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TESIS DOCTORAL

CARACTERIZACIÓN NEUROPSICOLÓGICA DE LA PLANIFICACIÓN EN POLICONSUMIDORES DE DROGAS MEDIANTE UN PROGRAMA "FUNCTION LED"

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“Be gentle with yourself.

You are doing the best you can”

-Unknown

A mi familia, por su distante paciencia, especialmente a Àngela, a quien le debo muchas horas de juego.

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….y al conejo blanco….por hacerme correr mucho…

ÍNDICE

Presentación

El córtex frontal en los humanos es una de las estructuras más desarrolladas en comparación con la de otras especies. En ella se sitúan más de 15 áreas de Brodmann con múltiples conexiones con áreas corticales posteriores y subcorticales (Petrides, Tomaiuolo, Yeterian, & Pandya, 2012). Estas regiones están implicadas con las redes neurales en las que tienen lugar las denominadas funciones ejecutivas, definidas como un conjunto de habilidades cognitivas responsables de procesos de planificación, secuenciación y monitorización de conductas dirigidas a objetivos, toma de decisiones, expresión de la personalidad, comportamiento social, entre otros (Diamond, 2013). Su funcionamiento está estrechamente relacionado con las actividades de la vida diaria (Royall & Palmer, 2014), el funcionamiento académico en niños (Karbach & Unger, 2014) o éxito laboral (Allan & Lonigan, 2011). Las alteraciones de las funciones ejecutivas se asocian con patologías como los problemas de control de impulsos o de planificación, cuya manifiestación es evidente en conductas desadaptativas como los problemas de adicción, obesidad, etc. (Crews & Boettiger, 2009; Miller, Lee, & Lumeng, 2015).

Según la Organización Mundial de la Salud (OMS), la dependencia y consumo de drogas son un problema a escala global que constituye una de las principales causas de enfermedad física y mental, discapacidad, muerte y violencia. El último informe mundial sobre drogas (UNODC, 2014) alerta de que las tasas mundiales permanecen relativamente estables. Entre 162 y 324 millones de personas consumen algún tipo de droga cada año y más de 1,3 millones de europeos acuden a tratamiento, hecho que evidencia el fracaso de las políticas de intervención en materia de drogas.

Desde la neuropsicología, las investigaciones señalan que existe una necesidad creciente en el desarrollo de instrumentos de evaluación, que permitan medir la relación entre las funciones ejecutivas, el consumo de sustancias y los aspectos más ecológicos de la conducta humana (Verdejo-García & Pérez-García, 2007). Además, el ajustado éxito terapéutico en los tratamientos para la adicción anima a explorar nuevas vías de intervención, como la rehabilitación neuropsicológica, dada la relación existente entre el buen funcionamiento ejecutivo y el éxito terapéutico (Stevens et al., 2014).

Así pues, el principal objetivo de esta tesis es estudiar desde una aproximación *function-led* la evaluación de procesos ejecutivos de orden superior y la intervención para mejorarlos en personas en tratamiento comunitario por trastorno por policonsumo de drogas.

Resumen

La presente tesis doctoral está formada por un conjunto de 8 capítulos agrupados en cuatro secciones: (i) introducción, (ii) justificación y objetivos, (iii) memoria de trabajos, (iv) discusión general, conclusiones y perspectivas futuras.

La primera sección de esta tesis consta de tres capítulos en los que se exponen el marco teórico y los antecedentes. El tema central del Capítulo 1 es la planificación y para su exposición se lleva a cabo una definición de las funciones ejecutivas, se explican principales modelos propuestos sobre el funcionamiento de las funciones ejecutivas y su relación con los procesos de planificación y su relevancia en el funcionamiento cotidiano. A continuación se ofrece una visión amplia de las pruebas de evaluación de la planificación, en la que se exploran las principales diferencias psicométricas, estructurales, así como su relación con otros constructos neuropsicológicos y de neuroimagen.

El tema del Capítulo 2 es el consumo de sustancias. En primer lugar se presentan datos epidemiológicos, la relevancia sociosanitaria y las consecuencias más directas para el propio consumidor. A continuación se revisan las principales consecuencias neuropsicológicas derivadas del consumo, especialmente las relacionadas con los procesos de planificación.

En el Capítulo 3 se aborda la situación actual a nivel nacional y europeo sobre los programas de tratamiento en consumo de sustancias y los programas de nueva generación en rehabilitación neuropsicológica.

La segunda sección contiene el Capítulo 4, en el que se exponen la justificación de la tesis, así como las hipótesis y los objetivos que se persiguen en los trabajos experimentales.

La tercera sección contiene tres capítulos con la memoria de trabajo de cada uno de los tres estudios empíricos realizados. En el Capítulo 5 se presenta el estudio de validación y adaptación de la tarea de planificación de baja estructura denominada Multiple Errands Test – Contextualized Version (MET–CV). En este estudio participaron 60 policonsumidores de sustancias en tratamiento comunitario y 30 controles sanos. Los resultados mostraron que la versión MET–CV se adaptó a los distintos contextos físicos con buenos niveles de fiabilidad y validez de constructo. Los resultados también mostraron que el MET-CV permite discriminar la ejecución entre población adicta y población sana con mayor claridad que las tareas neuropsicológicas tradicionales.

El Capítulo 6 muestra el estudio en el que se describen las diferencias estructurales entre tareas de planificación tradicionales o de laboratorio (Stocking of Cambridge y Mapa del Zoo) y la tarea de planificación natural (MET-CV). Además los hallazgos sobre la contribución de variables de consumo y de inteligencia en cada una de las pruebas, demuestran que el consumo de sustancias deteriora la ejecución en las tareas de planificación, mientras que la inteligencia contribuye en sentido positivo. Entre los principales hallazgos destacaron que la contribución de estas variables en la ejecución de la planificación medida con el MET-CV es notablemente superior a la de las demás pruebas, y que además en ella interviene la inteligencia cristalizada, que no se hallaba entre las variables independientes de los modeles explicativos de las otras tareas. En el Capítulo 7 se expone el estudio sobre la eficacia del programa Goal Management Training + Mindfulness Meditation en la mejora cognitiva y su transferencia a las actividades de la vida diaria en un grupo de policonsumidores de sustancias en tratamiento comunitario. Los resultados obtenidos indicaron que, respecto al grupo que sólo recibió el tratamiento estándar, la intervención experimental produjo una mejora en los procesos de memoria de trabajo, de reflexión/impulsividad en la toma de decisiones y de regulación emocional. Además se produjo una transferencia positiva a las actividades de la vida diaria, explicada por la aplicación de las estrategias metacognitivas aprendidas, que actúan como procesos arriba-abajo que posibilitan el encadenamiento de las conductas, evitando de esa forma las distracciones que provocan la negligencia en el logro de los objetivos.

En la última sección de la tesis, correspondiente al Capítulo 8, se lleva a cabo la discusión general conjunta de los tres estudios empíricos previos. En este apartado se incluyen las principales implicaciones teóricas y clínicas, las conclusiones y se proporcionan perspectivas de trabajo futuro.

I. INTRODUCCIÓN

Capítulo 1

Funciones ejecutivas y planificación

1. Definición y conceptos introductorios

Las funciones ejecutivas son un conjunto de habilidades cognitivas responsables de la planificación, iniciación, secuenciación y monitorización de conductas dirigidas a objetivos complejos (Royall & Palmer, 2014). Dicho de otro modo, son las capacidades que permiten a las personas enfrentar de forma efectiva nuevos objetivos de naturaleza cognitiva o socioemocional (Barkley, 2001).

El estudio de las funciones ejecutivas y su relación con la autorregulación de la conducta humana tiene origen en el caso de Phineas Gage, descrito por el médico John Harlow (1896). La historia de Phineas Gage es conocida debido al aparatoso accidente que sufrió mientras realizaba trabajos en la construcción de vías de ferrocarril, en el que debido a un error manipulando explosivos utilizados para realizar excavaciones provocó que la barra de metal que manejaba terminase atravesando su cráneo, en concreto su lóbulo frontal izquierdo, a pesar de la gravedad Phineas Gage sobrevivió. Por aquel entonces la descripción que se tiene de Phineas Gage es básicamente médica, pero algunos fragmentos sobre su conducta inspiraron a los futuros médicos y psicólogos a establecer relaciones entre los lóbulos frontales y el comportamiento ejecutivo. Así pues Harlow describe: "*Sus contratistas, quienes lo consideraban como el hombre más eficiente y capacitado para su trabajo antes del accidente, no pudieron devolverle su trabajo nunca más. El equilibrio, el habla o sus facultades intelectuales parecían haber sido destruidas*", "*ideaba muchos planes de futuro, de manera poco organizada y que enseguida abandonaba…*".

Años después, gracias a las aportaciones de Alexander Luria, considerado el propulsor de la neuropsicología moderna, comenzó el estudio de los procesos cognitivos y su relación con las estructuras cerebrales, dando lugar con el paso de las décadas al estudio de las funciones ejecutivas (Haggbloom et al., 2002). En la actualidad, aunque existe un consenso general sobre la definición de funciones ejecutivas, el debate sobre su organización y estructura ha dado lugar a múltiples modelos teóricos que ofrecen diversas perspectivas explicativas. Algunos modelos entienden las funciones ejecutivas como un constructo único, como el modelo de memoria de trabajo de Baddeley y Hitch (1974) o el modelo de inteligencia general de Sperman (1904). En cambio, otros modelos definen las funciones ejecutivas como un conjunto de habilidades en las que pueden diferenciarse varios componentes, como el modelo de sistema atencional supervisor de Norman y Shallice (1980) o el modelo factorial de Miyake (2000).

Los modelos no unitarios tienen el apoyo de los estudios de neuroimagen que confirman que no existe un ejecutivo central y que los lóbulos frontales se dividen en diferentes zonas encargadas de funciones concretas, que pueden ser agrupadas en dos ejes anatomicofuncionales, uno encargado de la regulación emocional y conductual y el otro integra las funciones metacognitivas (Stuss, 2011). Muchos de los modelos teóricos también comparten una descripción jerárquica de las funciones ejecutivas, con existencia de componentes o estructuras moleculares que actúan en conjunto para facilitar procesos cognitivos complejos o molares. Uno de los modelos más famosos debido a su apoyo empírico es el modelo factorial de Miyake y cols., (2000) basado en un modelo de ecuaciones estructurales que sustenta la existencia de tres componentes principales, memoria de trabajo (habilidad de mantener de la información en mente para trabajar con ella, manipulando ideas y relacionándolas con lo aprendido), inhibición (habilidad para resistirse a impulsos tentadores y realizar lo que es más apropiado en ese momento) y flexibilidad (capacidad para cambiar las perspectivas o el foco de atención, pensando “fuera de la caja” para resolver un problema). Estos constructos correlacionaban moderadamente entre ellos, pero eran claramente distinguibles. Además el modelo permitía diferenciar estos constructos de otros más complejos, como la planificación, sugiriendo que las funciones ejecutivas eran un componente diversificado pero que a su vez se organizaban entre ellos para dar lugar a procesos superiores o de alto orden como el razonamiento o la planificación.

La atención de los investigadores ha recaído principalmente en los constructos moleculares de las funciones ejecutivas, debido a su especificidad y operatividad para ser estudiadas. Sin embargo, son los procesos de orden superior los que más se relacionan con aspectos importantes de la vida diaria (Royall et al., 2007). Por ejemplo, la capacidad de autorregulación y de organización de la conducta dirigida al logro de una meta se relacionan con el éxito académico, en el que existe una creciente evidencia de que las funciones ejecutivas son buenos predictores de las habilidades matemáticas o literarias en niños(Allan & Lonigan, 2011; Blair & Razza, 2007), en cambio en adultos determinan el éxito laboral (Carlson, Mandell, & Williams, 2004; Gonzalez et al., 2014).

1.1 Planificación y solución de problemas.

La planificación es considerada un proceso de alto orden dentro de las funciones ejecutivas. El término de planificación ha sido un concepto cambiante, términos como planificación, solución de problemas o multitarea, entre otros, son usados de manera intercambiable, dando lugar a diferentes interpretaciones a la hora de definir estos procesos neuropsicológicos, hecho que ha dificultado la evaluación e intervención.

La solución de problemas se considera sinónimo de planificación en la literatura neuropsicológica. Ambos se utilizan para describir los esfuerzos para adaptarse en situaciones novedosas que requieren habilidades o estrategias poco comunes. Afrontar un problema implica la intencionalidad de alcanzar un objetivo específico mediante un proceso donde los pasos para resolverlo son inciertos, desconocidos y/o necesitan ser ejecutados en un orden concreto. Es decir la planificación requiere de una toma de decisiones previa que facilite la consecución de un objetivo (Unterrainer & Owen, 2006).

Sternberg (2001) apunta que en la solución de problemas están envuelto las habilidades de pensamiento de alto orden (higher-order thinking skills). Estas habilidades estarían implicadas en gran variedad de tareas como averiguar el problema mecánico de un coche, diagnosticar la enfermedad de un paciente o enseñar a resolver un problema matemático a los niños en la escuela. Sin embargo, las situaciones cotidianas son tan variadas y diversas que las habilidades específicas necesarias para resolver los problemas de la vida diaria varían según el objetivo a alcanzar. A pesar de que la naturaleza del proceso de planificación pueda ser distinta según la situación, todos los problemas tendrían una estructura común dividida en: (1) un estado inicial donde la persona clasifica los datos disponibles; (2) un objetivo o la solución del problema que la persona quiere alcanzar y (3) los pasos que se deben dar para transformar el estado inicial hasta llegar al objetivo final.

Otros autores como Anderson (2001) dividen la solución de problemas en: (1) un objetivo, por el que la conducta se organiza para alcanzarlo; (2) subobjetivos en los que se desmenuza el objetivo principal; (3) operadores, que son las acciones que transforman el estado del problema en otro estado. Goel (2010) describe que la solución de problemas consta de las siguientes condiciones: (1) hay dos distintos estados del problema, (2) la persona se encuentra en un estado y quiere estar en otro estado, (3) no hay una aparente forma de cambiar de estado de forma clara, (4) la persona consigue llegar al estado deseado mediante una guía multipasos conscientemente guiada.

Más allá de la estructura de los procesos de planificación, los procesos cognitivos implicados en la solución de problemas, o dicho de otra forma, el tipo de operadores utilizados, ha recibido gran atención. Los mecanismos de resolución son variados pero han sido divididos en dos sistemas principales. El primer sistema (tipo 1), se considera automático, rápido y con bajo coste de recursos. Este sistema contribuye a la toma de decisiones basada en la experiencia y sería independiente de la habilidad cognitiva, conduciendo a menudo a proporcionar respuestas sesgadas. Al contrario del tipo 2, que sería un sistema lento, controlado, analítico, racional, que consume mayor cantidad de recursos y ligado a la habilidad cognitiva. Este sistema tendría una capacidad limitada y estaría basado en la aplicación de reglas, es decir es un sistema reflexivo (Sowden, Pringle, & Gabora, 2015).

Lo heurística sería el método predominante en el sistema tipo 1. Los heurísticos son definidos como métodos o técnicas que ignoran parte de la información, con el objetivo de tomar decisiones más rápidas, y con menor coste de recursos que con métodos más complejos y costosos, esto tiene el inconveniente de que no se puede estar seguro de que una respuesta sea resolutoria del problema. El estudio de los heurísticos en humanos, ha sido abordado principalmente por la psicología social, debido a que estos están implicados en muchos juicios y toma de decisiones (Capraro, Jordan, & Rand, 2014). Un ejemplo, sería cuando queremos juzgar o predecir el comportamiento de un individuo perteneciente a un colectivo determinado; los estereotipos nos permiten tomar una serie de atajos mentales que nos aportan información, aunque esta sea poco representativa, e ignore datos objetivos de frecuencia y probabilidad.

Los heurísticos están condicionados según diversos factores, por ejemplo; la evolución, que predispone a las abejas donde localizar una nueva colmena, o el aprendizaje, pues a pesar de que los heurísticos ignoran parte de la información, el conocimiento previo influye en estos, alterando la estrategia a utilizar; del mismo modo el aprendizaje social influye en la imitación y aprendizaje explícito de heurísticos. Otros procesos como la memoria también tienen un papel muy importante en el uso de estos y han sido relacionados con la "racionalidad ecológica". El estudio de la racionalidad ecológica de los heurísticos, o estrategia en general, se presenta como un nuevo marco: "Un heurístico es racionalmente ecológico en el grado en el que se adapta a la estructura de su ambiente", hecho que señala la importancia del contexto en la solución de problemas (Gigerenzer, 2002).

El otro sistema de resolución de problemas, más consciente, analítico, costoso y lento estaría basado en el uso de reglas o algoritmos. Un algoritmo es definido como el conjunto ordenado y finito de operaciones que permite hallar la solución de un problema. Este método de resolución, resulta efectivo porque la solución siempre es encontrada, pero es muy costoso, pues depende del número de operaciones a aplicar. Este nivel de procesamiento tiene la capacidad de abstraer y descontextualizar la información, mediante el uso de reglas presentes en la memoria de trabajo. Este segundo sistema precedería al primero basado en heurísticos, que sería encargado de inhibir las respuestas, monitorizando y corrigiendo los juicios intuitivos. Por ejemplo, tendemos a juzgar a personas de un colectivo determinado mediante heurísticos (estereotipos), pues nos aportan cierta información de forma rápida, aunque no sea ni representativa ni veraz. En cambio juzgar a una persona por una condición determinada mediante algoritmos implicaría, evaluar y juzgar a cada miembro de ese colectivo, y aunque esta estrategia permitiría tomar una decisión más justa, resultaría prácticamente imposible por la gran cantidad de tiempo que se necesitaría. A pesar de ello algunos estudios han demostrado que el procesamiento del primer sistema sería predominante a la hora de enfrentarse a tareas complejas y poco estructuradas, donde las probabilidades son inciertas, como puede ser la toma de decisiones médicas (Hicks & Kluemper, 2011). Los problemas de la vida diaria son lo suficientemente variados y complejos para que en diferentes ocasiones y en mayor o menor medida sea necesario que ambos tipos de procesamiento intervengan, con sus diferentes niveles de automatismo, velocidad y uso de recursos.

Más allá de los hallazgos en el campo de la psicología cognitiva del razonamiento y solución de problemas. La neuropsicología de las funciones ejecutivas ha dado cabida a estos dos niveles de procesamiento. El modelo del Sistema Atencional Supervisor (SAS) propuesto por Norman y Shallice (1980) distingue entre dos mecanismos diferenciados, uno de control y otro de acción. El primero denominado "contention scheduling" se encarga de responder ante problemas aprendidos y rutinarios que pueden ser resueltos de forma automática. El segundo mecanismo del SAS se activa ante situaciones complejas y novedosas en las que los esquemas de acción aprendidos previamente no pueden ser aplicados y que requieren de nuevos planes de acción deliberados. Otros modelos de función ejecutiva también incluyen elementos similares al SAS como es el caso del Ejecutivo central de la propuesta de Baddeley, el cual distingue entre conductas que responden ante demandas previamente aprendidas y otras conductas ante situaciones novedosas (Baddeley, 2000). La relevancia de estos modelos recae en que aportan una nueva forma de entender la solución de problemas, pues dan cabida a distinguir entre conductas complejas que movilizan un gran número de recursos cognitivos para facilitar el autocontrol y otras conductas que a pesar de ser también complejas, se ejecutan con cierto automatismo.

2. Instrumentos de evaluación

La evaluación neuropsicológica consiste en la evaluación normativa de diversas habilidades cognitivas (memoria, atención, solución de problemas…), normalmente realizadas mediante una batería de tests, con el fin de obtener información diagnóstica, evaluación de la repuesta a un tratamiento o la predicción del funcionamiento cotidiano (Harvey, 2012). En la actualidad se dispone de una amplia gama de pruebas, pero como se ha señalado anteriormente, los constructos de orden superior son más complejos y multicompuestos por lo que no resulta fácil desarrollar instrumentos válidos y fiables para su medida. En el caso concreto de la planificación, las tareas neuropsicológicas de evaluación son escasas. Muchas de ellas fueron desarrolladas hace décadas con fines exclusivamente de investigación, como la Torre de Londres. Actualmente estas tareas reciben críticas por su escasa semejanza con los procesos de planificación en situaciones cotidianas y se asocian al estudio de la planificación en contextos científicos y artificiales (Burgess et al., 2006; Goel & Grafman, 2000). En el intento de superar estas limitaciones se han realizado esfuerzos para desarrollar tests que permitan evaluar esta habilidad ejecutiva de forma más precisa y facilitar la predicción de habilidades funcionales relevantes en la vida cotidiana. Un ejemplo del fruto de esos intentos es el Multiple Errands Test (Shallice & Burgess, 1991).

A pesar de que las dos tareas mencionadas se centran en evaluar la planificación, las diferencias entre ellas son notables. Basándonos en la clasificación propuesta por Reitmann (1964), las tareas pueden ser diferenciadas según su estructura; por un lado se encontrarían las tareas desarrolladas en contextos artificiales o de laboratorio llamadas de alta estructura, como la Torre de Londres. Por otro lado estarían las desarrolladas en contextos naturales o consideradas de baja estructura, como el Multiple Errands Test, las cuales presentan características similares a las actividades de la vida diaria (Reitmann, 1964).

Los principales factores estructurales que diferenciarían unas tareas de otras dependerían del *estado inicial del problema*, el *objetivo* y la *transformación* aplicada para su resolución. Según Reitman (1964) los problemas altamente estructurados presentan un estado inicial claramente definido, los elementos que componen la tarea están presentes y la información que se tiene sobre ellos es completa (por ejemplo, los laberintos clásicos, son problemas con un punto de inicio y de finalización concretos, en el que el espacio está marcado claramente y en el que la persona conoce toda la información, que tiende a resumirse en que se debe encontrar la salida sin atravesar las paredes que conforman el laberinto). En cambio, en los problemas cotidianos o de baja estructura no existe un *estado inicial* definido (por ejemplo al planificar una fiesta de cumpleaños, se desconoce información relevante como el hambre tendrán los asistentes o las actividades de ocio que son del agrado de todos). Respecto al *objetivo* del problema, las tareas de alta estructura tienen un objetivo claramente definido en las instrucciones, por lo que no hay cabida a interpretaciones individuales (por ejemplo, salir del laberinto), en cambio en los problemas de baja estructura los objetivos presentan cierta ambigüedad (siguiendo el ejemplo anterior del cumpleaños, el objetivo no estaría claro ya que se desconoce información importante sobre la fiesta de cumpleaños, ¿se pretende tener una charla agradable mientras se merienda? ¿o sería más apropiado realizar actividades de ocio como juegos de mesa o escuchar música?). En la misma dirección la forma de resolver el problema o dicho de otro modo, la *transformación del problema,* está claramente marcada por las instrucciones en los problemas altamente estructurados. Esto además conlleva que las soluciones aportadas puedan definirse de forma clara, como respuestas correctas o incorrectas (por ejemplo, se ha conseguido salir del laberinto, no se ha podido salir del laberinto). En cambio en los problemas de baja estructura no existen soluciones correctas o incorrectas, pues la resolución depende de múltiples variables personales, sociales, económicas, etc. (en el ejemplo anterior, la fiesta de cumpleaños podría celebrarse en una casa, en un restaurante, etc. sin implicar que una solución sea más o menos correcta que otra).

También existirían otras variables discriminativas como el grado de interconectividad entre las partes del problema, las cuales son lógicas en los de alta estructura, pues para llegar al objetivo final hay que avanzar a través de distintos subobjetivos necesarios. Sin embargo en los problemas de baja estructura no existe una interconectividad clara, puesto que podríamos olvidarnos de comprar la tarta de cumpleaños y esto no significaría que la fiesta dejase de celebrarse. Finalmente el grado de descomposición que requiere el problema sería mucho mayor en los problemas de baja estructura, debido tanto a la complejidad del problema, como a la falta de información, condiciones que no suelen estar presentes en los problemas de laboratorio o altamente estructurados.

2.1 Instrumentos clásicos de alta estructura

Los problemas de Torres

Los problemas de torres son las pruebas neuropsicológicas clásicas más conocidas y empleadas para medir la planificación. Actualmente existen diferentes versiones pero todas ellas tienen su origen en la Torre de Hanoi. Originalmente concebido como un juego o problema, creado por el matemático francés Edouard Lucas (Gardner, 1983), ha sido objeto de discusión en el campo de las matemáticas a lo largo de la historia (Anglin, 1990). No fue hasta 1932 cuando empezó a emplearse para estudiar la influencia de las instrucciones verbales en la resolución de problemas y su relación con componentes cognitivos como el aprendizaje o la inteligencia (Ewert & Lambert, 1932). Durante las siguientes décadas surgieron diversos estudios que analizaron la solución de problemas utilizando tareas basadas en los problemas de torres como los "Problemas de jarras de agua" (Luchins, 1942) o "El problema de misioneros y caníbales" (Reed, Ernst, & Banerji, 1974), pero no fue hasta la década de los 70 cuando gracias al auge de la psicología experimental se empezó a formalizar el estudio de la planificación (o de los procesos ejecutivos superiores) con una mayor calidad metodológica. Siendo Herbert Simon el primer autor en emplear la Torre de Hanoi con el fin de estudiar los procesos cognitivos subyacentes en este tipo de tareas (Simon, 1975).

La tarea Torre de Hanoi consta de tres bastones con tres discos de distinto tamaño apilados uno encima de otro formando una pequeña pirámide. El objetivo consiste en mover los tres discos a otro bastón sin quebrantar la regla de que ningún disco puede situarse sobre otro disco de menor tamaño. La Torre de Hanoi inspiró el desarrollo de otras tareas de planificación como la Torre de Londres, una de las tareas que más atención recibe por parte de clínicos e investigadores. La Torre de Londres fue desarrollada por Shallice y McCarthy (ver, Shallice, 1982) como una aplicación de la teoría de la inteligencia artificial en la neurociencia cognitiva. Aunque esta tarea puede parecer similar a la Torre de Hanoi existen diferencias destacables entre ellas. La Torre de Londres consta de tres bastones en el que se sitúan tres bolas de diferente color, al participante se le presenta una estructura donde las bolas están situadas en una posición determinada, llamado problema final; y también un problema inicial en el que las bolas están dispuestas en una posición diferente a la del problema final. El objetivo consiste en mover las bolas de una en una y situarlas en la misma posición que el problema final, todo ello con el menor número de movimientos posibles. Esta tarea permite formular problemas de distinta dificultad, marcados por el número de movimientos a realizar.

Posteriormente se han desarrollado diferentes versiones, aunque todas ellas conservan la misma estructura, siendo versiones isomórficas, algunos ejemplos son la Torre de Toronto (Pitel et al., 2007), la Torre de Londres DX (Culbertson & Zillmer, 1998) o versiones por ordenador como el Stocking of Cambridge (SOC) (CANTAB, Cambridge Cognition Ltd., 1999). Del mismo modo, también se han adaptado tareas que son similares a la Torre de Hanoi, como la Delis-Kaplan Executive Function System Tower Test (D-KEFS-TT) (Culbertson & Zilmer, 2001), compartiendo la misma estructura de discos y reglas.

One-Touch Tower of London (Adrian M. Owen et al., 1995)

El One-Touch Tower of London es una tarea basada en la Torre de Londres. Perteneciente a la batería Cambridge Cognition (CANTAB), se considerada que permite evaluar la capacidad de planificación espacial y memoria de trabajo. Con una estructura isomórfica a la Torre de Londres, el objetivo de esta tarea consiste en averiguar la cantidad de movimientos que serían necesarios para igualar el estado inicial del problema al del estado final. La complejidad de la tarea se mide según el número de movimientos a realizar.

Mapa del Zoo (Wilson et al., 1996)

Una de las críticas que han recibido los problemas de torres es su escasa semejanza con las actividades de la vida diaria. Por este motivo se desarrollaron nuevas pruebas que representasen mejor los procesos de planificación cotidianos. Las características principales son que la información que se maneja es ecológica y que su nivel de estructuración es menor, con información más ambigua, reglas quebrantables o una interconectividad menos marcada. Una de las tareas más conocidas es "El mapa del Zoo", que junto con otros cinco subtests conforman la batería Behavioural Assessment of the Dysexecutive Syndrome (BADS). Esta batería fue creada para evaluar el síndrome disejecutivo de forma ecológica en personas con daño cerebral adquirido. Este subtest consiste en un mapa de un zoo con instrucciones que señalan una serie de lugares a visitar, con unas reglas que deben cumplirse. Una de las particularidades de esta prueba es que consta de dos versiones, una parte considerada de alta demanda y otra de baja demanda. En la primera versión, los objetivos y las reglas tienen baja estructura, es decir a priori la solución del problema es compleja siendo necesario que el participante reestructure la información disponible para construir los objetivos marcados y sin romper las reglas. En cambio en la segunda parte o de baja demanda, se proporciona mayor información que en la parte de alta demanda. Esta información, ayuda al participante a conseguir el objetivo de la tarea, sin romper ninguna regla, simplemente con seguir los pasos marcados en las instrucciones. Así pues, a diferencia de los problemas de torres, el Mapa del Zoo permite discriminar entre un problema poco estructurado (alta demanda) y otra altamente estructurado (baja demanda).

Test de la búsqueda de las llaves (Wilson et al., 1996)

Otro test perteneciente a la batería BADS es el Test de la búsqueda de las llaves. Es considerado una tarea de planificación pero en el que se evalúa concretamente la aplicación de una estrategia. En este test se pide a los participantes que desarrollen un plan de acción para encontrar unas llaves que se han perdido dentro de un terreno (representado por un cuadrado). El resultado de la tarea depende del patrón de búsqueda que haya realizado, teniendo en cuenta aspectos como lugar de entrada y salida en el cuadrado, eficacia de la estrategia, capacidad de abordar todo el cuadrado o el patrón de búsqueda. Estas condiciones, señalan que el grado de estructuración es menor al de los problemas clásicos de torres, pues la respuesta al problema es abierta sin existir un feedback claro sobre el éxito de la respuesta.

Plan a Day (Funke & Krüger, 1995)

Otra tarea que persigue los mismos cometidos que el Mapa del Zoo es la prueba "Plan a Day". Esta tarea de ordenador, fue creada con el fin de desligar las habilidades de planificación del componente visuoespacial tan marcado en otros test neuropsicológicos. Mediante un mapa el participante debe planificar un día de trabajo realizar una serie de tareas, en las que debe priorizar determinados objetivos o controlar el tiempo de los desplazamientos, entre otros.

Porteus Maze Test (Porteus, 1933)

Desarrollado por el profesor Stanley Porteus, este test no verbal permite evaluar la capacidad de planificación y visión de futuro. Los participantes deben de trazar con un lápiz una serie de laberintos que van aumentando de dificultad. El participante debe de trazar el camino sin traspasar las líneas marcadas y sin caer en callejones sin salida. Posteriormente han salido varias versiones actualizadas o pertenecientes a otras baterías, como el Mazes test (Stern, 2003) de la bateria Neuropsychological Assessment Batery (NAB). De naturaleza similar, consta en siete laberintos de diferente dificultad y tiene versiones paralelas que evitan el efecto retest.

2.2 Tareas de baja estructura

Como se ha señalado anteriormente, a diferencia de las tareas de alta estructura, las de baja estructura se caracterizan por tener unas condiciones estructurales (estado inicial del problema, objetivo, transformación, reglas, solución, estructura e interconectividad) ambiguas, poco precisas e inestables, debido principalmente a la falta de información.

En este grupo conviene diferenciar dos grupos de tareas, las de realidad virtual y las ejecutadas en un ambiente real con actividades cotidianas.

Los avances tecnológicos han permitido desarrollar entornos virtuales parecidos al mundo real, permitiendo crear tareas que simulan actividades naturales y testar su validez ecológica. El uso de realidad virtual ha facilitado la investigación, evaluación y tratamiento en el campo de la neuropsicología. La posibilidad de crear contextos virtuales parecidos a los reales, así como la facilidad para controlar y manejar las condiciones por parte de los examinadores, permite una evaluación con una gran gama de posibilidades de interacción entre las personas y el entorno, que no ofrecen las herramientas clásicas (Schultheis, Himelstein, & Rizzo, 2002).

La mayoría de los estudios mediante realidad virtual se han llevado a cabo con pacientes con daño cerebral (Canty et al., 2014; Zhang et al., 2003), pero también los hay con personas con síndrome obsesivo compulsivo (La Paglia et al., 2014), adicciones (Paraskevaides et al., 2010) o esquizofrenia (La Paglia et al., 2013). Aunque los resultados en general permiten que se logren los objetivos propuestos por los estudios, la realidad virtual presenta una serie de limitaciones, por ejemplo, la variedad de paradigmas utilizados, que dificulta la comparación entre los estudios. En lo que respecta a la estructura de las tareas, a pesar de tener un grado de estructura bajo, aun distan de las actividades de la vida diaria en algunos aspectos. Por ejemplo, la complejidad de un contexto real es mucho mayor a uno virtual (por ejemplo en parámetros como la intromisión de distractores no controlados), la transformación o forma de resolver el problema se realiza a través de mecanismos virtuales y no reales (manejo del ratón o controladores), que pueden ignorar parte de las habilidades cognitivas implicadas en estas tareas y añadir otros nuevos asociados al manejo del propio entorno virtual. Finalmente sigue existiendo artificialidad en sus elementos, siendo difícil evaluar de una forma realmente ecológica determinadas conductas de interacción social o manejo de recursos.

En el segundo grupo de pruebas con tareas de baja estructura se situarían las que se ejecutan en ambientes reales y que exigen la realización de una o varias actividades de la vida diaria (orientación en el espacio-tiempo, manejo de dinero, búsqueda de información…). Dentro de ellas conviene distinguir las tareas se centran en actividades cotidianas más concretas o unitarias, como la preparación de un café (Cooper & Shallice, 2000) o de una merienda *[test Rabideau Kitchen Evaluation – Revised]* de Yantz, Johnson-Greene, Higginson, & Emmerson (2010). Los estudios centrados en una sola tarea han permitido establecer relaciones entre esas actividades de la vida diría y diversos dominios neuropsicológicos. Por otro lado estarían las pruebas basadas en tareas que se desarrollan en un contexto real que incluyen varios quehaceres y no solo una actividad en concreta. Entre todas las pruebas de este tipo, la que más estudios y repercusión está teniendo en el campo de la neuropsicología es el Multiple Errands Test-MET (Shallice & Burgess, 1991). Esta prueba fue desarrollada para detectar y evaluar los déficits de ejecución en actividades cotidianas en pacientes con daño cerebral. El MET presenta unos elementos estructurales característicos de las pruebas de baja estructura, tiene múltiples objetivos y el estado inicial del problema es ambiguo, dejando una interpretación abierta al participante acerca de cómo alcanzarlos. La transformación del problema es compleja y variada, ya que al administrarse en un contexto natural y tener múltiples objetivos, se deben poner en marcha diversas habilidades que incluyen manejo de dinero, orientación en el espacio y tiempo, habilidades de búsqueda de información, etc. Además esta prueba presenta características diferenciales respecto a otras pruebas tradicionales, como su duración que suele ser mayor, o el papel activo de los participantes pues por ejemplo determinan el cuando comienza la tarea y cuando termina, en cambio el examinador tiene un papel pasivo de mero observador, sin interactuar durante la prueba y sin facilitar feedback sobre la ejecución.

El MET ha sido adaptado a diferentes contextos como el entorno de un hospital (Knight, Alderman, & Burgess, 2002) o un centro comercial (Alderman, Burgess, Knight, & Henman, 2003). El test consiste en realizar una serie de actividades cotidianas como hacer unas compras, obtener diversos tipos de información o acudir a una cita en un lugar y momento determinado. Durante la ejecución el participante recibe una serie de reglas escritas que debe de seguir, aunque también al evaluar la ejecución se tendrá en cuenta el cumplimiento de reglas no explicitadas como el respeto de las reglas sociales implícitas para ese contexto, como aguardar el turno en una cola de espera, etc. La corrección del MET se lleva a cabo mediante un registro de la observación natural del comportamiento. Las conductas se consideran incorrectas cuando obedecen a 4 tipos de errores: 1) fallos de tarea, cuando no se alcanza el objetivo especificado para la tarea concreta; 2) ineficiencias, cuando de una forma lógica y sencilla se hubiese podido llevar a cabo una estrategia más efectiva que la que ha puesto en marcha para resolver cualquier aspecto de una tarea; 3) malinterpretaciones, cuando el objetivo de una tarea no se comprendió y la persona ha puesto en marcha actuaciones en caminadas a lograr un objetivo diferente; y 4) ruptura de reglas, cuando una de las reglas específicas del ejercicio o cualquier otra regla social no se cumple. También se registran las conductas que indican el uso de distintas estrategias encaminadas a alcanzar objetivos.

El MET ha demostrado su efectividad para discriminar entre pacientes con daño cerebral (Cuberos-Urbano et al., 2013), esclerosis múltiple (Roca et al., 2008), simuladores (Castiel, Alderman, Jenkins, Knight, & Burgess, 2012), esquizofrenia o transtorno bipolar (Caletti et al., 2013) respecto la ejecución de controles sanos.

Además, las variables resultados del MET ha permitido establecer perfiles neuropsicológicos concretos; Alderman (2003) halló que los pacientes con daño cerebral que mostraban fallos de tarea, presentaban problemas de intencionalidad y apatía, mientras que los que se caracterizaban por romper las reglas, mostraban problemas de memoria.

Aunque el MET ha recibido gran parte de la atención, existen otras tareas similares como el *Amap Task*. Esta tarea desarrollada tras el MET, es una tarea de baja estructura que se realiza en un apartamento real. Durante el test, el participante debe de realizar algunas tareas como colocar objetos en una determinada localización, o recabar información del contexto. A diferencia del MET, esta tarea tiene una duración determinada de 10 minutos (Sanders & Schmitter-Edgecombe, 2015).

2.3 Otras tareas de planificación y alto orden.

Como hemos señalado, los constructos ejecutivos de alto orden se caracterizan por su complejidad, debida en parte a la necesidad de implicación de componentes de primer orden como memoria de trabajo, inhibición y flexibilidad que deben participan de una forma coordinada para el logro de una meta final. Esta complejidad puede llevar a que constructos de alto orden como planificación y multitarea se utilicen como si fuesen intercambiables o muy cercanos conceptualmente. Para intentar arrojar un poco de claridad, definiremos la multitarea como la habilidad que permite la consecución de múltiple objetivos en el mismo periodo de tiempo, cambiando la atención entre las distintas tareas individuales (Delbridge, 2000). Esta definición tiene algunas similitudes con las definiciones de planificación aportadas anteriormente. Por un lado, ambos constructos tienen una visión prospectiva, es decir, el objetivo a conseguir no está en el momento presente y hay que realizar determinadas operaciones para avanzar temporalmente gracias a la realización de transformaciones en el problema hasta llegar a la forma final o meta. Por otro lado, ambos constructos con frecuencia persiguen alcanzar múltiples objetivos. A pesar de las similitudes, las investigaciones realizadas hasta el momento indican discrepancias en la naturaleza del constructo multitarea y en su relación con la planificación. Por ejemplo, en estudios que han empleado ecuaciones estructurales para determinar los componentes implicados en la multitarea muestran una alta relación entre ésta y la planificación, la memoria prospectiva y la memoria a largo plazo (Burgess, Veitch, Costello, & Shallice, 2000). En cambio, otros señalan que son la inteligencia fluida, la atención y la memoria de trabajo, los predictores de la multitarea (König, Bühner, & Mürling, 2005), excluyendo a la planificación.

Este solapamiento teórico y la falta de estudios esclarecedores han llevado a los investigadores a asignar arbitrariamente los constructos cognitivos implicados en la ejecución de algunos tests. Por ejemplo, el MET era considerado anteriormente una “tarea de planificación de múltiples sub-objetivos” (Shallice & Burgess, 1993), en cambio posteriormente pasó a considerarse una prueba de “multitarea”, en referencia a las tareas que tenía que llevar a cabo en el espacio el astronauta Jerry Lineger.

Un ejemplo es la tarea *Modified Six Elements Test* (Wilson, Alderman, Burgess, Emslie, & Evans, 1996). En esta tarea se le pide al participante que realice tres actividades sencillas (operaciones matemáticas simples, denominación de objetos dibujados y hablar sobre sus vacaciones), cada una de ellas dividida en dos partes similares, constituyendo así los seis elementos del test. Disponen de 10 minutos (visibles en un cronómetro) para lograr el objetivo de hacer algo de cada uno de los 6 elementos y tan solo se le pide que cumpla una regla consistente en que al cambiar de un elemento a otro, debe de hacerlo de manera que la nueva actividad elegida no sea de la misma naturaleza que la anterior. Desarrollada originalmente por Shallice y Burgess (1991), en la actualidad se utiliza con propósitos difusos como evaluar la multitarea (Fernández-Serrano, Pérez-García, Perales, & Verdejo-García, 2010), la multitarea y la planificación (Norris & Tate, 2000); la planificación, la monitorización y la aplicación de estrategias (Siklos & Kerns, 2004) o la planificación y la atención dividida (Moriyama et al., 2002). Otro ejemplo es el *Tile Manipulation Test* (Haaxma et al., 1993), descrito por algunos autores como una tarea de memoria de trabajo espacial y planificación (Roiser, Rogers, & Sahakian, 2007).

Para evitar parte de la confusión en torno a las pruebas de evaluación de constructos ejecutivos de alto orden, proponemos una nueva clasificación que tenga como criterios las características de los objetivos y de las reglas, categorizándolas en tres grupos. El primer grupo estaría formado por *tareas de planificación con un único objetivo y reglas específicas*. En este grupo lo conformarían pruebas como los problemas de torres, el mapa del zoo o el test de la búsqueda de la llave. En estas tareas el participante debe centrarse en un único objetivo y las reglas además, están claramente delimitadas. Estas tareas se caracterizan por administrarse en contextos de laboratorio y ser altamente estructuradas. La consecución de objetivos es el eje central de estos tests. Aunque esta clasificación está basada en pruebas neuropsicológicas y no en tareas cotidianas, un posible ejemplo cotidiano en el que pondríamos en marcha procesos cognitivos similares sería la tarea de preparar una maleta, en la que la organización espacio temporal de los elementos es importante, teniendo en cuenta reglas simples y concretas (ej. Que quepa todo dentro y que nada se arrugue o se rompa).

El segundo grupo de pruebas serían las que conllevan *objetivos simples pero reglas complejas*. Este grupo lo formarían tareas como Modified Six Elements Test, Revised Strategy Application Test (Levine et al., 2007) o el Greenwich Multitask Test (Burgess et al., 2000). A diferencia del primer grupo, estas pruebas tienen múltiples objetivos a alcanzar, pero suelen consistir en tareas sencillas sin complejidad. La verdadera dificultad consiste en cumplir las reglas del ejercicio, que son múltiples y variadas. Estas tareas son las que tienen mayor relación con el concepto de multitarea, pues las exigencias son básicamente el cambio de la atención y la ejecución del participante entre las tareas de forma intermitente, en base al seguimiento de reglas explicitadas pero artificiales. En la mayoría de las pruebas de este tipo ni las tareas que las componen ni las reglas incluidas suelen tener validez aparente ni relación directa con el tipo de multitarea que realizan en la vida cotidiana (Chevignard, Taillefer, Picq, Poncet, & Pradat-Diehl, 2006). Estos procesos los pondríamos en marcha en momentos muy concretos en los que tenemos que estar pendientes de muchas cosas a la vez. En el entorno laboral se producen muchos ejemplos, como en el trabajo de un controlador aéreo, donde la sincronización de todas las tareas y el seguimiento estricto de unas reglas es lo relevante, más que la tarea en sí, que suele ser sencilla (ej. pulsar un botón).

Finalmente en el tercer grupo, estarían las pruebas *de planificación con múltiples objetivos y reglas*. Estas pruebas se administran en contextos naturales o virtuales, se debe manejar gran cantidad de información, suelen tener una mayor duración temporal y no se puede obtener un feedback claro sobre la calidad de la conducta que se está realizando. A diferencia del primer grupo, en estas pruebas se persigue más de un objetivo, y a diferencia del segundo grupo, la alternancia entre tareas no es la única dificultad presente, a pesar de que se requiera en algunos momentos determinados. Los procesos cognitivos puestos en marcha durante estas pruebas, serían más similares a los que aplicamos en nuestro día a día. Por ejemplo, cuando planificamos un día cualquiera ordenamos espacio-temporalmente todas las tareas que debemos de hacer, siendo frecuente que durante la ejecución existan periodos concretos en los que tenemos que encargarnos de realizar dos o más actividades a la vez.

3. Estudios con humanos

La mayoría de los estudios neuropsicológicos sobre la planificación han empleado los problemas de torres como paradigma conductual. Las líneas de investigación que han surgido de ellas se centran en: (1) la comparación de poblaciones clínicas y personas sanas, (2) el estudio de las zonas neuroanatómicas implicadas en la ejecución de procesos de planificación, (3) las propiedades estructurales y psicométricas de las pruebas, y (4) el estudio de los procesos subyacentes a la planificación. Estas líneas de investigación han aportado avances en la neuropsicología clínica, psicología cognitiva o psicometría, pero también han generado críticas y preguntas sobre los instrumentos de evaluación.

3.1 Estudios en poblaciones clínicas y sanas

Los estudios de neuroimagen muestran que el córtex prefrontal dorsolateral y el rostral, están implicados en procesos de planificación basados en los problemas de torres. Dado que las pruebas de planificación han mostrado ser indicadores del funcionamiento del córtex prefrontal, estas pruebas se utilizan frecuentemente para el estudio de patologías como el daño frontal adquirido, las demencias (Carlin et al., 2000), la esquizofrenia (Morris, Rushe, Woodruffe, & Murray, 1995), la enfermedad de Parkinson (A. M. Owen et al., 1992) o la enfermedad de Huntington (Lange, Sahakian, Quinn, Marsden, & Robbins, 1995).

Los problemas de torres han sido utilizados también en estudios de neurodesarrollo de las diferentes etapas de la vida. Los cambios asociados a la edad afectan predominantemente a los procesos mediados por los lóbulos frontales, en particular a las funciones ejecutivas y a los procesos superiores de control consciente de la conducta

(Gilhooly, Wynn, Phillips, Logie, & Sala, 2002). La consideración de la planificación como una función de alta orden sustentada sobre otros procesos más básicos no se basa en la complejidad del constructo, sino en la demostración de que su correcto desarrollo depende del buen funcionamiento de otros constructos que tienen un origen más temprano. Por ejemplo, Luciana y cols. encontraron que las habilidades espaciales o de memoria de trabajo no verbal se desarrollaban desde los 9 años, en cambio la autorregulación estratégica no lo hacía hasta los 16-17 años (Luciana, Conklin, Hooper, & Yarger, 2005). Los autores interpretan que existe una disociación entre tareas que solo necesitan mantener información en la memoria de trabajo, función que recae principalmente en el córtex prefrontal ventrolateral, versus las tareas que requieren una autorregulación estratégica y control ejecutivo, más relacionada con el córtex dorsolateral prefrontal. La mayoría de los estudios, apuntan que es alrededor de los 15 años cuando se producen avances significativos en la capacidad de planificación (Huizinga, Dolan, & van der Molen, 2006; Luna, Garver, Urban, Lazar, & Sweeney, 2004). Los principales apoyos se basan en estudios de neuroimagen, los cuales señalan que la madurez funcional del córtex dorsolateral y rostrolateral prefrontal se alcanza en la adolescencia (Giedd, 2008).

En la misma dirección, las pruebas de planificación también han aportado información sobre el declive cognitivo producido por la edad. Las evidencias sugieren que los lóbulos frontales son una de las primeras áreas del cerebro afectadas negativamente por la edad. Estos deterioros se ven reflejados principalmente en los procesos ejecutivos (Bryan & Luszcz, 2000). Los hallazgos señalan que a partir de los 60 años empezarían a deteriorarse las funciones de alto orden, pues los adultos mayores requieren más movimientos para resolver los problemas de torres (Köstering, Stahl, Leonhart, Weiller,

& Kaller, 2014), o precisan más tiempo de planificación previo antes de iniciar el problema (Phillips, Smith, & Gilhooly, 2002).

Estos hallazgos de deterioro asociado a la edad han sido replicados en varios estudios con tareas de planificación altamente estructurada, sin embargo, son menos consistentes en estudios con tareas de baja estructura o mayor validez ecológica como el Mapa del Zoo o la Amap Task (Allain et al., 2005; Sanders & Schmitter-Edgecombe, 2015). Por ejemplo, Phillips y cols. (2006) observaron una peor ejecución en la TOL asociada a la edad pero no en la tarea ecológica Plan a Day, sugiriendo que el conocimiento previo relacionado con las tareas ecológicas compensaría los déficits de planificación asociados al envejecimiento (Phillips, Kliegel, & Martin, 2006).

3.2 Propiedades estructurales, psicométricas y metodológicas

Debido a que los problemas de torres son los instrumentos más utilizados en el estudio de la planificación, existen datos que nos permiten profundizar sobre sus propiedades psicométricas e indicar algunas de sus dificultades estructurales y metodológicas. Entre los principales hallazgos destaca la baja consistencia interna debida a una baja correlación entre los distintos problemas que componen las pruebas de torres (Kafer & Hunter, 1997). Las instrucciones de administración empleadas en los diferentes estudios no son isomórficas, y por ejemplo, en algunos estudios no se le indica al participante que piense la solución al problema antes de comenzar a resolverlo, a pesar de que el tiempo de planificación inicial es uno de los mejores predictores de una ejecución exitosa (Unterrainer et al., 2004). La mayor parte de los estudios no registran la estrategia utilizada por el participante durante la ejecución (Goel & Grafman, 1995). Por otro lado, la dificultad de la tarea se establece según el número de movimientos necesarios para resolverlo. Sin embargo, esta no es la única condición determinante de la dificultad ya que problemas que se resuelven con el mismo número de movimientos difieren en dificultad por las características estructurales que presentan el estado inicial y final del problema. Mientras la jerarquía al objetivo (referida como la ambigüedad con la cual la secuencia final de movimientos se deriva de la mera configuración del estado del objetivo) de algunos problemas puede resolverse con una estrategia de aproximación "hill-climbing strategy" (estrategia que consiste en realizar movimientos arbitrarios que permiten aproximarse a la solución); este no puede ser aplicado en otros problemas donde se requieren subobjetivos óptimos para su resolución (necesidad de pasar por un subobjetivo de forma obligatoria). Es decir, la comparación entre estudios se ve dificultada, si se tiene en cuenta que la estructura del problema es la que realmente determina la dificultad y que la mayoría de los estudios no informan sobre esta (Kaller, Unterrainer, Rahm, & Halsband, 2004). Este problema se agrava si se tiene en cuenta que se pueden generar hasta 1260 problemas distintos (Keith Berg & Byrd, 2002).

La estructura del problema no sólo afecta a la dificultad de la tarea, también influye en qué procesos cognitivos deben implicarse en la resolución del problema. Imaginemos un problema de torres en el que en el estado inicial las tres bolas están situadas una encima de otra. Se trata de una distribución en la que, según las reglas que se deben seguir, sólo existe la posibilidad de mover la bola superior. Se trata de un escenario en el que no se requieren procesos de inhibición. Por otro lado, en los problemas donde el número de movimientos necesarios para resolver el problema sea bajo, la información manejada por la memoria de trabajo es menor que en los problemas con mayor número de movimientos (Kaller et al., 2004).

Sin embargo, las dificultades detectadas en los problemas de torres no son exclusivas de las tareas altamente estructuradas sino que también pueden afectar a las tareas de baja estructura realizadas en entornos virtuales o naturales, donde las características contextuales que son menos controladas pueden provocar variaciones en el grado de dificultad, en los constructos cognitivos implicados en la resolución o una menor fiabilidad interjueces, entre otros. Lamentablemente, los pocos estudios existentes con tareas naturales nos impiden profundizar en estas hipótesis. Aun así, estos inconvenientes serían los esperables en las tareas con poca estructura y lo que resulta sorprendente es la presencia de problemas metodológicos y los escasos datos consistentes que muestran las tareas de planificación que están altamente controladas.

3.2 Estudio de los procesos subyacentes de la planificación

Según Miyake (Miyake et al., 2000) y Diamond (2013) los procesos de orden superior como la planificación, se sustentarían sobre tres procesos básicos, memoria de trabajo, inhibición y flexibilidad. Los investigadores han tratado de delimitar la contribución de estos constructos básicos en la ejecución de la Torre de Londres y Torre de Hanoi. Aunque estructuralmente ambas tareas parecen similares, los estudios no han llegado a una conclusión clara y apuntan a que no lo son. Welsh y cols. (1999) encontraron que la memoria de trabajo y la inhibición eran buenos predictores de la ejecución en la TOL, pero en la TOH el único predictor era la inhibición. Estos resultados no fueron replicados por Zook y cols. (2004) que indicaron que tan solo la inteligencia fluida contribuyó a explicar la varianza en la ejecución de la TOL, mientras que en la TOH además contribuyeron la memoria de trabajo y la inhibición. En la misma dirección, un estudio realizado con niños con la TOH y TOL, demostró que la inhibición, la memoria a corto plazo y la flexibilidad contribuían de forma distinta en el resultado de ambas tareas, y que el grado de contribución se modificaba a medida que se incrementaba el nivel de dificultad (Bull, Espy, & Senn, 2004).

Otros estudios realizados con adaptaciones de la Torre de Londres tampoco han hallado resultados claros. En un estudio realizado con personas sanas y enfermos de Parkinson se encontraron diferencias en el SOC pero no en el D-KEFS-TT, además los análisis de regresión mostraron que el SOC era dependiente de la inhibición y de la memoria de trabajo espacial mientras que el D-KEFS-TT era dependiente sólo de la memoria de trabajo (McKinlay et al., 2009). Por otra parte, la ejecución de 42 estudiantes universitarios fue similar entre la TOL-DX ni la D-KEFS-TT, en cambio los análisis de regresión mostraron escasa relación entre ellas, por lo que los autores concluyeron que ambas tareas evalúan aspectos diferentes de las FE (Larochette, Benn, & Harrison, 2009).

Estos resultados confusos se repiten incluso analizando la contribución de componentes más simples de las FE; por ejemplo, en el caso de la memoria de trabajo se ha analizado la contribución por separado de componentes más moleculares, como la memoria de trabajo verbal o la memoria de trabajo visual. Las características visuoespaciales de la tarea, han llevado a hipotetizar que este componente intervendría en mayor grado que el verbal, en cambio los resultados son confusos. Unterrainer y cols. (2004) encontraron que la memoria visuoespacial correlacionaba con la TOL, pero no la memoria verbal, apoyando la hipótesis de la dependencia visual (Unterrainer et al., 2004). En cambio, Phillips y cols. (1999) si encontraron una correlación de los dos componentes de la memoria de trabajo con la ejecución en la TOL; estos autores explicaron estos resultados atribuyendo a que la memoria verbal se ve implicada en la verbalización interna de las instrucciones, contribuyendo por lo tanto en la ejecución de la tarea, aunque esta sea visuoespacial. Para arrojar luz sobre la dualidad de la memoria de trabajo en la torre de Londres, de Cheetham y cols. (2012) mediante una *dual task* comprobaron que la memoria de trabajo visual se veía más afectada que la memoria de trabajo verbal durante la ejecución de la TOL. Estos estudios vuelven a poner en evidencia la falta de consenso sobre los constructos implicados en la realización de las tareas, incluso en los componentes más moleculares de éstos. Muchos autores achacan estás diferencias a los diferencias estructurales de las tareas y a la complejidad del constructo de la planificación.

En lo que respecta a estudios de planificación con otras tareas, las conclusiones extraíbles son escasas debido a la menor atención que han recibido. En un estudio con adolescentes con síndrome de déficit de atención con hiperactividad, el Mapa del Zoo no mostró correlación con índices de inteligencia ni con otras tareas de planificación como la TOL o la Búsqueda de las Llaves, a pesar de la teórica semejanza entre ellas (Boyer, Geurts, & Van der Oord, 2014). En la misma dirección, en un estudio con enfermos de Alzheimer, los análisis factoriales con el Mapa del Zoo y la TOL mostraron que ambas tareas cargaban en distintos factores, hecho que llevó a concluir que estas tareas no evalúan los mismos procesos de planificación (Coubard et al., 2011; Frisch, Förstl, Legler, Schöpe, & Goebel, 2012).

4. Estudios de neuroimagen y planificación.

El cortex frontal, asociado a los procesos de planificación y las funciones ejecutivas en general, incluye más de 15 áreas de Brodmann y mantiene múltiples conexiones, tanto hacia áreas corticales posteriores como subcorticales (Petrides, Tomaiuolo, Yeterian, & Pandya, 2012). El estudio de estructuras subcorticales como los ganglios basales, muestra que éstas tienen múltiples conexiones con áreas corticales, siendo en parte responsables de la regulación conductual. El núcleo caudado estaría implicado en la activación de esquemas de acción y en la selección de subobjetivos basados en la evaluación de probabilidades, iniciando las denominadas conductas dirigidas a objetivos. En cambio, otras estructuras como el nucleo estriado ventral estaría más implicado en procesos motivacionales, imprescindibles en la selección de objetivos. Por otro lado, el caudado tendría una relación directa con los procesos cognitivos, mientras que el putamen sería responsable de la implementación de la conducta mediante la coordinación sensiomotora (Grahn, Parkinson, & Owen, 2008).

Aunque estás estructuras subcorticales iniciarían procesos cognitivo comportamentales de una forma primitiva, el peso más grande en el caso de primates y humanos recae en las estructuras corticales frontales. El desarrollo y modificación de las conductas dirigidas a objetivos requiere de actualizaciones continuas en la secuencia de eventos, estos se reflejan en una retroalimentación en conexiones estriato-nigrales y talamo-corticales. Esta información se redirigiría a los diferentes circuitos cognitivos, motores y de toma de decisiones, que integrarían la información principal, permitiendo responder a las demandas del entorno. Tanto los circuitos paralelos como los integrantes, trabajarían juntos para permitir que las conductas coordinadas sean mantenidas o modificadas (circuitos integrantes) según reglas internas o externas. Así pues tanto la incapacidad de centrar y mantener una conducta, como la incapacidad para adaptarse a las reglas internas o externas estaría relacionado con deficiencias en los ganglios basales, dando un papel importante a las estructuras subcorticales en el comportamiento humano hecho que quita la exclusividad a las estructuras corticales frontales sobre los procesos de planificación (Haber & Calzavara, 2009).

Estas afirmaciones estarían apoyadas por estudios en población clínica que evidenciarían la relación de estas estructuras subcorticales con procesos de planificación. La enfermedad de Parkinson, causada por el deterioro de la sustancia negra, se caracteriza por mostrar déficits ejecutivos entre los que se encuentra la planificación. Esto se atribuye a un mal funcionamiento de estructuras subcorticales como los ganglios basales y no del córtex prefrontal. En un estudio con tomografía por emisión de positrones (PET) en el que se administró la TOL, los ganglios de la base se mostraron activados en el grupo control pero no en el grupo de pacientes con Parkinson, mientras que las áreas frontales, se encontraron igualmente activadas en ambos grupos (Dagher, Owen, Boecker, & Brooks, 2001).

En cambio, en la enfermedad de Hungtinton se mostraría la otra cara de la moneda, dando importancia a las estructuras corticales. Esta enfermedad neurodegenerativa provoca la perdida de las neuronas espinosas medias en el neoestriado. A causa de las conexiones de estas zonas con áreas corticales, los enfermos de Hungtinton muestran déficits similares a los que tienen las personas con daño frontal (Hedreen & Folstein, 1995). En el estudio de Watkins et al., (2000) en el que se administró la tarea de toma de decisiones Iowa Gambling Task y la tarea de planificación torre de Londres, solo se encontraron diferencias en esta última. Según los autores, estos resultados vendrían dados por el mal funcionamiento de los distintos bucles paralelos que tienen origen en el estriado y que se proyectan al córtex frontal. En esta población parecía existir un daño más pronunciado en el caudado dorsal (un componente del córtex dorsolateral prefrontal) que en el estriado ventral (componente del circuito en bucle del cortex orbitofrontal)

A pesar de estos resultados, también existen sólidas evidencias del papel de las estructuras corticales frontales en el funcionamiento ejecutivo y por lo tanto en la planificación. Tanto las funciones ejecutivas (Bechara, Damasio, Tranel, & Anderson, 1998) como los lóbulos frontales (Stuss, 2011) pueden ser divididas en componentes moleculares. El córtex dorsolateral prefrontal (DLPFC) ha sido considerada una zona implicada directamente con la cognición, la memoria de trabajo y la planificación estratégica (Constantinidis, Franowicz, & Goldman-Rakic, 2001). Este córtex dorsal junto con el córtex premotor rostral se encargarían de la monitorización y la acción de la planificación (Calzavara, Mailly, & Haber, 2007). Mientras que el córtex cingulado anterior (ACC) y el córtex orbitofrontal (OFC) se encargarían de mediar aspectos en conductas basadas en recompensas, jugando por tanto un papel principal en la toma de decisiones (Hadland, Rushworth, Gaffan, & Passingham, 2003). Otra zona relevante en humanos y primates sería el córtex fronto-polar. Esta región se encontraría activada en situaciones donde es necesario mantener un objetivo en mente mientras se realizan otros objetivos secundarios. Esta zona sería independiente de la activación de la memoria de trabajo o de la distribución de la atención en diferentes tareas (Koechlin, Basso, Pietrini, Panzer, & Grafman, 1999).

No todos los estudios de neuroimagen se han llevado a cabo con los problemas de torres, también se han utilizado otras tareas o juegos de solución de problemas tradicionales. Los resultados muestran que las zonas activadas varían según el problema. En el caso del ajedrez, zonas del cingulado posterior, del córtex orbitofrontal y el córtex temporal derecho se veían activadas en jugadores expertos y no en novatos, señalando que el aprendizaje y experiencia sobre una conducta modifica las zonas implicadas en la resolución (Krawczyk, Boggan, McClelland, & Bartlett, 2011). Estudios llevados a cabo con el juego tradicional chino GO; este juego tiene un componente más espacial que el ajedrez (basado más en reglas). Los resultados mostraron que en el GO se activan más áreas cerebrales del hemisferio derecho mientras que en el ajedrez el hemisferio izquierdo está más activado (Chen et al., 2003).

Aun así, los estudios de neuroimagen que mayor información han aportado han sido los realizados mediante las tareas neuropsicológicas clásicas de planificación, como los problemas de torres, pues aunque son conocidas determinadas limitaciones metodológicas, los hallazgos son más homogeneos. Tanto los estudios con PET (Dagher, Owen, Boecker, & Brooks, 1999) como los estudios de resonancia magnética funcional (Cazalis et al., 2003) indican que el córtex frontal dorsolateral, región que corresponde a las areas 9 y 46 de Brodmann, se ve activada ante procesos de planificación.

Capítulo 2

Drogodependencias

1. Epidemiología y relevancia clínica del problema

Según la Organización Mundial de la Salud (OMS), la dependencia y consumo de drogas son un problema a escala global que constituye una de las principales causas de enfermedad física y mental, discapacidad, muerte y violencia. Es un problema que altera el bienestar de las personas consumidoras y del conjunto de la sociedad, provocando un alto coste económico, social y sanitario. En su último informe mundial sobre drogas (UNODC, 2014) la OMS nos alerta de que a pesar de las pequeñas variaciones debidas principalmente a factores sociopolíticos, las tasas mundiales de consumo han permanecido estables en los últimos años. Como consecuencia, para el estudio e intervención de los procesos adictivos se ha adoptado un enfoque multidisciplinar en el que las distintas áreas contribuyen al conocimiento de las causas, consecuencias sociosanitarias, estrategias de prevención y tratamiento.

1.1 Prevalencia de consumo.

Según el último informe de la OMS (UNODC, 2014) entre 162 y 324 millones de personas (3,5% - 7% de la población mundial), de edades comprendidas entre los 15 y 64 años, consumieron en el último año algún tipo de sustancia ilícita. A pesar de estos datos existen diferencias de prevalencia o consumo de sustancias entre distintos continentes y países relacionado con las diferentes culturas, religiones, políticas gubernamentales, factores históricos o de acceso al consumo. En el ámbito europeo, las sustancias ilegales más consumidas son el cannabis y la cocaína. En España aproximadamente el 9,6% de la población entre 15 y 64 años refirió haber consumido alguna vez cannabis durante el último año, y el 2,3% indicó consumo de cocaína. Entre las drogas legales, el alcohol fue la más consumida (78,8%) (OED, 2013).

Más allá de un uso esporádico o recreacional, el número de personas a escala mundial que presenta trastornos de consumo como abuso o dependencia se sitúa entre 16 y 39 millones de personas (UNODC, 2014). El perfil general que presentan las personas que acuden a tratamiento es un patrón de policonsumo, es decir, personas que han consumido dos o más sustancias (policonsumo). Entre los policonsumidores se distinguen tres patrones de policonsumo. El primer patrón se caracteriza por el consumo de varias drogas a la vez para beneficiarse de efectos acumulativos o complementarios. Por ejemplo, el uso de cannabis y cocaína junto con el alcohol, o el uso de heroína junto con benzodiacepinas o alcohol (Boys, Marsden, & Strang, 2001). El segundo patrón de policonsumo persigue eliminar los efectos adversos de una droga. El ejemplo más claro sería el de la "bola de poder", es decir, el uso conjunto de cocaína con opioides. En este caso, el uso conjunto provoca los efectos de euforia pero eliminando los efectos adversos de la ansiedad o sedación (Leri, Bruneau, & Stewart, 2003). Finalmente, el tercer patrón se basa en el consumo de una nueva droga como sustitución de otra droga consumida anteriormente, debido a razones económicas o de disponibilidad. El ejemplo más frecuente es la sustitución de la heroína por oxicodona, desmorfina u otros opioides.

El porcentaje de personas admitidas en 2011 en tratamientos España con patrones de policonsumo fue del 62,3% (OED, 2013). Esta característica se repite en países como EEUU, donde el 48,7% de los admitidos a tratamiento en el Sudeste del país presentaban un patrón de policonsumo, con alcohol, cocaína y cannabis como las drogas más usadas (Kedia, Sell, & Relyea, 2007). Estos datos resaltan la necesidad de que el estudio de la dependencia y abuso de sustancias se realice desde una perspectiva de policonsumo, pues es la mayoría de estudios se centran en patrones de monoconsumo y estos están alejados de la problemática real.

1.2 Consecuencias individuales y sociales del consumo de sustancias.

Las consecuencias del consumo de sustancias van desde las que sufre el propio individuo, pasando por las consecuencias que afectan a sus círculos más próximos como familiares y amigos, hasta llegar a las consecuencias que afectan al conjunto de la sociedad. Las repercusiones más destacadas en el propio individuo tienen que ver con los problemas médicos, que cursan desde daños directos que afectan al organismo (Chen & Lin, 2009; Cregler, 1989) a enfermedades mentales como trastornos ansiosos, depresivos o psicóticos; enfermedades derivadas frecuentemente del consumo de drogas como la infección por VIH, Hepatitis C y Hepatitis B (Volkow & Li, 2005) o en algunos casos, la muerte. La *United Nations Office on Drugs and Crime* calcula que en 2012 se produjeron alrededor de 183.000 muertes relacionadas con las drogas, con sobredosis como la principal causa y mayoritariamente en policonsumidores (EMCDDA, 2014). En concreto, el informe sobre la salud en el mundo (WHO, 2002) indicaba que el 4% de la morbilidad y el 3,2% de la mortalidad mundial eran atribuibles al alcohol, convertido por tanto en el tercer mayor riesgo para la salud en países desarrollados.

Además de las repercusiones físicas, los cambios emocionales asociados al consumo terminan afectando a las relaciones sociales próximas al individuo, provocando en muchos casos violencia doméstica (Livingston, 2011), abusos sexuales (Roizen, 1997), o violencia en general (Boles & Miotto, 2003). Los efectos sobre la vida diaria se traducen en baja productividad y pérdida del trabajo o dificultades para encontrarlo (Cartwright, 2008), fomentando en muchos casos la realización de actividades ilegales para conseguir ingresos con los que costear el consumo de drogas, como el tráfico de sustancias o la prostitución (DeBeck et al., 2007).

Las distintas repercusiones sociales del consumo de sustancias han motivado que en los últimos años se haya intentado calcular cuál es el coste económico que provoca. A pesar de los problemas metodológicos a la hora de cuantificar el gasto económico entre distintos países y la comparación entre ellos (Moore & Caulkins, 2006), diversos estudios e informes apuntan a un alto coste en materia sanitaria, social, productividad o derivados de la criminalidad. En EEUU el gasto total ascendió hasta los 180,9 billones de dólares en 2002, aumentando un 5,34% anualmente desde 1992 (ONDCP, 2004). En Australia el coste fue de 55,2 billones de dólares en 2004, con un incremento del 11,3% desde 1998 (Collins & Lapsley, 2008). En España (García-Altés, Ollé, Antoñanzas, & Colom, 2002) en 1997 el coste se situó entre 467 y 707 millones de dólares, cifra obtenida mediante el cálculo del coste sanitario, en investigación, programas sociales, programas de prevención y gastos en los órganos de justicia. De todos éstos, la partida con mayor coste económico es la sanitaria, con un 46% del gasto total.

2. Consecuencias neuropsicológicas del consumo de drogas

El estudio de las drogodependencias tiene un enfoque multidisciplinar con aportaciones de disciplinas como la sociología (Adrian, 2003), la psicología (Robinson & Berridge, 2000), la neuroimagen (Goldstein & Volkow, 2002), la farmacología (Weiss et al., 2001), y la genética (Agrawal et al., 2012) entre otros. Del mismo modo, la neuropsicología, disciplina encargada de estudiar las relaciones entre el cerebro y la conducta, ha arrojado luz a la hora de comprender los procesos adictivos. Los conocimientos acerca de las bases neurobiológicas de la adicción apuntan a que el consumo de drogas provoca alteraciones en los sistemas de recompensa, sistemas cerebrales de estrés sobreactivados y alteraciones en el córtex prefrontal orbitofrontal y zonas subcorticales, que serían los responsables de conductas de abuso o dependencia (Koob, 2006). A pesar de ello, existen diferentes interpretaciones acerca de que zonas neuroanatómicas o sistemas de neurotransmisión se ven implicados en los procesos adictivos. Durante los últimos 40 años se ha apuntado que las alteraciones en el sistema dopaminérgico serían la clave explicativa de los procesos de adicción, pero la mayoría de estudios se basan en el consumo de psicoestimulantes como la cocaína, y en menor grado en otras sustancias como el consumo de alcohol o cannabis (Nutt, Lingford-Hughes, Erritzoe, & Stokes, 2015). Por otro lado, la interacción existente entre los distintos sistemas de neurotransmisión complica la extracción de conclusiones claras, pues los sistemas de neurotransmisión de la serotonina (5-HT), norerpinefrina (NE), glutamato (GLU), GABA, opioides y endocanabinoides interactúan con el sistema dopaminérgico (Olière, Joliette-Riopel, Potvin, & Jutras-Aswad, 2013). Las conclusiones son más difíciles si se tiene en cuenta que gran parte de las personas dependientes presentan un perfil policonsumidor que afecta a múltiples vías de transmisión.

Los estudios de neuroimagen también muestran la variabilidad de zonas alteradas según el tipo de droga consumida (Borne, Riascos, Cuellar, Vargas, & Rojas, 2005; Rojas, Riascos, Vargas, Cuellar, & Borne, 2005). De igual modo, las alteraciones de las funciones cognitivas también presentan un patrón heterogéneo según el tipo de adicción. En general, existe evidencia de que el consumo de drogas se asocia con alteraciones en las estructuras cerebrales más frontales y por lo tanto en las funciones ejecutivas. De este modo, existen alteraciones generales como los déficits en memoria de trabajo, que suelen presentarse en distintos tipos de consumidores y a lo largo de periodos de abstinencia prolongados. Otros componentes parecen estar más alterados tras el consumo de determinadas drogas, como la flexibilidad y el control de la impulsividad en consumidores de cocaína o de alcohol, y la velocidad de procesamiento en consumidores de cannabis y MDMA (Fernández-Serrano, Pérez-García, & Verdejo-García, 2011). En cuanto a estudios con consumidores de sustancias centrados en la planificación como un componente de la función ejecutiva, los pocos que se han realizado han utilizado fundamentalmente pruebas basadas en problemas de torres. La población alcohólica ha mostrado déficits de ejecución en este tipo de tareas, tanto en el número de movimientos realizados, como en los problemas resueltos en el número mínimo de movimientos o el número de movimientos para resolver el problema tras cometer un error (Fishbein et al., 2007; Flannery et al., 2007; Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2006; Noël et al., 2001). Estos estudios también muestran diferencias de género en la misma dirección que los estudios realizados con controles, pues en el estudio de Flannery (2007) el grupo de mujeres alcohólicas resolvió un menor número de problemas con el mínimo de movimientos respecto a hombres sanos, y en cambio no hubo diferencia entre mujeres controles y mujeres alcohólicas. Otros estudios realizados con poblaciones de consumidores de heroína y anfetaminas muestran déficits generales de ejecución (Fishbein et al., 2007; Ornstein et al., 2000), a excepción de un estudio en el que se encontró igual rendimiento en la Torre de Hanoi en los consumidores de opiáceos y los controles (Brand, Roth-Bauer, Driessen, & Markowitsch, 2008). Cabe destacar que en un estudio de Fishbein (2007) en el que se evaluaron consumidores de alcohol, de heroína y policonsumidores de alcohol y heroína, y todos ellos mostraron una peor ejecución que el grupo control. A pesar de que entre los distintos consumidores no hubo diferencias significativas, el grupo policonsumidor mostró peor puntuación que los otros dos. En todos los estudios, los grupos de consumidores mostraron diferencias con el grupo control en la ejecución en alguno de los componentes que sustentan los procesos de planificación a nivel teórico (memoria de trabajo, inhibición o flexibilidad). Sin embargo, no se ha llevado a cabo un estudio que relacione la ejecución en estas pruebas de planificación con el conjunto de los procesos cognitivos moleculares que se relacionan con ella en los modelos teóricos.

Capítulo 3

Intervención neuropsicológica en Drogodependencias

1. Introducción situación Europa.

En Europa, se calcula que 1,3 millones de personas recibieron tratamiento por consumo de drogas ilegales durante el año 2002 (EMCDDA, 2014). Mientras que en España durante el año 2011, el número de personas incluidas en programas de tratamiento aceptadas a tratamiento fue de 50.581, siendo el consumo de cocaína y los opioides las principales drogas causantes de la necesidad de intervención (OED,2013).

En Europa existen más de 2500 centros de tratamiento, en los que se reciben distintos programas intervención. El tratamiento de las adicciones tiene un enfoque transdisciplinar y en lo que respeta a la intervención psicológica, las diferencias entre los programas vienen marcadas principalmente por la corriente psicológica utilizada. Entre los tratamientos más difundidos se encuentran la intervención en comunidades terapéuticas, el tratamiento residencial, la terapia cognitivo-conductual, los 12 pasos de Minnesota y combinaciones de los anteriores. Los objetivos principales se centran en la desintoxicación y el abordaje psicológico de los problemas psicosociales del paciente y la prevención de recaídas. También se pretenden objetivos para la reinserción, como la búsqueda de empleo o de vivienda y la mejora de la autonomía personal. Entre los programas, destaca el tratamiento en comunidades terapéuticas por ser el predominante con más de 2330 centros y el único con disponibilidad común en 17 países. Las dificultades metodológicas limitan la realización de estudios que comparen la eficacia de los distintos programas de tratamiento. Los resultados de los programas en comunidades terapéuticas son positivos en cuanto al aumento de la permanencia en el tratamiento y de la calidad de vida, y una mayor reducción del consumo y de los problemas legales (EMCDDA, 2014).

1.1 Intervención en la comunidad Andaluza

En 2013 el número de admisiones en algún programa de tratamiento de drogodependencias y adicciones en los servicios públicos de la Comunidad de Andalucía fue de 21.999 personas, mayoritariamente hombres (83,52%). A estos hay que añadir 1403 personas que se acogieron a algún programa de desintoxicación en centros penitenciarios. Las dos sustancias principales que motivaron la adscripción a un programa de tratamiento fueron el alcohol y la cocaína (DGSSAD, 2013).

En Andalucía los programas de intervención van desde la prevención, tratamiento ambulatorio, unidades de desintoxicación hospitalaria, centros de acogida, programas de reinserción o protocolos de actuación conjunta entre unidades de salud mental y de tratamiento en drogodependencias, hasta la intervención en comunidad terapéutica. Con la creación del I Plan Andaluz sobre drogas y adicciones en 1987 aparecen las primeras comunidades terapéuticas de titularidad pública, aunque anteriormente existían otras privadas. El número de personas admitidas a tratamiento comunitario ha pasado de 108 en 1988 hasta 1019 personas en 2001. La derivación a las comunidades terapéuticas se realiza desde centros públicos de tratamiento o centros concertados.

Los objetivos generales de la intervención en las comunidades son la desintoxicación, la deshabituación y el tratamiento de los problemas adictivos en un entorno controlado. De forma específica se persigue una mejora de la autonomía personal y la participación social gracias a programas de búsqueda de vivienda y trabajo. La intervención psicológica tiene entre sus objetivos la extinción de conductas desadaptativas por medio de la adquisición e impulso de hábitos saludables. Asimismo, se persigue el desarrollo y mejora de la capacidad de autocontrol mediante estrategias de autorregulación, el entrenamiento en habilidades sociales y la prevención de recaídas. También se proporciona entrenamiento educativo-ocupacional para la mejora y aprendizaje de hábitos de limpieza, cumplimiento de normas, adquisición de prerrequisitos laborales y formación ocupacional, entre otros aspectos. Aunque también se emplean otros enfoques, el modelo de intervención psicológica más frecuente es el cognitivo-conductual. A lo largo de cada semana se combinan los formatos de intervención individual y grupal. La intervención familiar es parte importante del proceso, con empleo del modelo sistémico de forma habitual. La duración de la estancia varía dependiendo de los resultados obtenidos, y no suele ser menor a tres meses ni superar los nueve meses en total (PICTA, 2003).

Entre los programas de tratamiento que gozan de mayor popularidad tanto a nivel nacional como en la comunidad andaluza, son los que ofrece la ONG Proyecto Hombre, en funcionamiento desde 1985. Durante el año 2013, un total de 19141 personas fueron atendidas en alguno de los programas ofrecidos por Proyecto Hombre. Uno de los más reconocidos es el programa base, un tratamiento comunitario en el que fueron atendidas 4476 personas, además de las 832 personas que fueron aceptadas en el programa comunidad terapéutica interpenitenciaria (APH, 2013). El tratamiento comunitario de Proyecto Hombre está diseñado principalmente para consumidores de opiáceos, cocaína, alcohol y policonsumidores que además presenten características de desestructuración familiar y social. Las tres fases en las que se divide el programa son: (i) Acogida, en la que se establecen las primeras normas y responsabilidades personales (control medicación, alimentación, higiene…) aunque su principal objetivo es el control de la abstinencia; (ii) Comunidad terapéutica, que es la fase más duradera y en la que el equipo multidisciplinar interviene con el propio individuo y su entorno, desde las distintas orientaciones psicológicas que se describen más adelante; y (iii) Reinserción, una tercera fase centrada en la reinserción sociolaboral y en la que se refuerza la autonomía centrada en un proyecto personal de vida, con planes familiares, sociales, de ocio y salud (AHP, 2013).

El Programa terapéutico-educativo Proyecto Hombre basa su metodología en distintas corrientes psicológicas. En las líneas básicas del abordaje terapéutico individual está la orientación humanista-existencial, influenciada por la Logoterapia de Frankl (Reker, 1994), la psicoterapia y consejo Adleriano (Townes & Ireton, 1976) o la Gestalterapia de Perls (Tønnesvang, Sommer, Hammink, & Sonne, 2010). Se pretende facilitar al individuo herramientas para la búsqueda del sentido de la vida y el descubrimiento de valores positivos que permitan la toma de decisiones futuras y la ruptura con su pasado. La intervención pretende que mediante la verbalización se hagan conscientes las metas marcadas y se detecten elementos erróneos, desmontando creencias distorsionadas y reordenando actitudes equivocadas. También se incluyen aportaciones cognitivo-conductuales, desde las que se trabajan elementos como el Locus de Control de Rotter, el análisis de expectativas personales y de esquemas de comportamiento. Los aprendizajes operantes también son de gran relevancia en el funcionamiento diario de la comunidad, tanto en la programación de las tareas como en las intervenciones de los terapeutas ante conductas inapropiadas. Otros enfoques basados en terapia de grupo o familiar sistémica son elementos claves en el tratamiento debido a la concepción de que la droga no es el problema, sino la persona y el entorno, siendo la toxicomanía sólo la consecuencia o manifestación de esos problemas (Proyecto, 2015).

2. Rehabilitación neuropsicológica de las funciones ejecutivas

2.1 Tratamientos de nueva generación

En la actualidad existe una amplia gama de tratamientos complementarios que a pesar de no constituir un programa de intervención por si solos, tienen efectos que pueden reforzar la eficacia de los tratamientos principales. La mayoría de los tratamientos en adicciones, y especialmente los desarrollados en comunidades terapéuticas, persiguen una amplia variedad de objetivos. La mejora de las funciones ejecutivas, cuyo deterioro está frecuentemente asociado al consumo abusivo de sustancias, podría facilitar la consecución de conductas dirigidas a alcanzar estos objetivos (Stevens et al., 2014). Uno de los programas con mayor respaldo empírico es el *Goal Management Training* (GMT) desarrollado inicialmente por Robertson (Robertson, 1996) y ampliado por Levine, Manly, & Robertson (2005). En base a la teoría de la negligencia al objetivo de Duncan (Duncan, 1986) el GMT se desarrolló para mejorar los déficits de autorregulación en pacientes con daño cerebral (Levine et al., 2011). El objetivo del programa es dar estructura a la conducta, creando planes de acción para alcanzar los objetivos, desde una perspectiva ecológica y haciendo hincapié en las actividades de la vida diaria. El GMT consta de 7 sesiones semanales con una duración aproximada de dos horas, en las que se incluyen debates sobre ejemplos de problemas cotidianos, actividades individuales y grupales y se proponen actividades diarias para afianzar el aprendizaje. En cada sesión se abordan distintos aspectos de la cognición y conducta humana, creando un entorno de aprendizaje progresivo mediante un encadenamiento que permite finalmente estructurar la conducta. Entre los temas abordados en las sesiones destacan: detección de errores debidos a distracciones, aprendizaje de qué son los procesos automáticos y su relación con los errores, definición de la memoria de trabajo y orientación al presente, afianzamiento de metas, toma de decisiones, división de objetivos en componentes más simples, procesamiento de tareas en paralelo y revisión de la conducta. Todos estos componentes cognitivos y emocionales mencionados se entrenan y debaten en relación a las actividades de la vida diaria. Gracias a un proceso de encadenamiento se va creando una metaconducta o estrategia general que permite alcanzar objetivos. Los pasos básicos del entrenamiento son: (i) parar la conducta y orientarse al presente, (ii) definir el objetivo de la tarea, (iii) dividir la tarea en sus diferentes componentes o subobjetivos, (iv) realizar las actividades necesarias para cada subobjetivo y (v) revisar la conducta.

El programa GMT proporciona una estrategia de regulación arriba-abajo de diferentes procesos cognitivos como la atención, monitorización, memoria de trabajo, toma de decisiones y solución de problemas, y regulación emocional (Levine et al., 2011). El GMT ha mostrado su eficacia en el entrenamiento de las funciones ejecutivas en poblaciones clínicas con daño cerebral adquirido (Krasny-Pacini, Chevignard, & Evans, 2014), espina bífida (Stubberud, Langenbahn, Levine, Stanghelle, & Schanke, 2014), trastorno de déficit de atención con hiperactividad (Braek, Dijkstra, Ponds, & Jolles, 2012) , esquizofrenia (Levaux et al., 2012) y mayores (Levine et al., 2007).

Sin embargo, algunos autores sugieren que la eficacia del GMT aumenta al combinarlo con otros programas (Krasny-Pacini et al., 2014). Se ha probado la eficacia del programa GMT junto con el programa Mindfulness Based Stress Reduction (Kabat-Zinn, 1994) en policonsumidores de sustancias en tratamiento comunitario. Los hallazgos de este estudio mostraron una mejora en procesos de memoria de trabajo, inhibición, atención y toma de decisiones (Alfonso, Caracuel, Delgado-Pastor, & Verdejo-García, 2011).

2.2 Mindfulness

Mindfulness ha sido descrito como un estado de conciencia del momento presente en el que se experimentan las cogniciones, emociones y percepciones sin juzgarlas, sin reaccionar ni agarrarse a pensamientos pasados y futuros, y adoptando una actitud de aceptación sin evitar la experiencia presente (Garland, 2007).

Uno de los programas más extendidos es el Mindfulness Based Stress Reduction (MBSR), de intervención grupal y dividida en ocho sesiones semanales de una duración aproximada de dos horas. Las sesiones introducen progresivamente técnicas de desarrollo de la conciencia y percepción estimular, como el *body scan*, meditación sentada o yoga. Además se incluyen elementos psicoeducativos sobre el estrés, en los que se debaten en grupo situaciones negativas y cómo afrontarlas (Salmon et al., 2004). La estructura del programa ha sido modificada para adaptarse a poblaciones objetivo, como el Mindfulness-based cognitive therapy, que incluye elementos cognitivo comportamentales que permiten intervenir con mayor eficacia desordenes como depresión o ansiedad (Bédard et al., 2012).

Aunque en general la metodología usada en los estudios no es precisa, el programa Mindfulness ha mostrado resultados positivos en diferentes poblaciones clínicas con trastorno de déficit de atención con hiperactividad (Schoenberg et al., 2014), cáncer (Henderson et al., 2013), trastorno de personalidad límite (Wupperman, Fickling, Klemanski, Berking, & Whitman, 2013), trastornos de ansiedad (Asmaee Majid, Seghatoleslam, Homan, Akhvast, & Habil, 2012), síntomas depresivos en pacientes con traumatismo craneoencefálico (Bédard et al., 2012), trastornos comórbidos de depresión y ansiedad (Hazlett-Stevens, 2012), recaída y recurrencia en episodios depresivos (Teasdale et al., 2000), dolor crónico (Chiesa & Serretti, 2011), fibromialgia (Grossman, Tiefenthaler-Gilmer, Raysz, & Kesper, 2007) o problemas de sueño (Black, O'Reilly, Olmstead, Breen, & Irwin, 2015). En la misma dirección, los estudios con pacientes sanos también han mostrado efectos en la reducción del estrés, depresión, mejora de la calidad de vida (Khoury, Sharma, Rush, & Fournier, 2015) así como los efectos del burnout en el trabajo y mejora de la satisfacción laboral (Hülsheger, Alberts, Feinholdt, & Lang, 2013). Estudios con población adicta también han mostrado resultados positivos. Mediante el programa adaptado, Mindfulness-Based Relapse Prevention aplicado a 168 adultos con problemas de sustancias, se hallaron reducciones en el craving e incremento la aceptación y actuación del problema respecto a las personas que recibían un tratamiento estándar (Bowen et al., 2009). El programa MBSR también ha mostrado su eficacia para mejorar la calidad de vida de drogodependientes, la reducción de síntomas depresivos (Hosseinzadeh Asl & Barahmand, 2014), así como la reducción del dolor en consumidores de opioides (Garland, Thomas, & Howard, 2014).

Desde la neuroimagen se ha evidenciado el impacto del programa Mindfulness sobre diferentes estructuras corticales, modificando el funcionamiento del córtex medial, asociado al "defaul mode network". También se han visto cambios en la ínsula, que juega un papel importante en la conciencia, amígdala o hipocampo estructuras relacionada con el aprendizaje y procesos de memoria y modulación emocional (Hölzel et al., 2011; Marchand, 2014). En los estudios que han probado los efectos del Mindfulness sobre la cognición se han encontrado tres tipos de mejoras. Por un lado, cambios en redes atencionales, mejorando los procesos de alerta o vigilancia, orientación y atención dividida. Por otro lado, mejoras en los procesos de memoria, incluyendo la memoria semántica, memoria episódica, memoria procedimental y la memoria de trabajo. Y finalmente, cambios en procesos de orden superior como solución de problemas, planificación o toma de decisiones, que facilitarían el afrontamiento de situaciones novedosas ante las demandas contextuales (Chiesa, Calati, & Serretti, 2011).

II. JUSTIFICACIÓN Y OBJETIVOS

Capítulo 4

Justificación y objetivos de la tesis

1. Justificación, objetivos e hipótesis.

Las funciones ejecutivas son un conjunto interrelacionado de habilidades implicadas en el control, monitorización y ejecución de conductas, dirigido al logro de objetivos de naturaleza cognitiva, emocional o social (Verdejo-García & Bechara, 2010). Diversos estudios (Fox et al., 2005; Miyake et al., 2000) muestran que las funciones ejecutivas son un constructo heterogéneo que incluye tanto componentes más moleculares, como otros de orden superior como la planificación o la multitarea, cuyo funcionamiento se sustenta en los anteriores (Diamond, 2013). Los procesos superiores han sido relacionados con aspectos importantes de la vida diaria, como el éxito laboral, académico o habilidades de la vida diaria (Allan & Lonigan, 2011; Blair & Razza, 2007).

La evaluación de constructos complejos como la planificación se ha realizado tradicionalmente mediante los problemas de torres (Shallice, 1982). En su origen, estas tareas fueron creadas para el estudio de problemas matemáticos o de inteligencia artificial, en cambio en la actualidad son usados como una herramienta de evaluación clínica. Por este motivo, presentan determinadas limitaciones dada su artificialidad y su alto nivel de estructuración (Goel, 2010). Según el modelo de Burgess (Burgess et al., 2006) estas tareas están centradas en la validez de constructo, es decir representan conceptos teóricos propuestos por los investigadores, pero distan de ser pruebas representativas de los procesos de planificación que se ponen en marcha en la vida diaria. En el otro polo del continuo estaría una nueva generación de pruebas denominadas "function-led" que además de los requisitos básicos de cualquier herramienta, sus resultados deberían ser generalizables al funcionamiento en contextos reales (Parson, 2016, p. 2). Los primeros en ser plenamente conscientes de ello y diseñar una de esas nuevas herramientas fueron Shallice y Burguess (Shallice &

Burgess, 1991), creando la tarea de baja estructura Multiple Errands Test como prueba de evaluación de los procesos de planificación desde una perspectiva funcional. A diferencia de las tareas de laboratorio, su aplicación se lleva a cabo en un ambiente natural, en el que los participantes deben de realizar una serie de actividades cotidianas. El uso del MET ha mostrado su validez para la generalización al rendimiento ejecutivo de pacientes en la vida real (Cuberos-Urbano et al., 2013). Sin embargo, este tipo de herramientas tampoco está exento de limitaciones, pues requieren de una adaptación que va a depender en gran medida de los recursos presentes en los distintos contextos físicos. Además, aunque se han aplicado en estudios con poblaciones clínicas, como pacientes con daño cerebral, trastorno bipolar, espina bífida, etc. (Castiel, Alderman, Jenkins, Knight, & Burgess, 2012; Roca et al., 2008) no hay ningún estudio con policonsumidores de sustancias, una población con demostrados déficits ejecutivos y específicamente, de planificación (Fishbein et al., 2007).

El consumo de sustancias es un problema mundial, con graves consecuencias sociales, sanitarias y económicas, y cuya prevención primaria no permite hablar de que su incidencia esté disminuyendo (UNODC, 2014). Entre las repercusiones para el consumidor, destacan las alteraciones de las funciones ejecutivas (Fernández-Serrano, Pérez-García, & Verdejo-García, 2011), relacionadas con el funcionamiento cotidiano del individuo, y con el éxito terapéutico de los programas de rehabilitación (Stevens et al., 2014). Por estos motivos, es necesario desarrollar herramientas con aproximación *function-led* que permitan determinar cuál es el funcionamiento ejecutivo real del individuo, además de ser sensibles a los efectos del consumo y de los cambios derivados de los tratamientos.

Actualmente, se aplican tratamientos por consumo de sustancias a 1,3 millones de personas en Europa (EMCDDA, 2014). Los programas de intervención son variados, con predominio del tratamiento en comunidades terapéuticas. La mayoría de ellos abordan objetivos como el cese de consumo, el mantenimiento de la abstinencia, la obtención de empleo, vivienda y la mejora de la autonomía personal. Sin embargo, el entrenamiento neuropsicológico especializado como estrategia para mejorar las capacidades cognitivas y emocionales, asociadas a la mejora de la eficacia del tratamiento base (Stevens et al., 2014), no está presente en la mayoría de los casos. Programas de nueva generación como el *Goal Management Training* y *Mindfulness Meditation* que ya han mostrado su eficacia en la mejora de procesos emocionales y cognitivos, podrían reforzar y complementar los tratamientos base con el fin de organizar la conducta y fortalecer la consecución de objetivos (Alfonso et al., 2011).

2. Objetivos específicos e hipótesis

El **objetivo principal** de la tesis fue estudiar desde una aproximación *function-led* la evaluación de procesos ejecutivos de orden superior y la intervención para mejorarlos en personas en tratamiento comunitario por trastorno por policonsumo de drogas.

Los objetivos específicos se desarrollaron en los tres estudios que componen la tesis. .

Objetivos específicos del primer estudio.

1. Desarrollar y aplicar una nueva versión contextualizada del Multiple Errands Test (MET-CV) en tres grupos de policonsumidores en tratamiento comunitario
2. Determinar la fiabilidad del MET-CV mediante evidencias de la consistencia de la puntuación del entre los pacientes de distintas comunidades, y determinar la validez de constructo mediante correlaciones con otras tareas de función ejecutiva.

3. Determinar las diferencias en el MET-CV y otras tareas de planificación y función ejecutiva entre policonsumidores de sustancias y controles sanos.

Las hipótesis planteadas en este estudio fueron (i) será posible la implementación de una nueva versión del Multiple Errands Test (MET-CV) adaptada al contexto de tratamiento de las adicciones en comunidades terapéuticas; (ii) el MET-CV obtendrá buenos índices de fiabilidad en términos de consistencia entre las puntuaciones de los participantes de distintas comunidades terapéuticas, y de validez concurrente, en términos de la asociación con otras tareas tradicionales de planificación y función ejecutiva; y (iii) los policonsumidores de sustancias mostrarán déficits de planificación, que podrán ser evidenciados no sólo con los test tradicionales sino también con la tarea *function-led* MET-CV.

Este estudio ha sido enviado con el título de “Development of the contextualized version of the Multiple Errands Test: validation data from polysbustance users” a la revista *Journal of International Neuropsychological Society,* donde se encuentra actualmente en la fase de revisión (ver Anexo I para la revisión íntegra del artículo).

Tras la adaptación de la tarea MET-CV y comprobar que permite discriminar entre población adicta y personas sanas y los buenos índices de validez de constructo y fiabilidad, se plantearon nuevos objetivos específicos en un segundo estudio relacionado con la contribución de los factores generales de inteligencia e índices de consumo en diferentes tipos de tareas de planificación que dimensionalmente representan desde la evaluación de procesos más centrados en el constructo teórico (altamente estructuradas o de laboratorio) hasta tareas *function-led* (de baja estructura y representativas del mundo real) como el MET-CV.

Objetivos específicos del segundo estudio:

1. Analizar las diferencias en tareas de planificación entre un grupo de policonsumidores y un grupo control sano
2. Determinar la influencia de la inteligencia fluida y cristalizada, el consumo de alcohol, de cocaína y de heroína en la ejecución de tareas de planificación con distinto grado de estructura.

Basándonos en estudios previos, nuestra hipótesis fueron: (i) el consumo de sustancias deteriora la ejecución en tareas de planificación y (ii) la inteligencia y el consumo de sustancias explicaran mayor variabilidad en la ejecución en tareas de planificación con baja estructura.

Este estudio con el título "Planning déficits in polysubstance dependent users: Differential association with severity of drug use and intelligence" ha sido publicado en la revista *Drug and Alcohol Dependence*, donde se encuentra disponible online desde el 27 de febrero de 2016 (ver Anexo II para la revisión íntegra del artículo).

Los resultados de los estudios previos mostraron que los policonsumidores presentaban déficits ejecutivos en procesos de planificación asociados al consumo, y que la inteligencia cristalizada tenía un papel específico en la ejecución en pruebas representativas de actividades de la vida diaria. Con estos hallazgos de planteó un tercer estudio para aplicar una intervención dirigida a los déficits encontrados.

Objetivos específicos del tercer estudio:

Determinar si los programas Goal Management Training (GMT) y Mindfulness Meditation (MM) comparado con un grupo control:

1. es eficaz para mejorar la memoria de trabajo, inhibición y toma de decisiones en personas con trastorno por policonsumo de sustancias en tratamiento comunitario.
2. produce mejoras que se transfieren a tareas de planificación y multitarea representativas del funcionamiento cotidiano.

Las hipótesis del tercer estudio fueron que el programa GMT + MM será eficaz para mejorar las funciones ejecutivas, y las mejoras se transferirán a las tareas de evaluación más ecológicas, además de reducir el nivel de estrés percibido.

Este estudio con título "Goal Management Training + Mindfulness Meditation improve executive functions and transfer to ecological tasks of daily life in polysubstance users enrolled in therapeutic community treatment" se ha enviado a la revista *Drug and Alcohol Dependence,* donde se encuentra actualmente en la fase de revisión (Ver Anexo III para la versión íntegra del artículo).

III.MEMORIA DE TRABAJOS

Capítulo 5

Development of the contextualized version of the Multiple Errands Test: validation data from polysubstance users.

Valls-Serrano, C., Verdejo-García, A., Nöel, X., Caracuel, A. (2016). Development of the contextualized version of the Multiple Errands Test: validation data from polysubstance users.*Journal of the International Neuropsychological Society*. (Under Review)

Introduction

Drug use is a worldwide problem with high socioeconomic costs (Mark, Woody, Juday, & Kleber, 2001). Drug-related harms also affect families and social circles (Taylor et al., 2012). One of the most significant consequences of repeated drug use are deficits in executive function (Fernández-Serrano, Pérez-García, & Verdejo-García, 2011), which stands out for negatively interfering with the performance of daily activities (DA), such as job difficulties, accidents, financial problems (Diamond, 2011). An optimal approach to evaluating executive deficits requires of a comprehensive assessment that allows to define different executive profiles (Gonzalez, Bechara, & Martin, 2007) and to assess what the repercussions are for daily functioning. For example, Moriyama et al. (2002) found an association between performance on several ecological tests and occupational status in alcoholics.

High order executive constructs, such as multitasking and planning, have proven to be good predictors of academic, work, and social outcomes (Baars, Nije Bijvank, Tonnaer, & Jolles, 2015; C. L. R. Gonzalez et al., 2014). Furthermore, they have the strongest relationship with performance on DA (Frisch, Förstl, Legler, Schöpe, & Goebel, 2012; Krabbendam, de Vugt, Derix, & Jolles, 1999). Most of the instruments measuring these constructs are composed of items of low ecological validity, as they were designed by the researchers to test experimental hypotheses (Burgess et al., 2006). Nonetheless, these laboratory tests are also used in clinical assessment, although in many cases the examinee's performance does not correspond with responses in real world situations (Shallice & Burgess, 1993). More recent neuropsychological research has shown that the use of instruments with high ecological validity, based on verisimilitude with DA, enable to adequately assess daily problems associated with executive dysfunction in drug users (Verdejo-García & Pérez-García, 2007).

Neuropsychological tasks that have been used thus far to assess higher-order executive components can be classified into three groups. The first group consists of *planning tasks with simple goals and specific rules*. These tasks are administered in highly structured artificial contexts and provide explicit instructions about the sequence of steps that permit goal achievement. The literature often refers to these tests as planning tasks, such as the tower tasks (e.g., of London, of Hanoi) (Shallice, 1982), Zoo Map Test (Wilson et al., 1996) or Key search test (Wilson et al., 1996). The second group consists of *planning tasks with simple goals and complex rules*, in which the examinee must maintain and monitor a high amount of online information in the form of rules. In these tasks, the compliance to rules is the central and most important aspect than is the actual execution of the tasks. The contexts in which they are administered are also artificial and are traditionally called multitasking tests, such as the Six Elements Test (Wilson et al., 1996), the Revised Strategy Application Test (Levine et al., 2000) or the Greenwich Multitask test (Burgess, Veitch, de Lacy Costello, & Shallice, 2000). The third group would consist of *planning tasks with multiple goals and rules* and whose contexts, whether natural or virtual, are unstructured. Its distinctive features include greater temporal duration, sequencing targets and the absence of immediate feedback, organization and monitoring. At present there is no clear conceptual definition, but they can be referred to as complex planning tasks. Some notable examples of these include the Multiple Errands Test (Shallice & Burgess, 1991), the Executive Secretariat Task, the Task Hotel (Lamberts, Evans, & Spikman, 2010) , and the JAAM Test (Jansari, Agnew, Akesson, & Murphy, 2004).

The Multiple Errand Test (MET) was published in the 90's and is the pioneer test among the complex planning tasks (Shallice & Burgess, 1991). However, it was not used widely until recent years (Alderman, Burgess, Knight, & Henman, 2003). The task raises multiple goals and is administered in a real-life context. The duration of the test is not determined, and is often extensive due to the fact that the participant determines the start and end time. The role of the investigator is to explain the instructions, ensure an understanding of the test, and observe and record without providing feedback or interacting during test taking. Several studies using the MET have been conducted in patients with acquired brain injury (Cuberos-Urban et al, 2013), stroke (Manes, Villamil, Ameriso Rock & Torralva, 2009; Morrison et al, 2013), schizophrenia and bipolar disorder (Caletti et al., 2013), and multiple sclerosis (Roca et al., 2008). However, except one study performed in alcohol users alcoholics with a virtual reality task (Laloyaux et al., 2012), there are no studies with polysubstance users on a high ecological test as MET.

The present study is the first to assess executive functions in drug users administering the MET in a real-life setting. Several versions of the MET have been adapted to specific contexts such as hospital surroundings (Knight, Alderman, & Burgess, 2002) or a shopping center (Alderman, Burgess, Knight, & Henman, 2003). Despite being adaptations of the same version of the MET, they have very different objectives and there may yield different results depending on the appropriateness of the specific context in which they operate. In this case, we tested a new MET version adapted to one of the most representative treatment settings for drug users – a therapeutic community (European Drug Report, 2014).

In this study, we formulated the following hypotheses: (i) it will be feasible to implement a new version of the MET, adapted to the context of treating addiction in therapeutic communities (a drug abusing population in residential treatment), (ii) the new version of the MET will get good indices of reliability in terms of consistency of scores between participants from different therapeutic communities and validity in terms of its association with other traditional tasks of planning and executive functions, and (iii) polysubstance users will present deficits in planning, that can be objectified not only with the traditional tests, but also in an ecological test as MET-CV.

Therefore, the specific aims of this study are (i) to apply the new version of the MET on polysubstance users following addiction treatment in three therapeutic communities; (ii) to obtain evidence of reliability (i.e. consistency of the MET-CV score between patients in various therapeutic communities) and validity (i.e. correlations with other planning and executive function tests); (iii) to analyze differences in performance on the new version of MET and other traditional planning and executive function tests among the sample of polysubstance users and a non-drug using comparison group.

Methods

Sixty polysubstance dependent users (12 women) in residential treatment (PSD) and thirty healthy control participants (10 women), aged between 18 and 52 years old, participated in this study. The PSD group was recruited while receiving treatment at three long-stay (6 – 12 months) public therapeutic communities (TC): "Centro de Rehabilitación Cortijo Buenos Aires de Granada", "Comunidad terapéutica Proyecto Hombre de Huetor-Santillán," and "Comunidad terapéutica Proyecto Hombre de

Algarrobo". All PSD were abstinent as indicated by urine toxicological tests conducted before assessments (alcohol, cannabis, cocaine, opiates, benzodiazepines, and amphetamines). The control group was recruited via advertisements in newspapers and via email through email distribution lists. There were no differences between groups in gender, age, and educational level. Table 1 illustrates the sociodemographic characteristics of both groups. With respect to the three PSD groups, there were no

Table 1. Sociodemographic and consumption patterns in polysubstance users (PSD) and healthy controls (HC)

	PSD	HC		
Sociodemographic variables and consumption patterns	Mean (*SD*)	Mean (*SD*)	t / X^2	p
Age	35.88 (8.91)	35.8 (10.26)	0.04	0.994
Educational level (years)	10.32 (2.76)	11.1 (1.69)	- 1.66	0.1
Gender (%)				
Men	80	66.7	1.92	0.165
Women	20	33.3		
Duration of abstinence (months)	7.49 (6.16)			
Duration of alcohol consumption (years)	11.93 (9.47)			
Duration of cocaine consumption (years)	7.4 (7.92)			
Duration of heroin consumption (years)	2.69 (6.08)			

Note. *SD*, Standard Deviation

differences in age (TC1, *M* = 37.32, *SD* = 8.51; TC2, *M* = 36.5, *SD* = 7.51; TC3. *M* = 33.11, *SD* = 6.09; *F* = 1.683, *p* = 0.195), educational level in years (TC1, *M* = 10, *SD* = 2.97, TC2, *M* = 10.10, *SD* = 2.31, TC3, *M* = 10.94, *SD* = 2.98; *F* = 0.665, *p* = 0.518).

The inclusion criteria for substance users in the study were: (i) meeting DSM-IV criteria for substance abuse or dependence as indicated with the *Structured Clinical Interview for DSM-IV Disorders – Clinician Version* (SCID; First et al., 1997), (ii) having a minimum abstinence interval of 15 days – as determined by urine toxicological tests completed in therapeutic communities, (iii) absence of psychiatric comorbidity on Axis I (with the exception of nicotine dependence) and Axis II as indicated with the *SCID and the International Personality Disorders Examination* (IPDE; Loranger et al., 1994; Spanish version by López-Ibor, 1996), (iv) absence of a history of head injury and neurological, infectious, systemic or any other disease affecting the central nervous system, (v) not taking prescription drugs which affect the central nervous system (e.g. benzodiazepines, antipsychotics, etc.).

The inclusion criteria for the comparison group were the same as for the clinical group, except the first criterion, as they could meet diagnostic criteria for nicotine dependence. Other substance dependence diagnoses were considered exclusion criteria for this group.

Instruments

The interview for Research on Addictive Behavior (Verdejo-García et al., 2005): this is a semi-structured interview to assess the severity of drug use. This interview register detailed notes about the use of each drug from the earliest stages of consumption until the current day, differentiating between periods of regular consumption, maximum consumption and withdrawal, co-abuse substance, routes of administration, and age of onset for each drug. The amount consumed in each episode (number of alcoholic drinks, grams of cocaine, etc.), frequency of use (daily, four-five times a week, weekends, occasional use in a month, etc.), and the number of years consuming are recorded. The outcome dependent variables are the result of the severity index of each substance (alcohol, cocaine, heroin), the abstinence duration, and the duration of consumption of each drug.

Traditional neuropsychological instruments

Letter number sequencing (Wechsler adult intelligence scale, WAIS-III) (Wechsler, 1997a). In this test, the examiner is instructed to read a sequence of numbers and letters, with a frequency of one second per letter/number. The participant must recall the sequence and list the numbers in ascending order and the letters alphabetically. The outcome variable is the number of correct responses.

Information Sampling Test (IST) (CANTAB, Cambridge Cognition). This is a computerized test of the Cambridge neuropsychological Test Automated Battery (CANTAB). This test assesses the reflection-impulsivity ability, defined as the ability to evaluate the available contextual information before making a decision. During this test, participants are presented with a square chart composed of 25 grey boxes on a screen. When the box is touched, one of the two possible colors presented in the bottom of the screen are revealed in two colored boxes. The participant must tap as may boxes as he/she wants, and when the subject is certain, and thinks to know what colour predominates, makes a decision about what color thinks is mainly hidden under the square chart. There are two conditions. In the “fixed” condition, the participant wins

100 points each time if he/she is right and loses 100 points if he/she fails. In the "decreasing" condition, the participant could win a maximum of 250 points each time, but the amount of points decreases by 10 points each time a box is opened. If the is not correct, the participant loses 100 points. The goal is to win the highest amount of points possible. The outcome variables are the number of sampling errors, being the number of trials where the participant fails but in the moment of his/her decision the color selected was the predominant; probability of success at the moment of the decision ; the number of boxes opened; and the number of trials where the participant selects the hidden color correctly in the majority of the squares.

Stocking of Cambridge (SOC): SOC is a computerized version of the traditional Tower of London task (Shallice, 1982). Participants view two screens in which there are three different color balls and three cavities that have a different ball-holding capacity (three, two, and one ball respectively). The aim is to reproduce the ending position of the top screen in the bottom screen with the least number of movements possible. The task consists of problems of varying difficulty (2, 3, 4, and 5 moves to be solved). Participants must fulfill two rules that the program does not allow to be violated: A ball cannot be drawn from the cavity if there is another ball on top, and the balls can only be placed in the lower available cavity. The main outcome variable is the sum of displacements in 4 and 5 movement problems.

Zoo Map Test (Behavioural Assessment of the Dysexecutive Syndrome, BADS) (Wilson et al., 1996). This test assesses the ability to formulate and implement a plan. In this task, participants must draw a route to visit the six indicated places on a paper map of a zoo following three simple rules. These rules determine the execution, so that there are only four correct routes to solve the task correctly. In this study, only the first part of the test was used, in which the problem has low structure and it considered as high demand. The outcome variable is the total score on the first part of the test.

Revised Strategy Application Test (Levine et al., 2000): This test consists of six stacks of ten pages each. Each page has twelve items that could be big or small, and long, medium or short. Two stacks have drawn figures where the participant must trace them, while two of the other stacks are composed of sentences that must be copied. In the last two stacks, the participant must number a variety of group figures. The main goal is to gain the most amount of points possible, knowing that each small item completed grants points. Furthermore, the participant must remember and learn a list of rules to be followed. The test finishes when the participant has completed 50 items (except for the items of the first page of each stack). The most effective strategy is to complete the small items (which give points) because they are brief and faster to solve. At the end of the task, the participant is asked about the strategy implemented. The outcome variables are the number of small items, the percentage of the sample that recognizes the efficient strategy, and the self-regulation index (percentage of small items divided by total items performed).

Multiple Errands Test – Contextualized Version (MET-CV)

Test description.

This test is an adaptation of the hospital MET developed by Knight et al. (Knight, Alderman, & Burgess, 2002), and was designed according to the characteristics of the population and the assessment context (i.e. therapeutic communities). The specific characteristics are as follows: (1) All the subtasks are characterized by one main goal (e.g., preparing a meal) that is clear and relevant to everyday life. (2) The difficulty of the test has been increased slightly due to the better neurocognitive state of PSD compared to people with traumatic brain injury. (3) In the absence of certain elements of the original version, such as a shop, we designed a supermarket brochure, and the shopping task consisted in making the shopping list. (4) Sending a letter was replaced with hanging a sign to announce the location of a meal celebration. (5) The task of finding out opening times for different services was replaced with making note of the temperature from a thermometer (6) The laundry timetable, which is well known by the users of the TC, was replaced by a task to seek a newspaper and record the weather forecast for the next day. (7) Writing down the price of a product from the supermarket was replaced with writing down the address of the shop (written in the supermarket brochure information) where purchases would be held. (8) The objects to count were modified according to the availability of outside assessment centers. (9) Considering that the use of money is banned in therapeutic communities, money was replaced by a hypothetical budget provided to participants.

The test consists of performing 11 tasks that are grouped into three goals. The first goal was to complete the following tasks: pick up a bag that contains the necessary material to carry out the task; prepare a shopping list with three products, follow specific instructions from a supermarket catalog (represents three tasks); make a reservation for a venue to host a celebration by telephone; and create and hang a poster with information about the event. The second goal was to obtain information about the surroundings through four tasks: studying a thermometer and making note of the current temperature, making a weather prediction using a newspaper, obtaining and making note of the supermarket address, counting the number of specific items in the area (benches, lampposts, etc). The third goal consisted on meeting in a concrete place, 20 minutes before the start of the task.

Test administration

Participants were informed that they would conduct some activities related to preparing a meal for the center users. The examiner explained the task's instructions and rules. All questions were resolved and the participant was asked to explain what he/she should do to ensure that he/she understood the instructions. The participant was informed that the examiner would follow him/her at a safe distance and would not interact with him/her unless required by the task. Finally, all necessary material was provided (pen and folder with instructions and a map). During test performance, the examiner took notes on the implementation of the tasks, broken rules or any annotation of interest, without interacting with the participant. The task ends when the participant indicates.

During test performance, the participants' behaviors were registered and classified following the original procedures given by Shallice and Burgess (1991). Error measures were defined as follows: (1) Task failures: when a task goal has not been reached; (2) Rule violation: when a specific rule or social rule has been broken; (3) Inefficiencies: when a more effective strategy could have been used; (4) Misinterpretations: where the requirements of a task have been misunderstood. One point is assigned for each error. Subsequently, a weighted score is calculated based on the frequency of error in the control group. The errors made exclusively in the experimental group are assigned 3 points, and the errors made in less than 6.66% of the control group are allotted 2 points. The errors made in more than 6.66% of the control group are not weighed, and instead maintain the same value (1 point error). In resume, most amounts of points reflects worse performance.

Other collected variables included: initial planning time (time between the completion of the instructions and the start of the task), total execution time (time between the beginning of the task until the end), and number of times that the participant sees signals or consults the map.

The outcome variables are: total number of errors (task failures, total number of rules broken, total number of inefficiencies, total number of misinterpretations).

Procedures

Participants were assessed between September, 2012 and December, 2013. The evaluation sessions take up to 4 hours including breaks. Before testing, the participants had not taken any drugs and were in a physical and psychological state that enabled them to participate correctly in the session. The administration order of the tests was: diagnostic interviews, letters and numbers, Zoo Map Test, SOC, interview of drug consumption, IST, RSAT, and MET-CV. The tasks were administered in three therapeutic communities where the sample was recruited. In the case of controls, the assessment was administered in the "Research Center, Mind, Brain and Behavior" (CIMCYC) of the University of Granada. No participant received any benefit for participation in this study. This study was approved by the Ethics Committee of the University of Granada. Participants were informed of the study conditions and signed an informed consent form.

Statistical analysis

All analyses were conducted in SPSS v 19. We first explored the data in order to detect outliers (indicated with the SPSS Explore command) and missing data points. After removing outliers and accounting for missing data, the sample size was as follows: IST = 59, RSAT = 59, MET-CV = 58, SOC = 58. One-way ANOVAs were conducted to verify the consistency of test scores among participants from different therapeutic communities. Pearson correlation analyses were conducted to examine the validity of the evidence in relation to other traditional planning and executive function measures, and consumer variables. For the group comparison, parametric and non-parametric tests were carried out. Following the recommendations of Blakesley et. al. (2009), Bonferroni adjustments were made to prevent Type I error in the comparison of multiple hypotheses (23 variables were analyzed, adjusting the level of significance determined at 0.05 / 23 = 0.0021). Cohen's d values were calculated for each of the between-groups contrasts to index effect sizes. We used Pearson correlation analyses to examine the association between patterns of drug use on performance measures.

Results

Consistency of the MET-CV scores between participants from different TCs.

No significant differences were found among the three groups in the main indexes of MET-CV (table 2). No significant differences were either found in other secondary variables, with the exception of the total execution time, in which we found differences between two TCs (1 and 3, p = 0.006). With respect to the other traditional neuropsychological tasks, there were no significant differences in major variables of neuropsychological tasks (table 3).

Table 2. ANOVA's comparisons between the three polysbustance user groups on the MET-CV

	TC 1 (n=22)	TC 2 (n=20)	TC 3(n=18)		
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	*F*	*p*
Task faillures weighted	7.59 (4.52)	6.11 (4.23)	5.82 (3.11)	1.108	0.337
Rule breaks weighted	6 (3.74)	6 (2.47)	4.17 (3.76)	1.827	0.17
Inefficiencies weighted	3 (2.47)	3.47 (2.89)	3.53 (3.02)	0.223	0.801
Interpretation faillures weighted	1.77 (2.52)	1.11 (2.33)	7.59 (4.52)	1.032	0.363
Familiarity	2.18 (0.75)	2.38 (0.74)	2.5 (0.85)	0.439	0.650
Total time	27.07 (7.47)	23.09 (7.76)	19.77(6.96)	4.699	0.013
Initial planning time	38.64(59.89)	43.68(56.20)	81 (76.06)	2.387	0.101
Frequency looked at map and read signs	6.36 (5.21)	4.63 (2.83)	5.44 (2.2)	1.079	0.347

Note. MET-CV, Multiple Errands Test Contextualized Version, TC, Therapeutic Community, *SD*, Standard Deviation.

Table 3. ANOVA's comparisons between the three polysubstance user groups on the traditional neuropsychological tests.

	TC 1 (*n* = 22) Mean (*SD*)	TC 2 (*n* = 20) Mean (*SD*)	TC 3(*n* = 18) Mean (*SD*)	F/X^2	*p*
Letters and Numbers	9.36 (1.99)	9.35 (2.25)	9.61 (1.54)	0.106	0.900
Zoo Map Test (score part 1)	0.73 (4.82)	0.70 (3.08)	2.67 (3.58)	1.544	0.222
RSAT (brief items / total items)	0.83 (0.07)	0.83 (0.09)	0.80 (0.15)	0.399	0.673
RSAT (brief items)	42.85 (5.72)	45.25(9.01)	41.63 (9.36)	0.950	0.393
RSAT (strategy recognize)	35%	60%	50%	2.532	0.282
IST DC (mean)	0.73 (0.89)	0.72 (0.82)	0.72 (0.88)	0.083	0.921
IST DC (boxes per trial)	9.47 (4.05)	9.21 (3.98)	9.55 (4.08)	0.037	0.964
IST DC (sampling errors)	1.91 (1.27)	2.15 (1.35)	1.71 (1.1)	0.583	0.561
IST DC (total corrects)	7.82 (1.53)	7.5 (1.43)	7.65 (1.54)	0.236	0.790
IST FC (mean)	0.79 (0.1)	0.80 (0.12)	0.77 (0.11)	0.426	0.655
IST FC (boxes per trial)	13.18 (5.4)	13.92 (5.82)	11.86 (4.69)	0.690	0.506
IST FC (sampling errors)	1.18 (0.91)	1.25 (1.33)	1.17 (1.13)	0.026	0.974
IST FC (total correct)	8.45 (1.01)	8.35 (1.66)	8.59 (1.33)	0.143	0.867
Stocking of Cambridge (total movements 4-5)	12.48 (1.82)	12.72 (1.59)	11.55 (1.93)	2.082	0.134

Note. TC, Therapeutic Community, *SD*, Standard Deviation, RSAT, Revised Strategy Application Test, IST, Information Sampling Test, DC, Decreasing Condition, FC, Fixed Condition

Evidence of validity: Correlations between MET-CV, traditional neuropsychological tasks, and drug use variables.

The correlations between the performance on the MET-CV, with traditional neuropsychological tasks and consumer variables are shown in table 4. MET-CV error variables correlated with consumption indexes and executive function tests (working memory and planning).

MET-CV differences between PDS and controls.

The comparative results between groups on the complex planning task can be found in table 5. Task failures and inefficiencies showed significant differences between groups, with PSD showing significantly more errors than the comparison group.

There were also differences between the groups in the following secondary variables: initial planning time, number of times that the signals and map were consulted, and familiarity with the center. PSD showed more initial thinking time and less number of times that the signals and map were consulted than the comparison group.

Table 4. Pearson's correlations between the MET-CV and traditional neuropsychological tasks in polysubstance users.

	Task faillures	Rules breaks	Inefficiencies	Interpretation faillures
Abstinence (months)	,080 (0.549)	-,306 (0.019)	,074 (0.583)	-,154(0.249)
Alcohol consumption	,333 (0.011)	,389 (0.003)	-,108 (0.421)	,331 (0.011)
Cocaine consumption	-,072 (0.590)	,183 (0.169)	,000 (0.997)	-,147 (0.270)
Heroin consumption	,288 (0.029)	,029 (0.831)	,164 (0.220)	,346 (0.008)
Cannabis consumption	-,146(0.273)	,339 (0.009)	,045(0.735)	,019(0.886)
Letters and Numbers	-,341(0.009)	-.201 (0.130)	-.08 (0.551)	-.017(0.897)
Zoo Map Test (score part 1)	-.150 (0.262)	-.174(0.192)	-.003(0.980)	-.309 (0.018)
RSAT (brief items/total items)	-.191 (0.163)	.104(0.449)	-.099 (0.470)	-.141 (0.305)
IST DC total corrects	.036 (0.792)	.040(0.768)	.007(0.957)	-.054(0.690)
IST FC total corrects	.111 (0.412)	.094 (0.488)	.076 (0.575)	.173 (0.198)
Stocking of Cambridge (total movements 4-5)	.263 (0.078)	.273 (0.006)	-.144 (0.281)	.093 (0.485)

Note. MET-CV, Multiple Errands Test Contextualized Version, RSAT, Revised Strategy Application Test, IST, Information Sampling Test, DC, Decreasing Condition, FC, Fixed Condition.

Table 5. Descriptive Descriptive scores, group comparisons, and effect sizes between polysubstance users (PSD) and healthy controls (HC) on the MET-CV

Dependent Variables	PSD Mean (*SD*)	HC Mean (*SD*)	*F*	*p*	Cohen's *d*	Analysis
Familiarity	2.58 (0.72)	0.46 (1.13)	7.01	0.000	2.419	Parametric
Total execution time (minutes)	23.63 7.89)	22.75(5.77)	0.43	0.835	0.134	Parametric
Initial planning time (seconds)	52.71(5.46)	128.1(107.55)	440.5	0.000	0.918	Non parametric
Frequency looked at map and read signs	5.52 (3.77)	11.83 (5.44)	5.686	0.000	1.437	Parametric
Task failures weighted	6.59 (4.06)	3.87(2.12)	3.423	0.001	0.771	Parametric
Rule breaks weighted	5.43 (3.31)	3.47(2.43)	536.5	0.003	0.644	Non parametric
Inefficiencies weighted	3.31 (2.74)	1.27(1.11)	424.5	0.000	0.879	Non parametric
Interpretation faillures weighted	1.28 (2.14)	0.33(0.66)	583	0.005	0.533	Non parametric

Note. MET-CV, Multiple Errands Test Contextualized Version, *SD*, Standard Deviation.

Traditional neuropsychological task differences between PDS and controls

Performances of both groups are presented in table 6. PSD performed significantly worse than the control group on the LNS working memory task, with a large effect size (Cohen's $d > 0.8$). The IST showed differences between groups in the main variables of the fixed condition with a large effect size (Cohen's $d > 0.8$), but no significant differences in the decreasing condition. Regarding the simple goal planning tasks, SOC (problems 4 and 5 movements) and the Zoo Map Test, there were no significant between group differences. Finally, in the planning test with simple goals and multiple rules (RSAT), the number of brief items was significantly lower in the PSD. However, there were no significant differences for the index of self-regulation (brief items / total items) and the percentage of people who recognized the strategy.

Table 6. Descriptive scores, group comparisons, and effect sizes between polysubstance users (PSD) and healthy controls (HC) on traditional neuropsychological tests

Test	Dependent variable	PSD Mean (*SD*)	HC Mean (*SD*)	t / U / X^2	*p*	Cohen's *d*
Letters and Numbers	Correct responses	9.43(1.93)	11.37 (2.57)	506.5	0.001	0.897
SOC	Total movements 4-5	12.6(1.93)	11.44 (1.89)	2.63	0.010	0.605
Zoo Map Test	Score part 1	1.3 (3.98)	3.67 (3.84)	-2.691	0.009	0.602
RSAT						
	Brief items	43.36(8.1)	53.21 (14.89)	-3.937	0.002	0.755
	Brief / total items	0.82(0.11)	0.86 (0.11)	-1.427	0.157	
	% Strategy recognize	51.78%	71.43%	4.082	0.043	
Information Sampling Test						
FC	Mean	78.95%(10.87)	87.86%(10.31)	-3.628	0.000	0.833
FC	Boxes opened per trial	13.05 (5.33)	17.41(5.53)	-3.519	0.001	0.808
FC	Sampling errors	1.2 (1.1)	0.53(1)	497	0.002	0.627
FC	Total corrects	8.46 (1.33)	9.18 (0.98)	537	0.006	0.586
DC	Mean	72.19% (8.79)	76.71% (9.99)	-2.138	0.035	
DC	Boxes opened per trial	9.4 (3.97)	11.7 (5.03)	-2.307	0.023	
DC	Sampling erros	1.93 (1.24)	1.64 (1.22)	708.5	0.266	
DC	Total corrects	7.66 (1.48)	7.96 (1.5)	722.5	0.334	

Note. *SD*, Standard Deviation, FC, Fixed condition, DC, Decreasing condition.

Discussion

The aims of this study were to examine the feasibility of a contextualized version of the MET in drug users enrolled in TCs, to analyze the consistency of MET-CV scores and the validity in terms of association with other similar measures, and to analyze performance differences between PSD and a control group. We found that the new version of the MET can be effectively applied in the context of therapeutic communities, which is one of the main therapeutic settings for drug treatment, and is sensitive to detect executive function deficits in PSD.

The MET-CV showed consistency in the results obtained in three different therapeutic communities, and validity when correlated with traditional neuropsychological tests. Complex planning tasks, such as the MET, have been criticized for the feasibility of application in clinical settings (rand). This study confirms that it is possible to adapt this type of test to these contexts, using everyday tasks and universal elements. Comparisons between the subgroups of drug users evaluated in three different therapeutic communities' shows the consistency of MET-CV scores. There were only differences in the secondary variable of total execution time, which is likely due to the different size of the TCs installations. These findings indicate that the results of the MET-CV are reliable.

With regard to the second goal, the correlations between the performance indexes of traditional neuropsychological tasks and MET-CV support the external validity of the MET-CV. The traditional tests of working memory and single goal planning tasks correlate with all the MET variables with the exception of inefficiencies. The lack of correlation with inefficiencies could be explained by the fact that traditional neuropsychological tasks tend to assess performance in a dichotomous manner (error /

hit), while the MET-CV can encode inefficiencies as less optimal behavior to get a goal. Drug use patterns (of alcohol, cocaine, heroin and cannabis) also correlated with performance on the MET-CV in the expected direction (i.e. more use was associated with poorer performance). In the same direction, a longer duration of abstinence correlated with fewer broken rules. Previous studies indicate that prolonged periods of abstinence are associated with better executive performance (Schulte et al., 2014), but the results are variable depending on the type of task used (Fdz-Serrano et al., 2011 NBBR). This study suggests that the MET-CV is sensitive to fluctuations in performance associated with the abstinence period.

The third goal was to compare performance on traditional neuropsychological tasks and MET-CV, between PSD and a healthy control group. The results indicated that PSD had significant deficits in both types of tasks. Overall, they made a higher number of failures compared to the control group, but differences were only significant for task failures and inefficiencies. The number of broken rules and misinterpretations were not significant. The absence of differences in broken rules is striking. Some of these rules are context dependent; the greater familiarity in the PSD group with their surroundings as compared to the control group may have reduced the discriminative power of this variable. As for the misinterpretation, the low number of errors in both groups point out that this type of error is not common in this population. It is noted that in other studies on individuals with brain damage, this type of error is rare (Alderman et al., 2003; Knight, Alderman, & Burgess, 2002).

The initial planning time of the MET-CV was also different among the two groups. This finding is relevant because the relationship between the initial planning time and execution on the task, has been found in the traditional single goal planning tasks

(Kaller, Unterrainer, Rahm, & Halsband, 2004). Similarly the higher amount of signs and maps polled by the control group indicate that these benefit more from the available information, being useful to the objective. These results are consistent with those found in the IST task, where PSD gets less information about the context, represented by the number of boxes opened.

Finally, traditional neuropsychological tasks showed higher order executive deficits in PSD, consistent with previous studies (Verdejo-Garcia & Perez-Garcia, 2007). The deficits found in working memory are consistent with previous studies (Lawton-Craddock, Nixon & Tivis, 2003; Pitel et al., 2008). The reflection-impulsivity task, IST, showed different results depending on the condition being evaluated. Both groups showed similar performance in the decreasing condition, while significant differences were found in the fixed condition in the probability of success, sampling errors, and boxes opened. The discrepancy between conditions could be linked to their different level of risk: In the decreasing condition, considered high risk, PSD would have more thoughtful decision-making influenced by the perception of risk present (Lawrence, Luty, Bogdan, Sahakian, & Clark, 2009). In contrast, in the fixed condition, the absence of risk facilitates impulsivity and therefore poor decision making. In the simple goal planning tasks, SOC and the Zoo Map Test, there were no significant differences, although the PSD group showed poorer performance. Previous studies with these tests show mixed results (Brand, Roth-Bauer, Driessen, & Markowitsch, 2008; Fishbein et al., 2007; Flannery et al., 2007) (Ornstein et al., 2000). Similarly, the planning task with simple goals and multiple rules, RSAT, did not show a clear discriminative power consistent with previous studies (Fernandez-Serrano Perales, Moreno-Lopez, Perez-Garcia & Verdejo-García, 2012) (Moriyama et al. , 2002).

Finally, several limitations in this study should be mentioned. First, sample size is relatively limited; however the number of participants is appropriate for the statistical analysis used. Second, there was a lower prevalence of female participants, although this distribution is normally found in Spanish therapeutic communities (DGPND, 2011). Third, the cross-sectional design does not allow us to draw causation effects.

In conclusion, this study shows that it is feasible to use the MET-CV in the TC context, with sound reliability and validity. Both traditional neuropsychological tasks, such as MET-CV, allow discrimination between PSD and non-drug using controls. In addition, the complex nature of the MET-CV may have greater discriminative power over simple goal planning tasks (SOC and Zoo map) and tasks with simple goals and multiple rules (RSAT). As Frisch et al. (2012) noted, our findings reveal the need to consider the dynamics of real environments in neuropsychological assessment, in order to obtain information on executive functioning.

References

Las referencias pueden consultarse en el apartado Referencias.

Capítulo 6

Planning deficits in polysubstance dependent users: Differentialassociations with severity of drug use and intelligence.

Valls-Serrano, C., Verdejo-García, A., & Caracuel, A. (2016). Planning deficits in polysubstance dependent users: Differential associations with severity of drug use and intelligence. *Drug and Alcohol Dependence*

Introduction

Drug consumption is a major health and social problem worldwide: 5.2% of the world population has used at least one illegal substance in the past year (United Nations Office of Drugs and Crime, UNODC, 2014). Drug use is associated with neural abnormalities in the frontal lobes (Bechara et al., 2001; Moreno-López et al., 2012). There is ample evidence that heroin use (Ersche et al., 2006; Fishbein et al., 2007), cocaine use (van der Plas et al., 2009; Verdejo-García and Pérez-García, 2007), cannabis use (Fried et al., 2005), and alcohol use (Flannery et al., 2007; Noël et al., 2001) are linked to alterations in executive functioning (EF). The degree of deterioration associated with these substances cause in EF depends on the amount (Beatty et al., 2000) and duration of use (Fernández-Serrano et al., 2010b). EF models provide a theoretical framework to determine which components may be affected. The model developed by Miyake (2000) provides empirical support to the existence of three basic executive processes: inhibition, updating, and flexibility. Diamond (2013) postulates the existence of a second hierarchical level, which includes complex constructs that govern these three basic executive processes. These higher-order constructs comprise reasoning, problem solving, and planning. Related to these higher-order constructs are the concepts of fluid and crystallized intelligence. The g factor is composed of fluid and crystallized intelligence. Fluid intelligence is the ability to solve problems via inductive and deductive reasoning, is the most stable component and is the least dependent on education (Nisbett et al., 2012). On the other hand, crystallized intelligence represents the individual's learned store of knowledge of the world and is associated with contextual learning (Nisbett et al., 2012).

Planning is the higher-order construct that has been less examined in drug users, and currently available research has provided mixed findings. For example, in a sample of alcohol users, research has found a link between success in maintaining a stable job and performance on the Zoo Map test (Moriyama et al., 2002). However, no association has been found between performance on the planning tower tasks and success in maintaining abstinence in opiate users (Passetti et al., 2008, 2011). Conversely, planning skills have been consistently associated with clinical outcomes, e.g., success in day-to-day activities, in other populations with cognitive impairment, such as brain injury (Cuberos-Urbano et al., 2013) or Alzheimer disease (Piquard et al., 2004).

The lack of consistency in the research findings concerning planning in drug using populations may be accounted by other constructs associated with the cognitive operations that underpin planning skills (such as intelligence) and/or by the characteristics of the assessment tools used. Similar to planning, the g factor of intelligence is considered to be a good predictor for academic performance, job success, and daily activities such as money management, use of maps, or interpretation of news (Gottfredson, 1997). The g factor (incorporates fluid and crystallized intelligence) is thought to underpin the cognitive operations oriented to organize goal-directed behaviors, related to planning and problem solving skills (Unterrainer et al., 2004; Zook, Welsh, & Ewing, 2006). Low fluid intelligence scores are associated with goal neglect, and are indicators of planning capacity (Roberts and Anderson, 2014). Some studies have used tower problems to assess planning abilities, and have found that fluid intelligence is the best predictor of performance (Unterrainer et al., 2004; Zook et al., 2004). The relationship between crystallized intelligence and planning abilities has not been extensively studied, and the existing research indicates that there is not association with complex neuropsychological constructs (Zook et al., 2006).

When interpreting the results of currently available planning research, it is important to consider the type of assessment tests used. On the basis of the degree of task structure, planning tests can be positioned in a continuum that ranges from high structure on one end (for example, the tower problems) to low structure on the other (for example, Multiple Errands Test (MET) (Shallice and Burgess, 1991) (Goel and Grafman, 2000). High structure tasks have clear, specific and fixed rules (starting state, goal, transformation, rules, solution, structure and interconnectivity), whereas low structure tasks have ambiguous and flexible rules, due to the lack of relevant information that must be supplemented from the subjective experience of the participant (Goel, 2010).

The majority of planning studies have used tower tasks, which are considered highly structured, as they have only one goal, present a clearly defined initial state, have fixed rules, provide immediate feedback, and do not change their structure following performance errors (Goel, 2010). However, the use of highly structured tasks presents difficulties in generalizing the results or predicting behavior in everyday contexts that are characterized by low structure (Kaller et al., 2004). Furthermore, tower problems present a number of specific limitations. First, they were originally designed for purposes other than neuropsychological assessment (Burgess et al., 2006). Second, their psychometric properties have not been firmly established (Welsh et al., 1999). Third, the difficulty of these tasks is not only determined by the complexity of their trials, but also by the artificial configuration of these trials (Kaller et al., 2004). Fourth, these tasks tap into multiple basic executive components, and hence there is no consensus about the construct they measure.

Working memory, inhibition, and fluid intelligence are some of the potential cognitive contributors, but there is no agreement between studies (Cheetham et al., 2012; Gilhooly et al., 2002; Unterrainer et al., 2004). Finally, these types of tasks do not explore important aspects in planning, such as strategy making (Kaller et al., 2004). Such limitations make it difficult to understand the effects of drug use on planning behaviors. For this reason, some authors have proposed novel assessment approaches with a lower degree of structure, such as the Zoo Map test (Wilson et al., 1996). Even so, there is no study in poly-drug users that has evaluated tasks with a lower degree of structure such as the MET.

Therefore, the objectives of this study were to (i) determine if there is a difference in performance on planning tasks between a group of polydrug users and a healthy control group, and (ii) analyze the influence of fluid and crystallized intelligence, and alcohol, cocaine, and heroin consumption on the performance on planning tasks with different degrees of structure.

We hypothesize that (i) drug consumption deteriorates performance on planning tasks, and (ii) intelligence and drug consumption explain higher variability in performance on planning tasks when the structure is lower.

Methods

Participants

Sixty dependent polysubstance users (12 women) and 30 healthy controls (10 women) participated in this study; there were no significant differences between groups in age (t = 0.04, p = 0.97), gender (X^2 = 1.92, p = 0.165) or educational level (t = -1.66, p = 0.1). Sociodemographic variables are shown in table 1. All participants spoke Spanish and were originally from Spain. Descriptive information about the amount and duration of drug use in polysubstance users is displayed in table 2.

Polysubstance users were recruited in three different therapeutic communities in southern Spain: "Centro de Rehabilitación Cortijo Buenos Aires de Granada", "Comunidad terapéutica Proyecto Hombre de Huetor-Santillán," and "Comunidad terapéutica Proyecto Hombre de Algarrobo". These communities offer a rehabilitation program for substance abusers. The typical duration of these programs is of 6 to 12 months.

Table 1. Descriptive scores for the socio-demographic characteristics of polysubstance users (PSU) and healthy controls (HC). Numbers represent means and standard deviation (in parentheses).

	PSU (n=60)	HC (n=30)		
Variables	Mean	Mean	t/chi-square	*p*
Age	35.88 (8.91)	35.8 (10.26)	0.04	0.97
Educational level (years)	10.32 (2.76)	11.1 (1.69)	-1.66	0.1

The inclusion criteria for substance users in the study were: (i) meeting DSM-IV criteria for dependence or substance abuse- as assessed by the Structured Clinical Interview for DSM-IV Disorders – Clinician Version (SCID; First et al., 1997), (ii) having a minimum abstinence interval of 15 days – as determined by urine toxicological tests completed in therapeutic communities, (iii) absence of psychiatric comorbidity on Axis I (with the exception of nicotine dependence) and Axis II – assessed with the International Personality Disorders Examination (IPDE; Loranger et al., 1994; Spanish version by López-Ibor, 1996), (iv) absence of history of head injury and neurological, infectious, systemic or any other disease affecting the central nervous system, (v) have not been taking prescription drugs which affect the central nervous system.

The control group was recruited through advertisements in the local newspaper and through internet announcements. The inclusion criteria were the same as for the experimental group, except the criteria for nicotine dependence, which was not exclusionary in controls. Other substance dependence diagnoses were considered exclusion criteria for this group.

Table 2. Descriptive scores for patterns of quantity and duration of drug use in the group of polysubstance users (PSU). Numbers represent means and standard deviation (in parentheses).

		PSU
Substance	Dependent variables	Mean
Cocaine	Grams/month	37.2 (45.63)
	Duration (years)	7.4 (7.92)
Heroin	Grams/month	11.87 (32.24)
	Duration (years)	2.69 (6.08)
Alcohol	Units/month	385.14 (425.22)
	Duration (years)	11.93 (9.47)
Abstinence (months)		7.28 (6.23)

Instruments.

Planning tasks. Three planning tasks with different levels of structure were used, based on the classification of Goel (2010) (See table 3).

Stocking of Cambridge (SOC): SOC is a computerized task included in the Cambridge Neuropsychological Test Automated Battery (CANTAB, Cambridge Cognition). This task is a version of the Tower of London (Shallice, 1982), traditionally used to assess planning. At the top and the bottom of the screen, participants view three different colored balls and three cavities where they can place the balls vertically. Each cavity has a different ball-holding capacity with which it can hold one, two, or three balls. The aim is to reproduce the ending position of the top screen in the bottom screen with the least number of movements possible. The different trials are presented in blocks that require two, three, four or five movements to be solved. Participants must fulfill two rules: 1) A ball cannot be drawn from the cavity if there is another ball on top, 2) the balls can only be placed in the lower available cavity. The main outcome variables are the number of problems solved using the minimum number of movements and the sum of movements performed in each block.

Zoo Map test: This is a subtest of the Behavioral Assessment of the Dysexecutive Syndrome battery (BADS) (Wilson et al., 1996), which assesses the ability to formulate and implement a plan. In the first part of the task, participants must draw a route to visit the six indicated places on a paper map of a zoo following three simple rules. There are only four correct routes to solve the task correctly to obtain the maximum score. In the second part, the rules are the same but the participant must visit different places following the indicated order. The second zoo visit is considered of low cognitive demand because the participant receives an order to follow and can solve the problem without having to keep in mind the required rules. The outcome variable is the total score.

Table 3. Description of structural levels for the three planning tasks.

	Starting state	Goal	Transformation	Rules	Solution	Structure	Interconnectivity
SOC	Clearly defined. *The balls are located in an initial position that does not lead to misinterpretations.*	Concrete and clear. *The goal is to place the balls in the same position that the model presents.*	Concrete action. *The behavior that allows for the transformation of the problem is moving the balls.*	Very specific. Unbreakable. *The rules of this exercise are unbreakable; if the rules are broken the task is stopped.*	Right/Wrong defined, with presented feedback. *The participant is able to find out if the exercise is correctly solved.*	Stable. *The breakdown of the problem is logical. The elements and rules are defined and stable. The problem and the conditions are homogeneous for all participants.*	High. *The movements depend on previous movements to continue the problem and achieve the ultimate goal.*
Zoo Map Test	Defined. *The route starts at the entrance, but in case of misunderstanding the participant could start elsewhere.*	Clear, but open to interpretation. *The places to visit are marked, but nothing objectively prevents visitation of other places.*	Concrete action. *The transformation is to track a route.*	Specific. Breakable. *Specific rules can be broken, e.g. using the camel ride twice.*	Right/Wrong defined, without feedback. *The participant can deduce whether the execution has been correctly performed, but not with precision.*	Stable. *The decomposition of the problem is logical, because the elements and rules are defined and stable.*	Medium. *The order of the visited places does not depend on the previous choice, but the rules interfere with the order.*
MET-CV	It is not completely defined. *The information that is provided or that is available is incomplete, e.g. have to make a shopping list, but the products that will be available in the supermarket brochure are unknown.*	Marked, but depend largely on personal interpretation. *Does the weather forecast refer to the state of the sky or to the room temperature?*	Diverse and varied. *We must create routes to move, count money, write, read…*	Specific and breakable. *Rules that can be broken or be reinterpreted by the participant are provided. Contextual rules come into play (social), e.g. Wait in a queue.*	Right/Wrong is not defined. Not all tasks provide feedback. *Sometimes there is no perfect execution, depending on personal interpretation, e.g. is the purchased food enough?*	Less stable. *Depends on the decomposition of the participant.*	Low. *As there are multiple objectives, the tasks are relatively independent. However, in some cases, there is interconnectivity, e.g.: you have to find the blue bag to make the purchase correctly.*

Note. SOC, Stocking of Cambridge; MET-CV, Multiple Errands Test Contextualized Version.

Multiple Errands Test – Contextualized Version (MET-CV): This test was directly adapted from the hospital version MET (Alderman et al., 2003).. MET-CV assesses complex planning abilities and it is administered in a natural environment. The study was developed in four contexts including three therapeutic communities and one university research center. Every context was analyzed in depth in order to reach parallel goals between the different centers and participants. In contrast to the original version, the different tasks follow in line with one general functional activity (e.g. preparing a meal). This adds a coherent sense of functionality to the demands asked of the participants. In contrast, the earlier versions of the MET lack a general goal as the test is based on different and unrelated tasks.

The test consists of performing 11 tasks that are grouped into three goals. The first goal was to complete the following tasks: pick up a bag that contains the necessary material to carry out the task; prepare a shopping list with three products, follow specific instructions from a supermarket catalog (represents three tasks); make a reservation for a venue to host a celebration by telephone; and create and hang a poster with information about the event. The second goal was to obtain information about the surroundings through four tasks: studying a thermometer and making note of the current temperature, making a weather prediction using a newspaper, obtaining and making note of the supermarket address, counting the number of specific items in the area (benches, lampposts, etc). The third goal consisted on meeting in a concrete place, 20 minutes before the start of the task. The examiner plays a passive role and only observes the participant's behavior and would not interact with him/her unless required by the task. The task starts and ends when the participant indicates.

During test performance, the participants' behaviors were registered and classified following the original procedures given by Shallice and Burgess (1991). Error measures were defined as follows: (1) Task failures: when a task goal has not been reached; (2) Rule violation: when a specific rule or social rule has been broken; (3) Inefficiencies: when a more effective strategy could have been used; (4) Misinterpretations: where the requirements of a task have been misunderstood. Common errors that occurred in up to 93.33% of the control group were allotted 1 point error. Errors that occurred in 6.66% or less of control group were allotted 2 points. Errors made exclusively in the experimental group were assigned 3 point error. The outcome dependent variable was the sum of all errors (task failures, total number of rules broken, total number of inefficiencies, total number of interpretation failures).

The interview for Research on Addictive Behavior (Verdejo-García et al., 2005). This is a structured interview to assess the severity of drug use. The examiner asks and registers detailed notes about the use of each drug from the earliest stages of consumption until the current day, differentiating between periods of regular consumption, maximum consumption and withdrawal, co-abuse substance, routes of administration, and age of onset for each drug. The amount consumed in each episode (number of alcoholic drinks, grams of cocaine, etc.), frequency of use (daily, four-five times a week, weekends, occasional use in a month, etc.), and the number of years consuming are recorded. With these data, a severity index is obtained for each substance = [Quantity consumed per episode x Frequency of consumption per month x Chronicity in years]. The outcome dependent variables are the results of the Z-scores from the severity index of each substance. This study includes the results from alcohol, cocaine, and heroin consumption.

Kaufman Brief Intelligence Test (KBIT) (Kaufman & Kaufman, 1990): This test consists of three subtests: Vocabulary, definitions, and matrices. Crystallized intelligence, or the ability to use knowledge and information from experience, is obtained using the vocabulary and definitions subtest. This factor is related to general knowledge and represents the level of cognitive development achieved through learning history. Fluid intelligence is obtained utilizing the matrices subtest. This variable is completely independent of acquired knowledge, and is related to logical thinking, including inductive and deductive reasoning, and solving problems in novel situations.

Procedures

Participants were assessed between September 2012 and December 2013. The results reported here were obtained as part of a larger project including additional assessments unrelated to the aims of this study. Before testing, the participants had not taken any drugs and were in a physical and psychological state that enabled them to adequately conduct the assessments. The order of administration of the tasks was as follows: Diagnostic interview, addiction interview, Zoo Map test, KBIT, SOC, and MET-CV.

This study was approved by the Ethics Committee of the University of Granada, Spain. Participants' were informed of the study conditions and signed an informed consent form aligned with the Declaration of Helsinki.

Statistical analysis

All analyses were conducted in SPSS v 19. We first explored the data in order to detect outliers and missing data. We found missing data in the control group for the SOC task (due to a software error) and two participants in polysubstance users group for the MET-CV task (due to appointment issues in the therapeutic community). Descriptive analyses were applied to determine the demographic profile of the participants. All variables were explored with the Kolmogorov-Smirnov test and had normal distributions. Between-group contrasts were performed using one-way ANOVA. Cohen's d values were calculated for each of the between-groups contrasts to examine effect sizes. A hierarchical regression was conducted to determine the impact of intelligence and drug use (independent variables) on planning tasks' performance (dependent variables). Independent variables included crystallized intelligence, fluid intelligence, and estimates of alcohol, cocaine, and heroin use. The number of predictors (n=5) is aligned with statistical recommendations for sample size in regression analyses (Hair et al., 2000). Predictors were entered in the regression model in sequential blocks. The first block included two intelligence factors (crystallized and fluid), and the second block included the drug use estimates (duration x quantity) for alcohol, cocaine, and heroin. For each new block, we estimated the R^2 of the prediction change associated with that block, and its statistical significance in order to determine their unique contribution.

Results

Differences between polysubstance users and healthy controls on planning tasks

Polysubstance users performed significantly poorer compared to the group control in all the planning tests (see table 4). Effect sizes were moderate for the SOC and the Zoo Map tests, and high for the MET-CV (Cohen, 1988). Duration of abstinence did not correlate with any performance index on planning tests.

Table 4. Descriptive scores, independent group t-test and effects sizes on neuropsychological planning measures for polysubstance users (PSU) and healthy controls (HC). Numbers represent means and standard deviation (in parentheses).

Task	Dependent Variables	PSU Mean	HC Mean	F	*p*	Effect size (Cohen's *d*)
Stocking of Cambridge	Problems solved with minimal movements	8.17 (1.97)	9.36 (1.77)	-2.728	0.008	0.623
	Total moves	17.74(1.99)	16.50 (1.93)	2.759	0.007	0.629
Zoo Map test	Total score	7.62 (5.57)	10.9 (3.97)	-2.878	0.005	0.643
MET-CV	Total errors weighted	16.60(7.37)	8.93(4.25)	5.251	<0.001	1.182

Note. MET-CV, Multiple Errands Test Contextualized Version.

Multiple hierarchical regression models

Results are displayed in table 5.

Stocking of Cambridge: Intelligence was a significant predictor of total moves for problems with 2-5 movements. Prediction significantly improved after inclusion of the drug use estimates. The full model explained 16.6% of variance, and fluid intelligence and alcohol use were significant individual predictors. Analysis of the variable representing the total number of problems solved with minimum movements revealed that the intelligence block was a significant predictor. However, the inclusion of the second block did not improve the prediction of the model. The global model explained 13.2% of total variance, and the best predictor was fluid intelligence.

Table 5. Multiple hierarchical regression models, contribution of drug consumption and intelligence to performance on tasks of different structure.

Task	Dependent variables	Intelligence R^2 change (p-value)	Alcohol/ Cocaine / Heroin QxF R^2 change (p-value)	Full model R^2 adjusted (p-value)	Unstandardized ß	Stand. ß	Significant contributors
SOC	Problems solved with minimal movements	0.131 (0.003)	0.051 (0.175)	0.132 (0.005)	0.077	0.442	Fluid Intell (0.002)
SOC	Total moves	0.092 (0,016)	0.122 (0.008)	0.166 (0.001)	-0.058	-0.321	Fluid Intell (0.023)
					0.337	0.275	QxF Alcohol (0.007)
Zoo Map test	Total score	0.134 (0.002)	0.044 (0.223)	0.129 (0.005)	0.162	0.344	Fluid Intell (0.019)
MET-CV	Total errors weighted	0.411 (<0.001)	0.137 (<0.001)	0.521 (<0.001)	-0.160	-0.245	Fluid Intell (0.046)
					-0.362	-0.463	Crystallized Intell (<0.001)
					1.394	0.306	QxF Alcohol (0.046)
					1.809	0.247	QxF Heroin (0.043)

Note. SOC, Stocking of Cambridge; MET-CV, Multiple Errands Test Contextualized Version; Q, Quantity; F, Frequency.

Zoo Map test: Intelligence was a significant predictor of Zoo Map test. Prediction did not improved significantly after inclusion of the drug use estimates. The full model explained 12.9% of variance; fluid intelligence was the only significant individual predictor.

Multiple Errands Test: Intelligence was a significant predictor of the sum of errors in the MET-CV. Prediction significantly improved after inclusion of the drug use estimates. The full model explained 52.1% of variance, fluid and crystallized intelligence, heroin and alcohol use were significant individual predictors.

Discussion

The first aim of this study was to establish differences in planning performance between polysubstance users and healthy controls. We found that polysubstance users had poorer performance than controls in all the planning tasks, supporting the hypothesis that drug use is associated with impairment of planning ability. The differences in performance on the high-structure task SOC have been previously described in heroin users (Baldacchino, Balfour, Passetti, Humphris, & Matthews, 2012) and alcohol users (Fishbein et al., 2007; Flannery et al., 2007; Goudriaan et al., 2006; Noël et al., 2001; Pitel et al., 2007). However, there are few available studies using the medium-structure task, i.e., Zoo Map test. Poorer performance in the Zoo Map has been previously reported in polysubstance users (Fernández-Serrano et al., 2010a) and alcohol users (Moriyama et al., 2002), but not in cocaine users (Madoz-Gúrpide et al., 2011). This study is the first to find poorer performance on a low-structure test (MET-CV) in polysubstance users. The effect size of the MET-CV results is considerably higher than the effect sizes observed in tasks of high and medium structure. These findings indicate that polysubstance users have planning deficits that are more evident when using low-structure tests in more ecological contexts.

The second aim of this study was to analyze the influence of fluid and crystallized intelligence, and alcohol, cocaine, and heroin use on three planning tasks with different degrees of structure. Results indicate that general intelligence (comprising fluid and crystallized components) is a significant predictor of performance in the three planning tests. This association between intelligence and planning has been consistently established in healthy (Duncan et al., 1997) and brain injury populations (Knight et al., 2002), but has generally been neglected in drug use studies. More specifically, fluid intelligence is a significant predictor of performance in tests of planning, regardless of degree of structure. The fundamental role of fluid intelligence in highly structured planning tasks, such as tower problems, has been established in previous studies (McManus et al., 2014; Obonsawin et al., 2002; Unterrainer et al., 2004; Zook et al., 2004, 2006). However, this study is the first to demonstrate that fluid intelligence is a factor with a unique contribution to performance on tasks with medium and low structure.

Conversely, crystallized intelligence is a specific predictor of performance in the low structure test, i.e., the MET-CV. Crystallized intelligence represents some of the core skills acquired in the academic, professional, familial, and social contexts (Catell, 1987). Therefore, this finding is relevant to understand the high-order cognitive processes that take place while planning in natural settings. In the MET-CV, participants face a novel task but the activities that must be done are everyday ones. Therefore, it is reasonable to think that performance in this task is sensitive to abilities acquired throughout life to operate in everyday complex environments. This is also supported by the idea that crystallized knowledge is related to divergent thinking, which is responsible for generating new hypotheses and exploring new perspectives on unconventional or novel situations (Madore, Addis, & Schacter, 2015). Divergent thinking must be guided by knowledge about how to organize or apply strategies; such knowledge indicates which kinds of attack on a problem are likely to be fruitful (Cropley, 2006). In other words divergent thinking builds on prior knowledge, which provides the general foundations to navigate in ambiguous low-structured tasks. It is possible that laboratory tasks, such as the SOC or the Zoo Map test, have enough structure to not require the activation of these everyday abilities.

According to Diamond (2013), planning is a higher-order construct that requires the correct functioning of other basic executive processes, such as working memory, inhibition, and flexibility, as well as other higher-order constructs such as reasoning. The degree of structure of the task determines the number of resources that are needed. When the structure is lower, the ambiguity and instability of the task increases, and more resources become necessary. When the structure is higher, the specific rules of the task determine what cognitive processes are needed. Accordingly, factor analysis studies have shown that planning tasks with very different levels of structure, such as the Tower of London and the Zoo Map test, load into different factorial components (Piquard et al., 2004). These findings indicate that prior knowledge is not as critical for highly structured tasks as it is for tasks of lower structure, as all the information that the person needs to know is offered during the task through clear instructions and explicit rules. However, the artificial and arbitrary conditions of highly-structures tasks, do not match real life conditions. The quiet environment, with few distractors, and the existence of clear correct versus incorrect responses are not typically found in activities of daily living (Chaytor and Schmitter-Edgecombe, 2003). Natural environments are very different and generally more demanding for individuals than experimental contexts (Frisch et al., 2012).

The findings of this study indicate that the prediction of performance on the SOC and the MET-CV improves when we consider alcohol, cocaine, and heroin use in addition to intelligence. Alcohol consumption has been associated with performance in the tower planning task (Fishbein et al., 2007). We are not aware of previous studies that have used MET in natural environments with drug users. The only study conducted with alcohol users' using a low-structure task was performed in a virtual reality environment (Laloyaux et al., 2012). This study also showed the impact of cocaine use on performance in tasks of high structure (SOC). These planning deficits may be explained by the reduction in volume and the abnormal connectivity of the dorsolateral prefrontal cortices associated with alcohol consumption (Chanraud et al., 2007) and cocaine (Alia-Klein et al., 2011). Both cortical areas are involved in orchestrating the cognitive components of goal-directed behavior, such as the orientation of the reward (orbitofrontal cortex) or executive planning (dorsolateral prefrontal cortex) (Haber, 2003).

Only on the MET-CV test was shown to be impacted by the effect of heroin consumption as an independent predictor of planning. No previous studies had reported this association, although there are data about non-significant effects of heroin on performance in highly structured tasks based on comparisons between heroin users and healthy controls (Fishbein et al., 2007; Ornstein et al., 2000).

Study variables explain the variance in performance on the MET-CV, which is three times higher than the other two tasks. Findings show that the structure of the task determines the cognitive resources used to solve the problems, and when the degree structure is lower, the uncertainty and variability of responses increases. This more closely resembles real contexts because it allows more information on individual skills (Razani et al., 2007).

The use of tasks with low structure has implications in clinical practice. First, it has more similarities to real environments, allowing for a better prediction on daily functioning than with highly structured tasks (Tanguay et al., 2014). Second, it can improve assessment of cognitive impairment associated with substance use in a process as complex as planning. Sensitivity to assessed impairment is enhanced by taking into account factors such as the relevant context surrounding the person, activities (Chaytor and Schmitter-Edgecombe, 2003), and their degree of structure (Goel, 2010). Third, the standardization of shorter versions of the MET (Alderman et al., 2003) and its adaptation to different natural environments can enable clinical professionals to administer it as part of regular assessments. Furthermore, this type of tests effectively addresses the problem of ecological validity, and the high costs of traditional measures.

In conclusion, this study shows the existence of executive deficits in planning tasks in polysubstance users. These deficits are more notable on tests with low structure. Furthermore, intelligence and substance use better explain performance on tasks with low structure, which are highly representative of everyday activities. This reveals the need to consider structural elements in the development of planning tests.

Finally, several limitations in this study should be mentioned. First, a bigger sample should be recruited. Nevertheless, the number of participants is appropriate for the statistical analysis used (Hair et. al., 2000). Second, a lower proportion of female participants in the groups is detected, although this distribution is normally found in Spanish therapeutics communities (DGPND, 2011). Third, the drug consumption index did not include the use of recreational drugs in order to not alter the statistical analysis. Fourth, the available cross-sectional data does not allow us to determine this result in other populations. Fifth, the use of a new version of the MET could be discussed. This version is currently in process of adaptation and validation, and has been tested in another study (in press). Sixth, due that the tasks were administered in a specific context, blind assessment ratings were not feasible

References

Las referencias pueden consultarse en el apartado de REFERENCIAS

Capítulo 7

Goal Management Training + Mindfulness Meditation improve executive functions and transfer to ecological task of daily life in polysubstance users enrolled in therapeutic community treatment.

Valls-Serrano, C., Verdejo-García, A., & Caracuel, A. (2016). Goal Management Training + Mindfulness Meditation improve executive functions and transfer to ecological task of daily life in polysubstance users enrolled in therapeutic community treatment. *Drug and Alcohol Dependence.* (Under Revie

Introduction

Poly-substance use disorders are the most common presentation in specialized addiction treatment services (European Drug Report, 2014). Individuals with poly-substance use disorders (PSUD) have general deficits in executive functions (Fernández-Serrano et al., 2010), and hence cognitive training of executive functions is a promising new adjunct strategy to treat PSUD (Stevens et al., 2014). In a previous study, we showed that a regiment of eight weeks of Goal Management Training + Mindfulness Meditation (GMT+MM) was linked to improvement of basic executive functions, including working memory, inhibition and decision-making, in PSUD enrolled in outpatient treatment (Alfonso et al., 2011). However, PSUD are often referred to residential treatment, and specifically to therapeutic communities, as these services provide a holistic intervention approach that is more suitable for complex cases (European Drug Report, 2014). It remains unknown to what extent GMT+MM can be similarly efficacious in this context.

In addition to showing efficacy in ameliorating cognitive performance, novel treatment studies need to pinpoint outcome measures that are meaningfully related to activities of daily life (Tiffany et al., 2012). Our previous study, and most of the cognitive training literature, have focused on outcome measures related to basic executive functions as measured by laboratory tasks (i.e., working memory, inhibition and shifting) (Miyake et al., 2000). Conversely, higher-order executive functions, such as planning and multitasking, as measured by ecologically valid tasks are better “models” of day-to-day demands, and better predictors of treatment success in the neuropsychological literature

(Burgess et al., 2006; Frisch et al., 2012). GMT has shown to be effective to improve performance in these ecological tasks in brain injury populations (Krasny-Pacini et al., 2014); however, it remains unknown if it can be similarly efficacious in PSUD.

In this proof of principle study, we aimed to test if GMT+MM, compared to a no-intervention control group, is: (1) efficacious to improve working memory, inhibition and decision-making in PSUD enrolled in therapeutic community treatment (as it is in outpatient treatment); (2) associated with executive functions gains that transfer to ecologically valid tasks of real-life planning and multitasking (as it has been shown in the brain injury literature). Self-reported stress was included as a secondary outcome measure, as better executive functions have been associated with reduced stress levels (Liston et al., 2009; Luethi et al., 2009). We hypothesize that GMT+MM will be efficacious to improve executive functions, and that improvements will transfer to ecological tasks, along with stress reduction.

Methods

Participants

Thirty six PSUD participants, recruited from two therapeutic communities pertaining to the organization "Proyecto Hombre", located in two Spanish cities, Huetor Santillan (Granada) and Algarrobo (Málaga). Both communities apply the same program based on a holistic approach with a psycho-educational focus. The functioning of both communities is homogeneous; participants receive the same individual and group therapy sessions, perform the same daily activities, follow the same stages of treatment and the centers share the same rules. The duration of treatment varies between 6 and 12 months. 50% of the total sample was recruited from each community.

The inclusion criteria for PSUD in the study were: (i) meeting DSM-IV criteria for substance abuse or dependence as indicated with the *Structured Clinical Interview for DSM-IV Disorders – Clinician Version* (SCID; First et al., 1997), (ii) having a minimum abstinence period of 15 days – as determined by weekly urine toxicological tests completed in therapeutic communities, (iii) absence of psychiatric comorbidity on Axis I (with the exception of nicotine dependence) and Axis II as indicated with the *SCID and the International Personality Disorders Examination* (IPDE; Loranger et al., 1994; Spanish version by López-Ibor, 1996), (iv) absence of a history of head injury and neurological, infectious, systemic or any other disease affecting the central nervous system, (v) not taking prescription drugs which affect the central nervous system (e.g. benzodiazepines, antipsychotics, etc.).

Instruments

Participants were evaluated between one and fifteen days before onset of treatments (pre-treatment assessment) and after end of treatments (post-treatment assessment). The mean duration of assessment was 3 hrs. and 30 minutes, including two breaks to avoid the effects of fatigue.

The assessment of DSM criteria was conducted using the Structured Clinical Interview for DSM-IV Disorders Clinician Version (SCID; First et al., 1997), and the International Personality Disorders Examination (IPDE; Loranger et al., 1994; Spanish version by López-Ibor, 1996). History of drug use was ascertained via the Interview for Research on Addictive Behaviour (Verdejo-García et al., 2005). The Spanish version of the Perceived Stress Scale (Cohen et al., 1983; Spanish version by Remor, 2006) was used to assess stress levels.

Outcome measures

Basic executive functions

Letter-number sequencing (Wechsler Adult Intelligence Scale, WAIS-III) (Wechsler, 1997a): Subtest of the WAIS-III, this test allows for the assessment of working memory. In this test, the examiner reads a sequence of numbers and letters, with a frequency of one second per letter/number. Then, the participant must recall the sequence and list the numbers in ascending order and the letters alphabetically. The main outcome variable from this test was the total of correct answers.

Color-word interference test Stroop. Delis-Kaplan executive functions system (Delis et al., 2001). Subtest of the Delis-Kaplan battery, assesses the response inhibition process. Participants have to read as quickly and accurately as possible the items represented in each condition. The first condition presents patches of colors. In the second condition presents the words “red”, “blue” and “green” printed in black ink and participants have to read these words. The third condition presents the same words but they are printed in incongruent color inks and participants have to name the color, ignoring the word written. The main outcome variables were the composite measures: Inhibition v Color naming (time part 3 – time part 1) and total errors in part 3.

Information Sampling Test (IST) (CANTAB, Cambridge Cognition): This computerized test assesses reflection-impulsivity, defined as the tendency to evaluate the available information before making a decision. An array of 25 grey squares were presented each time the participant touched a box, showing one of the two colors represented in the bottom of the array by two squares of different colors. The participant must reveal the squares and, when they deem it appropriate, must make a decision about what color they believe to be in the majority of the array. There are two conditions: one condition is "fixed", in which the participants earn 100 points per trial if they are right, and lose 100 points if they fail. In the "decreasing" condition, the participant could earn 100 points per trial, but each time they reveal a box, the prize is reduced by 10 points, if they fail they lose 100 points. The aim is to reach the highest score possible. The main outcome variables were the number of boxes opened per trial and the total of error selection, under both conditions.

Stocking of Cambridge (SOC) (CANTAB, Cambridge Cognition): Computerized version adapted from the Tower of London test. Participants view two screens in which there are three different color balls and three cavities that have a different ball-holding capacity (three, two, and one ball respectively). The aim is to reproduce the ending position of the top screen in the bottom screen with the least number of movements possible. The main outcome variables were the sum of all moves for problems with 2, 3, 4 and 5 movements and the initial thinking planning time.

Ecological measures of planning and multitasking

Zoo Map test (Behavioural Assessment of the Dysexecutive Syndrome, BADS) (Wilson et al., 1996): Subtest of the BADS to assess the ability to generate and implement a plan. Participants are required to plan and then draw a route to visit the six indicated places on a paper map of a zoo, following three rules. These rules determine the best possible performance, so that there are only four correct routes to solve the task correctly. The main outcomes for this test were the initial thinking time, representing the amount of planning/forethought, and the total score, representing the success of the applied route.

Revised Strategy Application Test (Levine et al., 2007): This test assesses multitasking ability in the context of interference control and self-regulation. The task consists of six piles of 10 sheets, containing items of two sizes (big and small) and three types of time demand (long, medium and short). There are two piles with drawings which the participant must trace, two piles with written phrases that have to be copied on the bottom line and two other piles with groups of figures where they should write the numbers in ascending order inside each figure. Each small item completed provides 100 points, and big items provide 0 points (interference stimuli). The main goal is to reach the highest amount of points. The initial sheets only contain short items but from the second sheet onwards there are both long, medium and short, and the best strategy consist on doing the short ones and skipping the rest (self-regulation). The task ends when the participant has completed 50 items (excluding the first page). The main outcome variable is the total number of brief items relative to the total number of items completed.

Multiple Errands Test – contextualized version (MET-CV): This test is an adapted and modified version of the Multiple Errands Test (Shallice & Burgess, 1991). It assesses the ability to develop and implement a plan in a natural environment, in which the examiner is present only as an observer.

The aim is to perform 11 tasks, grouped into three categories of goals. The first goal involves completing a series of tasks: picking up a bag that contains the necessary material to carry out the task, preparing a shopping list following specific instructions from a supermarket catalog (represents three tasks), making a reservation for a venue to host a celebration by telephone and creating and hanging a poster with information about the event. The second goal is to obtain information about the surroundings through four tasks: studying a thermometer and making note of the current temperature, making a weather prediction using a newspaper, obtaining and taking note of the supermarket address and counting the number of specific items in the area (benches, lampposts, etc). The third goal consists of meeting at a specific location 20 minutes before the start of the task. To avoid test-retest effect, there is a parallel version for assessment post treatment, in which the nature of goals was created. In this version the goals are the same, but some aspects, such as the location of the material, products to be purchased, products to be counted or the place of the rendezvous are modified.

During completion of the test, the participants' behaviors are registered and classified following the original procedures given by Shallice and Burgess (1991). The different errors are classified in three types: (1) Task failures: when a task goal has not been reached; (2) Rule violation: when a specific rule or social rule has been broken; (3) Inefficiencies: when a more effective strategy could have been used. One point is assigned for each error. Subsequently, a weighted score for each error is calculated based on the frequency of each error in the control group. The main outcome variables were: the number of task failures, inefficiencies, rules broken, total amount of errors, initial thinking time and the number of strategies used (times when the map and other signs were viewed).

Procedures

Participants meeting inclusion criteria were randomly assigned to one of two possible Treatment Groups: GMT + MM with Treatment as usual (*n* = 18), or Treatment-as-usual only group (TAU only) (*n* = 18). Randomization was conducted by the administration staff of the centers. Two participants were excluded from the GMT + MM Group, and two participants from the TAU only group for disciplinary reasons. The final sample size for both groups was GMT + MM (*n* = 16) and TAU only group (*n* = 16). Socio-demographic variables for both groups are described in table 1, no differences were found between the groups in age, gender, years of schooling, main drug of choice or amount of alcohol, cocaine or heroin consumed per month. Nor were there any significant differences in duration of treatment (t= 0.360, p = 0.721), between GMT + MM Group (M_{days} = 184.62, *SD* = 39.99) and the Treatment-as-usual Group (M_{days} = 179.5, *SD* = 40.44). The group GMT + MM received 8 sessions of GMT and 8 sessions of Mindfulness Meditation across 8 weeks.

The GMT program includes theoretical and practical elements pursuing the development and implementation of goal-directed behavior. The exercises applied consist of five progressive strategies in which the participant is trained to (i) stop, inhibiting automatic behaviors and directing attention to the present, (ii) establish and maintain goals in mind, (iii) divide the task into smaller steps, (iv) monitor their conduct and make decisions, (v) reassess and adjust behavior (Tornås et al., 2016). The mindfulness program aims to regulate emotional input and to focus attention on the present moment and reduce stress through mindful attention and body scan techniques (Cropley et al., 2007).

GMT + MM is aimed at facilitating transfer to daily life activities. The treatment was administered by a clinical psychologist trained in neuropsychology and MM. The GMT sessions were held in the morning, and were of 120 minutes length. Meditation sessions lasted 40 minutes each.

Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Science (SPSS). We found two outliers in the Stroop test, defined as scores >3 standard deviations below the mean of the sample distribution, one for GMT + MM group (n = 15) and the other in the TAU only group (n = 15). A missing value was detected in the TAU only group (n = 15). All variables showed a normal distribution confirmed for the

Table 1. Descriptive information for sociodemographic variables, patterns of drug use and treatment.

	GMT + MF (*n* = 16)	TAU only(*n* = 16)	Statistic
	Mean (*SD*)	Mean (*SD*)	
Gender	Male = 9, Female = 7	Male = 12, Female = 4	X^2 = 1.247, *p* = 0.264
Age	35.19 (5.39)	30.94 (7.29)	*t* = 1.875, *p* = 0.071
Educational level	11.25 (1.92)	10.13 (2.03)	*t* = 1.249, p = 0.221
Abstinence duration	9.62 (6.01)	7.29 (4.98)	*t* =1.195, *p* = 0.242
Main drug of choice	Alcohol (*n* = 5), Cocaine (*n* = 7), Heroin/Cocaine (*n* = 4)	Alcohol (*n* = 9), Cocaine (*n* = 5), Heroin/Cocaine (*n* = 2)	X^2 = 2.143, *p* = 0.343
Relapses in residential treatment	1.56 (1.71)	0.75 (0.68)	*t* = 1.764, *p* = 0.088
Relapses in community treatment	0.31 (0.60)	0.25 (0.45)	*t* =0.333, *p* = 0.741
Alcohol amount per month (SDU)	159.62 (237.07)	281.12 (243.59)	*t* =1.430, *p* = 0.163
Cocaine amount per month (gr.)	26.34 (28.60)	18.06 (22.13)	*U* = 108.5, *p* = 0.468
Heroine amount per month (gr.)	7.97 (2.62)	15.36 (7.89)	*U* = 109.5, *p* = 0.491

Note: GMT+MF = Goal Management Training and Mindfulness, TAU only= Standard treatment as usual only group, *SD* = Standard deviation, SDU = Standard Drink Units, X^2 = Chi-square, *t* = t-student, *U* = U Mann-Whitney.

Kolmogorov-Smirnov test, except for the variables of drug consumption “amount of cocaine per month” and “amount of heroin per month”. Socio-demographic and consumption differences were performed using the t student test for quantitative variables with normal distribution, U-Mann Whitney for variables that did not show normal distribution and Chi square for nominal variables. ANOVAs repeated measures were conducted to examine the effects of “Time x Treatment”.

Results

The results of the Time (post- versus pre- interventions) x Treatment (GMT + MM versus TAU only) ANOVAs are shown in table 2.

For Letter Number Sequencing, a significant interaction of “Time x Treatment” was found. Planned univariate repeated-measures ANOVAs showed that the interaction effect was driven by a significant improvement of performance in the GMT + MM group, $F(1,15) = 9.099$, $p = 0.009$), but not in the TAU only group, $F(1,15) = 0.789$, $p = 0.388$. For the IST “decreasing” condition, a significant “Time x Treatment” interaction was found in the two main dependent variables: number of boxes opened per trial and total number of errors.

Table 2. Results on neuropsychological performance in GMT + Mindfulness vs. Standard Treatment in polysubstance users.

Test	Dependent Variables	GMT+MF		TAU only		F-Interac. (*p*)	
		Pre – Mean (*SD*)	Post – Mean (*SD*)	Pre – Mean (*SD*)	Post– Mean (*SD*)		
L&N	Raw score	9.56 (1.78)	10.88 (2.24)	9.81 (2.01)	10.06 (2.02)	4.516 (0.049)	GMT+MF > ST
Zoo map	Raw score	1.5 (2.42)	4.88 (2.63)	1.56 (4.30)	3.63 (3.36)	0.727 (0.401)	
	Initial thinking time (s.)	57.56 (39.14)	86.81 (53.75)	101.2(85.96)	48.62 (54.75)	8.143 (0.008)	GMT+MF > ST
RSAT	Brief/total	0.79 (0.16)	0.88 (0.09)	0.84 (0.09)	0.90 (0.09)	0.498 (0.486)	
IST DC	Boxes opened per trial	9.33 (4.77)	12.09 (5.06)	8.82 (2.66)	8.44 (3.40)	5.513 (0.026)	GMT+MF > ST
	Sampling Errors	2 (1.26)	1 (0.89)	2.06 (1.34)	2.25 (1)	6.217 (0.018)	GMT+MF > ST
IST FC	Boxes opened per trial	13.47 (6.56)	14.94 (6.17)	13.08(4.21)	12.11 (4.95)	1.398 (0.246)	
	Sampling Errors	1.06 (1.53)	1 (1.15)	1.06 (0.85)	1.18 (1.17)	0.135 (0.716)	
SOC	Total moves	16.73 (1.54)	16.08 (1.67)	16.94(1.51)	17.05 (1.37)	1.380 (0.249)	
	Initial thinking time (s.)	24.46 (10.88)	22.83(11.25)	23.76(11.44)	14.55 (8.69)	2.666 (0.113)	
Stroop	Inhibition time (s.)	19.67 (5.45)	16.20 (5.70)	20.07(8.01)	17.21 (3.85)	0.232 (0.634)	
	Errors inhibition	0.75 (1.06)	0.37 (0.72)	0.80 (1.37)	0.87 (0.99)	0.864 (0.360)	
MET-CV	Task failures	6.69 (3.82)	3.81 (3.29)	4.47 (2.64)	4.93 (2.34)	8.485 (0.007)	GMT+MF > ST
	Inefficiencies	2.94 (1.98)	1.06 (1.24)	4.4 (3.79)	3.13 (2.97)	0.367 (0.550)	
	Rules broken	4.63 (2.31)	3.90 (2.22)	5.27 (3.19)	6.13 (2.95)	1.608 (0.215)	
	Total errors	15.69 (6.56)	9.65 (6.23)	14.80(6.25)	14.80 (5.68)	5.217 (0.030)	GMT+MF > ST
	Initial thinking time (s.)	62.25 (75.36)	97.81 (53.20)	45 (41.92)	17.80 (20.31)	4.189 (0.050)	GMT+MF > ST
	Total strategies	6.06 (2.91)	8.50 (3.26)	6.27 (2.68)	5.4 (2.90)	7.216 (0.012)	GMT+MF > ST

Note: GMT+MF = Goal Management Training + Mindfulness, TAU only = Standard treatment as usual only group, *SD* = Standard Deviation, L&N = Letters and Numbers, RSAT = Revised Strategy Application Test, IST = Information Sampling Test, SOC = Stocking Of Cambridge, MET-CV = Multiple Errands Test- Contextualized Version

Planned univariate repeated-measures ANOVAs showed that the interaction effect was driven by a significant increase in the number of boxes opened per trial in the GMT + MM Group, F(1,15) = 5.548, *p* = 0.033, but not in the TAU only group, F (1,15) = 0.343, *p* = 0.567. There was also a reduction in number of errors in the GMT + MM Group, F (1,15) = 8.571, *p* = 0.010, but not in the TAU only group, F(1,15) = 0.319, *p* = 0.580. In the fixed condition none of the dependent variables were significant.

For the Zoo Map Test, a significant "Time x Treatment" interaction was found in the initial thinking time. Planned univariate repeated-measures ANOVAs showed that the interaction effect was driven by a significant decrease in the TAU only group, F (1,15) = 6.027, *p* = 0.027, while it remained stable in the GMT + MM group, F(1,15) = 2.352, *p* = 0.146. No significant differences were found in the raw score.

For the MET-CV, the number of task failures, total amount of strategies, initial thinking planning time and the total number of errors showed a significant "Time x Treatment" interaction. Planned univariate repeated-measures ANOVAs showed that the interaction effect was driven by a significant reduction of task failures in the GMT + MM group, F(1,15) = 8.787, *p* = 0.010, but not in the TAU only group, F(1,14) = 0.656, *p* = 0.432; a significant reduction of total errors in the GMT + MM group, F(1,15) = 8.843, *p* = 0.009, but not in the TAU group, F(1,14) = 0.000, *p* = 1.000; a significant improvement in the total amount of strategies used in the GMT + MM group, F(1,15) = 6.148, *p* = 0.026, but not in the TAU only group, F(1,14) = 1.464, *p* = 0.246 and a significant reduction of the initial thinking time in TAU only group, F(1,15) = 4.507, *p* = 0.052, but not in the GMT + MM group, F(1,14) = 1.621, *p* = 0.222. The indices breaking of rules and inefficiencies did not reach significance.

No significant effects of the "Time x Treatment" interaction were found for the Stocking of Cambridge, Stroop or Revised Strategy Application test.

The results of the Perceived Stress Scale, showed a "Time x Treatment" interaction (F = 6.769, p = 0.014). Planned univariate repeated-measures ANOVAs showed that the interaction effect was driven by a significant reduction in the GMT + MM group [Pre, M = 30.5, SD = 7.27; Post, M = 21.56, SD = 6.02; F (1,15) = 20.034, p = 0.000], but not in the TAU only group [Pre, M = 28.12, SD = 8.40; Post, M = 26.06, SD = 9.61; F(1,15) = 1.420, p = 0.252].

Discussion

This study aimed to test the efficacy of GMT + MM to improve executive functions and its transfer to tasks that mimic daily life activities. The results show that GMT + MM improves working memory, reflection-impulsivity/decision-making and performance in an ecological task including daily life activities. GMT + MM was also associated with a significant reduction of stress levels compared to control. These results extend the findings of our previous study, demonstrating for the first time that cognitive training with GMT + MM produces a positive transfer to daily activities in PSUD. These results have special importance for the application of cognitive rehabilitation in the context of substance use disorders, as they show that cognitive training gains relate to laboratory tasks-measured executive functions, but also to significant improvements in daily life activities.

The improvement in working memory was one of the anticipated effects of the training, as GMT and MM have previously demonstrated efficacy in improving this construct (Chiesa et al., 2011). These results have special relevance to real-life goals given that working memory facilitates the processes of keeping goals in mind and preventing attentional slips (Chen et al., 2011). The GMT + MM intervention provides specific strategies to hold goals in mind and to stop and check before action, empowering participants with a general execution schema that allows goals to be achieved. These strategies putatively facilitated the transfer of executive functions' gains into the ecological task (MET-CV), which showed a reduction of task failures and total errors in the GMT + MM group. A main effect of GMT in reducing planning and sequencing errors after GMT have also been found in a recent randomized control trial in patients with acquired brain injury (Tornas et al, 2016). Hypothetically, MM provides skills to smooth the transition between habit-based and goal-related behavior (Garland et al., 2014; McConnell & Froeliger, 2015), and thus it is also a potential contributor to these effects.

Significant increases in planning time were specifically observed in participants enrolled in GMT + MM in the MET-CV and in the Zoo Map tests. Initial thinking time is a key measure of cognitive planning, as more deliberation has been shown to be meaningfully associated with better performance in planning tasks (Cohen-Kdoshay & Meiran, 2009; Duncan et al., 2008). Initial thinking time has also been linked to the concept of reflection-impulsivity, defined as the amount of information gathered before making a decision (Verdejo-García et al., 2008). Accordingly, the GMT + MM group also showed significant changes in the IST, a specific measure of reflection-impulsivity

(Clark et al., 2006). Some specific trainings included in GMT, such as stop techniques and present-moment orientation, may have promoted greater reflection before decision-making (Slagter et al., 2007), contributing to explain the IST results. By having access to more information, the level of uncertainty associated with decision-making is reduced, as illustrated by reduced number of errors in this task. However, these results were only found in the decreasing condition and not in the fixed condition of IST. Several studies have suggested that the decreasing condition conveys greater uncertainty than the fixed condition, causing participants tend to make decisions based on a less information in order to obtain higher winnings (Clark et al., 2009; Solowij et al., 2012). In this study, participants prioritized making correct decisions over opting to greater reward specifically in this riskier condition. The focus of GMT+MM on facilitating recognition of interoceptive signals may have contributed to increased reflection in these risky scenarios (Alfonso et al., 2011).

In agreement with the well-established link between better working memory and impulsivity and lower stress levels, we also found that GMT + MM had positive effects on stress reduction (Diamond, 2013). MM mechanisms geared towards regulation of emotional input also plausible direct contributors to stress reduction (Garland et al., 2014; Tang et al., 2015). In relation to other traditional planning and cognitive control tasks, the Zoo Map test, SOC, RSAT, and Stroop, no significant changes were observed. Although GMT has shown to be more likely to produce changes in ecological versus laboratory-based tasks (Krasny-Pacini et al., 2014), some positive changes were expected in these measures given the focus of GMT on executive functions and self-regulation. The fact that these tasks tax non-specific aspects of GMT training (i.e.

problem solving, interference control) and are relatively more structured and artificial, compared to for example the Multiple Errands Test (Goel, 2010), may have contributed to more limited transfer of GMT + MM effects.

Our findings demonstrate that the GMT + MM program increases the achievement of goals in daily activities in PSUD. The improvement of these complex planning processes, cannot be explained by improvement of any single individual construct, but as a result of the coordination of multiple processes including: (i) better maintenance of goals and rules in working memory, (ii) inhibition of action errors, (iii) reflexive processes that enable better organization and sequencing of subgoals, (iv) emotional regulation and mindfulness relevant to decision-making, and (v) metacognitive top-down strategies to overcome goal neglect. In addition, ecological tasks such as MET-CV, allow for the detection of changes in molar constructs more easily than laboratory tasks. Future studies should analyze clinical outcomes linked to treatment response, such as relapse episodes, motivation for treatment, employment, social reintegration. The main strengths of this study are the novelty of the approach (first time GMT + MM is applied in therapeutic communities), the replication of previous findings (GMT + MM improved working memory and impulsivity skills, as in our previous study), and the extension of findings into ecologically valid tasks. The amelioration of working memory and impulsivity skills is particularly relevant in the context of therapeutic community treatment, as both skills have been consistently associated with drug relapse following treatment (Loughead et al., 2015; Stevens et al., 2014). This study should also be appraised in the context of certain limitations: (i) the size of the groups was small, (ii) the heterogeneous polydrug consumption of the participants makes it difficult to draw conclusions about effectiveness in specific populations and (iii) the absence of follow-up measures of treatment outcomes. In addition, the combination of two complex trainings (GMT +MM), with relatively unclear treatment pathways, make it difficult to pinpoint the precise mechanisms by which the intervention achieved positive effects. This is a common problem, as it has been shown that cognitive training is more effective as more active trainings come into play (Buschkuehl et al., 2012), but that comes with the pay-off of reduced specificity.

References

Las referencias pueden consultarse en el apartado de REFERENCIAS

IV. DISCUSIÓN GENERAL, CONCLUSIONES Y PERSPECTIVAS FUTURAS

Capítulo 8.
Discusión general, conclusiones y perspectivas futuras

1. Discusión general

El objetivo principal de esta tesis doctoral fue estudiar, desde una aproximación *function-led* (utilizando pruebas que permitan la generalización de los resultados obtenidos al funcionamiento en contextos reales) (Parson, 2016, p. 2), la evaluación de procesos ejecutivos de orden superior y la intervención dirigida a mejorarlos, en personas en tratamiento comunitario por trastorno por policonsumo de drogas. Para alcanzar esta meta general se pusieron en marcha tres estudios con objetivos específicos. El primero de estos objetivos implicó el diseño y aplicación de una nueva versión del Multiple Errands Test desarrollado para entornos hospitalarios por Knight y cols. (2002). La nueva versión, denominada MET– Contextualized Version (MET-CV), ha demostrado que se adapta a diferentes entorno físicos manteniendo la consistencia en los resultados obtenidos por tres grupos de sujetos con características similares. Esta prevista capacidad para adaptarse puede basarse en que el eje central de la prueba es la contextualización de las tareas que la componen, es decir, que todas tienen un contexto que las dota de sentido y dejan de tener la arbitrariedad de las tareas contenidas en otras versiones del MET. El contexto interno lo aporta la actividad cotidiana de organizar una merienda o una fiesta de cumpleaños, por lo que el entorno físico en el que se distribuyen las diferentes tareas puede pasar a un plano secundario. Estimamos que, salvo grandes inconvenientes en el entorno físico del centro o lugar al que se pretenda adaptar la prueba, el MET-CV se podría adaptar a cualquier contexto ambiental. El propio diseño de la nueva herramienta de evaluación aporta estabilidad a los resultados en base a que las demandas a los sujetos son similares y no dependen del entorno en el que se realice. Una de las ventajas de la versatilidad para la administración de la prueba radica en la posibilidad de comparar resultados de diferentes estudios sin necesidad de adaptar y validar cada una de las versiones específicas del MET para entornos que probablemente no sean iguales en dos lugares diferentes, como supermercados, hospitales, etc. (Alderman, Burgess, Knight, & Henman, 2003; Knight et al., 2002). El MET-CV ha demostrado su validez de constructo como prueba de evaluación de funciones ejecutivas, gracias a las correlaciones que mantiene con pruebas validadas para componentes ejecutivos como la memoria de trabajo y la planificación. Sin embargo, el MET-CV, al igual que las otras versiones del MET aporta una información añadida sobre los sujetos evaluados, difícilmente extraíble de las pruebas con las que correlaciona, por ejemplo, la información sobre la puesta en marcha de estrategias poco eficaces cuando el contexto permite que de forma sencilla se utilicen otras estrategias altamente eficaces. Entre las estrategias eficaces disponibles se incluye la realización de dos tareas simples de forma simultánea o la planificación mínima antes o durante la ejecución, para evitar la pérdida de tiempo por la deambulación errática o por pasar más de una vez por un mismo lugar de forma innecesaria. Este aporte del MET-CV se añade a los ya encontrados para facilitar la elaboración de diferentes perfiles de alteraciones de la planificación en los usuarios. Knight et al. (2002) encontraron que con el MET se podían elaborar dos perfiles diferenciados, uno de sujetos que fallaban en las tareas, y otro caracterizado fundamentalmente por la ruptura de las reglas. Con los hallazgos del estudio actual, a estos dos perfiles se puede añadir un tercero, caracterizado por el uso no forzado de estrategias ineficaces.

El diseño de pruebas *function-led* implica también la necesidad de que la herramienta permita detectar alteraciones cognitivas (Parsons, 2016, p. 8). Los hallazgos del MET-CV indican que la ejecución de los policonsumidores difiere significativamente de la de sujetos sanos, y que en algunos de sus índices, como el tiempo de planificación inicial, el uso de información contextual y las ineficiencias, el tamaño del efecto es considerablemente mayor que el obtenido para el resto de pruebas de evaluación ejecutiva y de la planificación. Estos resultados avalan las adecuadas características psicométricas de la nueva versión contextualizada del MET como herramienta para detectar las alteraciones de la planificación y la elaboración de perfiles diferentes en las personas evaluadas.

En el segundo estudio se determinaron que las alteraciones de la planificación en policonsumidores son observables tanto en tareas ampliamente utilizadas que se caracterizan por un grado de estructuración alto (Stocking of Cambridge) (Baldacchino, Balfour, Passetti, Humphris, & Matthews, 2012; Fishbein et al., 2007a; Flannery et al., 2007; Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2006; Noel, Brevers, & Bechara, 2013; Pitel et al., 2007), como en otras menos aplicadas, tanto de estructuración media (Mapa del Zoo) [(Fernández-Serrano, Perales, Moreno-López, Pérez-García, & Verdejo-García, 2012; Moriyama et al., 2002)] como de tipo *function-led* (MET-CV) cuya estructura es considerablemente más baja. Sin embargo, tanto para los intereses de investigación como clínicos, es destacable que por primera vez se muestra que las alteraciones de la planificación en esta población son mucho más fácilmente evidenciables si utilizamos nuestra prueba de aproximación *function-led,* el MET-CV, al que también podríamos denominar prueba de tipo ecológico, por desarrollarse en contextos reales y con actividades cotidianas. Para establecer el grado de estructuración de las diferentes tareas utilizadas realizamos un análisis cualitativo basado en la clasificación de Goel (2010) y presentado en la Tabla 3 del segundo estudio (titulada *Description of structural levels for the three planning tasks*). Consideramos que, aunque no se trate de resultados directamente derivados del estudio realizado, el análisis de estas tres tareas podría suponer una contribución para una mayor comprensión de las pruebas que se utilizan cada vez con mayor frecuencia en la evaluación con fines clínicos y de investigación, y de factores que son determinantes en el diseño de las mismas.

Otro de los objetivos del segundo estudio fue determinar diferencias entre las contribuciones del consumo de sustancias y de los factores de inteligencia en los resultados de las tres diferentes tareas de planificación incluidas (Stocking of Cambridge, Mapa del Zoo y MET-CV). Resultados de regresiones lineales jerárquicas permitieron comprobar que el consumo de sustancias, específicamente el consumo de heroína y alcohol, contribuyen negativamente al resultado en este tipo de tareas independientemente de su grado de estructuración. La inteligencia también contribuyó a explicar los resultados en todas las tareas, pero lógicamente, a diferencia del consumo de sustancias, mayores niveles de inteligencia facilitaron positivamente la ejecución de estas. Ya era conocido el hallazgo de que la inteligencia fluida se relaciona con el rendimiento en las pruebas de planificación altamente estructuradas (McManus et al., 2014; Obonsawin et al., 2002; Unterrainer et al., 2004; Zook et al., 2004, 2006), sin embargo, en el análisis específico de las variables predictoras significativas, se observó por primera vez su contribución en las de media y baja estructura, así como que la inteligencia cristalizada sólo contribuyó a explicar la ejecución en el MET-CV, aumentando notablemente la varianza explicada del modelo en el MET-CV (52.1%) respecto a las otras tareas con menor grado de estructuración (12.9% - 16.6%). La influencia del factor de inteligencia cristalizada en el desempeño cotidiano podría abrir nuevas vías de intervención en el objetivo de autonomía personal de las terapias con policonsumidores.

Finalmente, el último estudio centrado en la intervención neuropsicológica de procesos cognitivos de orden superior, mostró que el programa combinado *Goal Management Training* y *Mindfulness Meditation*, permiten mejorar el funcionamiento ejecutivo de los procesos de memoria de trabajo, reflexión impulsividad en toma de decisiones. Los principales constructos que se beneficiaron de la intervención fueron los procesos reflexivos, derivados del aprendizaje de técnicas de frenado para dedicar un momento a pensar en los objetivos, así como de un mejor manejo de la información en la memoria de trabajo. El programa además contribuyó a reducir el nivel de estrés percibido. Finalmente cabe destacar que este es el primer estudio que permite comprobar una transferencia positiva del funcionamiento de las actividades diarias. Ninguno de estos beneficios se encontró en el grupo que sólo recibió el tratamiento comunitario estándar.

1.1 Implicaciones teóricas

Los hallazgos de los estudios que conforman la presente tesis permiten ampliar y avanzar en el conocimiento teórico en diversas áreas. Estos resultados permiten profundizar en el conocimiento teórico de las consecuencias derivadas del consumo de drogas en el funcionamiento ejecutivo de alto orden. Además, permite mejorar la comprensión de los procesos cognitivos que subyacen en el diseño de las pruebas de evaluación de la planificación.

Las hallazgos de nuestros estudios son consistentes con los estudios previos, que señalan que el consumo de sustancias se asocia con alteraciones en las funciones ejecutivas (Abi-Saab et al., 2005; Bolla, Funderburk, & Cadet, 2000; Rogers et al., 1999). Durante las últimas décadas, los déficits en determinados constructos cognitivos han sido estudiados por su estrecha relación con las conductas adictivas, como la impulsividad o la toma de decisiones (Berlin, Rolls, & Kischka, 2004; Bolla et al., 2003; Dom, De Wilde, Hulstijn, van den Brink, & Sabbe, 2006; Ersche et al., 2005). Poner el foco de estudio sobre la impulsividad y toma de decisiones en adictos, resulta lógico dado que la conducta de los adictos se caracteriza por una tendencia a la acción (consumo) sin toma de conciencia, valoración o juicio, a pesar de las consecuencias negativas inmediatas que produce en el individuo y su entorno. En la misma dirección, las personas adictas presentan una miopía hacia el futuro que les impide incorporar las consecuencias negativas a largo plazo del consumo de sustancias, evidenciando problemas en la toma de decisiones. El estudio de la impulsividad y toma de decisiones no sólo se debe a que el consumo de drogas altera los circuitos cerebrales implicados en su funcionamiento, sino también a su papel como marcadores de vulnerabilidad o de recaída (Adinoff et al., 2016; Pattij & De Vries, 2013; Verdejo-García, Lawrence, & Clark, 2008).

En cambio, constructos como la planificación o la multitarea han recibido menor atención, a pesar de su relación directa con aspectos importantes de la vida diaria como el éxito académico, laboral o social (Carlson, Mandell, & Williams, 2004; Gonzalez et al., 2014). Resulta llamativo que tan sólo se hayan encontrado 10 estudios en los que se haya analizado la ejecución de consumidores de drogas en tareas de planificación (Brand, Roth-Bauer, Driessen, & Markowitsch, 2008; Fernández-Serrano et al., 2012; Fishbein et al., 2007a; Flannery et al., 2007; Goudriaan et al., 2006; Madoz-Gúrpide, Blasco-Fontecilla, Baca-García, & Ochoa-Mangado, 2011; Moriyama et al., 2002; Noël et al., 2001; Ornstein et al., 2000; Pitel et al., 2007). Como se ha evidenciado en la introducción, prácticamente la totalidad de estos estudios han utilizado los problemas de torres como instrumentos de evaluación de la planificación. En esta tesis, por primera vez, se analiza y compara la ejecución de policonsumidores de drogas en la citadas tareas clásicas de planificación de alta estructura (problemas de torres) con el rendimiento en tareas con menor grado de estructura y que cumplen la aproximación funtion-led (MET-CV). El resultado del análisis indica las ventajas de la prueba MET-CV para capturar y caracterizar los déficits de planificación de las personas policonsumidoras. Según el modelo de Goel (2010) esta ventaja se apoya en que la resolución de problemas que se realiza en las tareas clásicas de laboratorio dista mucho de la solución de problemas que se lleva a cabo en nuestra vida cotidiana, ya que son pruebas caracterizadas por tener objetivos simples, reglas específicas, soluciones determinadas, una forma de resolver el problema concreta y una interconectividad alta. Poco que ver con los problemas del mundo real, que suelen tener múltiples objetivos y reglas, soluciones que dependen de criterios más subjetivos y una interconectividad mucho menos estricta. Por este motivo, en esta tesis se aporta un marco teórico que permite discriminar entre los distintos tipos de instrumentos de evaluación, y establecer un continuo basado en el grado de estructuración de las pruebas que facilitará una predicción más ajustada sobre el tipo de problemas de planificación que tiene la persona y cuál debería ser el foco de la intervención dirigida a mejorarlos.

Otra gran limitación en los hallazgos de la literatura se debe a que todos los estudios han sido llevados a cabo en consumidores de alcohol y heroína (Fishbein et al., 2007a; Noël et al., 2001). En consumidores de cannabis los estudios son limitados y los resultados contradictorios (Medina et al., 2007; Ramaekers et al., 2011) y en el caso de consumidores de cocaína, los dos únicos estudios publicados ofrecen más confusión que evidencias debido a que la muestra fue la misma en ambos estudios pero los resultados publicados en uno y otro artículo son distintos, impidiéndonos extraer conclusiones válidas (Madoz-Gúrpide et al., 2011; Madoz-Gúrpide & Ochoa-Mangado, 2012). En este panorama, la presente tesis refuerza que el consumo de alcohol contribuye negativamente a la resolución de problemas de alta y baja estructura, y la heroína a los de baja estructuración. Además, añade la confirmación de que el consumo de cocaína no aporta una contribución significativa independiente a la ejecución en ninguna de las tereas de planificación. La interpretación de estos resultados se fundamenta en la hipótesis de que el consumo de drogas produce alteraciones de las estructuras más frontales del cerebro, particularmente del córtex dorsolateral prefrontal derecho (Fishbein et al., 2007a), relacionado con habilidades ejecutivas como la planificación espacial, la solución de problemas, la memoria de trabajo o el razonamiento abstracto. Sin embargo, esta explicación no puede ser definitiva porque el consumo de cocaína también produce alteraciones específicas en estas áreas (Terraneo et al., 2016), por lo que se esperaban resultados similares para esta sustancia y no se han encontrado.

Finalmente, conviene destacar que el consumo de ninguna de las tres sustancias estudiadas (alcohol, heroína o cocaína) contribuyó a explicar la ejecución en el índice de número mínimo de movimientos del Stocking of Cambridge ni en el Mapa del Zoo, siendo en ambos casos, la inteligencia fluida el único contribuyente independiente en la explicación de la ejecución. El análisis de este hallazgo representa un reto. Podríamos basarnos en el enfoque dual planteado de partida, en base al cual se hipotetiza que el consumo de sustancias afecta negativamente al rendimiento ejecutivo, mientras que la inteligencia contribuye positivamente en la correcta ejecución de este tipo de tareas. Ambos índices se caracterizan por exigir del sujeto un rendimiento óptimo casi perfecto para tener una alta puntuación. Cuando se analizan los estudios realizados con los problemas de torres, encontramos que el número mínimo de movimientos es una variable en la que las diferencias entre grupos son más marcadas (Fishbein et al., 2007b; Ornstein et al., 2000). Igualmente ocurre con el mapa del Zoo, donde errores iniciales conducen casi irremediablemente a una baja puntuación final, hecho que ha motivado que los autores se planteen una revisión de las pautas de corrección. Los requerimientos para una ejecución perfecta movilizarían un número mayor de recursos cognitivos, otorgando a la inteligencia fluida un papel preponderante en la obtención de resultados polarizados (o son buenos o son malos), dejando el papel de los efectos del consumo de sustancias en un segundo plano.

Por otro lado, está tesis también contribuye a ampliar el conocimiento acerca de la relación existente entre la inteligencia y las tareas de planificación según su grado de estructura. Es conocido, que la inteligencia es un constructo global y amplio del funcionamiento cognitivo Stankov (2000). Creemos que esta tesis no aporta mucho al debate que se mantiene en algunos foros acerca de si la inteligencia fluida y las funciones ejecutivas pueden ser consideradas conceptos similares (García-Molina, Tirapu-Ustárroz, Luna-Lario, Ibáñez, & Duque, 2010). Sin embargo, los hallazgos de esta tesis son consistentes con la literatura que evidencia la clara relación entre la inteligencia fluida y el desempeño en las tareas altamente estructuradas (Duncan, Burgess, & Emslie, 1995; Numminen, Lehto, & Ruoppila, 2001; Unterrainer et al., 2004; Zook, Davalos, Delosh, & Davis, 2004). En lo que respecta a las tareas con un grado de estructura medio, la literatura es escasa y no respalda claramente la relación que hemos encontrado entre inteligencia fluida y planificación en contextos con estructuración moderada (Boyer, Geurts, & Van der Oord, 2014; Oosterman, Wijers, & Kessels, 2013). En cuanto a los estudios que emplean tareas de baja estructura como el MET, aparece una correlación entre la inteligencia en su conjunto y la ejecución de las pruebas (Alderman et al., 2003), pero ningún estudio analiza en profundidad los componentes implicados en esta relación. Esta tesis confirma que la inteligencia fluida se relaciona con el desempeño en tareas de planificación independientemente de su grado de estructura y aporta como novedad la evidencia del papel que desarrolla la inteligencia cristalizada en una tarea de baja estructura como el MET-CV. La notable contribución de la inteligencia cristalizada en esta prueba permite explorar nuevas perspectivas teóricas sobre la resolución de problemas en ambientes naturales. La inteligencia cristalizada es representativa del conocimiento adquirido a lo largo de nuestras vidas, incluyendo habilidades académicas, profesionales, sociales, etc. (Cattell, 1987). A pesar de la importancia que a priori deberíamos dar al conocimiento adquirido en la resolución de problemas, pues permitiría evitar errores pasados y beneficiarse de la información útil, éste apenas se ha tenido en cuenta en el estudio de las funciones ejecutivas. Las causas por las que el rol de la inteligencia cristalizada en la planificación no se ha evidenciado en estudios previos podrían ubicarse en las condiciones artificiales y altamente estructuradas de las tareas neuropsicológicas tradicionales. Estas pruebas, a las que nos hemos referido como tareas de laboratorio (por ejemplo, los problemas de torres), se administran en un entorno tranquilo, con muy pocos distractores y con una serie de reglas poco familiares que no se encuentran típicamente en las actividades de la vida diaria (Chaytor & Schmitter-Edgecombe, 2003; Duncan, Emslie, Williams, Johnson, & Freer, 1996). Estos datos apuntan a que las tareas de laboratorio altamente estructuradas impedirían, precisamente por su alto grado de estructuración, la necesidad de poner en marcha determinados recursos cognitivos como el conocimiento adquirido. En cambio, el MET-CV con una estructura funcional similar a las actividades de la vida diaria, es capaz de movilizar los recursos dependientes de la experiencia previa.

Cabe recordar que la diferencia entre las tareas de alta estructura y las de baja estructura, recae en que en las de baja estructura la información disponible para que el participante pueda resolver el problema es ambigua, poco precisa, por lo que no ayuda en la toma de decisiones sobre los pasos a dar. Por lo tanto, el participante debe completar las lagunas de información y reinterpretar los datos en base a su experiencia subjetiva previa, aportando así un tipo de estructura consistente con situaciones pasadas del sujeto. Esto implica clarificar y redefinir los objetivos, las reglas, la forma de resolver el problema (transformaciones) o valorar la idoneidad de la respuesta dada. Según Goel (2000) esta fase de estructuración requiere de procesos asociativos en los que el pensamiento lateral o divergente tiene un papel clave. Los procesos asociativos dependen de la información adquirida y por lo tanto están estrechamente relacionados con la memoria (Madore, Addis, & Schacter, 2015). Dicho de otro modo, ante problemas en los que la información no es facilitada de forma estructurada y clara, nuestro cerebro debe ajustar parámetros relacionados con los objetivos y organizar la forma de abordarlos. El pensamiento divergente, creativo o lateral es el encargado de realizar este proceso mediante la generación de nuevas hipótesis para explorar nuevas perspectivas o situaciones poco convencionales (Madore et al., 2015). Estas hipótesis, son guiadas por el conocimiento previo, que señala como debemos de organizarnos o como aplicar estrategias de forma que podamos enfrentarnos a nuestro objetivo de manera exitosa (Cropley, 2006). Estas nuevas hipótesis surgirían en la memoria de trabajo gracias a la propia dinámica de conexión entre ésta y la memoria a largo plazo en la que reside el conocimiento y nuestras habilidades (Hildebrandt, Brokate, Eling, & Lanz, 2004). Esta hipótesis ayuda a explicar porque determinados pacientes ejecutan perfectamente determinados test neuropsicológicos, pero muestran problemas para enfrentarse a la incertidumbre y ambigüedad que representan las actividades de la vida diaria (Burgess, 1997; Burgess, Alderman, Evans, Emslie, & Wilson, 1998). O visto de otra perspectiva, explicaría porque determinadas personas con buenos niveles intelectuales, son incapaces de generar respuestas creativas no ligadas a procesos lógicos.

Este tipo de pensamiento divergente es considerado sinónimo de creatividad. Los científicos siempre han mostrado curiosidad de cómo determinadas personas crean ideas originales y de gran utilidad. Cuando a las personas con ideas creativas se les pregunta cuál es el proceso que han seguido para desarrollar una idea original, la mayoría de las veces no saben responder y terminan diciendo que simplemente les vino a la mente una idea de forma automática (Goel, 2010). En cambio una persona conocida por su gran nivel de creatividad fue Steve Jobs que decía: "La gente creativa es capaz de conectar con experiencias que les permiten sintetizar nuevas cosas. Y la razón por la que tienen estas ideas es porque tienen más experiencias que otra gente". Es decir, no hay fórmulas mágicas para conseguir resolver problemas de formas creativas, sino que el peso recae en la experiencia previa. En la misma dirección Simon & Chase, fueron los autores de la famosa regla de las 10.000 horas, según ellos una persona puede considerarse un genio cuando dedica esta cantidad de tiempo a perfeccionar una habilidad.

En resumen, la forma de resolver los problemas en el mundo real dista de los problemas tradicionales de laboratorio, pues en los primeros el participante debe de pasar por un proceso previo de estructuración, que no está presente en las tareas de laboratorio pues la información que se facilita es completa. Esta fase de estructuración, depende del pensamiento lateral o divergente, que surge de procesos asociativos dependientes del conocimiento previo. Así pues, las tareas ecológicas proporcionan mayor información del desempeño real en las actividades de la vida diaria, puesto que estas tareas exigirían mayores demandas y por lo tanto el uso de más recursos cognitivos que las tareas tradicionales.

1.2 Implicaciones clínicas

Los hallazgos de los estudios de la presente tesis pueden tener implicaciones clínicas relevantes para el diagnóstico y evaluación de las funciones ejecutivas así como la intervención y mejora de los procesos cognitivos.

La principal aportación de esta tesis en la evaluación neuropsicológica es la adaptación del test Multiple Errands Test – Contextualized Version. Este test es el primer instrumento a nivel internacional, que permite evaluar los procesos de planificación de forma ecológica en población con desordenes por policonsumo de drogas.

Los resultados obtenidos del MET-CV muestran que esta tiene buenas propiedades para su uso en la práctica clínica y además incluye mejoras respecto a otras versiones previas. Una de las principales razones que originaron el desarrollo de esta versión contextualizada del MET, fue la incapacidad para adaptar y utilizar esta prueba más allá de los contextos originales en los que fue creada (e.g. centro comercial, hospital…) (Alderman et al., 2003; Knight et al., 2002). Esta tesis muestra que esta nueva versión pudo ser adaptada en tres comunidades terapéuticas diferentes y un centro de investigación universitario (CIMCYC), mostrando buena consistencia interna, es decir, la aplicación en distintos contextos físicos no produce variaciones significativas en la administración e interpretación de los resultados. Esto fue posible al eliminar los elementos del entorno físico implicados en la tarea (supermercado, lavandería…) y cambiarlos por elementos universales cotidianos que pueden encontrarse en la mayoría de los entornos (folleto de supermercado, periódico…). Estos hallazgos tienen especial relevancia para la evaluación clínica pues proporciona una herramienta que aporta información a nivel de función (ecológico) y que puede ser utilizada en la mayoría de los centros de intervención, como las comunidades terapéuticas, hospitales, centros de día, casas de acogida…

Además, el MET-CV tuvo buenas propiedades psicométricas en su validez de constructo. El MET-CV mostró correlaciones moderadas respecto otras tareas de planificación con menor grado de estructuración, con índices de memoria de trabajo, inteligencia e índices de consumo. Estos resultados señalan que este test puede ser usado en población drogodependiente debido a su sensibilidad con factores de consumo. En la misma dirección, la correlación con constructos neuropsicológicos de alto orden está apoyada por la literatura previa, que apuntan a que la memoria de trabajo, la inteligencia o la planificación de múltiples objetivos son elementos estrechamente relacionados que mejor reflejan el desempeño de las personas en el mundo real (Ackerman, Beier, & Boyle, 2002; Colom, Martínez-Molina, Shih, & Santacreu, 2010). Además las puntuaciones fueron estandarizadas en un grupo control.

Por otro lado, el MET-CV es una nueva herramienta de evaluación, con mayor capacidad discriminativa y por lo tanto diagnóstica. Los resultados muestran que la ejecución de los policonsumidores de sustancias en las tareas tradicionales, Stocking of Cambridge y Mapa del Zoo, permiten diferenciar la ejecución respecto a controles sanos. En cambio, al someter estos resultados a análisis estadísticos más exigentes como la corrección de Bonferroni, estos no mantienen la significación, generando dudas respecto al estado cognoscitivo real de los participantes. Algunos estudios previos muestran dificultades para encontrar diferencias ejecutivas en los problemas de torres entre policonsumidores de sustancias y controles sanos, hechos que apoyan nuestros resultados (Brand et al., 2008; Flannery et al., 2007). En cambio el MET-CV, permite discriminar la ejecución de consumidores de sustancias de población no consumidora de una forma clara y concisa, reflejada por tamaños del efecto mayores a los encontrados en tareas clásicas. Estas diferencias entre grupos se mantienen incluso aplicando análisis estadísticos más exigentes. Esta sensibilidad incrementada se debe a que esta tarea tiene en cuenta factores como el contexto que rodea las actividades diaria que desarrollan las personas (Chaytor and Schmitter-Edgecombe, 2003). La ausencia de estudios de esta índole impide contrastar nuestros resultados con el estudio previo. Sólo el estudio de Laloyaux y cols. (2012) en el que un grupo de alcohólicos realizó una tarea de realidad virtual, permite respaldar nuestros resultados, señalando que las tareas de baja estructura pueden discriminar fehacientemente la ejecución de consumidores de sustancias respecto a no consumidores.

Los estudios de esta tesis señalan que las características estructurales de las tareas que miden constructos de orden superior son relevantes si lo que se pretende es conseguir información más precisa y de carácter funcional de cómo las personas se desenvuelven en el mundo real. Es importante tener en cuenta que no se aboga por descartar las tareas de laboratorio como instrumentos de evaluación, sino utilizar sus resultados de una forma más cercana a una evaluación screening que a una representación de cómo la persona afronta problemas complejos en su vida cotidiana.

Finalmente, las implicaciones clínicas más notorias se extraen del estudio de tratamiento. Los resultados tras aplicar el programa de intervención *Goal Management Training* junto con *Mindfulness Meditation*, mostraron que estos programas permiten mejorar e entrenamiento ejecutivo, especialmente los procesos reflexivos en toma de decisiones y memoria de trabajo en policonsumidores de drogas en tratamiento comunitario. La eficacia de estos programas es de sobra conocida en poblaciones con alteraciones neurológicas (Krasny-Pacini, Chevignard, & Evans, 2014) y también en consumidores de sustancias (Alfonso, Caracuel, Delgado-Pastor, & Verdejo-García, 2011). Sin embargo, muchos de estos estudios han empleado instrumentos con escasa validez ecológica a pesar de que estos programas tienen una clara orientación funcional centrada en las actividades de la vida diaria. Este es el primer estudio en confirmar que el *Goal Managment Training* y *Mindfulness Meditation* producen una transferencia positiva a las actividades de la vida diaria en policonsumidores de drogas, evaluados con el MET-CV. Además también se halló una reducción del nivel de estrés percibido en el grupo que recibió el tratamiento, debido principalmente a los efectos del programa Mindfulness Meditation, que facilita la regulación del input emocional. Sin embargo, el programa Goal Managment training también podría facilitar la regulación emocional aunque este no sea su principal objetivo, pues estudios previos han evidenciado que el entrenamiento ejecutivo repercute en la reducción del nivel de estrés (Liston, McEwen, & Casey, 2009; Luethi, Meier, & Sandi, 2009).

Estos hallazgos tienen especial relevancia en el campo de la rehabilitación cognitiva, pues permiten confirmar que estos programas producen mejoras cognitivas en instrumentos neuropsicológicos tradicionales centrados en el nivel de constructo, pero esta mejora también alcanza el nivel más funcional de la conducta, que es en el que están interesados los profesionales clínicos. Así pues, estos programas actuarían movilizando múltiples constructos que se coordinarían para facilitar la consecución de objetivos. Estos procesos serían: (i) mantenimiento de reglas y objetivos en la memoria de trabajo, (ii) inhibición de errores de acción, (iii) procesos reflexivos que facilitan la organización y secuenciación de subobjetivos, (iv) regulación emocional y Mindfulness en toma de decisiones y (v) estrategias metacognitivas arriba abajo que evitan la negligencia al objetivo.

En conjunto, los hallazgos de esta tesis doctoral pueden suponer importantes implicaciones para la evaluación clínica y también para la intervención neuropsicológica, en consumidores de sustancias con problemas ejecutivos y de regulación emocional.

2. Conclusiones

Las conclusiones generales que se derivan de los tres estudios incluidos en la presente tesis doctoral son:

1. Las personas policonsumidoras de sustancias presentan alteraciones específicas en las funciones ejecutivas (memoria de trabajo, reflexión-impulsividad en toma de decisiones, planificación y multitarea).
2. Las personas policonsumidoras de sustancias presentan déficits ejecutivos en la planificación, tanto en tareas con un grado de estructuración bajo, medio y alto, pero las alteraciones son más evidentes en las tareas de baja estructura administradas en contextos reales (por ejemplo, el Multiple Errands Test-Contextualized Version).
3. El MET-CV es una herramienta con validez para la evaluación de la planificación, con un grado bajo de estructura, y adaptable para una medición fiable en diferentes contextos reales. Entre las propiedades psicométricas mostradas destaca la validez concurrente con tareas neuropsicológicas tradicionales de medida de la función ejecutivas y la consistencia interna entre las diferentes adaptaciones a contextos reales. El MET-CV es un instrumento útil para evaluación de la planificación con objetivos clínicos y de investigación.

4. El consumo de drogas, especialmente alcohol y heroína se relaciona negativamente con la ejecución en tareas de planificación de baja y alta estructura.
5. La inteligencia fluida se relaciona positivamente con la ejecución en tareas de planificación independientemente de su grado de estructuración. En cambio la inteligencia cristalizada contribuye de manera notable y específica en la ejecución de tareas de planificación de baja estructura.
6. El programa Goal Management Training + Mindfulness Meditation mejora la consecución de objetivos en actividades de la vida diaria en policonsumidores de sustancias.
7. El programa Goal Management Training + Mindfulness Meditation mejoran la ejecución de procesos complejos de planificación, que no pueden ser explicados por la mejora de constructos cognitivos independientes, sino como resultado de la coordinación conjunta de estrategias metacognitivas que actúan de arriba-abajo para evitar la negligencia de objetivos gracias a: (i) mantenimiento de objetivos y reglas en la memoria de trabajo, (ii) inhibición de errores de acción, (iii) procesos reflexivos que facilitan la organización y secuenciación de subobjetivos y la toma de decisiones, (v) regulación emocional y (vi) estrategias metacognitivas arriba-abajo que evitan la negligencia al objetivo

3. Perspectivas futuras.

Los resultados de esta tesis doctoral, abren nuevas cuestiones e hipótesis de trabajo futuro que deberían considerarse en el campo de las adicciones y de la planificación. Entre ellas se destacan:

1. Debido a que la mayoría de los usuarios de las comunidades terapéuticas presentan un perfil policonsumidor, futuros estudios deberían incluir grupos de consumidores puros de sustancias, que permitan concretar los efectos de determinadas sustancias sobre la planificación en ambientes naturales. Específicamente, existe un vacío científico respecto a los consumidores de cocaína que debería ser abordado en profundidad.
2. La muestra de esta tesis es predominantemente de género masculino, por lo que futuros estudios deberían considerar una distribución de género, que permitan discriminar tal y como se ha hipotetizado desde la literatura, si las diferencias de género en la solución de problemas se limita sólo a las tareas de planificación altamente estructuradas o también están presentes en los problemas más representativos de las actividades de la vida diaria.
3. La muestra de esta tesis tiene un rango de edad medio y debido a que la planificación es uno de los procesos cognitivos más tardíos en el neurodesarrollo y las consecuencias negativas del envejecimiento cerebral repercuten sobre los procesos de planificación, futuros estudios deberían ampliar los rangos de edad, incluyendo poblaciones jóvenes y mayores.
4. El estudio de la planificación en tareas de baja estructura, debería ampliarse a otras poblaciones no consumidoras.
5. Explorar la relación de constructos cognitivos específicos (memoria de trabajo, flexibilidad, memoria a largo plazo…) con los problemas de planificación de baja y alta estructura.
6. Analizar la relación entre los componentes más funcionales de la conducta obtenidos en tareas de planificación de baja estructura, con medidas más experimentales de conectividad funcional y neuroimagen. En la misma

dirección, apoyar los resultados mediante variables más biológicas, como la genética.

7. Desarrollar nuevos instrumentos de evaluación, que se asemejen en mayor grado tanto en forma y contenido al mundo real. Y que además permitan el registro de conductas que son ignoradas en ambientes artificiales, como por ejemplo los esfuerzos por mejorar respuestas que ya son consideradas correctas, permitiendo desarrollar nuevos perfiles diagnósticos ecológicos.
8. Profundizar en el estudio del pensamiento lateral o divergente, y su contribución para aportar estructura a los problemas de planificación de baja estructura. Así como su relación con otros constructos neuropsicológicos como la memoria, flexibilidad o fluidez cognitiva. En la misma dirección, mejorar la comprensión sobre el pensamiento vertical o lógico y su relación con constructos neuropsicológicos concretos.
9. Analizar qué componentes específicos del programa Goal Management Training + Mindfulness Meditation contribuyen a mejorar el pensamiento lateral o divergente implicado en la estructuración del problema; y que componentes contribuyen en el pensamiento vertical, implicado en la consecución lógica de los objetivos.
10. El programa Goal Management Training + Mindfulness Meditation ha mostrado mejorar procesos cognitivos evaluados mediante tareas de planificación tradicionales y tareas representativas de las actividades de la vida diaria. En estudios futuros se debería abordar la relación de estos cambios con variables clínicas como el éxito terapéutico, número de recaídas, funcionamiento laboral/académico,etc.

DOCTORADO INTERNACIONAL

Summary, conclusions and future perspectives

1. Summary, conclusions and future perspectives

1.1 Summary

The present doctoral thesis consists of a set of 8 chapters grouped into four sections: (i) introduction, (ii) justification and objectives, (iii) submitted and published studies, (iv) general discussion, conclusions, and future perspectives.

The first section of this thesis consists of three chapters in which the background and theoretical framework are exposed. Planning is the central theme for Chapter 1, which includes a definition for executive functions, a description of the main proposed models of executive functioning, their relation to planning processes, and their relevance for daily functioning. Next, a broad overview of the assessment instruments for planning abilities is provided. The main psychometric and structural differences are explored, as well as their relationship with other neuropsychological constructs and neuroimaging findings.

The theme of Chapter 2 is substance abuse. First, epidemiological data, the social and sanitary relevance of the problem, and the most direct consequence for the consumer are presented. Next, the main neuropsychological consequences of consumption, especially those related to planning processes, are reviewed.

In Chapter 3, the current national and European status for treatment programs and cognitive rehabilitations programs are addressed.

The second section contains Chapter 4, in which the justification for the thesis is presented, as well as the hypotheses and objectives pursued in the experimental tasks.

The third section contains three chapters, including a report for the three empirical studies performed. Chapter 5 introduces the study of an adaptation and validation of the low structured planning task, called Multiple Errands Test – Contextualized Version. In this study, participants included sixty individuals with polysubstance use disorders in community treatment and thirty healthy controls. The results show that the MET – CV was adapted to different physical contexts with good levels of reliability and validity. The results also showed that MET – CV can discriminate between the test execution of an addicted population and a healthy population more clearly than traditional neuropsychological tasks.

Chapter 6 describes a study which illustrates the difference between traditional or laboratory planning tasks (Stocking of Cambridge and Zoo Map test) and the naturalistic planning task (Multiple Errands Test – Contextualized Version). In addition, findings about the contribution of consumption variables and intelligence in each task show that substance consumption deteriorates performance on these planning tasks, while intelligence contributes in a positive direction. Among the main findings, the contribution of these variables in performance on the MET – CV stands out as it was notably higher than the other tests. Furthermore, crystallized intelligence intervenes in MET – CV performance. Nevertheless, it was not included as an independent variable of the explanatory model in the other planning tests.

Chapter 7 describes the study of the efficacy of Goal Management Training + Mindfulness Meditation program in cognitive enhancement, as well as its transference to daily activities in a group of individuals with polysubstance use disorders in community treatment. The results indicated that, with respect to the group that only received the standard treatment, the experimental intervention produced an improvement in working memory processes, reflection-impulsivity / decision-making, and emotional regulation. In addition, there was a positive transfer to daily activities, explained by the application of metacognitive strategies. Such strategies act as top-down modulation which enables a chained behavior and avoids the distractions that cause goal neglect.

The last section of the thesis, corresponding to Chapter 8, includes a general discussion of the three previous empirical studies. This section includes the main theoretical and clinical implications, conclusions, and future perspectives.

1.2 Conclusions

The general conclusions derived from the three studies included in this thesis are:

1. Individuals with polysubstance use disorders present specific alterations in executive functions (working memory, reflection-impulsivity / decision making, planning, and multitasking).
2. Individuals with polysubstance use disorders have executive deficits in planning processes, as well as in tasks with a low, medium, or high degree of structure. However, these changes are most evident in tasks with a low degree of structure administered in real contexts (e.g. Multiple Errands Test – Contextualized Version).
3. The MET – CV is a valid instrument for the assessment of planning processes, with a low degree of structure, and can be adapted as a reliable measure in different real contexts. Among the psychometric properties shown, the concurrent validity with traditional executive neuropsychological tasks and internal consistency between different adaptations to real contexts stands out. The MET – CV is a useful tool for the assessment of planning with clinical and research objectives.

4. Drug abuse, especially alcohol and heroin use, is negatively related to performance on planning tasks with low and high degrees of structure.
5. Fluid intelligence is positively associated with execution on planning tasks independent of their degree of structure. On the other hand, crystallized intelligence contributes significantly and specifically on the execution of planning tasks with low structure.
6. The Goal Management Training + Mindfulness Meditation program improves the achievement of goals in daily activities in individuals with polysbustance use disorders.
7. The Goal Management Training + Mindfulness Meditation program improves the execution of complex planning processes, which can not be explained by the improvement of independent cognitive constructs. Instead, it may be understood as a result of the coordination of multiple processes including: (i) maintenance of goals and rules on working memory, (ii) inhibition of action errors, (iii) reflexive processes that enable better organization and sequencing of subgoals, (vi) emotional regulation, and (v) metacognitive top-down strategies to overcome goal neglect.

1.3 Future perspectives

The results of this doctoral thesis open new questions and future hypotheses for research, which should be considered in the fields of addiction and planning processes.

1. Due to the fact that most users in therapeutic communities have a polysubstance use profile; future studies should include pure substance consumer groups, to delineate the specific effects of the substances on planning processes, precisely

in natural environments. Furthermore, the specific scientific gap regarding cocaine users should be addressed in depth.

2. The sample used in this thesis is predominantly male. Future studies should consider a comprehensive gender distribution so as to clarify, as has been hypothesized from literature, if gender differences in problem solving are only limited to tasks with a high degree of structure or if they are also present in problems most representative of daily activities.
3. The sample of this thesis only included middle-aged individuals. Future studies should expand the age range to include younger and older populations, due to the fact that planning is one of the latest cognitive processes to be defined in neurodevelopment and due to the negative consequence of aging.
4. The study of planning processes with a low degree of task structure should be extended to other non-consuming populations.
5. Explore the relationship between specific cognitive constructs (working memory, flexibility, long term memory, etc.) and planning problems with low and high degrees of structure.
6. Analyze the relationship between functional components of behavior obtained in tasks with a low structure with more experimental measurements, such as functional connectivity or neuroimaging techniques. Along these same lines, studies should consider the influence of other biological variables, such genetics.
7. Develop new assessment tools, which resemble the real world in form and content. Furthermore, future studies should register behaviors that are ignored in artificial environments, such as efforts to improve responses that are considered correct, allowing for the development of new ecological profiles.

8. Deepen the study of lateral or divergent thinking, and their contribution to providing structure to problems of low structural degree. In addition, study its relationship with other neuropsychological constructs such as memory, cognitive flexibility, or fluidity. Furthermore, improve the understanding of vertical or logical thought and its association with specific neuropsychological constructs.
9. Analyze which specific components of the Goal Management Training + Mindfulness Meditation program contribute to improving lateral or divergent thinking involved in the structuring phase of the problem; and what components contribute to vertical thinking, involved in the logical achievement of goals.
10. The Goal Management Training + Mindfulness Meditation program has been shown to improve cognitive processes assessed by traditional planning tasks and tasks representative of daily functioning. Future studies should address the relationship of these changes with clinical variables such as therapeutic success, number of relapses, job /academic performance, etc.

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ANEXOS CON ARTÍCULOS PUBLICADOS Y EN REVISIÓN

ANEXO I

Development of the contextualized version of the Multiple Errands Test: validation data from polysubstance users.

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Development of the contextualized version of the Multiple Errands Test: validation data from polysubstance users.

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Abstract

Drug use causes several deficits in executive functioning, such as planning and multitasking. Traditional neuropsychological planning tests have been criticized due to the fact that they do not reflect executive performance in daily activities. Shallice and Burgess (1991) developed the Multiple Errands Test (MET), in which participants are required to achieve multiple tasks in a real world environment. Even so, the MET has some limitations and it is not always adaptable for different contexts without changing its structure. Objective: The main goals of this study were, (1) to examine the applicability of a contextualized version of the MET (MET-CV), (2) to study its consistency and validity, and (3) to compare the performance of polysubstance users to a control group. Methods: Data were collected from 60 polysubstance users and 30 healthy controls. Both groups performed a neuropsychological assessment which consisted of the MET-CV and traditional neuropsychological tests (Letters and numbers, Zoo Map Test, Revised Strategy Application Test, Information Sampling Test, Stocking of Cambridge). Results: Results showed that the MET-CV can be applied to different contexts with a good reliability and validity. Polysubstance users showed significant executive deficits compared to healthy controls, most notably on the MET-CV than on the traditional neuropsychological tests. In addition, significant correlations were found between the MET-CV and the traditional neuropsychological tests. Conclusion: In conclusion, this contextualized version of the MET, can be applied in different environments, and it is a valid and reliable measure of executive functions. Furthermore, the MET-CV demonstrated clinical utility to evaluate executive deficits in polysubstance users.

Keywords: Multiple errands test, Ecological validity, polysubstance users, Planning, Multitasking, Executive functions

Introduction

Drug use is a worldwide problem with high socioeconomic costs (Mark, Woody, Juday, & Kleber, 2001). Drug-related harms also affect families and social circles (Taylor et al., 2012). One of the most significant consequences of repeated drug use are deficits in executive function (Fernández-Serrano, Pérez-García, & Verdejo-García, 2011), which stands out for negatively interfering with the performance of daily activities (DA), such as job difficulties, accidents, financial problems (Diamond, 2011). An optimal approach to evaluating executive deficits requires of a comprehensive assessment that allows to define different executive profiles (Gonzalez, Bechara, & Martin, 2007) and to assess what the repercussions are for daily functioning. For example, Moriyama et al. (2002) found an association between performance on several ecological tests and occupational status in alcoholics.

High order executive constructs, such as multitasking and planning, have proven to be good predictors of academic, work, and social outcomes (Baars, Nije Bijvank, Tonnaer, & Jolles, 2015; C. L. R. Gonzalez et al., 2014). Furthermore, they have the strongest relationship with performance on DA (Frisch, Förstl, Legler, Schöpe, & Goebel, 2012; Krabbendam, de Vugt, Derix, & Jolles, 1999). Most of the instruments measuring these constructs are composed of items of low ecological validity, as they were designed by the researchers to test experimental hypotheses (Burgess et al., 2006). Nonetheless, these laboratory tests are also used in clinical assessment, although in many cases the examinee's performance does not correspond with responses in real world situations (Shallice & Burgess, 1993). More recent neuropsychological research has shown that the use of instruments with high ecological validity, based on verisimilitude with DA, enable to adequately assess daily problems associated with executive dysfunction in drug users (Verdejo-García & Pérez-García, 2007).

Neuropsychological tasks that have been used thus far to assess higher-order executive components can be classified into three groups. The first group consists of *planning tasks with simple goals and specific rules*. These tasks are administered in highly structured artificial contexts and provide explicit instructions about the sequence of steps that permit goal achievement. The literature often refers to these tests as planning tasks, such as the tower tasks (e.g., of London, of Hanoi) (Shallice, 1982), Zoo Map Test (Wilson et al., 1996) or Key search test (Wilson et al., 1996). The second group consists of *planning tasks with simple goals and complex rules*, in which the examinee must maintain and monitor a high amount of online information in the form of rules. In these tasks, the compliance to rules is the central and most important aspect than is the actual execution of the tasks. The contexts in which they are administered are also artificial and are traditionally called multitasking tests, such as the Six Elements Test (Wilson et al., 1996), the Revised Strategy Application Test (Levine et al., 2000) or the Greenwich Multitask test (Burgess, Veitch, de Lacy Costello, & Shallice, 2000). The third group would consist of *planning tasks with multiple goals and rules* and whose contexts, whether natural or virtual, are unstructured. Its distinctive features include greater temporal duration, sequencing targets and the absence of immediate feedback, organization and monitoring. At present there is no clear conceptual definition, but they can be referred to as complex planning tasks. Some notable examples of these include the Multiple Errands Test (Shallice & Burgess, 1991), the Executive Secretariat Task, the Task Hotel (Lamberts, Evans, & Spikman, 2010) , and the JAAM Test (Jansari, Agnew, Akesson, & Murphy, 2004).

The Multiple Errand Test (MET) was published in the 90's and is the pioneer test among the complex planning tasks (Shallice & Burgess, 1991). However, it was not used widely until recent years (Alderman, Burgess, Knight, & Henman, 2003). The task raises multiple goals and is administered in a real-life context. The duration of the test is not determined, and is often extensive due to the fact that the participant determines the start and end time. The role of the investigator is to explain the instructions, ensure an understanding of the test, and observe and record without providing feedback or interacting during test taking. Several studies using the MET have been conducted in patients with acquired brain injury (Cuberos-Urban et al, 2013), stroke (Manes, Villamil, Ameriso Rock & Torralva, 2009; Morrison et al, 2013), schizophrenia and bipolar disorder (Caletti et al., 2013), and multiple sclerosis (Roca et al., 2008). However, except one study performed in alcohol users alcoholics with a virtual reality task (Laloyaux et al., 2012), there are no studies with polysubstance users on a high ecological test as MET.

The present study is the first to assess executive functions in drug users administering the MET in a real-life setting. Several versions of the MET have been adapted to specific contexts such as hospital surroundings (Knight, Alderman, & Burgess, 2002) or a shopping center (Alderman, Burgess, Knight, & Henman, 2003). Despite being adaptations of the same version of the MET, they have very different objectives and there may yield different results depending on the appropriateness of the specific context in which they operate. In this case, we tested a new MET version adapted to one of the most representative treatment settings for drug users – a therapeutic community (European Drug Report, 2014).

In this study, we formulated the following hypotheses: (i) it will be feasible to implement a new version of the MET, adapted to the context of treating addiction in therapeutic communities (a drug abusing population in residential treatment), (ii) the new version of the MET will get good indices of reliability in terms of consistency of scores between participants from different therapeutic communities and validity in terms of its association with other traditional tasks of planning and executive functions, and (iii) polysubstance users will present deficits in planning, that can be objectified not only with the traditional tests, but also in an ecological test as MET-CV.

Therefore, the specific aims of this study are (i) to apply the new version of the MET on polysubstance users following addiction treatment in three therapeutic communities; (ii) to obtain evidence of reliability (i.e. consistency of the MET-CV score between patients in various therapeutic communities) and validity (i.e. correlations with other planning and executive function tests); (iii) to analyze differences in performance on the new version of MET and other traditional planning and executive function tests among the sample of polysubstance users and a non-drug using comparison group.

Methods

Sixty polysubstance dependent users (12 women) in residential treatment (PSD) and thirty healthy control participants (10 women), aged between 18 and 52 years old, participated in this study. The PSD group was recruited while receiving treatment at three long-stay (6 – 12 months) public therapeutic communities (TC): “Centro de Rehabilitación Cortijo Buenos Aires de Granada”, “Comunidad terapéutica Proyecto Hombre de Huetor-Santillán,” and “Comunidad terapéutica Proyecto Hombre de Algarrobo”. All PSD were abstinent as indicated by urine toxicological tests conducted before assessments (alcohol, cannabis, cocaine, opiates, benzodiazepines, and amphetamines). The control group was recruited via advertisements in newspapers and via email through email distribution lists. There were no differences between groups in gender, age, and educational level. Table 1 illustrates the sociodemographic characteristics of both groups. With respect to the three PSD groups, there were no differences in age (TC1, $M = 37.32$, $SD = 8.51$; TC2, $M = 36.5$, $SD = 7.51$; TC3. $M = 33.11$, $SD = 6.09$; $F = 1.683$, $p = 0.195$), educational level in years (TC1, $M = 10$, $SD = 2.97$, TC2, $M = 10.10$, $SD = 2.31$, TC3, $M = 10.94$, $SD = 2.98$; $F = 0.665$, $p = 0.518$).

The inclusion criteria for substance users in the study were: (i) meeting DSM-IV criteria for substance abuse or dependence as indicated with the *Structured Clinical Interview for DSM-IV Disorders – Clinician Version* (SCID; First et al., 1997), (ii) having a minimum abstinence interval of 15 days – as determined by urine toxicological tests completed in therapeutic communities, (iii) absence of psychiatric comorbidity on Axis I (with the exception of nicotine dependence) and Axis II as indicated with the *SCID and the International Personality Disorders Examination* (IPDE; Loranger et al., 1994; Spanish version by López-Ibor, 1996), (iv) absence of a history of head injury and neurological, infectious, systemic or any other disease affecting the central nervous system, (v) not taking prescription drugs which affect the central nervous system (e.g. benzodiazepines, antipsychotics, etc.).

The inclusion criteria for the comparison group were the same as for the clinical group, except the first criterion, as they could meet diagnostic criteria for nicotine dependence. Other substance dependence diagnoses were considered exclusion criteria for this group.

Instruments

The interview for Research on Addictive Behavior (Verdejo-García et al., 2005): this is a semi-structured interview to assess the severity of drug use. This interview register detailed notes about the use of each drug from the earliest stages of consumption until the current day, differentiating between periods of regular consumption, maximum consumption and withdrawal, co-abuse substance, routes of administration, and age of onset for each drug. The amount consumed in each episode (number of alcoholic drinks, grams of cocaine, etc.), frequency of use (daily, four-five times a week, weekends, occasional use in a month, etc.), and the number of years consuming are recorded. The outcome dependent variables are the result of the severity index of each substance (alcohol, cocaine, heroin), the abstinence duration, and the duration of consumption of each drug.

Traditional neuropsychological instruments

Letter number sequencing (Wechsler adult intelligence scale, WAIS-III) (Wechsler, 1997a). In this test, the examiner is instructed to read a sequence of numbers and letters, with a frequency of one second per letter/number. The participant must recall the sequence and list the numbers in ascending order and the letters alphabetically. The outcome variable is the number of correct responses.

Information Sampling Test (IST) (CANTAB, Cambridge Cognition). This is a computerized test of the Cambridge neuropsychological Test Automated Battery (CANTAB). This test assesses the reflection-impulsivity ability, defined as the ability to evaluate the available contextual information before making a decision. During this test, participants are presented with a square chart composed of 25 grey boxes on a screen. When the box is touched, one of the two possible colors presented in the bottom of the screen are revealed in two colored boxes. The participant must tap as may boxes as he/she wants, and when the subject is certain, and thinks to know what colour predominates, makes a decision about what color thinks is mainly hidden under the square chart. There are two conditions. In the “fixed” condition, the participant wins 100 points each time if he/she is right and loses 100 points if he/she fails. In the "decreasing" condition, the participant could win a maximum of 250 points each time, but the amount of points decreases by 10 points each time a box is opened. If the is not correct, the participant loses 100 points. The goal is to win the highest amount of points possible. The outcome variables are the number of sampling errors, being the number of trials where the participant fails but in the moment of his/her decision the color selected was the predominant; probability of success at the moment of the decision ; the number of boxes opened; and the number of trials where the participant selects the hidden color correctly in the majority of the squares.

Stocking of Cambridge (SOC): SOC is a computerized version of the traditional Tower of London task (Shallice, 1982). Participants view two screens in which there are three different color balls and three cavities that have a different ball-holding capacity (three, two, and one ball respectively). The aim is to reproduce the ending position of the top screen in the bottom screen with the least number of movements possible. The task consists of problems of varying difficulty (2, 3, 4, and 5 moves to be solved). Participants must fulfill two rules that the program does not allow to be violated: A ball cannot be drawn from the cavity if there is another ball on top, and the balls can only be placed in the lower available cavity. The main outcome variable is the sum of displacements in 4 and 5 movement problems.

Zoo Map Test (Behavioural Assessment of the Dysexecutive Syndrome, BADS) (Wilson et al., 1996). This test assesses the ability to formulate and implement a plan. In this task, participants must draw a route to visit the six indicated places on a paper map of a zoo following three simple rules. These rules determine the execution, so that there are only four correct routes to solve the task correctly. In this study, only the first part of the test was used, in which the problem has low structure and it considered as high demand. The outcome variable is the total score on the first part of the test.

Revised Strategy Application Test (Levine et al., 2000): This test consists of six stacks of ten pages each. Each page has twelve items that could be big or small, and long, medium or short. Two stacks have drawn figures where the participant must trace them, while two of the other stacks are composed of sentences that must be copied. In the last two stacks, the participant must number a variety of group figures. The main goal is to gain the most amount of points possible, knowing that each small item completed grants points. Furthermore, the participant must remember and learn a list of rules to be followed. The test finishes when the participant has completed 50 items (except for the items of the first page of each stack). The most effective strategy is to complete the small items (which give points) because they are brief and faster to solve. At the end of the task, the participant is asked about the strategy implemented. The outcome variables are the number of small items, the percentage of the sample that recognizes the efficient strategy, and the self-regulation index (percentage of small items divided by total items performed).

Multiple Errands Test – Contextualized Version (MET-CV)

Test description.

This test is an adaptation of the hospital MET developed by Knight et al. (Knight, Alderman, & Burgess, 2002), and was designed according to the characteristics of the population and the assessment context (i.e. therapeutic communities). The specific characteristics are as follows: (1) All the subtasks are characterized by one main goal (e.g., preparing a meal) that is clear and relevant to everyday life. (2) The difficulty of the test has been increased slightly due to the better neurocognitive state of PSD compared to people with traumatic brain injury. (3) In the absence of certain elements of the original version, such as a shop, we designed a supermarket brochure, and the shopping task consisted in making the shopping list. (4) Sending a letter was replaced with hanging a sign to announce the location of a meal celebration. (5) The task of finding out opening times for different services was replaced with making note of the temperature from a thermometer (6) The laundry timetable, which is well known by the users of the TC, was replaced by a task to seek a newspaper and record the weather forecast for the next day. (7) Writing down the price of a product from the supermarket was replaced with writing down the address of the shop (written in the supermarket brochure information) where purchases would be held. (8) The objects to count were modified according to the availability of outside assessment centers. (9) Considering that the use of money is banned in therapeutic communities, money was replaced by a hypothetical budget provided to participants.

The test consists of performing 11 tasks that are grouped into three goals. The first goal was to complete the following tasks: pick up a bag that contains the necessary material to carry out the task; prepare a shopping list with three products, follow specific instructions from a supermarket catalog (represents three tasks); make a reservation for a venue to host a celebration by telephone; and create and hang a poster with information about the event. The second goal was to obtain information about the surroundings through four tasks: studying a thermometer and making note of the current temperature, making a weather prediction using a newspaper, obtaining and making note of the supermarket address, counting the number of specific items in the area (benches, lampposts, etc). The third goal consisted on meeting in a concrete place, 20 minutes before the start of the task.

Test administration

Participants were informed that they would conduct some activities related to preparing a meal for the center users. The examiner explained the task's instructions and rules. All questions were resolved and the participant was asked to explain what he/she should do to ensure that he/she understood the instructions. The participant was informed that the examiner would follow him/her at a safe distance and would not interact with him/her unless required by the task. Finally, all necessary material was provided (pen and folder with instructions and a map). During test performance, the examiner took notes on the implementation of the tasks, broken rules or any annotation of interest, without interacting with the participant. The task ends when the participant indicates.

During test performance, the participants' behaviors were registered and classified following the original procedures given by Shallice and Burgess (1991). Error measures were defined as follows: (1) Task failures: when a task goal has not been reached; (2) Rule violation: when a specific rule or social rule has been broken; (3) Inefficiencies: when a more effective strategy could have been used; (4) Misinterpretations: where the requirements of a task have been misunderstood. One point is assigned for each error. Subsequently, a weighted score is calculated based on the frequency of error in the control group. The errors made exclusively in the experimental group are assigned 3 points, and the errors made in less than 6.66% of the control group are allotted 2 points. The errors made in more than 6.66% of the control group are not weighed, and instead maintain the same value (1 point error). In resume, most amounts of points reflects worse performance.

Other collected variables included: initial planning time (time between the completion of the instructions and the start of the task), total execution time (time between the beginning of the task until the end), and number of times that the participant sees signals or consults the map.

The outcome variables are: total number of errors (task failures, total number of rules broken, total number of inefficiencies, total number of misinterpretations).

Procedures

Participants were assessed between September, 2012 and December, 2013. The evaluation sessions take up to 4 hours including breaks. Before testing, the participants had not taken any drugs and were in a physical and psychological state that enabled them to participate correctly in the session. The administration order of the tests was: diagnostic interviews, letters and numbers, Zoo Map Test, SOC, interview of drug consumption, IST, RSAT, and MET-CV. The tasks were administered in three therapeutic communities where the sample was recruited. In the case of controls, the assessment was administered in the "Research Center, Mind, Brain and Behavior" (CIMCYC) of the University of Granada. No participant received any benefit for participation in this study. This study was approved by the Ethics Committee of the University of Granada. Participants were informed of the study conditions and signed an informed consent form.

Statistical analysis

All analyses were conducted in SPSS v 19. We first explored the data in order to detect outliers (indicated with the SPSS Explore command) and missing data points. After removing outliers and accounting for missing data, the sample size was as follows: IST = 59, RSAT = 59, MET-CV = 58, SOC = 58. One-way ANOVAs were conducted to verify the consistency of test scores among participants from different therapeutic communities. Pearson correlation analyses were conducted to examine the validity of the evidence in relation to other traditional planning and executive function measures, and consumer variables. For the group comparison, parametric and non-parametric tests were carried out. Following the recommendations of Blakesley et. al. (2009), Bonferroni adjustments were made to prevent Type I error in the comparison of multiple hypotheses (23 variables were analyzed, adjusting the level of significance determined at 0.05 / 23 = 0.0021). Cohen's d values were calculated for each of the between-groups contrasts to index effect sizes. We used Pearson correlation analyses to examine the association between patterns of drug use on performance measures.

Results

Consistency of the MET-CV scores between participants from different TCs.

No significant differences were found among the three groups in the main indexes of MET-CV (table 2). No significant differences were either found in other secondary variables, with the exception of the total execution time, in which we found differences between two TCs (1 and 3, p = 0.006). With respect to the other traditional neuropsychological tasks, there were no significant differences in major variables of neuropsychological tasks (table 3).

Evidence of validity: Correlations between MET-CV, traditional neuropsychological tasks, and drug use variables.

The correlations between the performance on the MET-CV, with traditional neuropsychological tasks and consumer variables are shown in table 4. MET-CV error variables correlated with consumption indexes and executive function tests (working memory and planning).

MET-CV differences between PDS and controls.

The comparative results between groups on the complex planning task can be found in table 5. Task failures and inefficiencies showed significant differences between groups, with PSD showing significantly more errors than the comparison group.

There were also differences between the groups in the following secondary variables: initial planning time, number of times that the signals and map were consulted, and familiarity with the center. PSD showed more initial thinking time and less number of times that the signals and map were consulted than the comparison group.

Traditional neuropsychological task differences between PDS and controls

Performances of both groups are presented in table 6. PSD performed significantly worse than the control group on the LNS working memory task, with a large effect size (Cohen’s $d > 0.8$). The IST showed differences between groups in the main variables of the fixed condition with a large effect size (Cohen's $d > 0.8$), but no significant differences in the decreasing condition. Regarding the simple goal planning tasks, SOC (problems 4 and 5 movements) and the Zoo Map Test, there were no significant between group differences. Finally, in the planning test with simple goals and multiple rules (RSAT), the number of brief items was significantly lower in the PSD. However, there were no significant differences for the index of self-regulation (brief items / total items) and the percentage of people who recognized the strategy.

Discussion

The aims of this study were to examine the feasibility of a contextualized version of the MET in drug users enrolled in TCs, to analyze the consistency of MET-CV scores and the validity in terms of association with other similar measures, and to analyze performance differences between PSD and a control group. We found that the new version of the MET can be effectively applied in the context of therapeutic communities, which is one of the main therapeutic settings for drug treatment, and is sensitive to detect executive function deficits in PSD.

The MET-CV showed consistency in the results obtained in three different therapeutic communities, and validity when correlated with traditional neuropsychological tests. Complex planning tasks, such as the MET, have been criticized for the feasibility of application in clinical settings (rand). This study confirms that it is possible to adapt this type of test to these contexts, using everyday tasks and universal elements. Comparisons between the subgroups of drug users evaluated in three different therapeutic communities' shows the consistency of MET-CV scores. There were only differences in the secondary variable of total execution time, which is likely due to the different size of the TCs installations. These findings indicate that the results of the MET-CV are reliable.

With regard to the second goal, the correlations between the performance indexes of traditional neuropsychological tasks and MET-CV support the external validity of the MET-CV. The traditional tests of working memory and single goal planning tasks correlate with all the MET variables with the exception of inefficiencies. The lack of correlation with inefficiencies could be explained by the fact that traditional neuropsychological tasks tend to assess performance in a dichotomous manner (error /

hit), while the MET-CV can encode inefficiencies as less optimal behavior to get a goal. Drug use patterns (of alcohol, cocaine, heroin and cannabis) also correlated with performance on the MET-CV in the expected direction (i.e. more use was associated with poorer performance). In the same direction, a longer duration of abstinence correlated with fewer broken rules. Previous studies indicate that prolonged periods of abstinence are associated with better executive performance (Schulte et al., 2014), but the results are variable depending on the type of task used (Fdz-Serrano et al., 2011 NBBR). This study suggests that the MET-CV is sensitive to fluctuations in performance associated with the abstinence period.

The third goal was to compare performance on traditional neuropsychological tasks and MET-CV, between PSD and a healthy control group. The results indicated that PSD had significant deficits in both types of tasks. Overall, they made a higher number of failures compared to the control group, but differences were only significant for task failures and inefficiencies. The number of broken rules and misinterpretations were not significant. The absence of differences in broken rules is striking. Some of these rules are context dependent; the greater familiarity in the PSD group with their surroundings as compared to the control group may have reduced the discriminative power of this variable. As for the misinterpretation, the low number of errors in both groups point out that this type of error is not common in this population. It is noted that in other studies on individuals with brain damage, this type of error is rare (Alderman et al., 2003; Knight, Alderman, & Burgess, 2002).

The initial planning time of the MET-CV was also different among the two groups. This finding is relevant because the relationship between the initial planning time and execution on the task, has been found in the traditional single goal planning tasks (Kaller, Unterrainer, Rahm, & Halsband, 2004). Similarly the higher amount of signs and maps polled by the control group indicate that these benefit more from the available information, being useful to the objective. These results are consistent with those found in the IST task, where PSD gets less information about the context, represented by the number of boxes opened.

Finally, traditional neuropsychological tasks showed higher order executive deficits in PSD, consistent with previous studies (Verdejo-Garcia & Perez-Garcia, 2007). The deficits found in working memory are consistent with previous studies (Lawton-Craddock, Nixon & Tivis, 2003; Pitel et al., 2008). The reflection-impulsivity task, IST, showed different results depending on the condition being evaluated. Both groups showed similar performance in the decreasing condition, while significant differences were found in the fixed condition in the probability of success, sampling errors, and boxes opened. The discrepancy between conditions could be linked to their different level of risk: In the decreasing condition, considered high risk, PSD would have more thoughtful decision-making influenced by the perception of risk present (Lawrence, Luty, Bogdan, Sahakian, & Clark, 2009). In contrast, in the fixed condition, the absence of risk facilitates impulsivity and therefore poor decision making. In the simple goal planning tasks, SOC and the Zoo Map Test, there were no significant differences, although the PSD group showed poorer performance. Previous studies with these tests show mixed results (Brand, Roth-Bauer, Driessen, & Markowitsch, 2008; Fishbein et al., 2007; Flannery et al., 2007) (Ornstein et al., 2000). Similarly, the planning task with simple goals and multiple rules, RSAT, did not show a clear discriminative power consistent with previous studies (Fernandez-Serrano Perales, Moreno-Lopez, Perez-Garcia & Verdejo-García, 2012) (Moriyama et al. , 2002).

Finally, several limitations in this study should be mentioned. First, sample size is relatively limited; however the number of participants is appropriate for the statistical analysis used. Second, there was a lower prevalence of female participants, although this distribution is normally found in Spanish therapeutic communities (DGPND, 2011). Third, the cross-sectional design does not allow us to draw causation effects.

In conclusion, this study shows that it is feasible to use the MET-CV in the TC context, with sound reliability and validity. Both traditional neuropsychological tasks, such as MET-CV, allow discrimination between PSD and non-drug using controls. In addition, the complex nature of the MET-CV may have greater discriminative power over simple goal planning tasks (SOC and Zoo map) and tasks with simple goals and multiple rules (RSAT). As Frisch et al. (2012) noted, our findings reveal the need to consider the dynamics of real environments in neuropsychological assessment, in order to obtain information on executive functioning.

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Table 1. Sociodemographic and consumption patterns in polysubstance users (PSD) and healthy controls (HC)

Sociodemographic variables and consumption patterns	PSD Mean (*SD*)	HC Mean (*SD*)	t / X^2	p
Age	35.88 (8.91)	35.8 (10.26)	0.04	0.994
Educational level (years)	10.32 (2.76)	11.1 (1.69)	- 1.66	0.1
Gender (%)				
Men	80	66.7	1.92	0.165
Women	20	33.3		
Duration of abstinence (months)	7.49 (6.16)			
Duration of alcohol consumption (years)	11.93 (9.47)			
Duration of cocaine consumption (years)	7.4 (7.92)			
Duration of heroin consumption (years)	2.69 (6.08)			

Note. *SD*, Standard Deviation

Table 2. ANOVA's comparisons between the three polysbustance user groups on the MET-CV

	TC 1 (n=22)	TC 2 (n=20)	TC 3(n=18)		
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	*F*	*p*
Task faillures weighted	7.59 (4.52)	6.11 (4.23)	5.82 (3.11)	1.108	0.337
Rule breaks weighted	6 (3.74)	6 (2.47)	4.17 (3.76)	1.827	0.17
Inefficiencies weighted	3 (2.47)	3.47 (2.89)	3.53 (3.02)	0.223	0.801
Interpretation faillures weighted	1.77 (2.52)	1.11 (2.33)	7.59 (4.52)	1.032	0.363
Familiarity	2.18 (0.75)	2.38 (0.74)	2.5 (0.85)	0.439	0.650
Total time	27.07 (7.47)	23.09 (7.76)	19.77 (6.96)	4.699	0.013
Initial planning time	38.64 (59.89)	43.68 (56.20)	81 (76.06)	2.387	0.101
Frequency looked at map and read signs	6.36 (5.21)	4.63 (2.83)	5.44 (2.2)	1.079	0.347

Note. MET-CV, Multiple Errands Test Contextualized Version, TC, Therapeutic Community, *SD*, Standard Deviation.

Table 3. ANOVA's comparisons between the three polysubstance user groups on the traditional neuropsychological tests.

	TC 1 (*n* = 22)	TC 2 (*n* = 20)	TC 3(*n* = 18)		
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	F/X^2	*p*
Letters and Numbers	9.36 (1.99)	9.35 (2.25)	9.61 (1.54)	0.106	0.900
Zoo Map Test (score part 1)	0.73 (4.82)	0.70 (3.08)	2.67 (3.58)	1.544	0.222
RSAT (brief items / total items)	0.83 (0.07)	0.83 (0.09)	0.80 (0.15)	0.399	0.673
RSAT (brief items)	42.85 (5.72)	45.25 (9.01)	41.63 (9.36)	0.950	0.393
RSAT (strategy recognize)	35%	60%	50%	2.532	0.282
IST DC (mean)	0.73 (0.89)	0.72 (0.82)	0.72 (0.88)	0.083	0.921
IST DC (boxes per trial)	9.47 (4.05)	9.21 (3.98)	9.55 (4.08)	0.037	0.964
IST DC (sampling errors)	1.91 (1.27)	2.15 (1.35)	1.71 (1.1)	0.583	0.561
IST DC (total corrects)	7.82 (1.53)	7.5 (1.43)	7.65 (1.54)	0.236	0.790
IST FC (mean)	0.79 (0.1)	0.80 (0.12)	0.77 (0.11)	0.426	0.655
IST FC (boxes per trial)	13.18 (5.4)	13.92 (5.82)	11.86 (4.69)	0.690	0.506
IST FC (sampling errors)	1.18 (0.91)	1.25 (1.33)	1.17 (1.13)	0.026	0.974
IST FC (total correct)	8.45 (1.01)	8.35 (1.66)	8.59 (1.33)	0.143	0.867
Stocking of Cambridge (total movements 4-5)	12.48 (1.82)	12.72 (1.59)	11.55 (1.93)	2.082	0.134

Note. TC, Therapeutic Community, *SD*, Standard Deviation, RSAT, Revised Strategy Application Test, IST, Information Sampling Test, DC, Decreasing Condition, FC, Fixed Condition

Table 4. Pearson's correlations between the MET-CV and traditional neuropsychological tasks in polysubstance users.

	Task faillures	Rules breaks	Inefficiencies	Interpretation faillures
Abstinence (months)	,080 (0.549)	-,306 (0.019)	,074 (0.583)	-,154(0.249)
Alcohol consumption	,333 (0.011)	,389 (0.003)	-,108 (0.421)	,331 (0.011)
Cocaine consumption	-,072 (0.590)	,183 (0.169)	,000 (0.997)	-,147 (0.270)
Heroin consumption	,288 (0.029)	,029 (0.831)	,164 (0.220)	,346 (0.008)
Cannabis consumption	-,146(0.273)	,339 (0.009)	,045(0.735)	,019(0.886)
Letters and Numbers	-,341(0.009)	-.201 (0.130)	-.08 (0.551)	-.017(0.897)
Zoo Map Test (score part 1)	-.150 (0.262)	-.174(0.192)	-.003(0.980)	-.309 (0.018)
RSAT (brief items/total items)	-.191 (0.163)	.104(0.449)	-.099 (0.470)	-.141 (0.305)
IST DC total corrects	.036 (0.792)	.040(0.768)	.007(0.957)	-.054(0.690)
IST FC total corrects	.111 (0.412)	.094 (0.488)	.076 (0.575)	.173 (0.198)
Stocking of Cambridge (total movements 4-5)	.263 (0.078)	.273 (0.006)	-.144 (0.281)	.093 (0.485)

Note. MET-CV, Multiple Errands Test Contextualized Version, RSAT, Revised Strategy Application Test, IST, Information Sampling Test, DC, Decreasing Condition, FC, Fixed Condition.

Table 5. Descriptive Descriptive scores, group comparisons, and effect sizes between polysubstance users (PSD) and healthy controls (HC) on the MET-CV

	PSD	HC				
Dependent Variables	Mean (*SD*)	Mean (*SD*)	*F*	*p*	Cohen's *d*	Analysis
Familiarity	2.58 (0.72)	0.46 (1.13)	7.01	0.000	2.419	Parametric
Total execution time (minutes)	23.63 (7.89)	22.75(5.77)	0.43	0.835	0.134	Parametric
Initial planning time(seconds)	52.71 (65.46)	128.1 (107.55)	440.5	0.000	0.918	Non parametric
Frequency looked at map and read signs	5.52 (3.77)	11.83 (5.44)	5.686	0.000	1.437	Parametric
Task failures weighted	6.59 (4.06)	3.87(2.12)	3.423	0.001	0.771	Parametric
Rule breaks weighted	5.43 (3.31)	3.47(2.43)	536.5	0.003	0.644	Non parametric
Inefficiencies weighted	3.31 (2.74)	1.27(1.11)	424.5	0.000	0.879	Non parametric
Interpretation faillures weighted	1.28 (2.14)	0.33(0.66)	583	0.005	0.533	Non parametric

Note. MET-CV, Multiple Errands Test Contextualized Version, *SD*, Standard Deviation.

Table 6. Descriptive scores, group comparisons, and effect sizes between polysubstance users (PSD) and healthy controls (HC) on traditional neuropsychological tests

		PSD	HC				
Test	Dependent variable	Mean (*SD*)	Mean (*SD*)	$t / U / X^2$	*p*	Cohen's *d*	Analysis
Letters and Numbers	Correct responses	9.43 (1.93)	11.37 (2.57)	506.5	0.001	0.897	Non parametric
Stocking of Cambridge	Total movements 4-5	12.6 (1.93)	11.44 (1.89)	2.63	0.010	0.605	Parametric
Zoo Map Test	Score part 1	1.3 (3.98)	3.67 (3.84)	-2.691	0.009	0.602	Parametric
Revised Strategy Application Test							
	Brief items	43.36 (8.1)	53.21 (14.89)	-3.937	0.002	0.755	Parametric
	Brief items / total items	0.82 (0.11)	0.86 (0.11)	-1.427	0.157		Parametric
	% Strategy recognize	51.78%	71.43%	4.082	0.043		
Information Sampling Test							
FC	Mean	78.95% (10.87)	87.86% (10.31)	-3.628	0.000	0.833	Parametric
FC	Boxes opened per trial	13.05 (5.33)	17.41 (5.53)	-3.519	0.001	0.808	Parametric
FC	Sampling errors	1.2 (1.1)	0.53 (1)	497	0.002	0.627	Non parametric
FC	Total corrects	8.46 (1.33)	9.18 (0.98)	537	0.006	0.586	Non parametric
DC	Mean	72.19% (8.79)	76.71% (9.99)	-2.138	0.035		Parametric
DC	Boxes opened per trial	9.4 (3.97)	11.7 (5.03)	-2.307	0.023		Parametric
DC	Sampling erros	1.93 (1.24)	1.64 (1.22)	708.5	0.266		Non parametric
DC	Total corrects	7.66 (1.48)	7.96 (1.5)	722.5	0.334		Non parametric

Note. *SD*, Standard Deviation, FC, Fixed condition, DC, Decreasing condition.

ANEXO II

Drug and Alcohol Dependence xxx (2016) xxx–xxx

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Full length article

Planning deficits in polysubstance dependent users: Differential associations with severity of drug use and intelligence

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ABSTRACT

Background: Polysubstance use is associated with alterations in different components of executive functioning such as working memory and response inhibition. Nevertheless, less attention has been given to executive planning skills, which are required to benefit of low structured interventions. This study examines the association between severity of use of cocaine, heroin, alcohol, fluid and crystallized intelligence and planning tasks varying on degree of structure.
Methods: Data were collected from 60 polysubstance users and 30 healthy controls. Cognitive assessment consisted of three planning tasks with different structure levels: Stockings of Cambridge, Zoo Map test, and Multiple Errands Test.
Results: Polysubstance users had significant planning deficits across the three tasks compared to healthy controls. Hierarchical regression models showed that severity of drug use and fluid and crystallized intelligence significantly explained performance in all the planning tasks. However, these associations were higher for low-structured real world tasks. These low-structured tasks also showed a unique association with crystallized but not fluid intelligence.
Conclusion: Drug abuse is negatively associated with planning abilities, and intelligence is positively associated with planning performance in real-world tasks.

1. Introduction

Drug consumption is a major health and social problem worldwide: 5.2% of the world population has used at least one illegal substance in the past year (United Nations Office of Drugs and Crime, UNODC, 2014). Drug use is associated with neural abnormalities in the frontal lobes (Bechara et al., 2001; Moreno-López et al., 2012). There is ample evidence that heroin use (Ersche et al., 2006; Fishbein et al., 2007), cocaine use (van der Plas et al., 2009; Verdejo-García and Pérez-García, 2007), cannabis use (Fried et al., 2005), and alcohol use (Flannery et al., 2007; Noël et al., 2001) are linked to alterations in executive functioning (EF). The degree of deterioration associated with these substances cause in EF depends on the amount (Beatty et al., 2000) and duration of use (Fernández-Serrano et al., 2010b). EF models provide a theoretical framework to determine which components may be affected. The model developed by Miyake et al., (2000) provides empirical support to the existence of three basic executive processes: inhibition, updating, and flexibility. Diamond (2013) postulates the existence of a second hierarchical level, which includes complex constructs that govern these three basic executive processes. These higher-order constructs comprise reasoning, problem solving, and planning. Related to these higher-order constructs are the concepts of fluid and crystallized intelligence. The g factor is composed of fluid and crystallized intelligence. Fluid intelligence is the ability to solve problems via inductive and deductive reasoning, is the most stable component and is the least dependent on education (Nisbett et al., 2012). On the other hand, crystallized intelligence represents the individual's learned store of knowledge of the world and is associated with contextual learning (Nisbett et al., 2012).

Planning is the higher-order construct that has been less examined in drug users, and currently available research has provided mixed findings. For example, in a sample of alcohol users, research has found a link between success in maintaining a stable job and performance on the Zoo Map test (Moriyama et al., 2002). However, no association has been found between performance on the

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planning tower tasks and success in maintaining abstinence in opiate users (Passetti et al., 2008, 2011). Conversely, planning skills have been consistently associated with clinical outcomes, e.g., success in day-to-day activities, in other populations with cognitive impairment, such as brain injury (Cuberos-Urbano et al., 2013) or Alzheimer's disease (Piquard et al., 2004).

The lack of consistency in the research findings concerning planning in drug using populations may be accounted by other constructs associated with the cognitive operations that underpin planning skills (such as intelligence) and/or by the characteristics of the assessment tools used. Similar to planning, the g factor of intelligence is considered to be a good predictor for academic performance, job success, and daily activities such as money management, use of maps, or interpretation of news (Gottfredson, 1997). The g factor (incorporates fluid and crystallized intelligence) is thought to underpin the cognitive operations oriented to organize goal-directed behaviors, related to planning and problem solving skills (Unterrainer et al., 2004; Zook et al., 2006). Low fluid intelligence scores are associated with goal neglect, and are indicators of planning capacity (Roberts and Anderson, 2014). Some studies have used tower problems to assess planning abilities, and have found that fluid intelligence is the best predictor of performance (Unterrainer et al., 2004; Zook et al., 2004). The relationship between crystallized intelligence and planning abilities has not been extensively studied, and the existing research indicates that there is not association with complex neuropsychological constructs (Zook et al., 2006).

When interpreting the results of currently available planning research, it is important to consider the type of assessment tests used. On the basis of the degree of task structure, planning tests can be positioned in a continuum that ranges from high structure on one end (for example, the tower problems) to low structure on the other (for example, Multiple Errands Test (MET; Shallice and Burgess, 1991; Goel and Grafman, 2000). High structure tasks have clear, specific and fixed rules (starting state, goal, transformation, rules, solution, structure and interconnectivity), whereas low structure tasks have ambiguous and flexible rules, due to the lack of relevant information that must be supplemented from the subjective experience of the participant (Goel, 2010).

The majority of planning studies have used tower tasks, which are considered highly structured, as they have only one goal, present a clearly defined initial state, have fixed rules, provide immediate feedback, and do not change their structure following performance errors (Goel, 2010). However, the use of highly structured tasks presents difficulties in generalizing the results or predicting behavior in everyday contexts that are characterized by low structure (Kaller et al., 2004). Furthermore, tower problems present a number of specific limitations. First, they were originally designed for purposes other than neuropsychological assessment (Burgess et al., 2006). Second, their psychometric properties have not been firmly established (Welsh et al., 1999). Third, the difficulty of these tasks is not only determined by the complexity of their trials, but also by the artificial configuration of these trials (Kaller et al., 2004). Fourth, these tasks tap into multiple basic executive components, and hence there is no consensus about the construct they measure.

Working memory, inhibition, and fluid intelligence are some of the potential cognitive contributors, but there is no agreement between studies (Cheetham et al., 2012; Gilhooly et al., 2002; Unterrainer et al., 2004). Finally, these types of tasks do not explore important aspects in planning, such as strategy making (Kaller et al., 2004). Such limitations make it difficult to understand the effects of drug use on planning behaviors. For this reason, some authors have proposed novel assessment approaches with a lower degree of structure, such as the Zoo Map test (Wilson et al., 1996). Even so, there is no study in poly-drug users that has evaluated tasks with a lower degree of structure such as the MET.

Therefore, the objectives of this study were to (i) determine if there is a difference in performance on planning tasks between a group of polydrug users and a healthy control group, and (ii) analyze the influence of fluid and crystallized intelligence, and alcohol, cocaine, and heroin consumption on the performance on planning tasks with different degrees of structure.

We hypothesize that (i) drug consumption deteriorates performance on planning tasks, and (ii) intelligence and drug consumption explain higher variability in performance on planning tasks when the structure is lower.

Table 1
Descriptive scores for the socio-demographic characteristics of polysubstance users (PSU) and healthy controls (HC). Numbers represent means and standard deviation (in parentheses).

Variables	PSU (n = 60)	HC (n = 30)		
	Mean	Mean	t/chi–square	p
Age	35.88 (8.91)	35.8 (10.26)	0.04	0.97
Educational level (years)	10.32 (2.76)	11.1 (1.69)	−1.66	0.1

Table 2
Descriptive scores for patterns of quantity and duration of drug use in the group of polysubstance users (PSU). Numbers represent means and standard deviation (in parentheses).

Substance	Dependent variables	PSU Mean
Cocaine	Grams/month	37.2 (45.63)
	Duration (years)	7.4 (7.92)
Heroin	Grams/month	11.87 (32.24)
	Duration (years)	2.69 (6.08)
Alcohol	Units/month	385.14 (425.22)
	Duration (years)	11.93 (9.47)
Abstinence (months)		7.28 (6.23)

2. Methods

2.1. Participants

Sixty dependent polysubstance users (12 women) and 30 healthy controls (10 women) participated in this study; there were no significant differences between groups in age (t = 0.04, p = 0.97), gender (X^2 = 1.92, p = 0.165) or educational level (t = −1.66, p = 0.1). Sociodemographic variables are shown in Table 1. All participants spoke Spanish and were originally from Spain. Descriptive information about the amount and duration of drug use in polysubstance users is displayed in Table 2.

Polysubstance users were recruited in three different therapeutic communities in southern Spain: "Centro de Rehabilitación Cortijo Buenos Aires de Granada", "Comunidad terapéutica Proyecto Hombre de Huetor-Santillán," and "Comunidad terapéutica Proyecto Hombre de Algarrobo". These communities offer a rehabilitation program for substance abusers. The typical duration of these programs is of 6–12 months.

The inclusion criteria for substance users in the study were: (i) meeting DSM-IV criteria for dependence or substance abuse-as assessed by the Structured Clinical Interview for DSM-IV Disorders—Clinician Version (SCID; First et al., 1997), (ii) having a minimum abstinence interval of 15 days—as determined by urine toxicological tests completed in therapeutic communities, (iii) absence of psychiatric comorbidity on Axis I (with the exception of nicotine dependence) and Axis II—assessed with the International Personality Disorders Examination (IPDE; Loranger et al., 1994; Spanish version by López-Ibor, 1996), (iv) absence of history of head injury and neurological, infectious, systemic or any

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other disease affecting the central nervous system, (v) have not been taking prescription drugs which affect the central nervous system.

The control group was recruited through advertisements in the local newspaper and through internet announcements. The inclusion criteria were the same as for the experimental group, except the criteria for nicotine dependence, which was not exclusionary in controls. Other substance dependence diagnoses were considered exclusion criteria for this group.

2.2. Instruments

2.2.1. Planning tasks. Three planning tasks with different levels of structure were used, based on the classification of Goel (2010) (see Table 3).

2.2.2. Stocking of Cambridge (SOC). SOC is a computerized task included in the Cambridge Neuropsychological Test Automated Battery (CANTAB, Cambridge Cognition). This task is a version of the Tower of London (Shallice, 1982), traditionally used to assess planning. At the top and the bottom of the screen, participants view three different colored balls and three cavities where they can place the balls vertically. Each cavity has a different ball-holding capacity with which it can hold one, two, or three balls. The aim is to reproduce the ending position of the top screen in the bottom screen with the least number of movements possible. The different trials are presented in blocks that require two, three, four or five movements to be solved. Participants must fulfill two rules: (1) a ball cannot be drawn from the cavity if there is another ball on top, (2) the balls can only be placed in the lower available cavity. The main outcome variables are the number of problems solved using the minimum number of movements and the sum of movements performed in each block.

2.2.3. Zoo Map test. This is a subtest of the Behavioral Assessment of the Dysexecutive Syndrome battery (BADS; Wilson et al., 1996), which assesses the ability to formulate and implement a plan. In the first part of the task, participants must draw a route to visit the six indicated places on a paper map of a zoo following three simple rules. There are only four correct routes to solve the task correctly to obtain the maximum score. In the second part, the rules are the same but the participant must visit different places following the indicated order. The second zoo visit is considered of low cognitive demand because the participant receives an order to follow and can solve the problem without having to keep in mind the required rules. The outcome variable is the total score.

2.2.4. Multiple Errands Test—contextualized version (MET-CV). This test was directly adapted from the hospital version MET (Alderman et al., 2003). MET-CV assesses complex planning abilities and it is administered in a natural environment. The study was developed in four contexts including three therapeutic communities and one university research center. Every context was analyzed in depth in order to reach parallel goals between the different centers and participants. In contrast to the original version, the different tasks follow in line with one general functional activity (e.g., preparing a meal). This adds a coherent sense of functionality to the demands asked of the participants. In contrast, the earlier versions of the MET lack a general goal as the test is based on different and unrelated tasks.

The test consists of performing 11 tasks that are grouped into three goals. The first goal was to complete the following tasks: pick up a bag that contains the necessary material to carry out the task; prepare a shopping list with three products, follow specific instructions from a supermarket catalog (represents three tasks); make a reservation for a venue to host a celebration by telephone; and create and hang a poster with information about the event. The second goal was to obtain information about the surroundings through four tasks: studying a thermometer and making note of the current temperature, making a weather prediction using a newspaper, obtaining and making note of the supermarket address, counting the number of specific items in the area (benches, lampposts, etc.). The third goal consisted on meeting in a concrete place, 20 min before the start of the task. The examiner plays a passive role and only observes the participant's behavior and would not interact with him/her unless required by the task. The task starts and ends when the participant indicates.

During test performance, the participants' behaviors were registered and classified following the original procedures given by Shallice and Burgess (1991). Error measures were defined as follows: (1) Task failures: when a task goal has not been reached; (2) Rule violation: when a specific rule or social rule has been broken; (3) Inefficiencies: when a more effective strategy could have been used; (4) Misinterpretations: where the requirements of a task have been misunderstood. Common errors that occurred in up to 93.33% of the control group were allotted 1 point error. Errors that occurred in 6.66% or less of control group were allotted 2 points. Errors made exclusively in the experimental group were assigned 3 point error. The outcome dependent variable was the sum of all errors (task failures, total number of rules broken, total number of inefficiencies, total number of interpretation failures).

2.2.5. The interview for research on addictive behavior (Verdejo-García et al., 2005).. This is a structured interview to assess the severity of drug use. The examiner asks and registers detailed notes about the use of each drug from the earliest stages of consumption until the current day, differentiating between periods of regular consumption, maximum consumption and withdrawal, co-abuse substance, routes of administration, and age of onset for each drug. The amount consumed in each episode (number of alcoholic drinks, grams of cocaine, etc.), frequency of use (daily, four-five times a week, weekends, occasional use in a month, etc.), and the number of years consuming are recorded. With these data, a severity index is obtained for each substance = [Quantity consumed per episode × Frequency of consumption per month × Chronicity in years]. The outcome dependent variables are the results of the Z-scores from the severity index of each substance. This study includes the results from alcohol, cocaine, and heroin consumption.

2.2.6. Kaufman brief intelligence test (KBIT; Kaufman and Kaufman, 1990). This test consists of three subtests: Vocabulary, definitions, and matrices. Crystallized intelligence, or the ability to use knowledge and information from experience, is obtained using the vocabulary and definitions subtest. This factor is related to general knowledge and represents the level of cognitive development achieved through learning history. Fluid intelligence is obtained utilizing the matrices subtest. This variable is completely independent of acquired knowledge, and is related to logical thinking, including inductive and deductive reasoning, and solving problems in novel situations.

2.3. Procedures

Participants were assessed between September, 2012 and December, 2013. The results reported here were obtained as part of a larger project including additional assessments unrelated to the aims of this study. Before testing, the participants had not taken any drugs and were in a physical and psychological state that enabled them to adequately conduct the assessments. The order of administration of the tasks was as follows: Diagnostic interview, addiction interview, Zoo Map test, KBIT, SOC, and MET-CV.

Table 3
Description of structural levels for the three planning tasks.

	Starting state	Goal	Transformation	Rules	Solution	Structure	Interconnectivity
SOC	Clearly defined. *The balls are located in an initial position that does not lead to misinterpretations.*	Concrete and clear. *The goal is to place the balls in the same position that the model presents.*	Concrete action. *The behavior that allows for the transformation of the problem is moving the balls.*	Very specific. Unbreakable. *The rules of this exercise are unbreakable; if the rules are broken the task is stopped.*	Right/Wrong defined, with presented feedback. *The participant is able to find out if the exercise is correctly solved.*	Stable. *The breakdown of the problem is logical.The elements and rules are defined and stable. The problem and the conditions are homogeneous for all participants.*	High. *The movements depend on previous movements to continue the problem and achieve the ultimate goal.*
Zoo Map test	Defined. *The route starts at the entrance, but in case of misunderstanding the participant could start elsewhere.*	Clear, but open to interpretation. *The places to visit are marked, but nothing objectively prevents visitation of other places.*	Concrete action. *The transformation is to track a route.*	Specific. Breakable. *Specific rules can be broken, e.g. using the camel ride twice.*	Right/Wrong defined, without feedback. *The participant can deduce whether the execution has been correctly performed, but not with precision.*	Stable. *The decomposition of the problem is logical, because the elements and rules are defined and stable.*	Medium. *The order of the visited places does not depend on the previous choice, but the rules interfere with the order.*
MET-CV	It is not completely defined. *The information that is provided or that is available is incomplete, e.g. have to make a shopping list, but the products that will be available in the supermarket brochure are unknown.*	Marked, but depend largely on personal interpretation. *Does the weather forecast refer to the state of the sky or to the room temperature?*	Diverse and varied. *We must create routes to move, count money, write, read...*	Specific and breakable. *Rules that can be broken or be reinterpreted by the participant are provided. Contextual rules come into play (social), e.g. Wait in a queue.*	Right/Wrong is not defined. Not all tasks provide feedback. *Sometimes there is no perfect execution, depending on personal interpretation, e.g. is the purchased food enough?*	Less stable. *Depends on the decomposition of the participant.*	Low. *As there are multiple objectives, the tasks are relatively independent. However, in some cases, there is interconnectivity, e.g.: you have to find the blue bag to make the purchase correctly.*

Note: SOC, Stocking of Cambridge; MET-CV, Multiple Errands Test Contextualized Version.

This study was approved by the Ethics Committee of the University of Granada, Spain. Participants' were informed of the study conditions and signed an informed consent form aligned with the Declaration of Helsinki.

2.4. Analysis

All analyses were conducted in SPSS v 19. We first explored the data in order to detect outliers and missing data. We found missing data in the control group for the SOC task (due to a software error) and two participants in polysubstance users group for the MET-CV task (due to appointment issues in the therapeutic community). Descriptive analyses were applied to determine the demographic profile of the participants. All variables were explored with the Kolmogorov–Smirnov test and had normal distributions. Between-group contrasts were performed using one-way ANOVA. Cohen's d values were calculated for each of the between-groups contrasts to examine effect sizes. A hierarchical regression was conducted to determine the impact of intelligence and drug use (independent variables) on planning tasks' performance (dependent variables). Independent variables included crystallized intelligence, fluid intelligence, and estimates of alcohol, cocaine, and heroin use. The number of predictors ($n = 5$) is aligned with statistical recommendations for sample size in regression analyses (Hair et al., 2000). Predictors were entered in the regression model in sequential blocks. The first block included two intelligence factors (crystallized and fluid), and the second block included the drug use estimates (duration × quantity) for alcohol, cocaine, and heroin. For each new block, we estimated the R^2 of the prediction change associated with that block, and its statistical significance in order to determine their unique contribution.

3. Results

3.1. Differences between polysubstance users and healthy controls on planning tasks

Polysubstance users performed significantly poorer compared to the group control in all the planning tests (see Table 4). Effect sizes were moderate for the SOC and the Zoo Map tests, and high for the MET-CV (Cohen, 1988). Duration of abstinence did not correlate with any performance index on planning tests.

3.2. Multiple hierarchical regression models

Results are displayed in Table 5.

3.2.1. Stocking of Cambridge. Intelligence was a significant predictor of total moves for problems with 2–5 movements. Prediction significantly improved after inclusion of the drug use estimates. The full model explained 16.6% of variance, and fluid intelligence and alcohol use were significant individual predictors. Analysis of the variable representing the total number of problems solved with minimum movements revealed that the intelligence block was a significant predictor. However, the inclusion of the second block did not improve the prediction of the model. The global model explained 13.2% of total variance, and the best predictor was fluid intelligence.

3.2.2. Zoo Map test. Intelligence was a significant predictor of Zoo Map test. Prediction did not improved significantly after inclusion of the drug use estimates. The full model explained 12.9% of variance; fluid intelligence was the only significant individual predictor.

Table 4
Descriptive scores, independent group t-test and effects sizes on neuropsychological planning measures for polysubstance users (PSU) and healthy controls (HC). Numbers represent means and standard deviation (in parentheses).

Task	Dependent variables	PSU Mean	HC Mean	*F*	*p*	Effect size (Cohen's *d*)
Stocking of Cambridge	Problems solved with minimal movements	8.17 (1.97)	9.36 (1.77)	−2.728	0.008	0.623
	Total moves	17.74 (1.99)	16.50 (1.93)	2.759	0.007	0.629
Zoo Map test	Total score	7.62 (5.57)	10.9 (3.97)	−2.878	0.005	0.643
MET-CV	Total errors weighted	16.60 (7.37)	8.93(4.25)	5.251	0.001	1.182

Note:MET-CV, Multiple Errands Test Contextualized Version.

Table 5
Multiple hierarchical regression models, contribution of drug consumption and intelligence to performance on tasks of different structure.

Task	Dependent variables	Intelligence R^2 change (*p*-value)	Alcohol/cocaine/heroin Quantity × frequency R^2 change (*p*-value)	Full model R^2 adjusted (*p*-value)	Unstandardized ß	Standardized ß	Significant contributors
SOC	Problems solved with minimal movements	0.131 (0.003)	0.051 (0.175)	0.132 (0.005)	0.077	0.442	Fluid intell. (0.002)
SOC	Total moves	0.092 (0,016)	0.122 (0.008)	0.166 (0.001)	−0.058	−0.321	Fluid intell. (0.023)
					0.337	0.275	Q x F alcohol (0.007)
Zoo Map test	Total score	0.134 (0.002)	0.044 (0.223)	0.129 (0.005)	0.162	0.344	Fluid intell. (0.019)
MET-CV	Total errors weighted	0.411 (<0.001)	0.137 (<0.001)	0.521 (<0.001)	−0.160	−0.245	Fluid intell. (0.046)
					−0.362	−0.463	Crystallized intell. (<0.001)
					1.394	0.306	Q x F alcohol (0.046)
					1.809	0.247	Q x F heroin (0.043)

Note: SOC, Stocking of Cambridge; MET-CV, Multiple Errands Test Contextualized Version; Q, Quantity; F, Frequency.

3.2.3. Multiple Errands Test. Intelligence was a significant predictor of the sum of errors in the MET-CV. Prediction significantly improved after inclusion of the drug use estimates. The full model explained 52.1% of variance, fluid and crystallized intelligence, heroin and alcohol use were significant individual predictors.

4. Discussion

The first aim of this study was to establish differences in planning performance between polysubstance users and healthy controls. We found that polysubstance users had poorer performance than controls in all the planning tasks, supporting the hypothesis that drug use is associated with impairment of planning ability. The differences in performance on the high-structure task SOC have been previously described in heroin users (Baldacchino et al., 2012) and alcohol users (Fishbein et al., 2007; Flannery et al., 2007; Goudriaan et al., 2006; Noël et al., 2001; Pitel et al., 2007). However, there are few available studies using the medium-structure task, i.e., Zoo Map test. Poorer performance in the Zoo Map has been previously reported in polysubstance users (Fernández-Serrano et al., 2010a) and alcohol users (Moriyama et al., 2002), but not in cocaine users (Madoz-Gúrpide et al., 2011). This study is the first to find poorer performance on a low-structure test (MET-CV) in polysubstance users. The effect size of the MET-CV results is considerably higher than the effect sizes observed in tasks of high and medium structure. These findings indicate that polysubstance users have planning deficits that are more evident when using low-structure tests in more ecological contexts.

The second aim of this study was to analyze the influence of fluid and crystallized intelligence, and alcohol, cocaine, and heroin use on three planning tasks with different degrees of structure. Results indicate that general intelligence (comprising fluid and crystallized components) is a significant predictor of performance in the three planning tests. This association between intelligence and planning has been consistently established in healthy (Duncan et al., 1997) and brain injury populations (Knight et al., 2002), but has generally been neglected in drug use studies. More specifically, fluid intelligence is a significant predictor of performance in tests of planning, regardless of degree of structure. The fundamental role of fluid intelligence in highly structured planning tasks, such as tower problems, has been established in previous studies (McManus et al., 2014; Obonsawin et al., 2002; Unterrainer et al., 2004; Zook et al., 2004, 2006). However, this study is the first to demonstrate that fluid intelligence is a factor with a unique contribution to performance on tasks with medium and low structure.

Conversely, crystallized intelligence is a specific predictor of performance in the low structure test, i.e., the MET-CV. Crystallized intelligence represents some of the core skills acquired in the academic, professional, familial, and social contexts (Cattell, 1987). Therefore, this finding is relevant to understand the high-order cognitive processes that take place while planning in natural settings. In the MET-CV, participants face a novel task but the activities that must be done are everyday ones. Therefore, it is reasonable to think that performance in this task is sensitive to abilities acquired throughout life to operate in everyday complex environments. This is also supported by the idea that crystallized knowledge is related to divergent thinking, which is responsible for generating new hypotheses and exploring new perspectives on unconventional or novel situations (Madore et al., 2015). Divergent thinking must be guided by knowledge about how to organize or apply strategies; such knowledge indicates which kinds of attack on a problem are likely to be fruitful (Cropley, 2006). In other words divergent thinking builds on prior knowledge, which provides the general foundations to navigate in ambiguous low-structured tasks. It is possible that laboratory tasks, such as the SOC or the Zoo Map test, have enough structure to not require the activation of these everyday abilities.

According to Diamond (2013), planning is a higher-order construct that requires the correct functioning of other basic executive processes, such as working memory, inhibition, and flexibility, as well as other higher-order constructs such as reasoning. The degree of structure of the task determines the number of resources that are

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needed. When the structure is lower, the ambiguity and instability of the task increases, and more resources become necessary. When the structure is higher, the specific rules of the task determine what cognitive processes are needed. Accordingly, factor analysis studies have shown that planning tasks with very different levels of structure, such as the Tower of London and the Zoo Map test, load into different factorial components (Piquard et al., 2004). These findings indicate that prior knowledge is not as critical for highly structured tasks as it is for tasks of lower structure, as all the information that the person needs to know is offered during the task through clear instructions and explicit rules. However, the artificial and arbitrary conditions of highly-structures tasks, do not match real life conditions. The quiet environment, with few distractors, and the existence of clear correct versus incorrect responses are not typically found in activities of daily living (Chaytor and Schmitter-Edgecombe, 2003). Natural environments are very different and generally more demanding for individuals than experimental contexts (Frisch et al., 2012).

The findings of this study indicate that the prediction of performance on the SOC and the MET-CV improves when we consider alcohol, cocaine, and heroin use in addition to intelligence. Alcohol consumption has been associated with performance in the tower planning task (Fishbein et al., 2007). We are not aware of previous studies that have used MET in natural environments with drug users. The only study conducted with alcohol users' using a low-structure task was performed in a virtual reality environment (Laloyaux et al., 2012). This study also showed the impact of cocaine use on performance in tasks of high structure (SOC). These planning deficits may be explained by the reduction in volume and the abnormal connectivity of the dorsolateral prefrontal cortices associated with alcohol consumption (Chanraud et al., 2007) and cocaine (Alia-Klein et al., 2011). Both cortical areas are involved in orchestrating the cognitive components of goal-directed behavior, such as the orientation of the reward (orbitofrontal cortex) or executive planning (dorsolateral prefrontal cortex) (Haber, 2003).

Only on the MET-CV test was shown to be impacted by the effect of heroin consumption as an independent predictor of planning. No previous studies had reported this association, although there are data about non-significant effects of heroin on performance in highly structured tasks based on comparisons between heroin users and healthy controls (Fishbein et al., 2007; Ornstein et al., 2000).

Study variables explain the variance in performance on the MET-CV, which is three times higher than the other two tasks. Findings show that the structure of the task determines the cognitive resources used to solve the problems, and when the degree structure is lower, the uncertainty and variability of responses increases. This more closely resembles real contexts because it allows more information on individual skills (Razani et al., 2007).

The use of tasks with low structure has implications in clinical practice. First, it has more similarities to real environments, allowing for a better prediction on daily functioning than with highly structured tasks (Tanguay et al., 2014). Second, it can improve assessment of cognitive impairment associated with substance use in a process as complex as planning. Sensitivity to assessed impairment is enhanced by taking into account factors such as the relevant context surrounding the person, activities (Chaytor and Schmitter-Edgecombe, 2003), and their degree of structure (Goel, 2010). Third, the standardization of shorter versions of the MET (Alderman et al., 2003) and its adaptation to different natural environments can enable clinical professionals to administer it as part of regular assessments. Furthermore, this type of tests effectively addresses the problem of ecological validity, and the high costs of traditional measures.

In conclusion, this study shows the existence of executive deficits in planning tasks in polysubstance users. These deficits are more notable on tests with low structure. Furthermore, intelligence and substance use better explain performance on tasks with low structure, which are highly representative of everyday activities. This reveals the need to consider structural elements in the development of planning tests.

Finally, several limitations in this study should be mentioned. First, a bigger sample should be recruited. Nevertheless, the number of participants is appropriate for the statistical analysis used (Hair et al., 2000). Second, a lower proportion of female participants in the groups is detected, although this distribution is normally found in Spanish therapeutics communities (DGPND, 2011). Third, the drug consumption index did not include the use of recreational drugs in order to not alter the statistical analysis. Fourth, the available cross-sectional data does not allow us to determine this result in other populations. Fifth, the use of a new version of the MET could be discussed. This version is currently in process of adaptation and validation, and has been tested in another study (in press). Sixth, due that the tasks were administered in a specific context, blind assessment ratings were not feasible.

5. Conflict of interest

No conflict declared.

6. Role of funding source

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7. Contributors

C. Valls-Serrano, A. Verdejo-García and A. Caracuel-Romero designed the study. C. Valls-Serrano performed clinical and neuropsychological assessments and wrote-up a first draft of the Manuscript. All authors contributed to the final versions of the manuscript.

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ANEXO III

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Manuscript Draft

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Title: Goal Management Training + Mindfulness Meditation improve executive functions and transfers to ecological tasks of daily life in polysubstance users enrolled in therapeutic community treatment.

Article Type: Full Length Article

Section/Category: Treatment

Keywords: Goal management training; Mindfulness meditation; Multiple errands test; Executive functions; Polysbustance abuse

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Abstract: We have previously shown that Goal Management Training + Mindfulness Meditation (GMT+MM) improves executive functions in polysubstance users enrolled in outpatient treatment. The aim of this study was to establish if GMT+MM has similar positive effects on executive functions in polysubstance users in residential treatment, and if executive functions' gains transfer to more ecologically valid goal-oriented tasks. Thirty-two polysbustance users were randomly allocated to eight weeks of GMT+MM (n=16) or control, i.e., no-intervention (n=16); both groups received treatment as usual. Outcome measures included performance in laboratory tasks of basic and complex executive functions (i.e., basic: working memory and inhibition; complex: planning and self-regulation) and in an ecological task of goal-directed behavior (the Multiple Errands Test - contextualized version, MET-CV) measured post-interventions. Results showed that GMT+MM was superior to control in improving basic measures of working memory and reflection impulsivity, along with initial thinking times during planning. In addition, GMT+MM was superior to control in improving performance in the MET-CV. Our findings demonstrate that GMT+MM increases reflective processes and the achievement of goals in daily activities, furthermore ecological test can detects changes easily than laboratory tasks.

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Her research aims to understand the neural underpinnings of cognitive control in humans. This involves the investigation of control abilities, drug use, stress, emotions, intelligence, working memory capacity... A central theme in this research is how different aspects and subsystems of cognitive control (such as maintenance and flexibility, top-down bias and inhibition) can be disentangled and how the underlying processes interact to regulate thought and action.

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Goal Management Training + Mindfulness Meditation improve executive functions and transfers to ecological tasks of daily life in polysubstance users enrolled in therapeutic community treatment.

Abstract

We have previously shown that Goal Management Training + Mindfulness Meditation (GMT+MM) improves executive functions in polysubstance users enrolled in outpatient treatment. The aim of this study was to establish if GMT+MM has similar positive effects on executive functions in polysubstance users in residential treatment, and if executive functions' gains transfer to more ecologically valid goal-oriented tasks. Thirty-two polysbustance users were randomly allocated to eight weeks of GMT+MM (n=16) or control, i.e., no-intervention (n=16); both groups received treatment as usual. Outcome measures included performance in laboratory tasks of basic and complex executive functions (i.e., basic: working memory and inhibition; complex: planning and self-regulation) and in an ecological task of goal-directed behavior (the Multiple Errands Test - contextualized version, MET-CV) measured post-interventions. Results showed that GMT+MM was superior to control in improving basic measures of working memory and reflection impulsivity, along with initial thinking times during planning. In addition, GMT+MM was superior to control in improving performance in the MET-CV. Our findings demonstrate that GMT+MM increases reflective processes and the achievement of goals in daily activities, furthermore ecological test can detects changes easily than laboratory tasks.

Keywords:

Goal management training, Mindfulness meditation, Multiple errands test, Executive functions, Polysbustance abuse

1. Introduction

Poly-substance use disorders are the most common presentation in specialized addiction treatment services (European Drug Report, 2014). Individuals with poly-substance use disorders (PSUD) have general deficits in executive functions (Fernández-Serrano et al., 2010), and hence cognitive training of executive functions is a promising new adjunct strategy to treat PSUD (Stevens et al., 2014). In a previous study, we showed that a regiment of eight weeks of Goal Management Training + Mindfulness Meditation (GMT+MM) was linked to improvement of basic executive functions, including working memory, inhibition and decision-making, in PSUD enrolled in outpatient treatment (Alfonso et al., 2011). However, PSUD are often referred to residential treatment, and specifically to therapeutic communities, as these services provide a holistic intervention approach that is more suitable for complex cases (European Drug Report, 2014). It remains unknown to what extent GMT+MM can be similarly efficacious in this context.

In addition to showing efficacy in ameliorating cognitive performance, novel treatment studies need to pinpoint outcome measures that are meaningfully related to activities of daily life (Tiffany et al., 2012). Our previous study, and most of the cognitive training literature, have focused on outcome measures related to basic executive functions as measured by laboratory tasks (i.e., working memory, inhibition and shifting) (Miyake et al., 2000). Conversely, higher-order executive functions, such as planning and multitasking, as measured by ecologically valid tasks are better “models” of day-to-day demands, and better predictors of treatment success in the neuropsychological literature

(Burgess et al., 2006; Frisch et al., 2012). GMT has shown to be effective to improve performance in these ecological tasks in brain injury populations (Krasny-Pacini et al., 2014); however, it remains unknown if it can be similarly efficacious in PSUD.

In this proof of principle study, we aimed to test if GMT+MM, compared to a no-intervention control group, is: (1) efficacious to improve working memory, inhibition and decision-making in PSUD enrolled in therapeutic community treatment (as it is in outpatient treatment); (2) associated with executive functions gains that transfer to ecologically valid tasks of real-life planning and multitasking (as it has been shown in the brain injury literature). Self-reported stress was included as a secondary outcome measure, as better executive functions have been associated with reduced stress levels (Liston et al., 2009; Luethi et al., 2009). We hypothesize that GMT+MM will be efficacious to improve executive functions, and that improvements will transfer to ecological tasks, along with stress reduction.

2. Methods

2.1. Participants

Thirty six PSUD participants, recruited from two therapeutic communities pertaining to the organization "Proyecto Hombre", located in two Spanish cities, Huetor Santillan (Granada) and Algarrobo (Málaga). Both communities apply the same program based on a holistic approach with a psycho-educational focus. The functioning of both communities is homogeneous; participants receive the same individual and group therapy sessions, perform the same daily activities, follow the same stages of treatment and the centers share the same rules. The duration of treatment varies between 6 and 12 months. 50% of the total sample was recruited from each community.

The inclusion criteria for PSUD in the study were: (i) meeting DSM-IV criteria for substance abuse or dependence as indicated with the *Structured Clinical Interview for DSM-IV Disorders – Clinician Version* (SCID; First et al., 1997), (ii) having a minimum abstinence period of 15 days – as determined by weekly urine toxicological tests completed in therapeutic communities, (iii) absence of psychiatric comorbidity on Axis I (with the exception of nicotine dependence) and Axis II as indicated with the *SCID and the International Personality Disorders Examination* (IPDE; Loranger et al., 1994; Spanish version by López-Ibor, 1996), (iv) absence of a history of head injury and neurological, infectious, systemic or any other disease affecting the central nervous system, (v) not taking prescription drugs which affect the central nervous system (e.g. benzodiazepines, antipsychotics, etc.).

2.2. Instruments

Participants were evaluated between one and fifteen days before onset of treatments (pre-treatment assessment) and after end of treatments (post-treatment assessment). The mean duration of assessment was 3 hrs. and 30 minutes, including two breaks to avoid the effects of fatigue.

The assessment of DSM criteria was conducted using the Structured Clinical Interview for DSM-IV Disorders Clinician Version (SCID; First et al., 1997), and the International Personality Disorders Examination (IPDE; Loranger et al., 1994; Spanish version by López-Ibor, 1996). History of drug use was ascertained via the Interview for Research on Addictive Behaviour (Verdejo-García et al., 2005). The Spanish version of the Perceived Stress Scale (Cohen et al., 1983; Spanish version by Remor, 2006) was used to assess stress levels.

Outcome measures

Basic executive functions

2.2.1. Letter-number sequencing (Wechsler Adult Intelligence Scale, WAIS-III) (Wechsler, 1997a): Subtest of the WAIS-III, this test allows for the assessment of working memory. In this test, the examiner reads a sequence of numbers and letters, with a frequency of one second per letter/number. Then, the participant must recall the sequence and list the numbers in ascending order and the letters alphabetically. The main outcome variable from this test was the total of correct answers.

2.2.2. Color-word interference test Stroop. Delis-Kaplan executive functions system (Delis et al., 2001). Subtest of the Delis-Kaplan battery, assesses the response inhibition process. Participants have to read as quickly and accurately as possible the items represented in each condition. The first condition presents patches of colors. In the second condition presents the words “red”, “blue” and “green” printed in black ink and participants have to read these words. The third condition presents the same words but they are printed in incongruent color inks and participants have to name the color, ignoring the word written. The main outcome variables were the composite measures: Inhibition v Color naming (time part 3 – time part 1) and total errors in part 3.

2.2.3. Information Sampling Test (IST) (CANTAB, Cambridge Cognition): This computerized test assesses reflection-impulsivity, defined as the tendency to evaluate the available information before making a decision. An array of 25 grey squares were presented each time the participant touched a box, showing one of the two colors represented in the bottom of the array by two squares of different colors. The participant must reveal the squares and, when they deem it appropriate, must make a decision about what color they believe to be in the majority of the array. There are two conditions: one condition is “fixed”, in which the participants earn 100 points per trial if they are right, and lose 100 points if they fail. In the "decreasing" condition, the participant could earn 100 points per trial, but each time they reveal a box, the prize is reduced by 10 points, if they fail they lose 100 points. The aim is to reach the highest score possible. The main outcome variables were the number of boxes opened per trial and the total of error selection, under both conditions.

2.2.4. Stocking of Cambridge (SOC) (CANTAB, Cambridge Cognition): Computerized version adapted from the Tower of London test. Participants view two screens in which there are three different color balls and three cavities that have a different ball-holding capacity (three, two, and one ball respectively). The aim is to reproduce the ending position of the top screen in the bottom screen with the least number of movements possible. The main outcome variables were the sum of all moves for problems with 2, 3, 4 and 5 movements and the initial thinking planning time.

Ecological measures of planning and multitasking

2.2.5. Zoo Map test (Behavioural Assessment of the Dysexecutive Syndrome, BADS) (Wilson et al., 1996): Subtest of the BADS to assess the ability to generate and implement a plan. Participants are required to plan and then draw a route to visit the six indicated places on a paper map of a zoo, following three rules. These rules determine the best possible performance, so that there are only four correct routes to solve the task correctly. The main outcomes for this test were the initial thinking time, representing the amount of planning/forethought, and the total score, representing the success of the applied route.

2.2.6. Revised Strategy Application Test (Levine et al., 2007): This test assesses multitasking ability in the context of interference control and self-regulation. The task consists of six piles of 10 sheets, containing items of two sizes (big and small) and three types of time demand (long, medium and short). There are two piles with drawings which the participant must trace, two piles with written phrases that have to be copied on the bottom line and two other piles with groups of figures where they should write the numbers in ascending order inside each figure. Each small item completed provides 100 points, and big items provide 0 points (interference stimuli). The main goal is to reach the highest amount of points. The initial sheets only contain short items but from the second sheet onwards there are both long, medium and short, and the best strategy consist on doing the short ones and skipping the rest (self-regulation). The task ends when the participant has completed 50 items (excluding the first page). The main outcome variable is the total number of brief items relative to the total number of items completed.

2.2.7. Multiple Errands Test – contextualized version (MET-CV): This test is an adapted and modified version of the Multiple Errands Test (Shallice & Burgess, 1991). It assesses the ability to develop and implement a plan in a natural environment, in which the examiner is present only as an observer.

The aim is to perform 11 tasks, grouped into three categories of goals. The first goal involves completing a series of tasks: picking up a bag that contains the necessary material to carry out the task, preparing a shopping list following specific instructions from a supermarket catalog (represents three tasks), making a reservation for a venue to host a celebration by telephone and creating and hanging a poster with information about the event. The second goal is to obtain information about the surroundings through four tasks: studying a thermometer and making note of the current temperature, making a weather prediction using a newspaper, obtaining and taking note of the supermarket address and counting the number of specific items in the area (benches, lampposts, etc). The third goal consists of meeting at a specific location 20 minutes before the start of the task. To avoid test-retest effect, there is a parallel version for assessment post treatment, in which the nature of goals was created. In this version the goals are the same, but some aspects, such as the location of the material, products to be purchased, products to be counted or the place of the rendezvous are modified.

During completion of the test, the participants' behaviors are registered and classified following the original procedures given by Shallice and Burgess (1991). The different errors are classified in three types: (1) Task failures: when a task goal has not been reached; (2) Rule violation: when a specific rule or social rule has been broken; (3) Inefficiencies: when a more effective strategy could have been used. One point is assigned for each error. Subsequently, a weighted score for each error is calculated based on the frequency of each error in the control group. The main outcome variables were: the number of task failures, inefficiencies, rules broken, total amount of errors, initial thinking time and the number of strategies used (times when the map and other signs were viewed).

2.3. Procedures

Participants meeting inclusion criteria were randomly assigned to one of two possible Treatment Groups: GMT + MM with Treatment as usual (n = 18), or Treatment-as-usual only group (TAU only) (n = 18). Randomization was conducted by the administration staff of the centers. Two participants were excluded from the GMT + MM Group, and two participants from the TAU only group for disciplinary reasons. The final sample size for both groups was GMT + MM (n = 16) and TAU only group (n = 16). Socio-demographic variables for both groups are described in table 1, no differences were found between the groups in age, gender, years of schooling, main drug of choice or amount of alcohol, cocaine or heroin consumed per month. Nor were there any significant differences in duration of treatment ($t= 0.360$, $p = 0.721$), between GMT + MM Group ($M_{days} = 184.62$, $SD = 39.99$) and the Treatment-as-usual Group ($M_{days} = 179.5$, $SD = 40.44$). The group GMT + MM received 8 sessions of GMT and 8 sessions of Mindfulness Meditation across 8 weeks.

The GMT program includes theoretical and practical elements pursuing the development and implementation of goal-directed behavior. The exercises applied consist of five progressive strategies in which the participant is trained to (i) stop, inhibiting automatic behaviors and directing attention to the present, (ii) establish and maintain goals in mind, (iii) divide the task into smaller steps, (iv) monitor their conduct and make decisions, (v) reassess and adjust behavior (Tornås et al., 2016). The mindfulness program aims to regulate emotional input and to focus attention on the present moment and reduce stress through mindful attention and body scan techniques (Cropley et al., 2007).

GMT + MM is aimed at facilitating transfer to daily life activities. The treatment was administered by a clinical psychologist trained in neuropsychology and MM. The GMT sessions were held in the morning, and were of 120 minutes length. Meditation sessions lasted 40 minutes each.

2.4. Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Science (SPSS). We found two outliers in the Stroop test, defined as scores >3 standard deviations below the mean of the sample distribution, one for GMT + MM group (n = 15) and the other in the TAU only group (n = 15). A missing value was detected in the TAU only group (n = 15). All variables showed a normal distribution confirmed for the

Kolmogorov-Smirnov test, except for the variables of drug consumption “amount of cocaine per month” and “amount of heroin per month”. Socio-demographic and consumption differences were performed using the t student test for quantitative variables with normal distribution, U-Mann Whitney for variables that did not show normal distribution and Chi square for nominal variables. ANOVAs repeated measures were conducted to examine the effects of “Time x Treatment”.

3. Results

The results of the Time (post- versus pre- interventions) x Treatment (GMT + MM versus TAU only) ANOVAs are shown in table 2.

For Letter Number Sequencing, a significant interaction of “Time x Treatment” was found. Planned univariate repeated-measures ANOVAs showed that the interaction effect was driven by a significant improvement of performance in the GMT + MM group, $F(1,15) = 9.099$, $p = 0.009$), but not in the TAU only group, $F(1,15) = 0.789$, $p = 0.388$.

For the IST “decreasing” condition, a significant “Time x Treatment” interaction was found in the two main dependent variables: number of boxes opened per trial and total number of errors. Planned univariate repeated-measures ANOVAs showed that the interaction effect was driven by a significant increase in the number of boxes opened per trial in the GMT + MM Group, $F(1,15) = 5.548$, $p = 0.033$, but not in the TAU only group, $F(1,15) = 0.343$, $p = 0.567$. There was also a reduction in number of errors in the GMT + MM Group, $F(1,15) = 8.571$, $p = 0.010$, but not in the TAU only group, $F(1,15) = 0.319$, $p = 0.580$. In the fixed condition none of the dependent variables were significant.

For the Zoo Map Test, a significant "Time x Treatment" interaction was found in the initial thinking time. Planned univariate repeated-measures ANOVAs showed that the interaction effect was driven by a significant decrease in the TAU only group, $F(1,15) = 6.027$, $p = 0.027$, while it remained stable in the GMT + MM group, $F(1,15) = 2.352$, $p = 0.146$. No significant differences were found in the raw score.

For the MET-CV, the number of task failures, total amount of strategies, initial thinking planning time and the total number of errors showed a significant "Time x Treatment" interaction. Planned univariate repeated-measures ANOVAs showed that the interaction effect was driven by a significant reduction of task failures in the GMT + MM group, $F(1,15) = 8.787$, $p = 0.010$, but not in the TAU only group, $F(1,14) = 0.656$, $p = 0.432$; a significant reduction of total errors in the GMT + MM group, $F(1,15) = 8.843$, $p = 0.009$, but not in the TAU group, $F(1,14) = 0.000$, $p = 1.000$; a significant improvement in the total amount of strategies used in the GMT + MM group, $F(1,15) = 6.148$, $p = 0.026$, but not in the TAU only group, $F(1,14) = 1.464$, $p = 0.246$ and a significant reduction of the initial thinking time in TAU only group, $F(1,15) = 4.507$, $p = 0.052$, but not in the GMT + MM group, $F(1,14) = 1.621$, $p = 0.222$. The indices breaking of rules and inefficiencies did not reach significance.

No significant effects of the "Time x Treatment" interaction were found for the Stocking of Cambridge, Stroop or Revised Strategy Application test.

The results of the Perceived Stress Scale, showed a "Time x Treatment" interaction ($F = 6.769$, $p = 0.014$). Planned univariate repeated-measures ANOVAs showed that the interaction effect was driven by a significant reduction in the GMT + MM group [Pre, $M = 30.5$, $SD = 7.27$; Post, $M = 21.56$, $SD = 6.02$; $F(1,15) = 20.034$, $p = 0.000$], but not in the TAU only group [Pre, M = 28.12, SD = 8.40; Post, M = 26.06, SD = 9.61; $F(1,15) = 1.420$, $p = 0.252$].

4. Discussion

This study aimed to test the efficacy of GMT + MM to improve executive functions and its transfer to tasks that mimic daily life activities. The results show that GMT + MM improves working memory, reflection-impulsivity/decision-making and performance in an ecological task including daily life activities. GMT + MM was also associated with a significant reduction of stress levels compared to control. These results extend the findings of our previous study, demonstrating for the first time that cognitive training with GMT + MM produces a positive transfer to daily activities in PSUD. These results have special importance for the application of cognitive rehabilitation in the context of substance use disorders, as they show that cognitive training gains relate to laboratory tasks-measured executive functions, but also to significant improvements in daily life activities.

The improvement in working memory was one of the anticipated effects of the training, as GMT and MM have previously demonstrated efficacy in improving this construct (Chiesa et al., 2011). These results have special relevance to real-life goals given that working memory facilitates the processes of keeping goals in mind and preventing attentional slips (Chen et al., 2011). The GMT + MM intervention provides specific strategies to hold goals in mind and to stop and check before action, empowering participants with a general execution schema that allows goals to be achieved. These strategies putatively facilitated the transfer of executive functions' gains into the ecological task (MET-CV), which showed a reduction of task failures and total errors in the GMT + MM group. A main effect of GMT in reducing planning and sequencing errors after GMT have also been found in a recent randomized control trial in patients with acquired brain injury (Tornas et al, 2016). Hypothetically, MM provides skills to smooth the transition between habit-based and goal-related behavior (Garland et al., 2014; McConnell & Froeliger, 2015), and thus it is also a potential contributor to these effects.

Significant increases in planning time were specifically observed in participants enrolled in GMT + MM in the MET-CV and in the Zoo Map tests. Initial thinking time is a key measure of cognitive planning, as more deliberation has been shown to be meaningfully associated with better performance in planning tasks (Cohen-Kdoshay & Meiran, 2009; Duncan et al., 2008). Initial thinking time has also been linked to the concept of reflection-impulsivity, defined as the amount of information gathered before making a decision (Verdejo-García et al., 2008). Accordingly, the GMT + MM group also showed significant changes in the IST, a specific measure of reflection-impulsivity (Clark et al., 2006). Some specific trainings included in GMT, such as stop techniques and present-moment orientation, may have promoted greater reflection before decision-making (Slagter et al., 2007), contributing to explain the IST results. By having access to more information, the level of uncertainty associated with decision-making is reduced, as illustrated by reduced number of errors in this task. However, these results were only found in the decreasing condition and not in the fixed condition of IST. Several studies have suggested that the decreasing condition conveys greater uncertainty than the fixed condition, causing participants tend to make decisions based on a less information in order to obtain higher winnings (Clark et al., 2009; Solowij et al., 2012). In this study, participants prioritized making correct decisions over opting to greater reward specifically in this riskier condition. The focus of GMT+MM on facilitating recognition of interoceptive signals may have contributed to increased reflection in these risky scenarios (Alfonso et al., 2011).

In agreement with the well-established link between better working memory and impulsivity and lower stress levels, we also found that GMT + MM had positive effects on stress reduction (Diamond, 2013). MM mechanisms geared towards regulation of emotional input also plausible direct contributors to stress reduction (Garland et al., 2014; Tang et al., 2015). In relation to other traditional planning and cognitive control tasks, the Zoo Map test, SOC, RSAT, and Stroop, no significant changes were observed. Although GMT has shown to be more likely to produce changes in ecological versus laboratory-based tasks (Krasny-Pacini et al., 2014), some positive changes were expected in these measures given the focus of GMT on executive functions and self-regulation. The fact that these tasks tax non-specific aspects of GMT training (i.e. problem solving, interference control) and are relatively more structured and artificial, compared to for example the Multiple Errands Test (Goel, 2010), may have contributed to more limited transfer of GMT + MM effects.

Our findings demonstrate that the GMT + MM program increases the achievement of goals in daily activities in PSUD. The improvement of these complex planning processes, cannot be explained by improvement of any single individual construct, but as a result of the coordination of multiple processes including: (i) better maintenance of goals and rules in working memory, (ii) inhibition of action errors, (iii) reflexive processes that enable better organization and sequencing of subgoals, (iv) emotional regulation and mindfulness relevant to decision-making, and (v) metacognitive top-down strategies to overcome goal neglect. In addition, ecological tasks such as MET-CV, allow for the detection of changes in molar constructs more easily than laboratory tasks. Future studies should analyze clinical outcomes linked to treatment response, such as relapse episodes, motivation for treatment, employment, social reintegration. The main strengths of this study are the novelty of the approach (first time GMT + MM is applied in therapeutic communities), the replication of previous findings (GMT + MM improved working memory and impulsivity skills, as in our previous study), and the extension of findings into ecologically valid tasks. The amelioration of working memory and impulsivity skills is particularly relevant in the context of therapeutic community treatment, as both skills have been consistently associated with drug relapse following treatment (Loughead et al., 2015; Stevens et al., 2014). This study should also be appraised in the context of certain limitations: (i) the size of the groups was small, (ii) the heterogeneous polydrug consumption of the participants makes it difficult to draw conclusions about effectiveness in specific populations and (iii) the absence of follow-up measures of treatment outcomes. In addition, the combination of two complex trainings (GMT +MM), with relatively unclear treatment pathways, make it difficult to pinpoint the precise mechanisms by which the intervention achieved positive effects. This is a common problem, as it has been shown that cognitive training is more effective as more active trainings come into play (Buschkuehl et al., 2012), but that comes with the pay-off of reduced specificity.

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Table

Table 1. Descriptive information for sociodemographic variables, patterns of drug use and treatment.

	GMT + MF (*n* = 16)	TAU only(*n* = 16)	Statistic
	Mean (*SD*)	Mean (*SD*)	
Gender	Male = 9, Female = 7	Male = 12, Female = 4	X^2 = 1.247, *p* = 0.264
Age	35.19 (5.39)	30.94 (7.29)	*t* = 1.875, *p* = 0.071
Educational level	11.25 (1.92)	10.13 (2.03)	*t* = 1.249, p = 0.221
Abstinence duration	9.62 (6.01)	7.29 (4.98)	*t* =1.195, *p* = 0.242
Main drug of choice	Alcohol (*n* = 5), Cocaine (*n* = 7), Heroin/Cocaine (*n* = 4)	Alcohol (*n* = 9), Cocaine (*n* = 5), Heroin/Cocaine (*n* = 2)	X^2 = 2.143, *p* = 0.343
Relapses in residential treatment	1.56 (1.71)	0.75 (0.68)	*t* = 1.764, *p* = 0.088
Relapses in community treatment	0.31 (0.60)	0.25 (0.45)	*t* =0.333, *p* = 0.741
Alcohol amount per month (SDU)	159.62 (237.07)	281.12 (243.59)	*t* =1.430, *p* = 0.163
Cocaine amount per month (gr.)	26.34 (28.60)	18.06 (22.13)	*U* = 108.5, *p* = 0.468
Heroine amount per month (gr.)	7.97 (2.62)	15.36 (7.89)	*U* = 109.5, *p* = 0.491

Note: GMT+MF = Goal Management Training and Mindfulness, TAU only= Standard treatment as usual only group, *SD* = Standard deviation, SDU = Standard Drink Units, X^2 = Chi-square, *t* = t-student, *U* = U Mann-Whitney.

Table 2. Results on neuropsychological performance in GMT + Mindfulness vs. Standard Treatment in polysubstance users.

Test	Dependent Variables	GMT+MF		TAU only		F-Interac. (*p*)	
		Pre – M (*SD*)	Post – Mean (*SD*)	Pre – Mean (*SD*)	Post – Mean (*SD*)		
L&N	Raw score	9.56 (1.78)	10.88 (2.24)	9.81 (2.01)	10.06 (2.02)	4.516 (0.049)	GMT+MF > ST
Zoo map	Raw score	1.5 (2.42)	4.88 (2.63)	1.56 (4.30)	3.63 (3.36)	0.727 (0.401)	
	Initial thinking time (s.)	57.56 (39.14)	86.81 (53.75)	101.25 (85.96)	48.62 (54.75)	8.143 (0.008)	GMT+MF > ST
RSAT	Brief/total	0.79 (0.16)	0.88 (0.09)	0.84 (0.09)	0.90 (0.09)	0.498 (0.486)	
IST DC	Boxes opened per trial	9.33 (4.77)	12.09 (5.06)	8.82 (2.66)	8.44 (3.40)	5.513 (0.026)	GMT+MF > ST
	Sampling Errors	2 (1.26)	1 (0.89)	2.06 (1.34)	2.25 (1)	6.217 (0.018)	GMT+MF > ST
IST FC	Boxes opened per trial	13.47 (6.56)	14.94 (6.17)	13.08 (4.21)	12.11 (4.95)	1.398 (0.246)	
	Sampling Errors	1.06 (1.53)	1 (1.15)	1.06 (0.85)	1.18 (1.17)	0.135 (0.716)	
SOC	Total moves	16.73 (1.54)	16.08 (1.67)	16.94 (1.51)	17.05 (1.37)	1.380 (0.249)	
	Initial thinking time (s.)	24.46 (10.88)	22.83(11.25)	23.76(11.44)	14.55 (8.69)	2.666 (0.113)	
Stroop	Inhibition time (s.)	19.67 (5.45)	16.20 (5.70)	20.07 (8.01)	17.21 (3.85)	0.232 (0.634)	
	Errors inhibition	0.75 (1.06)	0.37 (0.72)	0.80 (1.37)	0.87 (0.99)	0.864 (0.360)	
MET-CV	Task failures	6.69 (3.82)	3.81 (3.29)	4.47 (2.64)	4.93 (2.34)	8.485 (0.007)	GMT+MF > ST
	Inefficiencies	2.94 (1.98)	1.06 (1.24)	4.4 (3.79)	3.13 (2.97)	0.367 (0.550)	
	Rules broken	4.63 (2.31)	3.90 (2.22)	5.27 (3.19)	6.13 (2.95)	1.608 (0.215)	
	Total errors	15.69 (6.56)	9.65 (6.23)	14.80 (6.25)	14.80 (5.68)	5.217 (0.030)	GMT+MF > ST
	Initial thinking time (s.)	62.25 (75.36)	97.81 (53.20)	45 (41.92)	17.80 (20.31)	4.189 (0.050)	GMT+MF > ST
	Total strategies	6.06 (2.91)	8.50 (3.26)	6.27 (2.68)	5.4 (2.90)	7.216 (0.012)	GMT+MF > ST

Note: GMT+MF = Goal Management Training + Mindfulness, TAU only = Standard treatment as usual only group, *SD* = Standard Deviation, L&N = Letters and Numbers, RSAT = Revised Strategy Application Test, IST = Information Sampling Test, SOC = Stocking Of Cambridge, MET-CV = Multiple Errands Test- Contextualized Version

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C. Valls-Serrano, A. Caracuel-Romero A. and Verdejo-García designed the study. C. Valls-Serrano performed clinical and neuropsychological assessments, administered the treatment and wrote-up a first draft of the Manuscript. All authors contributed to the final versions of the manuscript.

Conflict of interest

No conflict declared.

Contributors

C. Valls-Serrano, A. Caracuel-Romero A. and Verdejo-García designed the study. C. Valls-Serrano performed clinical and neuropsychological assessments, administered the treatment and wrote-up a first draft of the Manuscript. All authors contributed to the final versions of the manuscript.