control cognitivo y su relación con las comisiones y errores con los distractores.

Además de las manipulaciones experimentales, los estudios de correlaciones y de regresión llevados a cabo también corroboraron la necesidad de usar el sistema de control cognitivo bajo estas condiciones. Hallamos un índice para calcular la interferencia producida entre las condiciones, restando los errores cometidos en la condición de Tarea-Distractores a los realizados bajo la condición de Objetos-Distractores. Tanto el INECO Frontal Screnning, un test que agrupa diferentes tareas ejecutivas clásicas y que ha sido sensible en mostrar los fallos ejecutivos en pacientes con demencia (Torralva et al., 2009) como el *Mini-Mental State Examination*, mostraron correlaciones positivas y significativas con este índice. Sin embargo, solamente el INECO Frontal Screening fue predictor de este índice, lo cual nos demuestra la importante influencia de un buen sistema ejecutivo capaz de inhibir acciones preactivadas de manera automática, como las que ocurren ante objetos que activan un "*affordance de trabajo*". Son varias las investigaciones que han relacionado la ejecución de las AVD con las funciones ejecutivas, especialmente en el ámbito de la demencia y el DCL (Aretouli & Brandt, 2010; Hughes et al., 2012). Con el objetivo de poner en juego específicamente estos procesos, algunas de ellas han incrementado la complejidad de las tareas a realizar, diseñando multi-tareas, en las cuales los pacientes usaban su atención dividida o sus habilidades de planificación para poder completar los requerimientos de la evaluación (Schmitter-Edgecombe et al., 2012). Acorde con estos resultados, nuestro estudio añade una nueva forma de observar los fallos ejecutivos, centrándose especialmente en la interferencia que producen estos distractores en la vida cotidiana a personas con alteraciones en el sistema de control cognitivo, mediante manipulaciones muy simples y familiares. Las manipulaciones experimentales aquí realizadas permiten, de manera más aislada, comprobar que los fallos que se producen en la actividad se deben a problemas ejecutivos, de interferencia de los distractores, más que a déficits de otro tipo, como semánticos o de memoria. El estudio, llevado a cabo por Giovannetti y colaboradores (2010), en el que manipularon la similitud entre objetos distractores y target, sin embargo, no pudo disociar los procesos a la base de sus resultados. Aunque los autores interpretaron como problema ejecutivo el dato del incremento en sustituciones de objeto con los distractores y manipulaciones sin objetivo bajo la condición donde los distractores estuvieron semánticamente relacionados, también cabría la posibilidad de plantearlo como evidencia asociada a alteraciones semánticas del conocimiento de objetos. En este sentido, nuestra investigación arroja luz al conocimiento de la interferencia de los distractores.

De la misma forma que se relacionan tests ejecutivos con los errores cometidos con los distractores en demencia y DCL, el estudio llevado a cabo con pacientes frontales demuestra la existencia de una significativa y positiva relación entre el número de comisiones y los errores que aparecen ante un conflicto tipo Simon, aislando otros tipos de conflicto. Hemos de mencionar que en este estudio no pudimos comparar con otra condición donde los distractores no conformaran tareas distractoras. Sin embargo, el hecho de que en estudios previos con distractores que no elicitaban tareas que se debían inhibir no hayan encontrado diferencias (Humphreys & Forde, 1998) entre condiciones apunta, nuevamente, a la contribución de esta manipulación en la activación del sistema de control cognitivo.

Parece razonable que un conflicto a nivel de respuesta esté relacionado con los errores que se puedan cometer con los objetos, más que ante situaciones donde se deba resolver la incongruencia entre dos características del propio estímulo. Los estudios sobre la capacidad que tienen los objetos para elicitar acciones, esto es el "*affordance*", también han planteado la correspondencia entre este término y el tipo de conflicto Estímulo-Respuesta (McBride et al., 2012).

El efecto de los distractores semánticamente relacionados en el esquema de la tarea.

Además de manipular la posibilidad de que los objetos distractores puedan ser usados juntos para llevar a cabo una acción, también podemos manipular el nivel de relación semántica entre esos objetos distractores (y, por tanto, las tareas que elicitan) y los objetos y tareas target.

Un estudio con un paciente con ADS mostró cómo bajo condiciones donde los objetos distractores elicitaron acciones semánticamente relacionados con los objetos targets, cometió más omisiones. Nuestro capítulo 3 apunta en la misma dirección. En nuestro estudio, los pacientes con lesión frontal cometieron más omisiones bajo situaciones donde los distractores, además de poder usarse en conjunto para llevar a cabo una tarea, tuvieron una relación semántica más estrecha con los objetos target en comparación con la ejecución por parte de pacientes no frontales. Todo esto parece indicar que la presencia de distractores tras daño frontal no sólo podría afectar a las conductas dirigidas hacia los objetos distractores, sino también al mantenimiento del esquema de la tarea. Sin embargo, es necesario tener en cuenta que no todos los distractores ofrecen la misma interferencia ni afectan por igual a todos los tipos de errores. También al manipular la relación semántica los objetos distractores que eliciten una nueva acción podrían generar más interferencia que los objetos funcionalmente relacionados. De esta forma, sugerimos que la interferencia se produciría a dos niveles, siguiendo la propuesta de Cooper (2005). Uno a nivel de representación de objetos, ya que, al igual que en los estudios iniciales de Humphreys y Forde (1998), los objetos compitieron entre sí. Pero adicionalmente, los objetos también competirían a nivel de esquema de la tarea. El esquema de la tarea distractora semánticamente relacionada podría introducir todavía más ruido en el esquema de la tarea target, generando, por tanto, una menor activación de los pasos necesarios para llevar a cabo la tarea. Esta falta de activación de los pasos en la propia ejecución target tendría como consecuencia un incremento en el número de omisiones de pasos.

No obstante, nuestros datos también muestran que este efecto semántico no siempre perjudica. Tanto en los pacientes con demencia, DCL y controles sanos, como en el estudio en el que se incluyeron pacientes con lesiones no frontales se encontró un efecto facilitador por un contexto congruente, es decir, por la presencia de objetos distractores que elicitaron acciones semánticamente relacionadas con la tarea target. Los pacientes con demencia, DCL y los participantes mayores sanos mostraron, bajo la condición semánticamente relacionada, menos errores con los objetos target de la tarea, en general. Asimismo, los pacientes no-frontales, bajo estas mismas circunstancias, manifestaron un patrón similar circunscrito específicamente al número de omisiones de pasos generados. Congruente con estos resultados, estudios previos han puesto de manifiesto que ante tareas de reconocimiento de objetos, las respuestas se vieron facilitadas en condiciones donde el objeto fue insertado en un contexto congruente (Palmer, 1975). Más aún, esta facilitación parece incrementarse con la edad, ya que personas mayores de 75 años se vieron perjudicadas en mayor medida si los contextos fueron incongruentes cuando debieron llevar a cabo una tarea de categorización (Remy et al., 2013). De igual forma, se ha demostrado el beneficio que obtienen los pacientes con demencia semántica en el uso de objetos cuando éstos se han presentado en contextos coherentes y presentados de acuerdo a sus experiencias previas (Snowden, Griffiths, & Neary, 1994).

De todos estos estudios sobre los distractores y sus relaciones con los objetos target podemos sugerir un esquema de mecanismos que funcionaría de distinta manera ante diferentes procesos alterados (Ver figura 2). Según este modelo, en condiciones normales o ante problemas leves de memoria combinados con leves déficits ejecutivos, parece no necesitarse el sistema atencional supervisor en presencia de objetos distractores para llevar a cabo tareas rutinarias; el propio Dirimidor de Conflictos sería el encargado de controlar los pasos necesarios para llevar a cabo la tarea con los objetos correspondientes. En esta misma línea, los controles de nuestra tarea experimental usada en el capítulo 2 nos revelan que no se ven influenciados por estímulos distractores en una tarea de resolución de conflicto. De hecho, cuando se presentan objetos distractores semánticamente relacionados, se crea un contexto congruente que parece ayudar, tanto a pacientes con problemas en memoria como a controles, a activar el esquema de tarea, reduciendo los errores con los objetos target, como por ejemplo las omisiones. No ocurre los mismo ante déficits ejecutivos asociados a alteraciones mnésicas, ya que la mera presencia de objetos distractores interfiere de tal manera, que ya a este nivel sería necesario activar el sistema atencional supervisor. Estos objetos entran en conflicto con los objetos target, generando activaciones automáticas difíciles de inhibir, como ocurre en la ejecución de la tarea experimental de resolución de conflictos por parte de los pacientes frontales. Este sistema dañado es incapaz de inhibir esta activación, y, como consecuencia, genera una manipulación indiscriminada de los objetos, e incluso desencadena "conductas de utilización". Ante casos muy graves de déficits ejecutivos combinados con posibles alteraciones mnésicas no se encuentra un beneficio contextual de la presencia de objetos semánticamente relacionados, sino que la activación de la tarea distractora genera tal competición con el esquema de la tarea target, que hace que no se seleccionen apropiadamente los pasos de la tarea y, por tanto, que se produzcan omisiones de pasos esenciales para completarla. En futuras investigaciones, sería interesante llevar a cabo estudios analizando las relaciones entre estos dos patrones diferenciados de error, Facilitación vs. Interferencia en la tarea target y observar con qué zonas cerebrales se asocia.

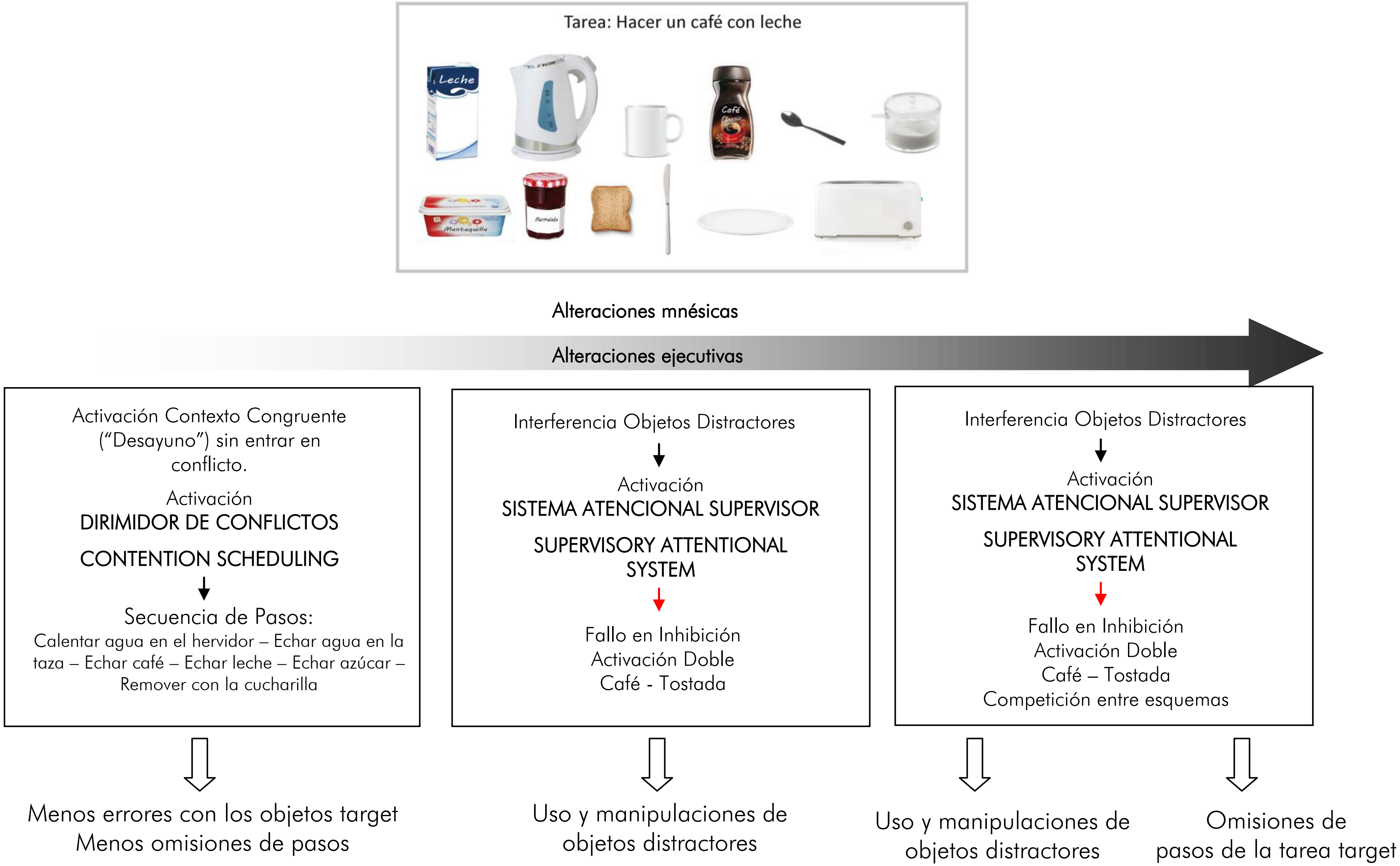


Figura. 2 Mecanismos de acción para llevar a cabo tareas rutinarias ante la presencia de distractores semánticamente relacionados y errores cometidos, según sea el gradiente de afectación mnésica y ejecutiva

4.2. Evaluando actividades básicas e instrumentales en contextos familiares: Esquema de tarea en memoria, Detección de Errores, Solución de Problemas e Iniciación.

Como ya se ha comentado, nuestro objetivo con esta tesis ha sido la de conocer en profundidad los procesos cognitivos, especialmente el control cognitivo, implicados en las actividades de la vida diaria. Las manipulaciones experimentales de los estudios con distractores han perseguido "recrear" de algún modo situaciones relativamente familiares para la persona, mostrando objetos que se podrían disponer en casa. Aunque estos estudios nos han permitido disociar muy específicamente diferentes tipos de errores, controlando exhaustivamente el ambiente, a su vez, conocemos las limitaciones de estas aproximaciones. Por un lado, somos conscientes de que hemos tenido que restringir el número de AVD que el paciente debía de realizar. Por otro lado, aunque nos hemos esforzado en la selección de objetos familiares, no podemos obviar que un contexto de laboratorio es diferente al de una casa propia, donde se usan determinados objetos diariamente que varían entre personas. Por todo ello, nos pareció importante elaborar un instrumento de medida de AVD, la Escala Preliminar Cognitiva de Actividades Básicas e Instrumentales, más acorde con los resultados experimentales de los que hasta el momento se dispone y se utilizan actualmente para evaluar el grado de dependencia funcional. Como hemos explicado, dicha escala nos permitió evaluar a través de un familiar o cuidador, diversas actividades básicas e instrumentales en contextos completamente familiares a pacientes con demencia, DCL y personas mayores sanas. En dicha escala pretendimos evaluar errores en procesos cognitivos que son más difíciles de observar en las tareas de ejecución directa, como por ejemplo, la detección de los propios errores, la corrección de éstos o capacidad de solucionar problemas inesperados, o la capacidad para iniciar las actividades por uno/a mismo/a. Además de estos tres tipos de errores que pensamos pueden estar relacionados con las funciones ejecutivas, dos ítems se presentaron para medir el nivel de degradación del esquema en memoria de la tarea. Consistente con todos los datos que hemos ido recogiendo en nuestros estudios previos, observamos que, mientras que los pacientes con demencia presentan problemas en todos estos aspectos cognitivos, los pacientes con DCL mostraron exclusivamente problemas ejecutivos, y no de recuperación y mantenimiento del esquema de tarea en memoria. Dichos resultados están en consonancia con los estudios que apuntan a que esta población muestra déficits de precisión o de eficacia en la realización de AVD (Gold, 2012; Griffith et al., 2003; Schmitter-Edgecombe et al., 2012). Sin embargo, lo destacable es que, frente a diversos estudios que inciden en la diferenciación entre actividades básicas e instrumentales para diferenciar la demencia del DCL, nuestros resultados nos muestran que la capacidad de resolución de problemas ya se ve afectada en DCL en actividades básicas, un resultado que hasta el momento no había aparecido en la literatura previa. Dar solución a una situación inesperada, novedosa, aunque sea dentro de una tarea cotidiana, requiere de la generación de respuestas no automáticas, necesitando, por tanto, al Sistema Atencional Supervisor para ser resuelta. Lo cual nos sugiere la cuestión de que, si bien es cierto que las actividades instrumentales son más complejas que las básicas, también hay ciertos procesos que podrían ser comunes a todos los tipos de AVD; resolver problemas cuando se presentan puede ser un proceso común, aunque también tenderán a presentarse con menos frecuencia en las actividades básicas que, por ser tan habituales y estar normalmente constituidas por menos pasos, tendrán menos probabilidad de dar lugar a una situación inesperada. Nuestros datos demuestran, además, que tanto la recuperación como el mantenimiento del esquema en memoria de la tarea se ven preservados en los dos tipos de actividades para los pacientes con DCL. Estos resultados diferenciales en los procesos implicados en la ejecución de las AVD de pacientes con DCL podría emplearse en futuras investigaciones para diferenciar cualitativamente la ejecución en AVD de pacientes con DCL y demencia en fases iniciales, para distinguir entre los diferentes cuadros diagnósticos de DCL que existen, e incluso para seguir la progresión del deterioro de aquellos pacientes con DCL que evolucionan a un cuadro de demencia. De hecho, estos datos podrían tener consecuencias en los criterios diagnósticos del DCL, porque actualmente la única diferenciación con la demencia es que comenten fallos sutiles, sin especificar, en las AIVD.

Investigaciones anteriores no han encontrado patrones de errores muy exhaustivos entre DCL y controles, usando escalas como la E-Cog (Farias et al., 2008). Ni tampoco han podido correlacionar los datos de tareas de ejecución directa con escalas como el Índice de Lawton (Giovannetti et al., 2008). Quizás, como planteamos, la cuestión reside en elaborar preguntas que incidan específicamente en los procesos cognitivos que toda la literatura previa ha informado que impactan en las actividades del día a día, más que administrar escalas que no circunscriben esos procesos a determinadas AVD o que ni siquiera diferencian entre causas físicas o cognitivas.

Toda esta investigación pretende, además de aportar conocimiento sobre el sistema de control cognitivo en las actividades de la vida diaria, ofrecer algunas claves de rehabilitación en el contexto clínico, especialmente para los profesionales que trabajan las AVD, como os terapeutas ocupacionales o los neuropsicólogos. En este sentido, creemos importante conocer que, ante alteraciones mnésicas y levemente ejecutivas, la presentación de objetos distractores semánticamente relacionados con los que se usarán para llevar a cabo las tareas, puede facilitar la realización de estas actividades. Sin embargo, sucedería lo contrario ante déficits ejecutivos severos, donde se recomendaría llevar a cabo las actividades sin la presencia de distractores. Incidimos, además, en la necesidad de que estos profesionales hagan uso de herramientas de evaluación para conocer y delimitar los problemas cognitivos que impactan en la realización de las AVD, así como abrir nuevos campos de actuación con pacientes con DCL, donde se trabaje en mayor medida los procesos ejecutivos aplicados a las AVD, para retrasar, en la medida de lo posible, un mayor empeoramiento cognitivo y consecuentemente funcional.

De acuerdo con múltiples estudios relacionados con diversas poblaciones clínicas (Arrighi et al., 2013; Giovannetti et al., 2008; Humphreys & Forde, 1998), junto con el trabajo aquí expuesto, podemos afirmar la importancia de observar y analizar meticulosamente las funciones cognitivas en las AVD en general y las ejecutivas en particular, puesto que éstas pueden ser la causa de graves fallos funcionales.

4.3. CONCLUSIONES FINALES

1. Como se ha demostrado anteriormente, los pacientes frontales manifiestan alteraciones específicamente en el sistema de control cognitivo, y no en otras redes atencionales, como en el sistema de vigilancia o en la red de orientación.
2. Una de las funciones que lleva a cabo el sistema de control cognitivo es el filtraje de distractores. Por tanto, la presencia de distractores, tanto en tareas experimentales como en tareas cotidianas, genera más interferencia en personas con alteraciones ejecutivas, haciendo que se active el Sistema Atencional Supervisor. Al estar dicho sistema alterado, a su vez, provoca que se incremente el TR y los errores en situaciones de conflicto y, del mismo modo que se cometan diferentes errores en la vida cotidiana.
3. Dentro del sistema de control cognitivo, la resolución de conflicto a nivel de estímulo-respuesta, se relaciona con errores de comisión en la realización de AVD. La inhibición de la evocación de los objetos para ser usados *(Affordance)* correlaciona significativamente con medidas ejecutivas de respuesta.
4. Dentro del estudio de las diferentes características de los objetos distractores, la presencia de distractores semánticamente relacionados, que a su vez se pueden usar en conjunto para realizar una acción, configuran un contexto congruente que hace disminuir el número de omisiones y, en general, los errores con los objetos target. Esto ocurre sólo en condiciones normales, o ante alteraciones mnésicas que pueden estar combinadas con algunos problemas ejecutivos
5. Ante graves déficits ejecutivos y/o asociados con alteraciones mnésicas, los objetos distractores que están relacionados semánticamente y que se pueden usar en conjunto, provocan un gran interferencia, al no poder inhibir los objetos ni el esquema de tarea que activan. Como consecuencia se generan más "conductas de utilización" hacia los objetos distractores. Así como, más omisiones de pasos.
6. Bajo condiciones en las que se presentan objetos distractores que elicitan tareas que comparten pasos u objetos con la tarea target, los pacientes con lesiones frontales, cometen más manipulaciones sin objetivo.

7. Por primera vez se demuestra que, aunque la clasificación de AVD en básicas e instrumentales es interesante, existen ciertos procesos implicados en las AVD que son independientes de esta organización, como los procesos ejecutivos a la hora de la resolución de problemas. Así, los pacientes con DCL ya comienzan a presentar alteraciones en estos procesos en actividades básicas. Asimismo, el análisis de procesos cognitivos a la base, nos ha permitido conocer que estos pacientes no tienen problemas en el mantenimiento del esquema de memoria en tareas que suelen hacer, independientemente de si éstas son básicas o instrumentales.

4.4. FINAL CONCLUSIONS

1. Frontal patients exhibit deficits specially on measures of the attentional control system, but they seem spared on other attentional networks, like vigilance or on the orientation network.
2. One of the functions of the cognitive control system is distractors filtering. Thus, the presence of distractors, in computer based experimental tasks as well as in multi-step everyday tasks, evoke more interference in people with executive deficits, and thus the Supervisory Attentional System is required to be activated. The activation of this system, in turn, increased RTs and errors under conflicting situations, and in the same way it increases errors in everyday life.
3. Within the cognitive control system, we found that conflict resolution at stimulus-response level in computer-based simple tasks is related to commission errors in ADL performance. This might indicate that ADL commission errors are especially due to inhibition deficits towards distractors at the level of the response.
4. By studying different characteristics of distractor objects, the presence of semantically related and action related distractors produced an increase in the number of errors, especially with the distractor objects, in patients with executive disorders (frontal, MCI and dementia). However, semantically related distractors also produced a benefit on most groups by decreasing the number of omissions, and in general, on the target errors. However this benefit didn't happened for frontal patients, who still showed a larger number of omissions with the presence of related objects. Altogether this might means that when executive deficits are very important, their exacerbated attraction towards distractors any form of benefit from the semantic context.
5. The development of a preliminary scale of cognitive deficits contextualized on either basic vs. instrumental ADL, allowed us to measure some forms of executive functions like problem solving and Self Initiations that are difficult to measure on performance-based ADL. In addition the distinction between basic vs. instrumental

ADL has helped to find, for the first time, that although this ADL classification is important to discriminate MCI, dementia and healthy participants, there are certain processes involved in ADL that are independent from that distinction and still discriminate between the three groups. The finding that MCI patients showed problem solving deficits even for basic ADL is an example of that and might have important consequences for the development of future diagnostic criteria.

5 REFERENCES

Albert, M. S., DeKosky, S. T., Dickson, D., Dubois, B., Feldman, H. H., Fox, N. C., . . . Phelps, C. H. (2011). The diagnosis of mild cognitive impairment due to Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimers & Dementia, 7*(3), 270-279. doi: 10.1016/j.jalz.2011.03.008

Alberto, M. J., Martín, E. M., Martinson, A., Raya, N., Rincón, M. J., Rodríguez-Bailón, M., & Romero, L. (2009). *Guía práctica para el cuidado en el entorno familiar de personas en situación de dependencia*: Consejería para la Igualdad y Bienestar Social. Junta de Andalucía.

Alexander, M. P., Stuss, D. T., Picton, T., Shallice, T., & Gillingham, S. (2007). Regional frontal injuries cause distinct impairments in cognitive control. *Neurology, 68*(18), 1515-1523.

Amado, I., Lupianez, J., Chirio, M., Landgraf, S., Willard, D., Olie, J. P. J.-P., & Krebs, M. O. (2011). Alertness can be improved by an interaction between orienting attention and alerting attention in schizophrenia. *Behavioral and Brain Functions, 7*. doi: 10.1186/1744-9081-7-24

American Psychiatric Association. (2000). *Diagnostic and Statistical Manual of Mental Disorders:DSM-IV-TR*. Washington DC: American Psychiatric Association.

American Psychiatric Association. (2003). *DSM-IV TR: Brevario: Criterios Diagnósticos*. Barcelona: Masson.

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of mental disorders* (5th ed. ed.). Arlington, VA: American Psychiatric Publishing.

Archibald, S. J., Mateer, C. A., & Kerns, K. A. (2001). Utilization behavior: Clinical manifestations and neurological mechanisms. *Neuropsychology Review, 11*(3), 117-130. doi: 10.1023/a:1016673807158

Ardila, A., Ostrosky-Solis, F., & Bernal, B. (2006). Cognitive testing toward the future: The example of Semantic Verbal Fluency (ANIMALS). *International Journal of Psychology, 41*(5), 324-332. doi: 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. doi: 10.1002/gps.2325

Aretouli, E., Tsilidis, K. K., & Brandt, J. (2013). Four-Year Outcome of Mild Cognitive Impairment: The Contribution of Executive Dysfunction. *Neuropsychology, 27*(1), 95-106. doi: 10.1037/a0030481

Arrighi, H. M., Gelinas, I., McLaughlin, T. P., Buchanan, J., & Gauthier, S. (2013). Longitudinal changes in functional disability in Alzheimer's disease patients. *International psychogeriatrics / IPA, 25*(6), 929-937. doi: 10.1017/s1041610212002360

Backman, L., Jones, S., Berger, A. K., Laukka, E. J., & Small, B. J. (2005). Cognitive impairment in preclinical Alzheimer's disease: A meta-analysis. *Neuropsychology, 19*(4), 520-531. doi: 10.1037/0894-4105.19.4.520

Baddeley, A. D. (1986). *Working Memory*. Oxford: Clarendon Press.

Bailey, C. E. (2007). Cognitive accuracy and intelligent executive function in the brain and in business. *Social Cognitive Neuroscience of Organizations, 1118*, 122-141. doi: 10.1196/annals.1412.011

Bailey, H. R., Kurby, C. A., Giovannetti, T., & Zacks, J. M. (2013). Action perception predicts action performance. *Neuropsychologia, 51*(11), 2294-2304. doi: 10.1016/j.neuropsychologia.2013.06.022

Balani, A. B., Soto, D., & Humphreys, G. W. (2012). Separating top-down and bottom-up cueing of attention from response inhibition in utilization behavior. *Neurocase, 18*(2), 98-111. doi: 10.1080/13554794.2011.568496

Bandura, A. (1977). *Self-efficacy: The exercise of control*. New York: W. H. Freeman.

Barker, L. A., Morton, N., Morrison, T. G., & McGuire, B. E. (2011). Inter-rater reliability of the Dysexecutive Questionnaire (DEX): Comparative data from non-clinician respondents-all raters are not equal. *Brain Injury, 25*(10), 997-1004. doi: 10.3109/02699052.2011.597046

Baudic, S., Dalla Barba, G., Thibaudet, M. C., Smagghe, A., Remy, P., & Traykov, L. (2006). Executive function deficits in early Alzheimer's disease and their relations with episodic memory. *Archives of Clinical Neuropsychology, 21*(1), 15-21. doi: 10.1016/j.acn.2005.07.002

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. *American Journal of Occupational Therapy, 62*(4), 446-455.

Belke, E., Humphreys, G. W., Watson, D. G., Meyer, A. S., & Telling, A. L. (2008). Top-down effects of semantic knowledge in visual search are modulated by cognitive but not perceptual load. *Perception and Psychophysics, 70*(8), 1444-1458.

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. doi: 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. doi: 10.1017/s1355617708080193

Bickerton, W. L., Humphreys, G. W., & Riddoch, M. J. (2006). The use of memorised verbal scripts in the rehabilitation of action disorganisation syndrome. *Neuropsychological Rehabilitation, 16*(2), 155-177. doi: 10.1080/09602010500172277

Bickerton, W. L., Humphreys, G. W., & Riddoch, M. J. (2007). The case of the unfamiliar implement: Schema-based over-riding of semantic knowledge from objects in everyday action. *Journal of the International Neuropsychological Society, 13*(6), 1035-1046. doi: 10.1017/s1355617707071585

Biederman, I., Mezzanotte, R. J., & Rabinowitz, J. C. (1982). Scene perception - detection and judging objects undergoing relational violations. *Cognitive Psychology, 14*(2), 143-177. doi: 10.1016/0010-0285(82)90007-x

Bier, N., Bottari, C., Hudon, C., Joubert, S., Paquette, G., & Macoir, J. L. (2013). The Impact of Semantic Dementia on Everyday Actions: Evidence from an Ecological Study. *Journal of* *the International Neuropsychological Society, 19*(2), 162-172. doi: 10.1017/s1355617712001105

Blair, R. J. R. (2004). The roles of orbital frontal cortex in the modulation of antisocial behavior. *Brain and Cognition, 55*(1), 198-208. doi: 10.1016/s0278-2626(03)00276-8

Blessed, G., Tomlinson, B. E., & Roth, M. (1988). Blessed-Roth Dementia Scale (DS). *Psychopharmacology Bulletin, 24*(4), 705-708.

Boccardi, E., Della Sala, S., Motto, C., & Spinnler, H. (2002). Utilisation behaviour consequent to bilateral SMA softening. *Cortex, 38*(3), 289-308. doi: 10.1016/s0010-9452(08)70661-0

Boelen, D. H. E., Allain, P., Spikman, J. M., & Fasotti, L. (2011). Script generation and the dysexecutive syndrome in patients with brain injury. *Brain Injury, 25*(11), 1091-1100. doi: 10.3109/02699052.2011.608207

Borella, E., Carretti, B., & Pelegrina, S. (2010). The Specific Role of Inhibition in Reading Comprehension in Good and Poor Comprehenders. *Journal of Learning Disabilities, 43*(6), 541-552. doi: 10.1177/0022219410371676

Botvinick, M. M., Cohen, J. D., & Carter, C. S. (2004). Conflict monitoring and anterior cingulate cortex: an update. *Trends in Cognitive Sciences, 8*(12), 539-546. doi: 10.1016/j.tics.2004.10.003

Boyce, S. J., & Pollatsek, A. (1992). Identification of objects in scenes - The role of scene background in object naming. *Journal of Experimental Psychology-Learning Memory and Cognition, 18*(3), 531-543. doi: 10.1037//0278-7393.18.3.531

Boyce, S. J., Pollatsek, A., & Rayner, K. (1989). Effect of background information on object identification. *Journal of Experimental Psychology-Human Perception and Performance, 15*(3), 556-566. doi: 10.1037//0096-1523.15.3.556

Boyle, P. A., Malloy, P. F., Salloway, S., Cahn-Weiner, D. A., Cohen, R., & Cummings, J. L. (2003). Executive dysfunction and apathy predict functional impairment in Alzheimer disease. *American Journal of Geriatric Psychiatry, 11*(2), 214-221. doi: 10.1176/appi.ajgp.11.2.214

Brandt, J., Aretouli, E., Neijstrom, E., Samek, J., Manning, K., Albert, M. S., & Bandeen-Roche, K. (2009). Selectivity of Executive Function Deficits in Mild Cognitive Impairment. *Neuropsychology, 23*(5), 607-618. doi: 10.1037/a0015851

Broadbent, D. E., Cooper, P. F., Fitzgerald, P., & Parkes, K. R. (1982). The cogntive failures questionnaire (CFQ) and its correlates. *British Journal of Clinical Psychology, 21*(FEB), 1-16.

Bunge, S. A., Hazeltine, E., Scanlon, M. D., Rosen, A. C., & Gabrieli, J. D. E. (2002). Dissociable contributions of prefrontal and parietal cortices to response selection. *Neuroimage, 17*(3), 1562-1571. doi: 10.1006/nimg.2002.1252

Burgess, N., & Hitch, G. J. (1992). Toward a network model of the articulatory loop. *Journal of Memory and Language, 31*(4), 429-460. doi: 10.1016/0749-596x(92)90022-p

Burgess, P. W., & Shallice, T. (1996). Response suppression, initiation and strategy use following frontal lobe lesions. *Neuropsychologia, 34*(4), 263-272.

Burns, T., Mortimer, J. A., & Merchak, P. (1994). Cognitive performance test. A new approach to functional assessment in Alzheimers disease. *Journal of Geriatric Psychiatry and Neurology, 7*(1), 46-54.

Bush, G., Luu, P., & Posner, M. I. (2000). Cognitive and emotional influences in anterior cingulate cortex. *Trends in Cognitive Sciences, 4*(6), 215-222.

Buxbaum, L. J., Schwartz, M. F., & Carew, T. G. (1997). The role of semantic memory in object use. *Cognitive Neuropsychology, 14*(2), 219-254.

Buxbaum, L. J., Schwartz, M. F., & Montgomery, M. W. (1998). Ideational apraxia and naturalistic action. *Cognitive Neuropsychology, 15*(6-8), 617-643. doi: 10.1080/026432998381032

Callejas, A., Lupianez, J., Funes, M. J., & Tudela, P. (2005). Modulations among the alerting, orienting and executive control networks. *Experimental Brain Research, 167*(1), 27-37. doi: 10.1007/s00221-005-2365-z

Callejas, A., Lupianez, J., & Tudela, P. (2004). The three attentional networks: On their independence and interactions. *Brain and Cognition, 54*(3), 225-227. doi: 10.1016/j.bandc.2004.02.012

Carter, C. S., Braver, T. S., Barch, D. M., Botvinick, M. M., Noll, D., & Cohen, J. D. (1998). Anterior cingulate cortex, error detection, and the online monitoring of performance. *Science, 280*(5364), 747-749. doi: 10.1126/science.280.5364.747

Castiello, U. (1996). Grasping a fruit: Selection for action. *Journal of Experimental Psychology-Human Perception and Performance, 22*(3), 582-603.

Chao, L. L., & Knight, R. T. (1995). Human prefrontal lesions increase distractibility to irrelevant sensory inputs. *Neuroreport, 6*(12), 1605-1610. doi: 10.1097/00001756-199508000-00005

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. doi: 10.1016/s0010-9452(08)70543-4

Chica, A. B., Thiebaut de Schotten, M., Toba, M., Malhotra, P., Lupianez, J., & Bartolomeo, P. (2012). Attention networks and their interactions after right-hemisphere damage. *Cortex, 48*(6), 654-663. doi: 10.1016/j.cortex.2011.01.009

Chikazoe, J. (2010). Localizing performance of go/no-go tasks to prefrontal cortical subregions. *Current Opinion in Psychiatry, 23*(3), 267-272. doi: 10.1097/YCO.0b013e3283387a9f

Cooke, K. Z., Fisher, A. G., Mayberry, W., & Oakley, F. (2000). Differences in activities of daily living process skills of persons with and without Alzheimer's disease. *Occupational Therapy Journal of Research, 20*(2), 87-105.

Cooper, R. (2002). Order and disorder in everyday action: the roles of contention scheduling and supervisory attention. *Neurocase, 8*(1-2), 61-79. doi: 10.1093/neucas/8.1.61

Cooper, R. P., Schwartz, M. F., Yule, P., & Shallice, T. (2005). The simulation of action disorganisation in complex activities of daily living. *Cognitive Neuropsychology, 22*(8), 959-1004. doi: 10.1080/02643290442000419

Craighero, L., Bello, A., Fadiga, L., & Rizzolatti, G. (2002). Hand action preparation influences the responses to hand pictures. *Neuropsychologia, 40*(5), 492-502. doi: 10.1016/s0028-3932(01)00134-8

Craighero, L., Fadiga, L., Rizzolatti, G., & Umilta, C. (1998). Visuomotor priming. *Visual Cognition, 5*(1-2), 109-125.

Danckert, J., Maruff, P., Crowe, S., & Currie, J. (1998). Inhibitory processes in covert orienting in patients with Alzheimer's disease. *Neuropsychology, 12*(2), 225-241. doi: 10.1037/0894-4105.12.2.225

De Stefani, E., Innocenti, A., Bernardi, N. F., Campione, G. C., & Gentilucci, M. (2012). The bottle and the glass say to me: "Pour!". *Experimental Brain Research, 218*(4), 539-549. doi: 10.1007/s00221-012-3047-2

Delis, D., Kaplan, E., & Kramer, J. (2001). *Delis–Kaplan Executive Function System.*San Antonio, TX: The Psychological Corporation, Harcourt Brace & Co

di Pellegrino, G., Ciaramelli, E., & Ladavas, E. (2007). The regulation of cognitive control following rostral anterior cingulate cortex lesion in humans. *Journal of Cognitive Neuroscience, 19*(2), 275-286. doi: 10.1162/jocn.2007.19.2.275

Diamond, A. (2013). Executive Functions. *Annual Review of Psychology, Vol 64, 64*, 135-168. doi: 10.1146/annurev-psych-113011-143750

Donnelly, S. (2002). The Rivermead Perceptual Assessment Battery: Can it predict functional performance? *Australian Occupational Therapy Journal, 49*(2), 71-81.

Donner, T., Kettermann, A., Diesch, E., Ostendorf, F., Villringer, A., & Brandt, S. A. (2000). Involvement of the human frontal eye field and multiple parietal areas in covert visual selection during conjunction search. *European Journal of Neuroscience, 12*(9), 3407-3414. doi: 10.1046/j.1460-9568.2000.00223.x

dos Santos Assef, E. C., Seabra Capovilla, A. G., & Capovilla, F. C. (2007). Computerized Stroop Test to assess selective attention in children with attention deficit hyperactivity disorder. *Spanish Journal of Psychology, 10*(1), 33-40.

Drijgers, R. L., Verhey, F. R. J., Leentjens, A. F. G., Kohler, S., & Aalten, P. (2011). Neuropsychological correlates of apathy in mild cognitive impairment and Alzheimer's disease: the role of executive functioning. *International Psychogeriatrics, 23*(8), 1327-1333. doi: 10.1017/s1041610211001037

Duchek, J., & Abreau, B. (1997). Meeting the challanges of cognitive disabilities. In C. C. y. B. CM (Ed.), *Occupational Therapy: Enabling Function and Well- Being* Thorofare, NJ: Snack.

Duncan, J., Emslie, H., Williams, P., Johnson, R., & Freer, C. (1996). Intelligence and the frontal lobe: The organization of goal-directed behavior. *Cognitive Psychology, 30*(3), 257-303. doi: 10.1006/cogp.1996.0008

Duncan, J., & Owen, A. M. (2000). Common regions of the human frontal lobe recruited by diverse cognitive demands. *Trends in Neurosciences, 23*(10), 475-483.

Egner, T. (2008). Multiple conflict-driven control mechanisms in the human brain. *Trends in Cognitive Sciences, 12*(10), 374-380. doi: 10.1016/j.tics.2008.07.001

Egner, T., Delano, M., & Hirsch, J. (2007). Separate conflict-specific cognitive control mechanisms in the human brain. *Neuroimage, 35*(2), 940-948. doi: 10.1016/j.neuroimage.2006.11.061

Eriksen, C. W. (1995). *The flankers task and response competition: A useful tool for investigating a variety of cognitive problems*.

Fan, J., Flombaum, J. I., McCandliss, B. D., Thomas, K. M., & Posner, M. I. (2003). Cognitive and brain consequences of conflict. *Neuroimage, 18*(1), 42-57. doi: 10.1006/nimg.2002.1319

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience, 14*(3), 340-347.

Farias, S. T., Mungas, D., Cahn-Weiner, D., Baynes, K., Reed, B. R., Jagust, W., & DeCarli, C. (2008). The measurement of Everyday Cognition (ECog): Scale development and psychometric properties. *Neuropsychology, 22*(4), 531-544. doi: 10.1037/0894-4105.22.4.531

Farias, S. T., Mungas, D., Reed, B. R., Harvey, D., Cahn-Weiner, D., & DeCarli, C. (2006). MCI is associated with deficits in everyday functioning. *Alzheimer Disease & Associated Disorders, 20*(4), 217-223. doi: 10.1097/01.wad.0000213849.51495.d9

Fastenau, P. S., Denburg, N. L., & Mauer, B. A. (1998). Parallel short forms for the Boston Naming Test: Psychometric properties and norms for older adults. *Journal of Clinical and Experimental Neuropsychology, 20*(6), 828-834. doi: 10.1076/jcen.20.6.828.1105

Fisher, A. (2006a). *Assesment of Motor and Process Skills: Vol 1. Development, standarization and administration manual.* (6th ed.). Fort Collins, CO: Three Star Press.

Fisher, A. (2006b). *Assesment of Motor and Process Skills: Vol 2. User manual.* (6th ed.). Fort Collins, CO: Three Star Press.

Folk, C. L., Remington, R. W., & Johnston, J. C. (1992). Involuntary covert orienting is contingent on attentional control settings. *Journal of Experimental Psychology-Human Perception and Performance, 18*(4), 1030-1044. doi: 10.1037//0096-1523.18.4.1030

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). Mini-Mental State. Practical method for grading cognitive state of patients for clinician. *Journal of Psychiatric Research, 12*(3), 189-198. doi: 10.1016/0022-3956(75)90026-6

Forde, E. M. E., & Humphreys, G. W. (2000). The role of semantic knowledge and working memory in everyday tasks. *Brain and Cognition, 44*(2), 214-252. doi: 10.1006/brcg.2000.1229

Forde, E. M. E., & Humphreys, G. W. (2002). Dissociations in routine behaviour across patients and everyday tasks. *Neurocase, 8*(1-2), 151-167. doi: 10.1093/neucas/8.1.151

Forstmann, B. U., Jahfari, S., Scholte, H. S., Wolfensteller, U., van den Wildenberg, W. P. M., & Ridderinkhof, K. R. (2008). Function and structure of the right inferior frontal cortex predict individual differences in response inhibition: A model-based approach. *Journal of Neuroscience, 28*(39), 9790-9796. doi: 10.1523/jneurosci.1465-08.2008

Frisch, S., Forstl, S., Legler, A., Schope, S., & Goebel, H. (2012). The interleaving of actions in everyday life multitasking demands. *Journal of Neuropsychology, 6*, 257-269. doi: 10.1111/j.1748-6653.2012.02026.x

Fu, C. H. Y., Walsh, N. D., Kim, J., Brammer, M. J., Bullmore, E. T., Cleare, A. J., . . . Williams, S. C. R. (2001). Mapping the Trail(s): neural correlates of visuomotor tracking and sequencing. *Neuroimage, 13*(6), S402-S402.

Funes, M. J., Lupianez, J., & Humphreys, G. (2010a). Analyzing the Generality of Conflict Adaptation Effects. *Journal of Experimental Psychology-Human Perception and Performance, 36*(1), 147-161. doi: 10.1037/a0017598

Funes, M. J., Lupianez, J., & Humphreys, G. (2010b). Top-down and bottom-up deficits in conflict adaptation after frontal lobe damage. *Cognitive Neuropsychology, 27*(4), 360-375. doi: 10.1080/02643294.2010.532618

Gehring, W. J., Goss, B., Coles, M. G. H., Meyer, D. E., & Donchin, E. (1993). A neural system for error-detection and compensation. *Psychological Science, 4*(6), 385-390. doi: 10.1111/j.1467-9280.1993.tb00586.x

Gehring, W. J., & Knight, R. T. (2000). Prefrontal-cingulate interactions in action monitoring. *Nature Neuroscience, 3*(5), 516-520. doi: 10.1038/74899

George, M., Whitfield, T., & Walker, Z. (2013). Association of apathy with frontal lobe dysfunction in amnestic mild cognitive impairment and Alzheimer's disease. *Journal of neurology, neurosurgery, and psychiatry, 84*(9), e1-e1. doi: 10.1136/jnnp-2013-306103.36

Geusgens, C. A., van Heugten, C. M., Hagedoren, E., Jolles, J., & van den Heuvel, W. J. (2010). Environmental Effects in the Performance of Daily Tasks in Healthy Adults. *American Journal of Occupational Therapy, 64*(6), 935-940. doi: 10.5014/ajot.2010.07171

Giovannetti, T., Bettcher, B. M., Brennan, L., Libon, D. J., Burke, M., Duey, K., . . . Wambach, D. (2008). Characterization of everyday functioning in mild cognitive impairment: A direct assessment approach. *Dementia and Geriatric Cognitive Disorders, 25*(4), 359-365. doi: 10.1159/000121005

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. doi: 10.1037/0894-4105.22.2.235

Giovannetti, T., Bettcher, B. M., Brennan, L., Libon, D. J., Wambach, D., & Seter, C. (2010). Target-related distractors disrupt object selection in everyday action: Evidence from participants with dementia. *Journal of the International Neuropsychological Society, 16*(3), 484-494. doi: 10.1017/s1355617710000081

Giovannetti, T., Libon, D. J., Buxbaum, L. J., & Schwartz, M. F. (2002). Naturalistic action impairments in dementia. *Neuropsychologia, 40*(8), 1220-1232. doi: Pii s0028-3932(01)00229-9 10.1016/s0028-3932(01)00229-9

Giovannetti, T., Schwartz, M. F., & Buxbaum, L. J. (2007). The Coffee Challenge: A new method for the study of everyday action errors. *Journal of Clinical and Experimental Neuropsychology, 29*(7), 690-705. doi: 10.1080/13803390600932286

Godbout, L., Grenier, M. C., Braun, C. M. J., & Gagnon, S. (2005). Cognitive structure of executive deficits in patients with frontal lesions performing activities of daily living. *Brain Injury, 19*(5), 337-348. doi: 10.1080/02699050400005093

Godefroy, O. (2003). Frontal syndrome and disorders of executive functions. *Journal of Neurology, 250*(1), 1-6. doi: 10.1007/s00415-003-0918-2

Gold, D. A. (2012). An examination of instrumental activities of daily living assessment in older adults and mild cognitive impairment. *Journal of Clinical and Experimental Neuropsychology, 34*(1), 11-34. doi: 10.1080/13803395.2011.614598

Gouveia, P. A. R., Brucki, S. M. D., Malheiros, S. M. F., & Bueno, O. F. A. (2007). Disorders in planning and strategy application in frontal lobe lesion patients. *Brain and Cognition, 63*(3), 240-246. doi: 10.1016/j.bandc.2006.09.001

Goverover, Y., Kalmar, J., Gaudino-Goering, E., Shawaryn, M., Moore, N. B., Halper, J., & DeLuca, J. (2005). The relation between subjective and objective measures of everyday life activities in persons with multiple sclerosis. *Archives of Physical Medicine and Rehabilitation, 86*(12), 2303-2308. doi: 10.1016/j.apmr.2005.05.016

Grace, J., Stout, J. C., & Malloy, P. F. (1999). Assessing frontal lobe behavioral syndromes with the Frontal Lobe Personality Scale. *Assessment, 6*(3), 269-284. doi: 10.1177/107319119900600307

Gratton, G., Coles, M. G. H., & Donchin, E. (1992). Optimizing the use of information - Strategic control of activation of responses. *Journal of Experimental Psychology-General, 121*(4), 480-506. doi: 10.1037//0096-3445.121.4.480

Grezes, J., & Decety, J. (2002). Does visual perception of object afford action? Evidence from a neuroimaging study. *Neuropsychologia, 40*(2), 212-222. doi: 10.1016/s0028-3932(01)00089-6

Grezes, J., Tucker, M., Armony, J., Ellis, R., & Passingham, R. E. (2003). Objects automatically potentiate action: an fMRI study of implicit processing. *European Journal of Neuroscience, 17*(12), 2735-2740. doi: 10.1046/j.1460-9568.2003.02695.x

Griffith, H. R., Belue, K., Sicola, A., Krzywanski, S., Zamrini, E., Harrell, L., & Marson, D. C. (2003). Impaired financial abilities in mild cognitive impairment - A direct assessment approach. *Neurology, 60*(3), 449-457.

Gure, T. R., Langa, K. M., Fisher, G. G., Piette, J. D., & Plassman, B. L. (2013). Functional Limitations in Older Adults Who Have Cognitive Impairment Without Dementia. *Journal of Geriatric Psychiatry and Neurology, 26*(2), 78-85. doi: 10.1177/0891988713481264

Harrison, B. J., Shaw, M., Yucel, M., Purcell, R., Brewer, W. J., Strother, S. C., . . . Pantelis, C. (2005). Functional connectivity during Stroop task performance. *Neuroimage, 24*(1), 181-191. doi: 10.1016/j.neuroimage.2004.08.033

Helbig, H. B., Graf, M., & Kiefer, M. (2006). The role of action representations in visual object recognition. *Experimental Brain Research, 174*(2), 221-228. doi: 10.1007/s00221-006-0443-5

Heled, E., Hoofien, D., Margalit, D., Natovich, R., & Agranov, E. (2012). The Delis-Kaplan Executive Function System Sorting Test as an evaluative tool for executive functions after severe traumatic brain injury: A comparative study. *Journal of Clinical and Experimental Neuropsychology, 34*(2), 151-159. doi: 10.1080/13803395.2011.625351

Hodges, J. R., Spatt, J., & Patterson, K. (1999). "What" and "how": Evidence for the dissociation of object knowledge and mechanical problem-solving skills in the human brain. *Proceedings of the National Academy of Sciences of the United States of America, 96*(16), 9444-9448. doi: 10.1073/pnas.96.16.9444

Hooker, C. I., & Knight, R. T. (2008). The role of lateral orbitofrontal cortex in inhibitory control of emotion *The Orbitofrontal Cortex*.

Hughes, T. F., Chang, C. C. H., Bilt, J. V., Snitz, B. E., & Ganguli, M. (2012). Mild Cognitive Deficits and Everyday Functioning Among Older Adults in the Community: The Monongahela-Youghiogheny Healthy Aging Team Study. *American Journal of Geriatric Psychiatry, 20*(10), 836-844. doi: 10.1097/JGP.0b013e3182423961

Humphreys, G. W., Bickerton, W. I., Samson, D., & Riddoch, M. J. (2012). *BCoS cognitive screen*. London: Psychology Press.

Humphreys, G. W., & Forde, E. M. E. (1998). Disordered action schema and action disorganisation syndrome. *Cognitive Neuropsychology, 15*(6-8), 771-811.

Humphreys, G. W., Kumar, S., Yoon, E. Y., Wulff, M., Roberts, K. L., & Riddoch, J. (2013). Attending to the possibilities of action. *Philosophical transactions of the Royal Society of*

London. Series B, Biological sciences, 368(1628), 20130059-20130059. doi: 10.1098/rstb.2013.0059

Humphreys, G. W., & Riddoch, J. (2007). How to define an object: Evidence from the effects of action on perception and attention. *Mind & Language, 22*(5), 534-547. doi: 10.1111/j.1468-0017.2007.00319.x

Humphreys, G. W., & Riddoch, M. J. (2000). One more cup of coffee for the road: object-action assemblies, response blocking and response capture after frontal lobe damage. *Experimental Brain Research, 133*(1), 81-93. doi: 10.1007/s002210000403

IBM Corporation. (2011). *Released 2011. IBM SPSS Statistics for Windows, Version 20.0*. Armonk NY: IBM Corp.

Jesus Funes, M., Rodriguez Bailon, M., Ruiz Perez, R., & Lupianez, J. (2009). Solving three spatial conflict types at a time: evidence for multiple conflict control mechanisms. *Cognitive Processing, 10*, S153-S153.

Jiang, J., & Egner, T. (2013). Using Neural Pattern Classifiers to Quantify the Modularity of Conflict–Control Mechanisms in the Human Brain *Cerebral Cortex, Feb*(12). doi: 10.1093/cercor/bht029

Jorm, A. F., & Korten, A. E. (1988). Assessment of cognitive decline in the elderly by informant interview. *British Journal of Psychiatry, 152*, 209-213. doi: 10.1192/bjp.152.2.209

Katz, N., Itzkovich, M., Averbuch, S., & Elazar, B. (1989). Loewenstein Occupational Therapy Cognitive Assessment (LOTCA) Battery for brain injured patients. Reability and validity. *American Journal of Occupational Therapy, 43*(3), 184-192.

Katz, N., Tadmor, I., Felzen, B., & Hartman-Maeir, A. (2007). The Behavioural Assessment of the Dysexecutive Syndrome (BADS) in schizophrenia and its relation to functional outcomes. *Neuropsychological Rehabilitation, 17*(2), 192-205. doi: 10.1080/09602010600685053

Katz, N., Todmor, I., Felzen, B., & Hartman-Moeir, A. (2007). Validity of the executive function performance test in individuals with schizophrenia. *Otjr-Occupation Participation and Health, 27*(2), 44-51.

Keith, R. A., Granger, C. V., Hamilton, B. B., & Sherwin, F. S. (1987). The functional independence measure: a new tool for rehabilitation. *Advances in clinical rehabilitation, 1*, 6-18.

Kornblum, S., Hasbroucq, T., & Osman, A. (1990). Dimensional overlap - cognitive basis for stimulus-response compability - A model and taxonomy. *Psychological Review, 97*(2), 253-270. doi: 10.1037//0033-295x.97.2.253

Kumada, T., & Hayashi, M. (2006). Deficits in feature-based control of attention in a patient with a right fronto-temporal lesion. *Cognitive Neuropsychology, 23*(3), 401-423. doi: 10.1080/02643290542000085

Kumada, T., & Humphreys, G. W. (2002). Early selection induced by perceptual load in a patient with frontal lobe damage: External vs. internal modulation of processing control. *Cognitive Neuropsychology, 19*(1), 49-65. doi: 10.1080/02643290143000088

Lavie, N. (2005). Distracted and confused?: Selective attention under load. *Trends in Cognitive Sciences, 9*(2), 75-82. doi: 10.1016/j.tics.2004.12.004

Lavie, N., & de Fockert, J. (2006). Frontal control of attentional capture in visual search. *Visual Cognition, 14*(4-8), 863-876. doi: 10.1080/13506280500195953

Lawton. (1982). A research and Service Oriented Multilevel Assesment Instrument (Vol. 37, pp. 91-99). Journal of Gerontology.

Ley 15/1999. (1999). Ley de Protección de Datos de Carácter Personal.

Ley 39/2006. (2006). Ley de Promoción de la Autonomía Personal y Atención a las personas en situación de dependencia.

Lhermitte, F. (1983). Utilization behavior and its relation to lesions of the frontal lobes. *Brain, 106*(JUN), 237-255. doi: 10.1093/brain/106.2.237

Lin, F., Weng, S., Xie, B., Wu, G., & Lei, H. (2011). Abnormal frontal cortex white matter connections in bipolar disorder: A DTI tractography study. *Journal of Affective Disorders, 131*(1-3), 299-306. doi: 10.1016/j.jad.2010.12.018

Loewenstein, D. A., Amigo, E., Duara, R., Guterman, A., Hurwitz, D., Berkowitz, N., . . . Eisdorfer, C. (1989). A new scale for the assessment of functional status in Alzheimer disease and related disorders. *Journals of Gerontology, 44*(4), P114-P121.

Long, C., & Collins, L. (1997). Ecological validity and forensic neuropsychological assessment. In R. McCaffrey, A. Williams, J. Fisher & L. Laing (Eds.), *Practice of Forensic Neuropsychology: Meeting Challenges in the Courtroom*. New York: Plenum.

Long, C., & Kibby, M. (1995). Ecological validity of neuropsychological tests: A look at neuropsychology's past and the impact that ecological issues may have on its future. *Adv. Med. Psychother*(8), 59-78.

Lu, C. H., & Proctor, R. W. (1995). The influence of irrelevant location information on performance - a review of the Simon and Spatial Stroop effects. *Psychonomic Bulletin & Review, 2*(2), 174-207. doi: 10.3758/bf03210959

Luria, A. (1966). *Higher cortical functions in man*. New York: Basic Books.

MacDonald, A. W., Cohen, J. D., Stenger, V. A., & Carter, C. S. (2000). Dissociating the role of the dorsolateral prefrontal and anterior cingulate cortex in cognitive control. *Science, 288*(5472), 1835-1838. doi: 10.1126/science.288.5472.1835

Mack, W. J., Freed, D. M., Williams, B. W., & Henderson, V. W. (1992). Boston naming test - shortened versions for use in Alzheimers- Disease. *Journals of Gerontology, 47*(3), P154-P158.

Macleod, C. M. (1991). Half a century of reserch on the stroop effect - an integrative review. *Psychological Bulletin, 109*(2), 163-203.

Mahoney, & Barthel. (1965). Functional Evaluation: The Barthel Index. *Maryland State Medical Journal, 14*, 56-61.

Mahurin, R. K., Debettignies, B. H., & Pirozzolo, F. J. (1991). Structured assessment of independent living skills – preliminary report of performance measure of functional abilities in dementia. *Journals of Gerontology, 46*(2), P58-P66.

Marshall, G. A., Rentz, D. M., Frey, M. T., Locascio, J. J., Johnson, K. A., Sperling, R. A., & Alzheimer's Dis, N. (2011). Executive function and instrumental activities of daily living in mild cognitive impairment and Alzheimer's disease. *Alzheimers & Dementia, 7*(3), 300-308. doi: 10.1016/j.jalz.2010.04.005

Martyr, A., & Clare, L. (2012). Executive Function and Activities of Daily Living in Alzheimer's Disease: A Correlational Meta-Analysis. *Dementia and Geriatric Cognitive Disorders, 33*(2-3), 189-203. doi: 10.1159/000338233

McBride, J., Sumner, P., & Husain, M. (2012). Conflict in object affordance revealed by grip force. *Quarterly Journal of Experimental Psychology, 65*(1), 13-24. doi: 10.1080/17470218.2011.588336

McBride, J., Sumner, P., Jackson, S. R., Bajaj, N., & Husain, M. (2013). Exaggerated object affordance and absent automatic inhibition in alien hand syndrome. *Cortex, 49*(8), 2040-2054. doi: 10.1016/j.cortex.2013.01.004

McKhann, G. M., Knopman, D. S., Chertkow, H., Hyman, B. T., Jack, C. R., Jr., Kawas, C. H., . . . Phelps, C. H. (2011). The diagnosis of dementia due to Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimers & Dementia, 7*(3), 263-269. doi: 10.1016/j.jalz.2011.03.005

Millon, T. (1987). *MCMI-II. Inventario Multiaxial Clínico de Millon*. Madrid: TEA.

Mioshi, E., Hodges, J. R., & Hornberger, M. (2013). Neural Correlates of Activities of Daily Living in Frontotemporal Dementia. *Journal of Geriatric Psychiatry and Neurology, 26*(1), 51-57. doi: 10.1177/0891988713477474

Mioshi, E., Kipps, C. M., Dawson, K., Mitchell, J., Graham, A., & Hodges, J. R. (2007). Activities of daily living in frontotemporal dementia and Alzheimer disease. *Neurology, 68*(24), 2077-2084. doi: 10.1212/01.wnl.0000264897.13722.53

Miro, E., Lupianez, J., Hita, E., Martinez, M. P., Sanchez, A. I., & Buela-Casal, G. (2011). Attentional deficits in fibromyalgia and its relationships with pain, emotional distress and sleep dysfunction complaints. *Psychology & Health, 26*(6), 765-780. doi: 10.1080/08870446.2010.493611

Mitchell, R. L. C. (2005). The BOLD response during Stroop task-like inhibition paradigms: Effects of task difficulty and task-relevant modality. *Brain and Cognition, 59*(1), 23-37. doi: 10.1016/j.bandc.2005.04.001

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. doi: 10.1006/cogp.1999.0734

Moores, E., Laiti, L., & Chelazzi, L. (2003). Associative knowledge controls deployment of visual selective attention. *Nature Neuroscience, 6*(2), 182-189. doi: 10.1038/nn996

Morady, K., & Humphreys, G.W. (2011). Multiple task demands in action disorganization syndrome. *Neurocase, 17*(5), 461-472. doi: 10.1080/13554794.2010.532144

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. doi: 10.1080/13554790802524214

Morady, K., & Humphreys, G. W. (2011). Eye movements in action disorganization syndrome: A single case analysis. *Visual Cognition, 19*(6), 817-831. doi: 10.1080/13506285.2011.588186

Moruno, P., & Romero, D. (2006). *Actividades de la Vida Diaria*. Barcelona: Masson.

Mullane, J., Corkum, P., Klein, R., McLaughlin, E., & Lawrence, M. (In press). Alerting, Orienting, and Executive Attention in Children With ADHD. *Journal of Attention Disorders*.

Nadler, J. D., Richardson, E. D., Malloy, P. F., Marran, M. E., & Brinson, M. E. H. (1993). The ability of the dementia rating scale to predict everyday functioning. *Archives of Clinical Neuropsychology, 8*(5), 449-460. doi: 10.1016/0887-6177(93)90008-o

Niki, C., Maruyama, T., Muragaki, Y., & Kumada, T. (2009). Disinhibition of sequential actions following right frontal lobe damage. *Cognitive Neuropsychology, 26*(3), 266-285. doi: 10.1080/02643290903028484

Norman, D. A. (1981). Categorization of action slips. *Psychological Review, 88*(1), 1-15. doi: 10.1037/0033-295x.88.1.1

Norman, D. A., & Shallice, T. (1980). *Attention to action: Willed and automatic control of behaviour*. Chip report 99, University of California, San Diego, CA.

Norman, D. A., & Shallice, T. (1983). Attention to action. Willed and automatic control of behavior. *Bulletin of the Psychonomic Society, 21*(5), 354-354.

Nott, M. T., Chapparo, C., & Heard, R. (2009). Reliability of the Perceive, Recall, Plan and Perform System of Task Analysis: A criterion-referenced assessment. *Australian Occupational Therapy Journal, 56*(5), 307-314. doi: 10.1111/j.1440-1630.2008.00763.x

Owsley, C., Sloane, M., McGwin, G., & Ball, K. (2002). Timed instrumental activities of daily living tasks: Relationship to cognitive function and everyday performance assessments in older adults. *Gerontology, 48*(4), 254-265. doi: 10.1159/000058360

Pacheco-Unguetti, A. P., Acosta, A., Callejas, A., & Lupianez, J. (2010). Attention and Anxiety: Different Attentional Functioning Under State and Trait Anxiety. *Psychological Science, 21*(2), 298-304. doi: 10.1177/0956797609359624

Padilla, R. (2011). Effectiveness of Occupational Therapy Services for People With Alzheimer's Disease and Related Dementias. *American Journal of Occupational Therapy, 65*(5), 487-489.

Pailing, P. E., Segalowitz, S. J., Dywan, J., & Davies, P. L. (2002). Error negativity and response control. *Psychophysiology, 39*(2), 198-206. doi: 10.1017/s0048577201392107

Palmer, T. E. (1975). The effects of contextual scenes on the identification of objects. *Memory & cognition, 3*(5), 519-526. doi: 10.3758/bf03197524

Partiot, A., Grafman, J., Sadato, N., Flitman, S., & Wild, K. (1996). Brain activation during script event processing. *NeuroReport, 7*(3), 761-766.

Paus, T. (2001). Primate anterior cingulate cortex: Where motor control, drive and cognition interface. *Nature Reviews Neuroscience, 2*(6), 417-424.

Pereira, F. S., Yassuda, M. S., Oliveira, A. M., Diniz, B. S., Radanovic, M., Talib, L. L., . . . Forlenza, O. V. (2010). Profiles of functional deficits in mild cognitive impairment and dementia: benefits from objective measurement. *Journal of the International Neuropsychological Society, 16*(2), 297-305. doi: 10.1017/s1355617709991330

Pereira, F. S., Yassuda, M. S., Oliveira, A. M., & Forlenza, O. V. (2008). Executive dysfunction correlates with impaired functional status in older adults with varying degrees of cognitive impairment. *International Psychogeriatrics, 20*(6), 1104-1115. doi: 10.1017/s1041610208007631

Perneczky, R., Pohl, C., Sorg, C., Hartmann, J., Tosic, N., Grimmer, T., . . . Kurz, A. (2006). Impairment of activities of daily living requiring memory or complex reasoning as part of the MCI syndrome. *International Journal of Geriatric Psychiatry, 21*(2), 158-162. doi: 10.1002/gps.1444

Petersen, R. C. (2004). Mild cognitive impairment as a diagnostic entity. *Journal of Internal Medicine, 256*(3), 183-194. doi: 10.1111/j.1365-2796.2004.01388.x

Petersen, R. C., Doody, R., Kurz, A., Mohs, R. C., Morris, J. C., Rabins, P. V., . . . Winblad, B. (2001). Current concepts in mild cognitive impairment. *Archives of Neurology, 58*(12), 1985-1992. doi: 10.1001/archneur.58.12.1985

Petersen, R. C., Smith, G. E., Waring, S. C., Ivnik, R. J., Tangalos, E. G., & Kokmen, E. (1999). Mild cognitive impairment - Clinical characterization and outcome. *Archives of Neurology, 56*(3), 303-308. doi: 10.1001/archneur.56.3.303

Peña Casanova, J. (1990). *Programa integrado de exploración neuropsicológica. Test Barcelona.* . Barcelona: Masson.

Picton, T. W., Stuss, D. T., Alexander, M. P., Shallice, T., Binns, M. A., & Gillingham, S. (2007). Effects of focal frontal lesions on response inhibition. *Cerebral Cortex, 17*(4), 826-838. doi: 10.1093/cercor/bhk031

Piquard, A., Lacomblez, L., Derouesne, C., & Sieroff, E. (2009). Problems inhibiting attentional capture by irrelevant stimuli in patients with frontotemporal dementia. *Brain and Cognition, 70*(1), 62-66. doi: 10.1016/j.bandc.2008.12.008

Pizzi, A. M., Chapin, J. S., Tesar, G. E., & Busch, R. M. (2009). Comparison of personality traits in patients with frontal and temporal lobe epilepsies. *Epilepsy & Behavior, 15*(2), 225-229. doi: 10.1016/j.yebeh.2009.03.028

Polonio, B., Durante, P., & Noya, B. (2001). *Conceptos fundamentales de terapia ocupacional*. Madrid: Panamericana.

Posner, M. I., & Dehaene, S. (1994). Attentional Networks. *Trends in Neurosciences, 17*(2), 75-79.

Posner, M. I., & Petersen, S. E. (1990). The attention system of human brain. *Annual Review of Neuroscience, 13*, 25-42.

Posner, M. I., & Rothbart, M. K. (1992). Attentional mechanisms and conscious experience. In D. M. a. M. Rugg (Ed.), *The neuropsychology of consciousness* (pp. 91-111). San Diego,CA: Academic Press.

Posner, M. I., Rothbart, M. K., Sheese, B. E., & Tang, Y. (2007). The anterior cingulate gyrus and the mechanism of self-regulation. *Cognitive Affective & Behavioral Neuroscience, 7*(4), 391-395.

Posner, M. I., Rothbart, M. K., Vizueta, N., Levy, K. N., Evans, D. E., Thomas, K. M., & Clarkin, J. F. (2002). Attentional mechanisms of borderline personality disorder. *Proceedings of the National Academy of Sciences of the United States of America, 99*(25), 16366-16370. doi: 10.1073/pnas.252644699

Quemada, J. I., Cespedes, J. M. M., Ezkerra, J., Ballesteros, J. M., Ibarra, N., & Urruticoechbea, I. (2003). Outcome of memory rehabilitation in traumatic brain injury assessed by neuropsychological tests and questionnaires. *Journal of Head Trauma Rehabilitation, 18*(6), 532-540.

Rainville, C., Lepage, E., Gauthier, S., Kergoat, M. J., & Belleville, S. (2012). Executive function deficits in persons with mild cognitive impairment: A study with a Tower of London task.

Journal of Clinical and Experimental Neuropsychology, 34(3), 306-324. doi: 10.1080/13803395.2011.639298

Rascovsky, K., Hodges, J. R., Knopman, D., Mendez, M. F., Kramer, J. H., Neuhaus, J., . . . Miller, B. L. (2011). Sensitivity of revised diagnostic criteria for the behavioural variant of frontotemporal dementia. *Brain, 134*, 2456-2477. doi: 10.1093/brain/awr179

Reason, J. (1990). Human error. Cambridge, England: Cmbridge University Press.

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. doi: 10.1080/02699050701785062

Reisberg, B., Finkel, S., Overall, J., Schmidt-Gollas, N., Kanowski, S., Lehfeld, H., . . . Erzigkeit, H. (2001). The Alzheimer's disease activities of daily living international scale (ADL-IS). *International Psychogeriatrics, 13*(2), 163-181. doi: 10.1017/s1041610201007566

Remy, F., Saint-Aubert, L., Bacon-Mace, N., Vayssiere, N., Barbeau, E., & Fabre-Thorpe, M. (2013). Object recognition in congruent and incongruent natural scenes: A life-span study. *Vision Research, 91*, 36-44. doi: 10.1016/j.visres.2013.07.006

Reppermund, S., Sachdev, P. S., Crawford, J., Kochan, N. A., Slavin, M. J., Kang, K., . . . Brodaty, H. (2011). The relationship of neuropsychological function to instrumental activities of daily living in mild cognitive impairment. *International Journal of Geriatric Psychiatry, 26*(8), 843-852. doi: 10.1002/gps.2612

Rey, A. (1964). *L'examen clinique en Psychologia*. Paris: Pressee Universitaires de France.

Riddoch, M. J., Humphreys, G. W., Heslop, J., & Castermans, E. (2002). Dissociations between object knowledge and everyday action. *Neurocase, 8*(1-2), 100-110. doi: 10.1093/neucas/8.1.100

Rodríguez-Bailón M., Lupiáñez, J., Ródenas-García, E., García-Morán, T., Triviño, M. & Funes, M. J. Relations between experimental measures of control cognitive and everyday errors after frontal lobe damage. In preparation.

Rodríguez-Bailón, M., Montoro-Membila, N., García-Morán, T., Ródenas-García, E. & Funes Molina, M.J. Different patterns of everyday errors in Mild Cognitive and Dementia patients. In preparation.

Rodriguez-Bailon, M., Trivino, M., & Lupianez, J. (2012). Executive Attention and Personality Variables in Patients with Frontal Lobe Damage. *Spanish Journal of Psychology, 15*(3), 967-977. doi: 10.5209/rev_SJOP.2012.v15.n3.39388

Rozzini, L., Chilovi, B. V., Conti, M., Bertoletti, E., Delriol, I., Trabucchi, M., & Padovani, A. (2007). Conversion of amnestic Mild Cognitive Impairment to Dementia of Alzheimer type is independent to memory deterioration. *International Journal of Geriatric Psychiatry, 22*(12), 1217-1222. doi: 10.1002/gps.1816

Sbordone, R. (1996). Ecological validity: some critical issues for the neuropsychologist. In R. Sbordone & C. Long (Eds.), *Ecological Validity of Neuropsychological Testing* (pp. 15-41): GR Press/St. Lucie Press, Delray Beach, FL.

Scepkowski, L. A., & Cronin-Golomb, A. (2003). The alien hand: cases, categorizations, and anatomical correlates. *Behavioral and cognitive neuroscience reviews, 2*(4), 261-277. doi: 10.1177/1534582303260119

Schaefer, M., Heinze, H.-J., & Galazky, I. (2010). Alien Hand Syndrome: Neural Correlates of Movements without Conscious Will. *Plos One, 5*(12). doi: 10.1371/journal.pone.0015010

Schmahl, C., & Bremner, J. D. (2006). Neuroimaging in borderline personality disorder. *Journal of Psychiatric Research, 40*(5), 419-427. doi: 10.1016/j.jpsychires.2005.08.011

Schmitter-Edgecombe, M., McAlister, C., & Weakley, A. (2012). Naturalistic Assessment of Everyday Functioning in Individuals With Mild Cognitive Impairment: The Day-Out Task. *Neuropsychology, 26*(5), 631-641. doi: 10.1037/a0029352

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime User's Guide*.

Schwartz, M. F. (2006). The cognitive neuropsychology of everyday action and planning. *Cognitive Neuropsychology, 23*(1), 202-221. doi: 10.1080/02643290500202623

Schwartz, M. F., Buxbaum, L. J., Montgomery, M. W., Fitzpatrick-DeSalme, E., Hart, T., Ferraro, M., . . . Coslett, H. B. (1999). Naturalistic action production following right hemisphere stroke. *Neuropsychologia, 37*(1), 51-66.

Schwartz, M. F., Montgomery, M. W., Buxbaum, L. J., Lee, S. S., Carew, T. G., Coslett, H. B., . . . Mayer, N. (1998). Naturalistic action impairment in closed head injury. *Neuropsychology, 12*(1), 13-28. doi: 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 Disorganization after brain damage - a case study. *Cognitive Neuropsychology, 8*(5), 381-414. doi: 10.1080/02643299108253379

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. doi: 10.1080/09602010244000084

Seidel, G. A., Giovannetti, T., Price, C. C., Tanner, J., Mitchell, S., Eppig, J., & Libon, D. J. (2013). Neuroimaging correlates of everyday action in dementia. *Journal of Clinical and Experimental Neuropsychology, 35*(9), 993-1005. doi: 10.1080/13803395.2013.844773

Sekuler, A. B., Bennett, P. J., & Mamelak, M. (2000). Effects of aging on the useful field of view. *Experimental Aging Research, 26*(2), 103-120.

Seligman, M. E. (1975). *Helplessness: On depression, development and death*. San Francisco: Freeman.

Seligman, M. E., & Weiss, J. M. (1980). Coping behavior: Learned helplessness, Physiological change and learned inactivity. *Behavior Research and Therapy, 18*, 459-512.

Seligman, S. C., Giovannetti, T., Sestito, J., & Libon, D. J. (2013). A New Approach to the Characterization of Subtle Errors in Everyday Action: Implications for Mild Cognitive Impairment. *Clinical Neuropsychologist*. doi: 10.1080/13854046.2013.852624

Simon, J. R., & Craft, J. L. (1972). Reaction time in an oddity task: Responding to the "different" element of a three-light display. *Journal of Experimental Psychology, 92*(3), 405-411. doi: 10.1037/h0032269

Snowden, J., Griffiths, H., & Neary, D. (1994). Semantic dementia - Autobiographical contribution to preservation of meaning. *Cognitive Neuropsychology, 11*(3), 265-288. doi: 10.1080/02643299408251976

Sohlberg, M. M., & Mateer, C. A. (1989). Remediation of executive functions impairments. In M. M. Sohlberg & C. A. Mateer (Eds.), *Introduction to cognitive rehabilitation* (pp. 232-263). New York: Guilford Press.

Soloff, P. H., Meltzer, C. C., Becker, C., Greer, P. J., Kelly, T. M., & Constantine, D. (2003). Impulsivity and prefrontal hypometabolism in borderline personality disorder. *Psychiatry Research-Neuroimaging, 123*(3), 153-163. doi: 10.1016/s0925-4927(03)00064-7

Stapleton, T., & McBrearty, C. (2009). Use of Standardised Assessments and Outcome Measures among a Sample of Irish Occupational Therapists working with Adults with Physical Disabilities. *British Journal of Occupational Therapy, 72*(2), 55-64.

Stemmer, B., Segalowitz, S. J., Witzke, W., & Schonle, P. W. (2004). Error detection in patients with lesions to the medial prefrontal cortex: an ERP study. *Neuropsychologia, 42*(1), 118-130. doi: 10.1016/s0028-3932(03)00121-0

Stuss, D. T., Floden, D., Alexander, M. P., Levine, B., & Katz, D. (2001). Stroop performance in focal lesion patients: dissociation of processes and frontal lobe lesion location. *Neuropsychologia, 39*(8), 771-786.

Stuss, D. T., & Levine, B. (2002). Adult clinical neuropsychology: Lessons from studies of the frontal lobes. *Annual Review of Psychology, 53*, 401-433. doi: 10.1146/annurev.psych.53.100901.135220

Suh, G. H., Ju, Y. S., Yeon, B. K., & Shah, A. (2004). A longitudinal study of Alzheimer's disease: rates of cognitive and functional decline. *International Journal of Geriatric Psychiatry, 19*(9), 817-824. doi: 10.1002/gps.1168

Szatkowska, I., Szymanska, O., Bojarski, P., & Grabowska, A. (2007). Cognitive inhibition in patients with medial orbitofrontal damage. *Experimental Brain Research, 181*(1), 109-115. doi: 10.1007/s00221-007-0906-3

Tan, J. E., Hultsch, D. F., & Strauss, E. (2009). Cognitive abilities and functional capacity in older adults: results form de modified scales of independent behavior - revised. *Clinical Neuropsychologist, 23*(3), 479-500. doi: 10.1080/13854040802368684

Telling, A. L., Meyer, A. S., & Humphreys, G. W. (2010). Distracted by relatives: Effects of frontal lobe damage on semantic distraction. *Brain and Cognition, 73*(3), 203-214. doi: 10.1016/j.bandc.2010.05.004

Tipper, S. P., Howard, L. A., & Jackson, S. R. (1997). Selective reaching to grasp: Evidence for distractor interference effects. *Visual Cognition, 4*(1), 1-38. doi: 10.1080/713756749

Tipper, S. P., Lortie, C., & Baylis, G. C. (1992). Selective reaching – Evidence for action-centered attention. *Journal of Experimental Psychology-Human Perception and Performance, 18*(4), 891-905. doi: 10.1037/0096-1523.18.4.891

Tipper, S. P., Paul, M. A., & Hayes, A. E. (2006). Vision-for-action: The effects of object property discrimination and action state on affordance compatibility effects. *Psychonomic Bulletin & Review, 13*(3), 493-498. doi: 10.3758/bf03193875

Tirapu-Ustarroz, J., Garcia-Molina, A., Luna-Lario, P., Roig-Rovira, T., & Pelegrin-Valero, C. (2008). Models of executive control and functions (I). *Revista De Neurologia, 46*(11), 684-692.

Torralva, T., Roca, M., Gleichgerrcht, E., Lopez, 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. doi: 10.1017/s1355617709990415

Traykov, L., Raoux, N., Latour, F., Gallo, L., Hanon, O., Baudic, S., . . . Rigaud, A.-S. (2007). Executive functions deficit in mild cognitive impairment. *Cognitive and Behavioral Neurology, 20*(4), 219-224.

Trivino, M., Correa, A., Arnedo, M., & Lupianez, J. (2010). Temporal orienting deficit after prefrontal damage. *Brain, 133*, 1173-1185. doi: 10.1093/brain/awp346

Tse, C.-S., Balota, D. A., Yap, M. J., Duchek, J. M., & McCabe, D. P. (2010). Effects of Healthy Aging and Early Stage Dementia of the Alzheimer's Type on Components of Response Time Distributions in Three Attention Tasks. *Neuropsychology, 24*(3), 300-315. doi: 10.1037/a0018274

Tucker, M., & Ellis, R. (1998). On the relations between seen objects and components of potential actions. *Journal of Experimental Psychology-Human Perception and Performance, 24*(3), 830-846. doi: 10.1037//0096-1523.24.3.830

Tyerman, R., Tyerman, A., Howard, P., & Hatfield, C. (1986). The Chessington Occupational Therapy Neurological Assessment Battery: Nottingham: Rehab. Ltd.

Ullsperger, M., Bylsma, L. M., & Botvinick, M. M. (2005). The conflict adaptation effect: It's not just priming. *Cognitive, Affective and Behavioral Neuroscience, 5*(4), 467-472.

van Hoof, J., Kort, H. S. M., van Waarde, H., & Blom, M. M. (2010). Environmental Interventions and the Design of Homes for Older Adults With Dementia: An Overview. *American Journal of Alzheimers Disease and Other Dementias, 25*(3), 202-232. doi: 10.1177/1533317509358885

Wang, K., Fan, J., Dong, Y., Wang, C. Q., Lee, T. M. C., & Posner, M. I. (2005). Selective impairment of attentional networks of orienting and executive control in schizophrenia. *Schizophrenia Research, 78*(2-3), 235-241. doi: 10.1016/j.schres.2005.01.019

Welsh, T. N. (2011). The relationship between attentional capture and deviations in movement trajectories in a selective reaching task. *Acta Psychologica, 137*(3), 300-308. doi: 10.1016/j.actpsy.2011.03.011

Wendt, M., Kluwe, R. H., & Peters, A. (2006). Sequential modulations of interference evoked by processing task-irrelevant stimulus features. *Journal of Experimental Psychology-Human Perception and Performance, 32*(3), 644-667. doi: 10.1037/0096-1523.32.3.644

Weston, A., Barton, C., Lesselyong, J., & Yaffe, K. (2011). Functional deficits among patients with mild cognitive impairment. *Alzheimers & Dementia, 7*(6), 611-614. doi: 10.1016/j.jalz.2010.12.011

Whiting, S., Lincoln, N., Bhavnani, G., & Cockburn, J. (1985). *The Rivermead perceptual assessment battery*. Windsor: NFER-Nelson.

Wilson, B., Cockburn, J., Baddeley, A., & Hiorns, R. (1989). The development and validation of a test battery for detecting and monitoring everyday memory problems. *Journal of Clinical and Experimental Neuropsychology, 11*(6), 855-870. doi: 10.1080/01688638908400940

Wilson, B. A., Evans, J. J., Emslie, H., Alderman, N., & Burgess, P. (1998). The development of an ecologically valid test for assessing patients with a dysexecutive syndrome. *Neuropsychological Rehabilitation, 8*(3), 213-228.

Winblad, B., Palmer, K., Kivipelto, M., Jelic, V., Fratiglioni, L., Wahlund, L. O., . . . Petersen, R. C. (2004). Mild cognitive impairment - beyond controversies, towards a consensus: report of the International Working Group on Mild Cognitive Impairment. *Journal of Internal Medicine, 256*(3), 240-246. doi: 10.1111/j.1365-2796.2004.01380.x

Youngstrom, M. J., Brayman, S. J., Anthony, P., Brinson, M., Brownrigg, S., Clark, G. F., . . . Commission, P. (2002). Occupational therapy practice framework: Domain and process. *American Journal of Occupational Therapy, 56*(6), 609-639.

Zanetti, O., Frisoni, G. B., Rozzini, L., Bianchetti, A., & Trabucchi, M. (1998). Validity of Direct Assessment of Functional Status as a tool for measuring Alzheimer's disease severity. *Age and Ageing, 27*(5), 615-622. doi: 10.1093/ageing/27.5.615

Zapf, D., & Reason, J. T. (1994). Introduction – human errors and error handling. *Applied Psychology-an International Review-Psychologie Appliquee-Revue Internationale, 43*(4), 427-432. doi: 10.1111/j.1464-0597.1994.tb00838.x

Zheng, D., Dong, X., Sun, H., Xu, Y., Ma, Y., & Wang, X. (2012). The overall impairment of core executive function components in patients with amnestic mild cognitive impairment: a cross-sectional study. *Bmc Neurology, 12*. doi: 10.1186/1471-2377-12-138

Zihl, J., & Hebel, N. (1997). Patterns of oculomotor scanning in patients with unilateral posterior parietal or frontal lobe damage. *Neuropsychologia, 35*(6), 893-906. doi: 10.1016/s0028-3932(97)00006-7