UNIVERSIDAD COMPLUTENSE DE MADRID

FACULTAD DE MEDICINA

TESIS DOCTORAL

Realidad virtual para el entrenamiento de la cognición social en esquizofrenia

MEMORIA PARA OPTAR AL GRADO DE DOCTOR

PRESENTADA POR

Patricia Fernández Sotos

DIRECTORES

Roberto Rodríguez Jiménez
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Dedicatoria

El presente trabajo de investigación lo dedico principalmente a Dios, por darme el sustento y la motivación necesarios a lo largo de mi carrera, y de mi vida.

Porque todas las cosas proceden de él, y existen por él y para él.
A él sea la gloria por siempre. Amén. (Romanos 11:36)

Agradecimientos

Mis agradecimientos al Dr. Roberto Rodríguez Jiménez por abrirme las puertas hacia un nuevo conocimiento, y permitirme realizar el proceso de investigación con su apoyo.

Mi profundo agradecimiento a mi padre, Antonio, por transmitirme su pasión por la investigación, por confiar en mí y enseñarme a confiar en mis posibilidades y por ser mi principal guía durante el proceso de investigación.

Doy las gracias a todo el equipo que ha formado parte de este trabajo, incluyendo a los grupos de investigación del Hospital Universitario 12 de Octubre, Hospital Virgen de la Luz de Cuenca, Hospital de San Juan (Alicante), Complejo Hospitalario Universitario de Albacete, Universidad de Alcalá e Instituto de Investigación en Informática de Albacete.

A mi marido Pablo, por ser mi pilar fundamental y estar siempre presente. Por haberme escuchado pacientemente, llenándome de paz y esperanza en los momentos de adversidad que se presentaron.

A mis hermanas, Alicia y Desirée, y a mi madre, Ana, por haberme apoyado incondicionalmente, relativizando la importancia de las piedras en el camino.

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Resumen

El deterioro en la cognición social determina una gran parte de la pérdida del funcionamiento y la calidad de vida de los pacientes que sufren de esquizofrenia. En los últimos años, se han desarrollado diferentes intervenciones dirigidas a la mejora de la cognición social, con resultados prometedores en términos de cognición social, habilidades sociales y funcionamiento social. Algunas de estas intervenciones utilizan la realidad virtual (RV) como herramienta básica de trabajo.

La presente tesis tiene como objetivo general investigar el área de las nuevas intervenciones psicoterapéuticas basadas en RV dirigidas a la mejora de los déficits en cognición social de los pacientes con esquizofrenia. El trabajo incluye ocho artículos de revista, estructurados en cinco secciones.

Los dos primeros artículos contienen revisiones sistemáticas de mapeo sobre las intervenciones psicoterapéuticas y farmacológicas dirigidas a la mejora de la cognición social en cualquier patología. De dichos artículos se desprende que existe un interés creciente en ambos tipos de intervención, especialmente en el área de la esquizofrenia.

El tercer artículo contiene un estudio de investigación multicéntrico llevado a cabo en España, en el que se analizó el acceso y patrón de uso de nuevas tecnologías en pacientes con esquizofrenia de menos de cinco años de evolución, en comparación con población sana. El trabajo mostró que una gran proporción de pacientes tienen acceso y utilizan con frecuencia los dispositivos tecnológicos, con un patrón de uso similar a la población sana.

El cuarto trabajo incluye una revisión sistemática sobre las intervenciones psicosociales basadas en RV en esquizofrenia, señalando que la RV ofrece una opción terapéutica interesante y prometedora para estos pacientes, aunque se necesitan más estudios para aclarar si estas intervenciones son más efectivas que las intervenciones clásicas y si son bien toleradas.

Los artículos quinto y sexto incluyen el trabajo de diseño de humanos virtuales (HV) y su validación en población sana. De estos trabajos se infirió que los HV son tan válidos como las caras naturales estandarizadas para recrear con precisión las expresiones faciales de emociones humanas.

Los dos últimos artículos analizaron la aceptación de avatares emocionales por parte de terapeutas, indicando que la mayoría de los profesionales de salud mental consideran que este tipo de herramientas son útiles y estarían dispuestos a utilizarlas.

Se prevé que, en los próximos años, las nuevas intervenciones basadas en RV continúen desarrollándose, resultando una opción accesible, divertida, innovadora y personalizada para rehabilitar los déficits en cognición social. Además, la combinación del abordaje tecnológico con sesiones interpersonales a nivel individual y grupal resulta compatible y favorece el vínculo terapéutico y la relación entre participantes. Bajo nuestro punto de vista, este tipo de abordaje integral promueve la participación activa de los pacientes en su recuperación funcional.

Abstract

Social cognition impairment determines a large part of the loss of functioning and quality of life in patients suffering from schizophrenia. In recent years, different interventions have been developed aimed at improving social cognition, with promising results in terms of social cognition, social skills, and social functioning. Some of these interventions use virtual reality (VR) as a basic work tool.

The present thesis has the general objective of investigating the area of new VR-based psychotherapeutic interventions aimed at improving social cognition deficits in patients with schizophrenia. It includes eight journal articles, structured in five sections.

The first two articles contain systematic mapping reviews on psychotherapeutic and pharmacological interventions aimed at improving social cognition in any pathology. These articles show that there is a growing interest in both types of intervention, especially in the area of schizophrenia.

The third article contains a multicenter research study carried out in Spain, in which the access and pattern of use of new technologies in patients with early stage schizophrenia compared to healthy population was analysed. As main result, a large proportion of patients had access and frequently used technological devices, with a pattern of use similar to healthy population.

The fourth work includes a systematic review on VR-based psychosocial interventions in schizophrenia, pointing out that VR offers an interesting and promising therapeutic option for these patients, although more studies are needed to clarify whether these interventions are more effective than classical interventions and if they are well tolerated.

The fifth and sixth articles include the work of virtual humans (VHs) design and its validation in healthy population. From these works it was inferred that HVs are as

valid as standardized natural faces to accurately recreate facial expressions of human emotions.

The last two articles studied the acceptance of emotional avatars by therapists, indicating that the majority of mental health professionals consider that these types of tools are useful and they would be willing to use them.

It is expected that, in the coming years, new VR-based interventions will continue to develop, resulting in an accessible, fun, innovative and personalized option to rehabilitate deficits in social cognition. In addition, the combination of the technological approach with interpersonal sessions at the individual and group level is compatible and favours the therapeutic bond and the relationship between participants. From our point of view, this type of comprehensive approach promotes the active participation of patients in their functional recovery.

Capítulo 1. Introducción

1.1. Antecedentes

La esquizofrenia es una de las enfermedades con mayor repercusión a nivel clínico, económico y social, no tanto por su prevalencia, sino por su enorme impacto sobre el funcionamiento y la calidad de vida de las personas que la padecen (Tomotake, 2011). La pérdida de funcionalidad se manifiesta en diferentes áreas como el mantenimiento de las relaciones interpersonales, la capacidad para desempeñar una actividad laboral, la capacidad para ser independiente para las actividades de la vida diaria, y el desempeño de actividades placenteras y de ocio (Rodriguez-Jimenez y cols., 2013).

Actualmente existe evidencia consistente sobre la relación estrecha entre funcionalidad, calidad de vida y cognición social (Rodriguez-Jimenez y cols., 2013). La cognición social hace referencia al conjunto de operaciones mentales que subyacen a las interacciones sociales, como percibir, interpretar y generar respuestas ante las intenciones, emociones, tendencias y comportamientos de otros (Green y cols., 2008).

En los últimos años, se han llevado a cabo grandes esfuerzos para el diseño de intervenciones (tanto farmacológicas como psicoterapéuticas) dirigidas a la mejora de la cognición social en esquizofrenia (Tan, Lee, y Lee, 2018). Las intervenciones psicoterapéuticas y más concretamente las terapias de rehabilitación en cognición social y habilidades sociales han obtenido resultados positivos en torno a las medidas de la cognición social, las habilidades sociales y la funcionalidad de los pacientes (Kurtz, Gagen, Rocha, Machado, y Penn, 2016). En los últimos 10 años, se ha desarrollado un campo

de investigación en torno a este tipo de intervenciones basadas en realidad virtual (RV), con resultados prometedores (Veling, Brinkman, Dorrestijn, y van der Gaag, 2014).

El presente trabajo se propuso profundizar en el conocimiento de las intervenciones dirigidas a la mejora de la cognición social en esquizofrenia, especialmente en el área de las nuevas tecnologías, con el objetivo final de desarrollar en un futuro próximo un programa de entrenamiento en cognición social, basado en RV para pacientes con esquizofrenia. Para ello se ha trabajado con un equipo multidisciplinar, incluyendo a los Servicios de Psiquiatría y Salud Mental del Hospital Universitario 12 de Octubre, Hospital Virgen de la Luz de Cuenca, Hospital de San Juan (Alicante) y Complejo Hospitalario Universitario de Albacete, al Departamento de Medicina y Especialidades Médicas de la Universidad de Alcalá y al Instituto de Investigación en Informática de Albacete de la Universidad de Castilla la Mancha.

1.2. Estado del arte

La esquizofrenia es uno de los trastornos médicos asociado a mayor repercusión clínica, social y económica, clasificada por la Organización Mundial de la Salud como una de las diez principales enfermedades con mayor carga económica mundial (World Health Organization, 2019). Esto es así no tanto por su prevalencia, con un riesgo de morbilidad a lo largo de la vida de aproximadamente 7 de cada 1000 personas (McGrath, Saha, Chant, y Welham, 2008), sino por la limitación severa en el funcionamiento y la calidad de vida que genera en los pacientes que la padecen (Patel y cols., 2006).

La esquizofrenia se asocia con tasas elevadas de suicidio (Palmer, Pankratz, y Bostwick, 2005) y un mayor riesgo de muerte prematura relacionada con una amplia gama de afecciones somáticas comórbidas (Brown, 1997), resultando en una esperanza de vida reducida entre 12 y 15 años en comparación con la población general (van Os y Kapur, 2009).

Aunque las manifestaciones clínicas de la esquizofrenia son muy diversas, existen cuatro dimensiones sintomáticas cardinales de la enfermedad que incluyen los síntomas positivos (alucinaciones, delirios y desorganización del lenguaje y de la conducta), los síntomas negativos (incluyendo la abulia, la asociabilidad, la anhedonia, la alogia y el aplanamiento afectivo), las alteraciones en el estado de ánimo y las deficiencias en la cognición, incluyendo la neurocognición y la cognición social (van Os y Kapur, 2009). La neurocognición puede definirse como los procesos de enlazar y evaluar información e incluye habilidades como velocidad de procesamiento, atención, aprendizaje y memoria verbal y visual, memoria de trabajo, o razonamiento y resolución de problemas (Kovasznay, 2012; Nuechterlein y cols., 2004). Por otro lado, la cognición social hace referencia a las operaciones mentales que están involucradas en las interacciones sociales, incluidos los procesos de percepción, interpretación y generación de respuestas a las intenciones, disposiciones y conductas de los demás (Green y cols., 2008; Pinkham y cols., 2014).

En el pasado, se ha considerado que los delirios y las alucinaciones eran las manifestaciones más llamativas en la esquizofrenia. Sin embargo, son los síntomas negativos y cognitivos los que parecen relacionarse más con la funcionalidad y la calidad de vida de los pacientes (Bowie, Reichenberg, Patterson, Heaton, y Harvey, 2006; Green, Kern, Braff, y Mintz, 2000; Leifker, Bowie, y Harvey, 2009). La funcionalidad se manifiesta en diferentes áreas como el mantenimiento de las relaciones interpersonales, la capacidad para ser independiente para las actividades de la vida diaria, y el desempeño de actividades placenteras y de ocio (Torio y cols., 2014).

En los últimos años se ha estudiado la influencia de la cognición social sobre la funcionalidad de los pacientes. Según se desprende de varios estudios, la cognición social podría tener una mayor influencia que la neurocognición en la funcionalidad (23,3 % frente al 15,2 %, respectivamente), o incluso actuar como una variable mediadora entre neurocognición y funcionalidad (Fett y cols., 2011; Schmidt, Mueller, y Roder, 2011).

Aunque se han identificado diferentes trastornos neuropsiquiátricos en los que se objetiva un deterioro en la cognición social, la esquizofrenia ha adquirido una posición

paradigmática en este campo. Algunas razones pragmáticas podrían explicar este hecho. (a) Un número importante de pacientes con esquizofrenia sufren déficits en la calidad de vida y el funcionamiento. (b) Estos déficits tienen un inicio temprano y persisten durante toda la vida. (c) El sufrimiento personal, familiar y la carga económica de este trastorno es muy alta. (d) Los impedimentos de la cognición social parecen contribuir de forma importante a los déficits en la calidad de vida y el funcionamiento. Todo esto ha desembocado en un aumento significativo en la investigación de la cognición social y sus estrategias de tratamiento tanto farmacológicos como psicosociales en la última década (Grant, Lawrence, Preti, Wykes, y Cella, 2017; Kurtz y cols., 2016; Tan y cols., 2018).

La cognición social se divide en cuatro dominios relativamente independientes: teoría de la mente, estilo atribucional, percepción social y procesamiento emocional. La teoría de la mente se define como la capacidad de reconocer las intenciones, disposiciones y creencias en uno mismo y otros (Baron-Cohen, Wheelwright, Hill, Raste, y Plumb, 2001). Incluye comprender formas especiales de comunicación como pistas, engaños, metáforas o ironías, haciendo inferencias sobre los sentimientos, creencias e intenciones de otros, y/o representando estados mentales humanos (Frith, 1992; Penn, Addington, y A., 2006). La teoría de la mente también se denomina mentalización, atribución del estado mental o empatía cognitiva (Shamay-Tsoory, 2011). La percepción social consiste en la capacidad de identificar reglas sociales, roles y objetivos (Addington, Saeedi, y Addington, 2006; Toomey, Schuldberg, Corrigan, y Green, 2002). También se define como la capacidad de interpretar correctamente los comportamientos de otras personas teniendo en cuenta el contexto y la información social (Corrigan y Green, 1993; Penn, Ritchie, Francis, Combs, y Martin, 2002). El estilo atribucional describe la forma en la que los individuos explican o interpretan diferentes hechos sociales. Las atribuciones pueden ser externas (hacia otros) o internas (hacia uno mismo) (Green y cols., 2008).

Finalmente, el procesamiento emocional se refiere a la capacidad de percibir, reconocer y gestionar la información emocional (Green y cols., 2008). También se define

como la capacidad de identificar, facilitar, regular, comprender y manejar las emociones (Mayer, Salovey, Caruso, y Sitarenios, 2001; Salovey y Sluyter, 1997). Este dominio se divide a su vez en tres subdominios (Pinkham y cols., 2014) que incluyen procesos de nivel inferior y superior. Los procesos de nivel superior abarcan la comprensión y el manejo emocional mientras que el nivel perceptual más bajo incluye el reconocimiento facial del afecto. Este se describe como la identificación y el reconocimiento de estados emocionales a través de expresiones faciales y/o señales no faciales como la voz (Pinkham y cols., 2014). Esta capacidad es utilizada diariamente por los individuos y es crucial para una interacción social efectiva, determinando una gran parte del funcionamiento social (Johnston y cols., 2010). Por lo tanto, la forma en que un individuo reconoce el estado emocional en otro afecta su éxito social, lo que es relevante para su adaptación en la comunidad (Sachs y cols., 2012).

Existe evidencia consistente de que los pacientes con esquizofrenia presentan una dificultad significativa para reconocer con precisión las emociones expresadas por otros (Marwick y Hall, 2008). Este déficit puede generar una mala interpretación de las situaciones sociales y, por lo tanto, un déficit importante en el funcionamiento social (Bordon, O'Rourke, y Hutton, 2017). El deterioro parece ser relativamente estable en el curso de estos trastornos y no relacionado con la psicopatología o el tratamiento farmacológico (Barkhof, de Sonneville, Meijer, y de Haan, 2015; Wölwer, Streit, Gaebel, y Polzer, 1996). Debido a la relevancia para el funcionamiento social en estos pacientes y para la calidad de vida, se han diseñado diferentes intervenciones para mejorar el reconocimiento del afecto facial. Los metanálisis recientes han mostrado resultados prometedores de estos enfoques psicoterapéuticos en términos de reconocimiento facial de emociones y de funcionalidad (Bordon y cols., 2017; Kurtz y Richardson, 2011).

Las intervenciones psicoterapéuticas pueden clasificarse en dos modalidades: computarizadas e interpersonales. Aunque ambos tipos de intervención pueden dirigirse hacia el mismo objetivo, su implementación es diferente (Kurtz y cols., 2016; Tan y cols., 2018) y no hay estudios que comparen su efectividad. Entre las intervenciones

computarizadas, las intervenciones más recientes se basan en la realidad virtual (RV). La RV es una potente herramienta que proporciona entornos y situaciones prácticamente similares a la realidad, utilizando avatares dinámicos que permiten la interacción social con el participante y que se pueden manipular para representar diferentes estados emocionales (Gutiérrez-Maldonado, Rus-Calafell, y González-Conde, 2014). La RV permite la evaluación en tiempo real de emociones, pensamientos, comportamientos y respuestas fisiológicas de individuos en un entorno creado que se puede controlar, a diferencia de la vida real (Eichenberg y Wolters, 2012; Fernández-Caballero y cols., 2017; Fernández-Caballero y cols., 2017).

La RV incluye diferentes modalidades, como la realidad virtual inmersiva (RVI), la realidad virtual no inmersiva (RVNI) y la realidad aumentada (RA). La RVI está vinculada a un entorno tridimensional creado por computadora que se manipula a través de cascos, guantes u otros dispositivos que capturan la posición y la rotación de diferentes partes del cuerpo (Snoswell y Snoswell, 2019). La RVNI permite la interacción en tiempo real con diferentes personas en espacios y entornos que realmente no existen, mostrados en la pantalla del ordenador, sin la necesidad de dispositivos adicionales. En la RA, a diferencia de la realidad virtual, el mundo movido por el usuario es el mismo que lo rodea, y los objetos virtuales se agregan al mundo real (Bin, Masood, y Jung, 2020).

Algunos autores consideran que la RV se convertirá en parte de nuestra vida cotidiana (Cipresso, Giglioli, Raya, y Riva, 2018). En los últimos quince años se han desarrollado tratamientos prometedores en el área de la salud mental basados en RV, sobre todo en el campo de los trastornos de ansiedad (Opris y cols., 2012) y, recientemente, en psicosis (Broome y cols., 2013; Moritz y cols., 2014; Veling y cols., 2014), concluyendo que la RV puede ser una herramienta valiosa para evaluar la presencia de síntomas en entornos válidos y controlados, con el potencial de facilitar el aprendizaje de nuevas respuestas emocionales y conductuales; pudiéndose aplicar a la rehabilitación

cognitiva e intervenciones de capacitación en habilidades sociales (Rus-Calafell, Garety, Sason, Craig, y Valmaggia, 2018).

En el área de intervenciones diseñadas a la mejora del reconocimiento facial de emociones, en la mayoría de los estudios se presenta el estímulo experimental a través de fotografías o imágenes estáticas (García-Martínez, Martínez-Rodrigo, Alcaraz, y Fernández-Caballero, 2018; Sánchez-Reolid y cols., 2018). Algunos autores coinciden en que este tipo de estímulo no refleja la realidad del estímulo facial (Collignon y cols., 2008). Otros estudios utilizan vídeos para presentar expresiones de manera más genuina (Davis y Gibson, 2000). Sin embargo, los vídeos no han sido validados y presentan varias limitaciones en términos de duración y formato de la escena (Edwards, Jackson, y Pattison, 2002). Los avances obtenidos gracias a la RV pueden ayudar a superar algunas de estas limitaciones.

Las expresiones faciales dinámicas de los humanos virtuales (HV) generan una experiencia emocional más intensa en el usuario y facilitan el reconocimiento emocional exitoso (Sato y Yoshikawa, 2007). Además, estos HV pueden ser modelados con cualquier combinación de raza, edad y género, observándose desde cualquier ángulo, bajo cualquier condición de iluminación y en cualquier contexto social. El uso de entornos ecológicos válidos permitirá simular interacciones sociales parecidas a la realidad, lo que proporcionará a los terapeutas la posibilidad de controlar y manipular el comportamiento de los avatares para evaluar y entrenar el reconocimiento emocional básico (Burden y Savin-Baden, 2019).

El crecimiento de las tecnologías de la información y la comunicación y el uso masivo de Internet en los últimos 20 años ha influido en el desarrollo de la actividad humana en múltiples áreas como la educación y la salud (Broadband Commission for Sustainable Development, 2017). Las nuevas tecnologías forman parte de la vida cotidiana en la era actual especialmente entre los jóvenes.

De cara a poder desarrollar intervenciones psicoterapéuticas apoyadas en nuevas tecnologías y diseñadas para la mejora del reconocimiento facial del afecto debemos

tener conocimiento relacionado con (a) la accesibilidad y el patrón de uso de nuevas tecnologías por parte de los pacientes con esquizofrenia y (b) la evaluación de herramientas basadas en RV para la mejora del reconocimiento facial del afecto en pacientes con esquizofrenia por parte de los profesionales de la salud mental en términos de aceptación e intención de uso.

Actualmente, existe una información limitada sobre el acceso y uso de la tecnología digital en pacientes psicóticos. Hasta la fecha, hay muy pocos estudios publicados en todo el mundo sobre el patrón de uso de dispositivos y aplicaciones de tecnología digital (incluida la RV) en pacientes con esquizofrenia y aún menos en comparación con participantes sanos (no con datos de encuestas de población general) de las mismas áreas demográficas (Abdel-Baki, Lal, D.-Charron, Stip, y Kara, 2017; Gay, Torous, Joseph, Pandya, y Duckworth, 2016; Miller, Stewart, Schrimsher, Peeples, y Buckley, 2015; Välimäki y cols., 2017). A día de hoy no existen estudios publicados que evalúen la opinión de los profesionales de la salud mental en relación a este tipo específico de terapias.

1.3. Objetivos

Objetivo general:

- Investigar el área de nuevas intervenciones psicoterapéuticas basadas en RV dirigidas a la mejora de los déficits en cognición social de los pacientes con esquizofrenia.

Objetivos secundarios:

- Revisar las intervenciones psicoterapéuticas llevadas a cabo en el área de la cognición social en los últimos años.
- Revisar las intervenciones farmacológicas llevadas a cabo en el área de la cognición social en los últimos años.

- Estudiar el patrón de acceso y uso de nuevas tecnologías en pacientes con esquizofrenia en comparación con población sana.
- Revisar las intervenciones de rehabilitación psicosocial basadas en RV para pacientes con esquizofrenia en los últimos años.
- Diseñar una nueva serie de caras dinámicas virtuales a través del sistema de codificación de acciones faciales.
- Diseñar una nueva serie de caras dinámicas virtuales que representen las seis emociones básicas desde la emoción neutra y validar su aplicación en la población sana, comparando el estímulo virtual con un estímulo natural previamente validado.
- Evaluar una herramienta basada en RV para la mejora del reconocimiento facial de emociones en pacientes con esquizofrenia por parte de los profesionales de la salud mental en términos de aceptación e intención de uso.

1.4. Hipótesis

Hipótesis principal:

- La investigación y el desarrollo de nuevas intervenciones psicoterapéuticas basadas en RV dirigidas a la mejora de los déficits en cognición social de los pacientes con esquizofrenia abre un novedoso y prometedor camino para abordar este problema.

Hipótesis secundarias:

- Existe un interés creciente en las intervenciones psicoterapéuticas dirigidas a la mejora de la cognición social.
- Existe un interés creciente en las intervenciones farmacológicas dirigidas a la mejora de la cognición social.

- Los pacientes con esquizofrenia tienen acceso y presentan un patrón de uso de las nuevas tecnologías similar a la población sana.
- Las intervenciones de rehabilitación psicosocial basadas en RV para pacientes con esquizofrenia obtendrán resultados positivos en términos de eficacia y tolerancia.
- La RV permite diseñar expresiones faciales que representan las emociones básicas de forma precisa.
- El conjunto de expresiones faciales virtuales diseñado por el equipo de investigación será tan válido como un estímulo natural previamente validado para recrear con precisión las emociones básicas.
- La RV es bien aceptada por los profesionales de la salud mental.

Capítulo 2. Material y Métodos

En la presente tesis se han incluido ocho artículos de revista, indexados y evaluados por pares, estructurados en cinco secciones.

La primera sección incluye dos revisiones de mapeo sistemáticas sobre las intervenciones psicoterapéuticas y farmacológicas diseñadas para la mejora de la cognición social. La segunda, está compuesta por un artículo original en el que se analiza el acceso y uso de las nuevas tecnologías por parte de los pacientes con esquizofrenia en estadios iniciales, en comparación con controles sanos emparejados por edad, género y lugar de residencia. La tercera contiene una revisión sistemática sobre las intervenciones psicosociales basadas en RV dirigidas a pacientes con esquizofrenia. La cuarta sección está formada por dos trabajos originales que incluyen el proceso de diseño de un conjunto de expresiones faciales a través de avatares dinámicos y su validación en población sana, comparando el estímulo virtual diseñado por el equipo de investigación, con un estímulo natural validado. La quinta sección incluye dos trabajos en los que se analizó la intención de uso por parte de los profesionales de Salud Mental de una herramienta basada en humanos virtuales para el entrenamiento del reconocimiento emocional. El primer trabajo incluyó una muestra de 41 terapeutas, mientras que el segundo trabajo amplió la muestra a 124.

A continuación, se muestra un resumen del material y métodos de cada uno de los artículos.

1. Estudios acerca de los tratamientos de los déficits en cognición social.

    - P. Fernández-Sotos, I. Torio, A. Fernández-Caballero, E. Navarro, P. González, M. Dompablo, and R. Rodriguez-Jimenez. Social cognition remediation interventions: A systematic mapping review. PLoS One, 14(6):1–20, 2019; doi: 10.1371/journal.pone.0218720
    - P. Fernández-Sotos, E. Navarro, I. Torio, M. Dompablo, A. Fernández-Caballero, and R. Rodriguez-Jimenez. Pharmacological interventions in social cognition deficits: A systematic mapping review. Psychiatry Research, 270:57–67, 2018; doi: 10.1016/j.psychres.2018.09.012

2. Uso de las tecnologías digitales por parte de los pacientes psicóticos.

    - P. Fernández-Sotos, A. Fernández-Caballero, P. González, A. I. Aparicio, I. Martínez-Gras, I. Torio, M. Dompablo, L. García-Fernández, J. L. Santos, and R. Rodriguez-Jimenez. Digital technology for internet access by patients with early-stage schizophrenia in spain: Multicenter research study. Journal of Medical Internet Research, 21(4):e11824, 2019; doi: 10.2196/11824

3. Cognición social y realidad virtual.

    - P. Fernández-Sotos, A. Fernández-Caballero, and R. Rodriguez-Jimenez. Virtual reality for psychosocial remediation in schizophrenia: A systematic review. European Journal of Psychiatry, 1–10, 2020 (enviado)

4. Diseño y validación de expresiones faciales humanas virtuales.

    - A. S. García, P. Fernández-Sotos, M. A. Vicente-Querol, G. Lahera, R. Rodriguez-Jimenez, and A. Fernández-Caballero. Design of reliable virtual human facial expressions and their validation by healthy people. Integrated Computer-Aided Engineering, 1–13, 2020 (enviado)

- P. Fernández-Sotos, A. S. García, M. A. Vicente-Querol, G. Lahera, A. Fernández-Caballero, and R. Rodriguez-Jimenez. Validation of dynamic virtual faces for facial affect recognition. Revista de Psiquiatría y Salud Mental, 1–27, 2020 (enviado)

5. Aceptación de avatares emocionales por parte de los profesionales de Salud Mental.

    - A. S. García, P. Fernández-Sotos, A. Fernández-Caballero, E. Navarro, J. M. Latorre, R. Rodriguez-Jimenez, and P. González. Acceptance and use of a multi-modal avatar-based tool for remediation of social cognition deficits. Journal of Ambient Intelligence and Humanized Computing, 2019; doi: 10.1007/s12652-019-01418-8
    - A. S. García, P. Fernández-Sotos, P. González, E. Navarro, R. Rodriguez-Jimenez, and A. Fernández-Caballero. Mental health professionals' intention to adopt virtual humans in affect recognition training. Health Informatics Journal, 1–10, 2020 (enviado)

2.1. Estudios acerca de los tratamientos de los déficits en cognición social

Incluye los dos artículos:

- Social Cognition Remediation Interventions: A Systematic Mapping Review (Fernández-Sotos y cols., 2019)
- Pharmacological Interventions in Social Cognition Deficits: A Systematic Mapping Review (Fernández-Sotos y cols., 2018)

Diseño:

Con el objetivo de investigar las estrategias farmacológicas y psicoterapéuticas dirigidas a la mejora de los déficits en cognición social, se llevaron a cabo dos revisiones de mapeo sistemáticas que incluyeron publicaciones de 2006 a 2016 en cuatro bases de datos: Scopus (https://www.scopus.com), PsycINFO (https://www.apa.org/pubs/databases/psycinfo/), PubMed (https://www.ncbi.nlm.nih.gov/pubmed/) y Embase (https://www.embase.com).

Una revisión de mapeo sistemática es un estudio empírico secundario que busca ofrecer una visión general del estado del arte sobre un tema extenso. Este tipo de revisión busca identificar, no resultados, sino vínculos (Cooper, 2016). En general, el "mapeo" se puede definir como un enfoque sistemático que permite obtener respuestas a una pregunta de investigación o una práctica clínica (Perryman, 2016). Este tipo de estudios ha aumentado su presencia en diferentes campos de la medicina, especialmente en los últimos años, mientras que los estudios en psiquiatría aún son escasos (Bantjes y cols., 2016; Evans-Lacko y cols., 2014; Fernandez y cols., 2015; Forsman, Ventus, van der Feltz-Cornelis, Wahlbeck, y on behalf of the ROAMER project, 2014; McDaniel Peters y Wood, 2017). Aunque hay varias revisiones con respecto a la utilidad de diferentes intervenciones dirigidas a la mejora de la cognición social (Fiszdon y Reddy, 2012; Grant y cols., 2017; Kurtz y cols., 2016; Tan y cols., 2018), ninguna revisión de mapeo sistemática previa ha examinado este tema.

Las razones por las que se llevaron a cabo las dos revisiones de mapeo sistemáticas incluyeron:

- Primero, proporcionar resúmenes de las intervenciones existentes de acuerdo con algunos criterios de clasificación.
- Segundo, identificar qué brechas actuales existen en las intervenciones farmacológicas y psicoterapéuticas en los déficits de cognición social, para ayudar a los clínicos y académicos a planificar futuras investigaciones en este área.

- Tercero, identificar temas y áreas para futuras revisiones sistemáticas de literatura que cubrirán áreas de investigación más pequeñas después de haber analizado la literatura en profundidad.

Criterios de inclusión:

(a) Artículos centrados en los déficits de cognición social y su tratamiento.

(b) Artículos publicados entre el 1 de enero de 2006 y el 31 de diciembre de 2016.

(c) Artículos centrados en el entrenamiento de la cognición social y las intervenciones de rehabilitación.

Criterios de exclusión:

(a) Literatura gris, debido a su proceso poco claro de revisión por pares: editoriales, resúmenes extendidos, tutoriales, demostraciones de herramientas, documentos de simposios doctorales, resúmenes de investigación, capítulos de libros, actas, conferencias magistrales, informes de talleres e informes técnicos.

(b) Las revisiones sistemáticas (incluidos los meta-análisis) y los documentos de la encuesta no se consideraron elegibles para su inclusión. Solo nos interesaba el trabajo de investigación experimental.

(c) Artículos de áreas diferentes a la medicina, psicología, neurociencia y / o biomedicina (por ejemplo, agricultura, ciencias ambientales, negocios, veterinaria, física, ciencias de la tierra, economía, energía).

(d) Artículos que no se relacionan con los humanos.

Proceso de búsqueda:

Dos investigadores seleccionaron de forma independiente los artículos mediante la selección del título, el resumen y las palabras clave. Si el investigador no estaba seguro de incluir un documento, se leían las secciones de introducción y conclusiones

del artículo. Si, a pesar de esto, el investigador aún no estaba seguro de incluir o excluir un documento, o si no hubo acuerdo entre ambos investigadores, el documento se presentaba a los otros investigadores y al coordinador clínico del estudio para su discusión y una decisión consensuada.

2.2. Uso de las tecnologías digitales por parte de los pacientes psicóticos

Se ha publicado un artículo:

- Digital Technology for Internet Access by Patients With Early Stage Schizophrenia in Spain: A Multicenter Research Study (Fernández-Sotos y cols., 2019)

Diseño:

Con el objetivo de conocer el patrón de acceso y uso de nuevas tecnologías en pacientes con esquizofrenia, se llevó a cabo un estudio transversal y multicéntrico de seis meses de duración (desde junio hasta noviembre de 2017). Se incluyeron tres centros de reclutamiento: "Hospital Universitario 12 de Octubre" (Madrid), "Hospital Virgen de la Luz" (Cuenca) y "Hospital Universitario de San Juan" (Alicante).

Sujetos del estudio:

El tamaño de la muestra se determinó en 90 pacientes (30 pacientes de cada uno de los centros). Todos ellos cumplieron criterios diagnósticos DSM-5 para esquizofrenia, a través de la evaluación de la Entrevista Clínica Estructurada para DSM-5 (First, Williams, Karg, y Spitzer, 2015). Todos los pacientes se encontraban en la etapa temprana del trastorno (menor de o igual a 5 años desde su primer episodio).

Se establecieron los siguientes criterios de inclusión para pacientes:

(a) Cumplir criterios de diagnóstico DSM-5 para esquizofrenia

(b) Mantenerse clínicamente estabilizado durante los tres meses anteriores a la realización de la entrevista semi-estructurada, de acuerdo con criterios utilizados por nuestro grupo previamente (Sánchez-Morla y cols., 2009).

(c) Ser un paciente ambulatorio

(d) Tener entre 18 y 55 años

(e) Hablar correctamente español

(f) Firmar el formulario de consentimiento informado

Se consideraron los siguientes criterios de exclusión:

(a) Padecer otros trastornos mentales principales del eje I del DSM-5

(b) Sufrir retraso mental (cociente intelectual <70)

(c) Sufrir patología somática que pueda interferir con el acceso a nuevas tecnologías

Por otra parte, se incluyeron 90 participantes sanos (30 en cada uno de los centros), con el mismo perfil sociodemográfico (edad, género y área sociodemográfica) que la muestra de pacientes.
Criterios de inclusión para participantes sanos:

(a) Edad entre 18-55 años

(b) Ausencia de diagnóstico psiquiátrico actual o pasado

(c) Ausencia de antecedentes de trastorno psicótico o bipolar en familiares de primer grado (entrevista "Family Interview for Genetics Studies", FIGS (NIMH Genetic Initiative, 2005)).

(d) Hablar correctamente castellano

(e) Consentimiento informado firmado

Los criterios de exclusión fueron comunes a los de los pacientes.

Aspectos éticos:

El estudio fue aprobado por los Comités de Ética de Investigación Clínica de los tres centros. Los participantes firmaron un Consentimiento informado en el que se explicaba en qué consistía el estudio (ver Anexo 1).

Procedimiento de recopilación de datos:

Los pacientes fueron reclutados de manera consecutiva en sus citas clínicas de sus respectivos programas de "Primeros episodios". Después de la evaluación clínica, el psiquiatra evaluó los criterios de inclusión y exclusión, y propuso participar en el estudio, que incluyó una encuesta sobre la frecuencia y el propósito de usar una serie de dispositivos de tecnología digital.

Los participantes sanos fueron reclutados en las mismas áreas socioculturales donde residían los pacientes.

Instrumentos de medida:

- Cuadernos de Recogida de Datos (CRD) desarrollados por el Grupo de Investigación en Psicosis y Adicciones de la Universidad Complutense de Madrid (UCM) para pacientes con esquizofrenia y sujetos control (ver Anexo 2). Estos CRD incluyen variables sociodemográficas, antecedentes personales psiquiátricos, antecedentes personales somáticos, antecedentes familiares psiquiátricos, antecedentes familiares somáticos, consumo de sustancias (actual y pasado), tratamiento (farmacológico y psicosocial), ingresos previos, visitas a urgencias.

- Encuesta de acceso y uso de nuevas tecnologías desarrollado por el equipo investigador, que incluyó dos partes: La primera, centrada en los dispositivos tecnológicos utilizados, y la segunda relativa al uso de aplicaciones. Ambas partes analizaron parámetros como frecuencia, nivel de interés o finalidad de uso (ver Anexo 3).

Abordaje estadístico:

El análisis estadístico de todos los datos se realizó utilizando Statistical Package for the Social Sciences (SPSS) versión 23.0 de IBM Corporation. Las medias y las desviaciones estándar se usaron para describir variables continuas, mientras que los porcentajes y las pruebas de chi-cuadrado se usaron para las variables categóricas. Se utilizó la prueba t de Student para variables continuas con una distribución normal. Para las variables que no presentaron una distribución normal después de usar la prueba de Levene (de homogeneidad de varianza u homocedasticidad) y las variables ordinales, se realizaron pruebas no paramétricas para muestras independientes.

2.3. Cognición social y realidad virtual

Recoge el artículo:

- Virtual Reality for Psychosocial Remediation in Schizophrenia: A Systematic Review (Fernández-Sotos, Fernández-Caballero, y Rodriguez-Jimenez, 2020)

El objetivo del presente estudio fue realizar una revisión sistemática de las intervenciones basadas en realidad virtual para la rehabilitación psicosocial de pacientes con esquizofrenia. Para ello se utilizaron as siguientes bases de datos: PubMed, Scopus, PsycINFO, IEEE Xplore (https://ieeexplore.ieee.org/Xplore/home.jsp) y Biblioteca Digital ACM (https://dl.acm.org/). Se incluyeron publicaciones desde el 1 de enero de 2000 al 1 de julio de 2019.

Criterios de inclusión de los artículos:

(a) Se basaron en realidad virtual

(b) El objetivo principal era la mejora de la cognición social o las habilidades sociales

(c) Incluyeron pacientes diagnosticados de esquizofrenia, de acuerdo con los criterios DSM-IV-TR29, DSM-530 e ICD-1031

(d) Fueron escritos en inglés

Criterios de exclusión:

(a) Literatura gris, debido a su proceso de revisión por pares poco claro: editoriales, resúmenes extendidos, tutoriales, demostraciones de herramientas, publicaciones de simposios doctorales, resúmenes de investigación, capítulos de libros, actas, conferencias magistrales, informes de talleres e informes técnicos.

(b) Revisiones sistemáticas, metaanálisis y publicaciones de encuestas.

Proceso de búsqueda:

Dos investigadores seleccionaron de forma independiente los artículos mediante la selección del título, el resumen y las palabras clave. Si el investigador no estaba seguro de incluir un documento, se leían las secciones de introducción y conclusión del documento de contenido completo. Si, a pesar de esto, el investigador aún no estaba seguro de incluir o excluir un documento, o si no hubo acuerdo entre ambos investigadores, el documento se presentó a los otros investigadores y al coordinador clínico del estudio para su discusión y una decisión consensuada.

2.4. Diseño y validación de expresiones faciales humanas virtuales

Esta sección recoge los materiales y métodos asociados a los artículos:

- Design of Reliable Virtual Human Facial Expressions and Validation by Healthy People (García, Fernández-Sotos, Vicente-Querol, y cols., 2020)
- Validation of Dynamic Virtual Faces for Facial Affect Recognition (Fernández-Sotos, García, y cols., 2020)

El objetivo de los presentes estudios fue crear un nuevo conjunto de caras virtuales que representasen las seis emociones básicas más la expresión neutra y validar su aplicación en participantes sanos.

El primer artículo describe el proceso de creación de humanos virtuales, desde un punto de vista tecnológico, presentando el procedimiento de diseño de expresiones faciales en humanos virtuales (HV). Parte de un estudio previa con un número menor de participantes (Vicente-Querol, García, Fernández-Sotos, Rodriguez-Jimenez, y Fernández-Caballero, 2019). El segundo artículo presenta un enfoque clínico del estudio, haciendo énfasis en el análisis de la muestra y comparando el estímulo virtual con un estímulo clásico ya validado.

Diseño:

Se llevó a cabo un estudio transversal de cinco meses de duración (desde enero hasta mayo de 2019). Se incluyeron participantes sanos de dos ciudades: Madrid y Albacete.

Sujetos del estudio:

El tamaño de la muestra se determinó en 204 voluntarios sanos. El único criterio de inclusión fue que los participantes tuvieran entre 20 y 79 años. Los criterios de exclusión incluían tener un diagnóstico de enfermedad mental, una historia personal de enfermedad médica y antecedentes familiares de primer grado de psicosis. La muestra se estratificó por género: 50 % hombres, 50 % mujeres; edad: dividida en 3 rangos de edad: 20-39, 40-59, 60-79 y nivel educativo: dividido en los tres estratos educativos recogidos en el Instituto Nacional de Estadística (INE): *le* 2, 3-4, *ge* 5.

Aspectos éticos:

El estudio fue aprobado por el Comité de Ética de Investigación Clínica del Hospital Universitario 12 de Octubre. Los participantes firmaron un consentimiento informado en el que se explicaba en qué consistía el estudio (ver Anexo 4).

Procedimiento de recopilación de datos:

La recolección de datos se realizó en una única sesión individual de 30 minutos de duración. En dicha sesión se comparó un estímulo clásico ya validado, el Penn Emotion Recognition Test (ER-40) (Gur y cols., 2002), frente al estímulo facial creado por el equipo de investigación. Al inicio de la sesión se preguntó al participante por antece-

dentes de enfermedad mental, historia personal de enfermedad médica y antecedentes familiares de primer grado de psicosis. Se administró a su vez la escala PANAS (Watson, Clark, y Tellegen, 1988) (ver Anexo 5). En caso de que el participante cumpliese los criterios de inclusión del estudio, se administraba el estímulo facial.

El estímulo facial fue presentado en 2 bloques separados (estímulo clásico y estímulo virtual) en un orden aleatorio. En el bloque de presentación de caras virtuales, se aleatorizó el orden de aparición de las caras avatarizadas para cada participante.

Estímulos presentados:

- **Caras virtuales**

  A todos los participantes se les presentaron 52 caras en pantalla en las que tenían que identificar la emoción básica presentada (alegría, tristeza, ira, miedo, asco y sorpresa) desde la emoción neutra, con una velocidad de 2 segundos. Estos avatares fueron diseñados a partir del "Sistema de codificación de acción facial" (FACS) (Ekman y Friesen, 1978). Los participantes tuvieron que identificar la emoción expresada en las caras virtuales entre las siete opciones ofrecidas.

- **Estímulo clásico**: Penn Emotion Recognition Test (ER-40)

  La prueba contiene 40 fotografías a color de rostros de diferentes etnias, que expresan cuatro emociones básicas: alegría, tristeza, ira y miedo y la expresión neutra. Incluye ocho fotografías de cada expresión (cuatro de alta intensidad y cuatro de baja intensidad). Los usuarios tuvieron que identificar la emoción que expresaban las fotografías entre las 5 opciones ofertadas.

Instrumentos de medida:

- Cuadernos de Recogida de Datos (CRD) desarrollados por el Grupo de Investigación en Psicosis y Adicciones (UCM) para pacientes con esquizofrenia y sujetos control. Estos CRD incluyen variables sociodemográficas como género, edad, raza, estado civil, lugar de residencia (rural, urbano), ciudad de residencia (Madrid,

Albacete), nivel educativo, situación laboral y profesión. Los datos clínicos incluyeron antecedentes somáticos personales (incluidos neurológicos), historia de consumo de tóxicos, historia personal psiquiátrica e historia familiar relevante.

- Versión en español (Sandín y cols., 1999) de la Escala de Afecto Positivo y Negativo, PANAS (Watson y cols., 1988) (ver Anexo 5). Es un cuestionario autoadministrado de 20 ítems que mide el afecto positivo y negativo del individuo. Este cronograma se incluyó para controlar el estado de ánimo del participante o los síntomas de depresión inespecíficos. Si un participante presentaba una puntuación de afecto positivo menor de 25 (PA <25) o una puntuación de afecto negativo mayor de 35 (NA >35), era excluido del estudio.

Abordaje estadístico:

El análisis estadístico de todos los datos se realizó utilizando SPSS versión 23.0. Se utilizaron pruebas no paramétricas para comparar los resultados debido a que el número de respuestas correctas no siguió una distribución normal (prueba de Kolmogorov-Smirnov: $Z = 0.165$, $p < .001$).

2.5. Aceptación de avatares emocionales por parte de los profesionales de Salud Mental

Incluye los dos siguientes artículos:

- Acceptance and Use of a Multi-modal Avatar-based Tool for Remediation of Social Cognition Deficits (García y cols., 2019)
- Mental Health Professionals' Intention to Adopt Virtual Humans in Affect Recognition Training (García, Fernández-Sotos, González, y cols., 2020)

Estos estudios tuvieron como objetivo evaluar la opinión de los profesionales de la salud mental en términos de aceptación e intención de uso de una herramienta basada en RV diseñada para la mejora del reconocimiento facial de emociones en pacientes con esquizofrenia. El primer estudio incluyó la opinión de 41 profesionales de la salud mental. El segundo amplió la muestra a 124 profesionales.

Diseño:

Se llevó a cabo un estudio transversal de 9 meses de duración (desde agosto de 2018 hasta abril de 2019).

Sujetos del estudio:

Se incluyó una muestra de 41 profesionales de la salud mental en el primer estudio y 124 en el segundo. Los profesionales reclutados incluyeron psiquiatras, psicólogos clínicos y enfermeros especializados en salud mental.

Procedimiento de recopilación de datos:

Se envió un correo electrónico de reclutamiento a más de 350 profesionales de la salud mental, incluidos psiquiatras, psicólogos clínicos y enfermeros especializados en salud mental, invitándolos a participar en el estudio. Solo 124 respondieron al cuestionario (N = 124). Esencialmente, se les pidió que siguieran un enlace a YouTube (http://youtu.be/itDxgQi5tY0) para ver el vídeo y luego otro enlace a un cuestionario basado en la web.

Instrumentos de medida:

Se usó un cuestionario demográfico y de aceptación e intención de uso diseñado por el equipo investigador (ver Anexo 6).

El cuestionario se basa en la Teoría Unificada Extendida de Aceptación y Uso de Tecnología (UTAUT2) (Venkatesh, Thong, y Xu, 2012) para investigar qué factores afectan a la adopción de una propuesta, en este caso, concretamente al uso de la herramienta descrita. Los factores estudiados incluyeron: expectativa de rendimiento, expectativa de esfuerzo, influencia social, condiciones facilitadoras y motivación hedónica.

El cuestionario fue desarrollado usando Google Forms y se dividió en varias partes. La primera proporcionó una breve introducción al propósito del estudio y al acuerdo de participación. La segunda tuvo como objetivo recopilar información demográfica de los participantes. La tercera reunió la intención de uso de la tecnología, medida en una escala Likert de 7 puntos (1 = totalmente en desacuerdo, 2 = bastante en desacuerdo, 3 = ligeramente en desacuerdo, 4 = ni de acuerdo ni en desacuerdo, 5 = ligeramente de acuerdo, 6 = bastante de acuerdo y 7 = muy de acuerdo).

Abordaje estadístico:

El análisis estadístico de todos los datos se realizó utilizando SPSS versión 23.0. Para probar la fiabilidad y la consistencia interna de los datos reunidos se calcularon alfa de Cronbach, fiabilidad compuesta y coeficientes promedio de varianza extraída (AVE).

Capítulo 3. Resultados

Como se señaló en el capítulo de Material y Métodos, en la presente tesis se han incluido ocho artículos de revista, estructurados en cinco secciones. Cada una de estas secciones aborda una temática que consideramos debe ser investigada para tratar de confirmar la hipótesis principal planteada: La investigación y el desarrollo de nuevas intervenciones psicoterapéuticas basadas en RV dirigidas a la mejora de los déficits en cognición social de los pacientes con esquizofrenia abre un novedoso y prometedor camino para abordar este problema.

A continuación, se resumen los resultados principales de cada uno de los artículos y se incluyen los artículos completos.

3.1. Estudios acerca de los tratamientos de los déficits en cognición social

Social Cognition Remediation Interventions: A Systematic Mapping Review

Esta revisión sistemática de mapeo acerca de las intervenciones en rehabilitación de la cognición social reveló un creciente interés en las intervenciones dirigidas a la mejora de la cognición social, especialmente en las áreas de psiquiatría y psicología, mostrando un aumento progresivo en el número de publicaciones. La mayoría de los artículos habían sido publicados en revistas con elevado factor de impacto y mostraron un fuerte nivel de evidencia científica. La mayor parte de estudios estaban centrados en la esquizofrenia, seguidos de los trastornos del espectro autista. La mayoría de las intervenciones se dirigieron a la mejora de la teoría de la mente y el procesamiento emocional, mientras que pocos estudios hicieron referencia al sesgo atribucional y a la percepción social. Las intervenciones dirigidas específicamente a la mejora de la cognición social fueron las más frecuentemente halladas, seguidas de las intervenciones de tratamiento no específicas (como por ejemplo las intervenciones en habilidades sociales) y las intervenciones combinadas (que incluyeron el entrenamiento de la cognición social combinado con entrenamiento neurocognitivo).

Pharmacological interventions in Social Cognition Deficits: A Systematic Mapping Review

Esta otra revisión sistemática de mapeo mostró un creciente interés en los tratamientos farmacológicos dirigidos a la mejora de la cognición social, con un aumento progresivo en el número de publicaciones, especialmente en los últimos cuatro años. La mayoría de las publicaciones tuvieron un alto nivel de evidencia y fueron publicadas en revistas con elevado factor de impacto. Las áreas más estudiadas fueron psiquiatría, farmacología y endocrinología. La mayor parte de estudios se llevaron a cabo con la hormona oxitocina, seguida de fármacos psicoestimulantes y antipsicóticos (principalmente risperidona y olanzapina), siendo pocos estudios que utilizaron otros tratamientos. Con respecto a los dominios de la cognición social, la mayoría de las publicaciones se centraron en el procesamiento emocional y la teoría de la mente, con pocos estudios sobre percepción social y solo uno que abordase el sesgo atribucional.

3.1.1. Social Cognition Remediation Interventions: A Systematic Mapping Review

Datos de la publicación

RESUMEN:

Antecedentes

Se han descrito deficiencias en la cognición social en varios trastornos psiquiátricos y neurológicos. Dada la importancia de la relación entre la cognición social y el funcionamiento y la calidad de vida en estos trastornos, existe un interés creciente en las intervenciones de remediación de la cognición social. El objetivo de este estudio fue realizar una revisión de mapeo sistemática para describir el estado del arte en el entrenamiento en las intervenciones de entrenamiento y remediación de la cognición social.

Métodos

Se revisaron las publicaciones del 2006 al 2016 sobre las intervenciones de cognición social en cuatro bases de datos: Scopus, PsycINFO, PubMed y Embase. Del conjunto inicial de resultados de 3229 publicaciones, se seleccionó finalmente un total de 241 publicaciones.

Resultados

El estudio reveló un creciente interés en las intervenciones de remediación de la cognición social, especialmente en los campos de la psiquiatría y la psicología, con un crecimiento gradual del número de publicaciones. Éstas se publicaron con frecuencia en revistas de alto factor de impacto y se sustentaron en sólidas pruebas científicas. La mayoría de los estudios se realizaron sobre la esquizofrenia, seguida de los trastornos del espectro autista. La teoría de la mente y el procesamiento emocional fueron el foco de la mayoría de las intervenciones, mientras que un número limitado de estudios trató el sesgo atribucional y la percepción social. Las intervenciones específicas en la cognición social fueron la práctica más frecuente en los documentos seleccionados, seguidas de las intervenciones de tratamiento no específicas y las intervenciones de base amplia.

Datos de la publicación (cont.)

CITACIÓN:
P. Fernández-Sotos, I. Torio, A. Fernández-Caballero, E. Navarro, P. González, M. Dompablo, R. Rodriguez-Jimenez (2019) "Social Cognition Remediation Interventions: A Systematic Mapping Review", *PLoS One* 14(6):e0218720; doi:10.1371/journal.pone.0218720.

ÍNDICES DE CALIDAD:
Índice de impacto 2019: 2,740.
Cuartil: Q2.
Rango (Categoría): 27/71 (Multidisciplinary Sciences).

PLOS ONE

RESEARCH ARTICLE

Social cognition remediation interventions: A systematic mapping review

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Citation: Fernández-Sotos P, Torio I, Fernández-Caballero A, Navarro E, González P, Dompablo M, et al. (2019) Social cognition remediation interventions: A systematic mapping review. PLoS ONE 14(6): e0218720. https://doi.org/10.1371/journal.pone.0218720

Editor: Eric J. Moody, University of Wyoming College of Health Sciences, UNITED STATES

Received: November 16, 2018

Accepted: June 7, 2019

Published: June 26, 2019

Data Availability Statement: All relevant data are within the manuscript and its Supporting Information files.

Funding: This work was partially supported by Spanish Instituto de Salud Carlos III under PI16/00359 grant, and Spanish Ministerio de Ciencia, Innovación y Universidades, Agencia Estatal de Investigación (AEI) / European Regional Development Fund (FEDER, UE) under DPI2016-80894-R and TIN2015-72931-EXP grants, by Madrid Regional Government (R&D activities in

Abstract

Background

Impairments in social cognition have been described in several psychiatric and neurological disorders. Given the importance of the relationship between social cognition and functioning and quality of life in these disorders, there is a growing interest in social cognition remediation interventions. The aim of this study was to carry out a systematic mapping review to describe the state of the art in social cognition training and remediation interventions.

Methods

Publications from 2006 to 2016 on social cognition interventions were reviewed in four databases: Scopus, PsycINFO, PubMed and Embase. From the initial result set of 3229 publications, a final total of 241 publications were selected.

Results

The study revealed an increasing interest in social cognition remediation interventions, especially in the fields of psychiatry and psychology, with a gradual growth in the number of publications. These were frequently published in high impact factor journals and underpinned by robust scientific evidence. Most studies were conducted on schizophrenia, followed by autism spectrum disorders. Theory of mind and emotional processing were the focus of most interventions, whilst a limited number of studies addressed attributional bias and social perception. Targeted interventions in social cognition were the most frequent practice in the selected papers, followed by non-specific treatment interventions and broad-based interventions.

Biomedicine S2017/BMD-3740 (AGES-CM 2-CM)) and Structural Funds of the European Union, by Castilla-La Mancha Regional Government / FEDER, UE under SBPLY/17/180501/000192 grant, and by the Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM) of the Instituto de Salud Carlos III. These funding sources have not been involved in study design; collection, analysis and interpretation of data; writing of the report; nor in the decision to submit the paper for publication.

Competing interests: Dr. R. Rodriguez-Jimenez has been a consultant for, spoken in activities of, or received grants from: Instituto de Salud Carlos III, Fondo de Investigación Sanitaria (FIS), Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM), Madrid Regional Government (S2010/ BMD-2422 AGES), Janssen- Cilag, Lundbeck, Otsuka, Pfizer, Ferrer, Juste. The other authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. This does not alter our adherence to PLOS ONE policies on sharing data and materials.

Conclusions

Research in social cognition remediation interventions is growing. Further studies are needed on attributional bias and social perception remediation programs, while the comparative efficacy of different interventions also remains unclear.

Introduction

Social cognition refers to the mental operations involved in social interactions, including processes of perceiving, interpreting, and generating responses to the intentions, dispositions, and behaviors of others [1–6]. Social cognition is a key determinant of the proper functioning and development of human beings. Although various disorders, such as autism [7–9], affective disorders [10–13] and eating disorders [14], have been associated with deficits in social cognition, schizophrenia has frequently been the focus of investigation in social cognition [15–17]. The fact that schizophrenia acquired an early paradigmatic position in psychiatry might partly explain this. Nevertheless, some pragmatic reasons may also be identified: (a) A significant number of patients with schizophrenia present deficits in quality of life and functioning; (b) There is an early onset of these deficits and they persist throughout life; (c) The personal, familiar and economic burden of this disorder is very high. (d) Social cognition impairments appear to make an important contribution to deficits in quality of life and functioning [7,18–21].

The last decade has seen a significant increase in research on social cognition and the strategies for its pharmacological and psychosocial treatment. A recent systematic mapping review of pharmacological interventions in social cognition deficits [22] shows an increase in the number of publications, with a significant number studying hypothalamic hormones (especially oxytocin), with a much less frequent focus on antipsychotics, amphetamines, and sex hormones, in that order.

Several non-pharmacological approaches designed to enhance social cognition abilities have also been developed. Some treatment interventions approach social cognition as a unitary construct, but emphasis has recently been placed on a multidimensional structure of social cognition. Initiatives such as the *Social Cognition Psychometric Evaluation* (SCOPE) study have defined social cognition as a multidimensional construct that includes four core domains: emotional processing, social perception, attributional style/bias, and theory of mind [23–25]. In this sense, specific remediation interventions have been developed to improve each of the domains of social cognition, either as the main intervention of the program, or as part of a broader training program targeting a variety of dimensions of the illness. Finally, other psychosocial interventions which do not specifically target social cognition, such as social skills training [26–27], have been shown to have a positive impact on social cognition.

Although several reviews have focused on the usefulness of different social cognition remediation interventions [28–31], to our knowledge, no prior systematic mapping review has examined social cognition remediation programs. A systematic mapping review is a secondary empirical study that provides an overview of the state of the art in a field, identifying venues and topics addressed in the literature. Furthermore, this type of review is a systematic approach to understanding the "map" of a field of knowledge, research question, or practice [32], by identifying linkages rather than results [33]. The presence of this type of study in different fields of medicine has increased, especially in recent years, although systematic mapping reviews are still scarce in psychiatry [34–38].

The aim of the present study was to describe the state of the art in social cognition remediation interventions following a systematic mapping review approach, to provide researchers and clinicians with a global picture on social cognition remediation interventions for psychiatric and other medical conditions.

Methods

Research methodology

Research interest. The present mapping review has been conducted for several reasons. The first is to perform a broad analysis of the literature on social cognition remediation interventions, with the aim of providing an overview of existing proposals according to a classification criterion. The second is, if possible, to identify existing research gaps in social cognition rehabilitation intervention programs to plan future research, while the third is to identify topics and areas for future systematic literature reviews focused on smaller research areas.

The steps described in the *Template for a Mapping Study Protocol* [39–40] were followed to conduct this study. A mapping review protocol includes three distinct phases: (a) *Research directives* defines the study protocol and identifies the dimensions to be analyzed and the research questions to be answered. (b) *Data collection* gathers relevant papers in accordance with the inclusion and exclusion criteria defined in the protocol. Finally, (c) *Results* maps the existing literature in line with the defined criteria and answers the research questions. Note that the PRISMA checklist [41] has not been used in this paper as it does not in fact fit recommendations for systematic mapping studies. Therefore, a checklist for the *Template for a Mapping Study Protocol* is provided in S1 Table (see supplementary material online).

Research directives. In this section, the definition of the research protocol and the description of the research questions is presented. The protocol included the study topic (social cognition remediation interventions); its rationale (previously mentioned); preliminary research questions; and search strategy, selection criteria, and data extraction form. Finally, the protocol included an overview of selected papers in terms of their publication venues and years.

The four research questions (RQ) for this systematic mapping review and their rationale were:

RQ1. ***How many papers have been published on social cognition remediation interventions? Is there any temporal trend? What is their level of scientific evidence?***

As previously discussed, deficits in social cognition are commonly found in psychiatric disorders such as autism, depressive disorder, bipolar disorder, and schizophrenia. Due to the prevalence and/or severity of these disorders, and the limited efficacy of pharmacological interventions [42–43], the number of papers published on non-pharmacological social cognition remediation interventions was studied. Second, the possible presence of a temporal trend (increasing or decreasing) was analyzed. Finally, the study of their level of scientific evidence provided complementary information regarding the quality of published studies.

RQ2. ***In what areas of medical knowledge and related disciplines has research on social cognition remediation programs been conducted?***

Deficits in social cognition are not exclusive to psychiatric disorders. Several neurological disorders such as behavioral-variant frontotemporal dementia [44], traumatic brain injury [45], or Parkinson's disease [46] are characterized by impairments in social cognition [47]. Other disorders with central nervous system involvement such as tuberous sclerosis [48], fragile X syndrome [49], Prader Willi syndrome [50], or Wilson's disease [51] have also been related to social cognition impairments. Therefore, it seems interesting to study which areas of

knowledge are developing research on social cognition remediation, including medicine and related fields such as psychology and neuroscience.

RQ3. *Which domains of social cognition are the focus of research in social cognition remediation*?

Social cognition is considered a multidimensional construct. There is some consensus regarding critical domains of social cognition as four partially overlapping domains (theory of mind/mental state attribution, social perception, attributional bias/style, and emotional processing) [24–25]:

- *Theory of mind* is defined as the ability to recognize intentions, dispositions, and beliefs in oneself and others [52]. Theory of mind includes understanding special ways of communication, such as hints, deception, metaphors or irony, by making inferences about the feelings of others, beliefs, and intentions, and/or by representing human mental states [53–54]. Theory of mind is also known as mentalizing, mental state attribution, or cognitive empathy [55].
- *Social perception* consists of the ability to identify social rules, roles, and goals [56–57]. Social perception is also defined as the ability to correctly interpret the behaviors of other people by means of context and social information [58–59].
- *Attributional bias/style* describes the way in which individuals explain or interpret different social facts or infer the causes of social events [3]. Attributions are external (to others) or internal (to oneself) and may be categorized further by dimensions such as ambiguity of the context or positive vs. negative outcome.
- *Emotional processing* refers to the ability to perceive, recognize and manage emotional information [3]. Emotional processing is also defined as the ability to identify, facilitate, regulate, understand and manage emotions [60–61].

Interventions on social cognition remediation may be focused on one or several social cognition domains. Thus, identifying the most frequently studied domains will help researchers recognize the domains that might need further investigation.

RQ4. *What types of interventions are employed in social cognitive remediation*?

Although various forms of interventions may potentially improve social cognition, three main types of training and remediation interventions have been distinguished [31]:

- *Targeted interventions* specifically directed at improving one or more domains of social cognition. Targeted interventions are often subcategorized, including "targeted" and "comprehensive" interventions. "Targeted" refers to brief interventions for a single aspect of social cognition. "Comprehensive" refers to programs that leverage all the elements of an extended training program in order to improve multiple domains of social cognition, typically including practice for the generalization of acquired skills for everyday life. Notice that the present work does not provide this subclassification.
- *Broad-based interventions*, including social cognition training in a broader approach oriented towards improving social cognition, neurocognition and/or social skills.
- *Non-specific interventions*, which do not target social cognition but may produce a positive effect on one or more of its domains.

Classifying published papers according to three main types of interventions facilitates an overview of the specificity of the interventions in social cognition remediation.

Data collection

With the aim of including relevant and excluding irrelevant papers, the search strategy of this study involved querying reference databases with customized search strings, followed by manual filtering of the query results using predefined inclusion and exclusion criteria. Five researchers were involved in executing the search strategy.

Source selection and search string. To minimize the risk of missing relevant papers on social cognition remediation, four reference databases were queried: Scopus (Elsevier), PsycINFO (American Psychological Association), PubMed (American Psychological Association) and Embase (Elsevier).

The keywords for the search string were identified by following mainly research questions RQ3 and RQ4. The first part of the search string was composed of words related to social cognition, using the nomenclature described under RQ3, while the second part included remediation and its synonyms (rehabilitation, therapy, training, treatment and enhancement) related to the types of interventions deduced from RQ4. Finally, all items in our search string were interleaved with or/and statements, to make sure that all relevant papers were retrieved. The final search string was: ("affect perception" OR "affect recognition" OR "attributional bias" OR "attributional style" OR "emotional processing" OR "emotion recognition" OR "mentalizing" OR "theory of mind" OR "social cognition" OR "social perception") AND ("rehabilitation" OR "remediation" OR "therapy" OR "treatment" OR "training" OR "enhancement"). It should be highlighted that no truncation was used in the terms of the final search string for the following reasons: First, not all reference databases enable this option, and using it would drastically deviate the number of records obtained of some database in comparison to others. Second, in the case of Scopus database, for instance, the number of initial results would become intractable (around 27,000 records). In each reference database, the complete string was queried in the title, abstract, and keywords fields.

Inclusion and exclusion criteria. The selection criteria of published studies comprised the following inclusion and exclusion criteria:

- Inclusion criteria:

I1. Papers focusing on social cognition deficits and their treatment.

I2. Papers published between January 1, 2006, and December 31, 2016.

I3. Papers focusing on social cognition training and remediation interventions.

- Exclusion criteria:

E1. Grey literature, because of their unclear peer review process: editorials, extended abstracts, tutorials, tool demos, doctoral symposium papers, research abstracts, book chapters, proceedings, keynote talks, workshop reports, and technical reports.

E2. Systematic reviews (including meta-analyses) and survey papers were not considered eligible for inclusion. We were only interested in first-hand experimental research work.

E3. Papers from venues other than medicine, psychology, neuroscience and/or biomedicine (e.g. agriculture, environmental sciences, business, veterinary, physics, earth sciences, economy, and energy).

E4. Papers not related to research with human subjects.

E5. Papers based on pharmacological interventions for social cognition deficits.

Inclusion criterion I2 deserves an explanation. It is usual to consider publications published within the last ten in similar systematic mapping studies. Therefore, we started our study with publications from 2006, which provided around 150 papers as the starting point of the search. Moreover, there are two reasons to end the study in 2016. First, systematic mappings study complete years, and it is not feasible to close a year before the third quarter of the following one, mainly due to delays inherent to data management in search engines. Thus, work on the study was started during the final months of 2017. Second, performing this systematic mapping study was a vast task that continued into 2018.

In relation to exclusion criterion E1, let us highlight that it does not limit the potential to determine interest in the topic, as we have verified the same tendency in the growth of the number of publications including and excluding grey literature. For the under study, grey literature represents around 22% of annual publications.

Search process. The steps described in Fig 1 were followed for the process of extracting and selecting articles. The search string was used on each of the four reference databases. After merging the references from each database and implementing the filters on the papers (according to inclusion and exclusion criteria), a total of 3571 papers were obtained. After eliminating repeated articles (n = 342), two researchers filtered the remaining 3229 papers independently through the screening of title, abstract and keywords. If the researcher was unsure whether to include a paper, the introduction and conclusion sections of the full content paper were read. If, despite this, the researcher was still not sure, or there was no agreement between the two researchers, the paper was presented to the other researchers and the clinical coordinator of the study for discussion and a consensus decision. This step resulted in 1233 references.

At this point, the 1233 references were filtered again by the same two researchers, who independently screened the full content of each paper. As in the preceding step, when a researcher was unsure whether to keep or remove a paper, or there was no agreement between the two researchers, the paper was presented in another session for discussion and a final decision. This step thus produced the final set of 241 references. To ensure that no references were missed during the process, a series of earlier [62–63] and more recent review papers [30–31,64], including a highly recent systematic literature review [65] were carefully studied. A full-text screening of all these papers revealed no undiscovered publications.

Results

A final number of 241 papers (see on-line material, S1 File for a complete list of selected papers) were extracted following the previously described process. Here, the four previously presented research questions will be answered with reference to the selected literature.

RQ1. *How many papers have been published on social cognition remediation interventions*? *Is there any temporal trend*? *What is their level of scientific evidence*?

As shown in Fig 2A, over the period of study, an increase was observed in the number of published papers on social cognition remediation and training programs. There was an overall progressive increase from 2006, growing from 9 papers published in 2006, to 45 papers in 2016. The greatest increase in the number of published papers was found over the last four years.

An overview of selected papers in terms of their level of scientific evidence provided data regarding the quality of published studies. As defined by the *US Agency for Healthcare Research and Quality* [66], 106 references presented IB level of evidence (evidence obtained from at least one randomized clinical trial), and 41 papers presented IIA level (obtained from at least one well-designed, non-randomized controlled prospective study). Among the remaining references, 50 studies were classified as IIB (scientific evidence obtained from at least one well-

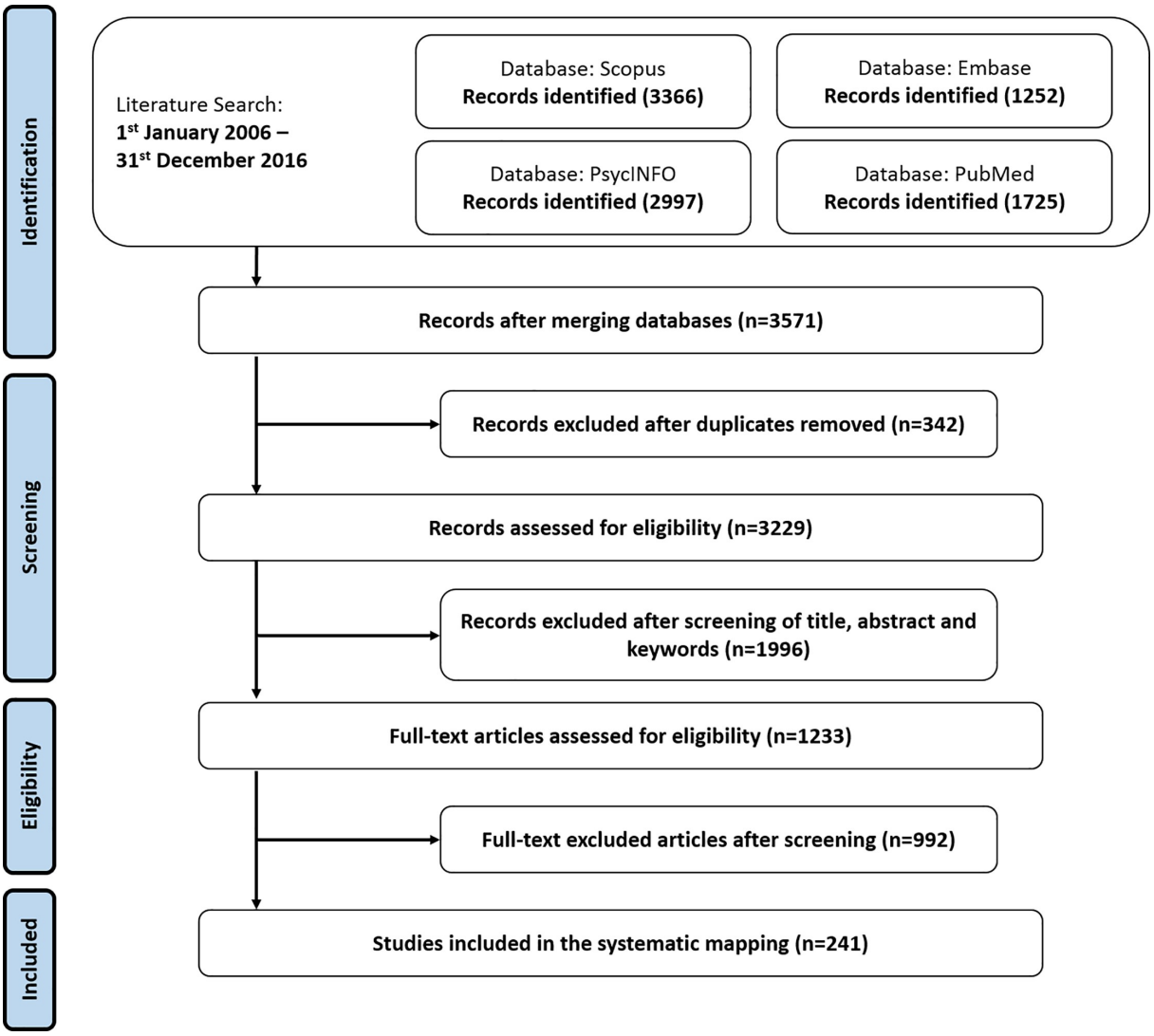

Fig 1. Steps for the process of extracting and selecting articles.

https://doi.org/10.1371/journal.pone.0218720.g001

designed, quasi-experimental study), while 29 papers presented III level of evidence (well-designed observational studies). The remaining 15 papers were classified as IV (documents or opinions of expert committees and/or clinical experiences of key opinion leaders). An increase in the number of published papers on social cognition remediation and training programs with IB level of evidence was seen in the period studied, as can be seen in the IB trend line (see Fig 2B).

Regarding publication venues, *Schizophrenia Research* journal was the most popular venue, with 19 papers, followed by *Journal of Autism and Developmental Disorders* with 10 papers, *Psychiatry Research* with 8 published papers, *Behavioural and Cognitive Psychotherapy* with 7

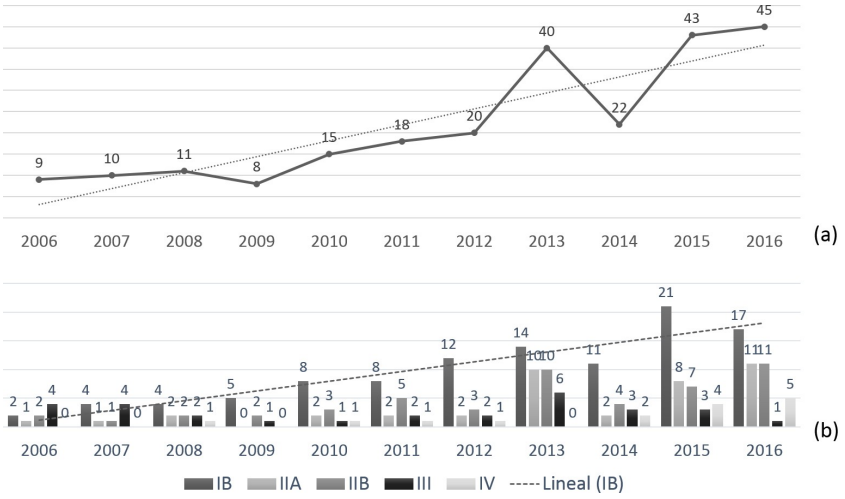

Fig 2. (a) Number of selected papers over publication years. (b) Number of references per year and level of scientific evidence.

https://doi.org/10.1371/journal.pone.0218720.g002

papers, *PLoS ONE* with 6 papers, *Schizophrenia Bulletin* with 5 papers, and *BMC Psychiatry* and *Developmental Psychology* with 4 papers each. Each of the remaining journals had 3 or fewer published papers (see on-line material, S2 Table for a complete list).

RQ2. *In what areas of medical knowledge and related disciplines has research on social cognition remediation programs been conducted*?

According to the area of knowledge of the publishing journal, 132 of the 241 included papers were published in journals classified as related to medicine. As shown in Table 1, papers on medicine were mostly in the field of psychiatry, according to the *EUMS* (*European Union of Medical Specialists*) (89 papers of a total of 132 in medical specialties). Other areas of

Table 1. References by EUMS medical specialties.

EUMS Medical Specialty	Ref.
Psychiatry	P5, P6, P10, P16, P23, P24, P26, P30, P31, P32, P34, P36, P39, P40, P43, P44, P45, P46, P47, P48, P59, P60, P61, P62, P63, P64, P65, P67, P70, P71, P73, P79, P80, P83, P84, P86, P93, P94, P100, P101, P102, P103, P104, P109, P110, P112, P113, P117, P121, P122, P130, P131, P132, P133, P136, P140, P143, P144, P146, P148, P149, P153, P156, P158, P159, P161, P164, P172, P179, P181, P185, P186, P189, P191, P192, P202, P204, P206, P209, P212, P215, P225, P226, P230, P231, P232, P237, P238, P240
Child and Adolescent Psychiatry and Psychotherapy	P7, P8, P11, P12, P13, P18, P19, P52, P77, P81, P107, P116, P123, P124, P125, P155, P194, P201, P208, P216, P219, P235
Neurology	P2, P76, P145, P157, P165, P171
Physical Medicine and Rehabilitation	P1, P50, P174, P183, P199, P218
Public Health Medicine	P25, P126, P227, P241
Geriatrics	P120
Laboratory Medicine / Medical Biopathology	P198
Pediatrics	P90
Non-Specific	P51, P99

https://doi.org/10.1371/journal.pone.0218720.t001

knowledge were child and adolescent psychiatry and psychotherapy (22 papers), neurology (6 papers), physical medicine and rehabilitation (6 papers), and public health medicine (4 papers).

Furthermore, as can be seen in Table 2, according to the area of knowledge of the publishing journal, the second most frequent studied knowledge area after medicine was psychology, which included 93 papers. The remaining 16 papers were included in science, neuroscience, and education journals.

RQ3. *Which domains of social cognition are the focus of research in social cognition remediation*?

Theory of mind was the most frequently studied domain with 146 publications, followed by 131 articles in emotional processing, 60 articles in attributional bias and 33 papers in social perception (see Fig 3). Although most studies focus on a single domain of social cognition, some evaluate two or more domains of social cognition, as shown in Fig 3. In this case, the most frequent combination was the pair formed by theory of mind and emotional processing (23 papers), as well as the triad of theory of mind, attributional bias and emotional processing (22 papers).

Studies with IB level of evidence were the most frequently found for each domain of social cognition. As can be observed in Fig 4, the greatest number focused on theory of mind and on emotional processing with IB level of evidence.

As a result of classifying publications according to domains of social cognition and the mental disorder they focus on, most publications in all four domains alluded to schizophrenia spectrum and other psychotic disorders. Autism spectrum disorder was the second most studied disorder (see Table 3).

RQ4. *What types of interventions are employed in social cognitive remediation*?

As previously stated, on the basis of previous reviews and meta-analyses, three types of programs can be distinguished [31]: targeted interventions, broad-based interventions, and non-specific interventions. The latter may influence social cognition, but do not address it directly. According to this classification, targeted interventions were the focus of the largest number of publications with 156 papers, followed by non-specific therapies with 59 publications, and broad-based interventions with 26 publications (see on-line material, S3 Table, for a complete list).

Table 2. References by journal knowledge area.

Knowledge Area	Ref.
Medicine	P1, P2, P5, P6, P7, P8, P10, P11, P12, P13, P16, P18, P19, P23, P24, P25, P26, P30, P31, P32, P34, P36, P39, P40, P43, P44, P45, P46, P47, P48, P50, P51, P52, P59, P60, P61, P62, P63, P64, P65, P67, P70, P71, P73, P76, P77, P79, P80, P81, P83, P84, P86, P90, P93, P94, P99, P100, P101, P102, P103, P104, P107, P109, P110, P112, P113, P116, P117, P120, P121, P122, P123, P124, P125, P126, P130, P131, P132, P133, P136, P140, P143, P144, P145, P146, P148, P149, P153, P155, P156, P157, P158, P159, P161, P164, P165, P171, P172, P174, P179, P181, P183, P185, P186, P189, P191, P192, P194, P198, P199, P201, P202, P204, P206, P208, P209, P212, P215, P216, P218, P219, P225, P226, P227, P230, P231, P232, P235, P237, P238, P240, P241
Psychology	P3, P4, P9, P14, P15, P17, P20, P21, P22, P28, P29, P33, P35, P37, P38, P41, P42, P49, P54, P55, P56, P57, P58, P69, P72, P74, P75, P78, P82, P85, P87, P88, P89, P91, P92, P95, P96, P97, P98, P105, P106, P108, P114, P118, P119, P127, P134, P135, P137, P138, P141, P147, P150, P151, P152, P154, P160, P162, P166, P167, P168, P169, P170, P173, P175, P176, P177, P178, P180, P182, P184, P187, P188, P190, P195, P196, P200, P205, P210, P211, P213, P214, P217, P220, P221, P222, P223, P224, P228, P229, P233, P234, P239
Science	P66, P68, P111, P129, P142, P163, P193, P197, P203, P207, P236
Neuroscience	P27, P53, P128, P139
Education	P115

https://doi.org/10.1371/journal.pone.0218720.t002

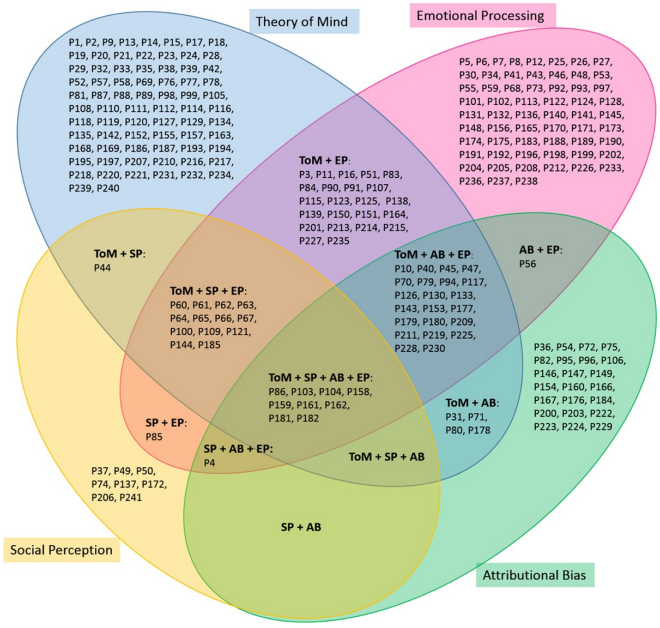

Fig 3. References by domains of social cognition. Venn diagram with four sets.

https://doi.org/10.1371/journal.pone.0218720.g003

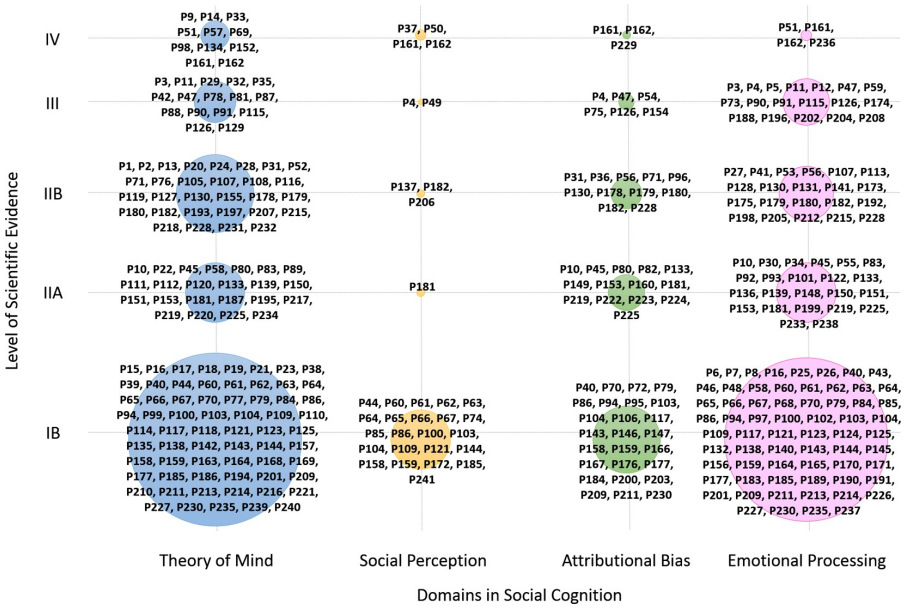

Fig 4. Categorization of papers in terms of social cognition domain and level of scientific evidence.

https://doi.org/10.1371/journal.pone.0218720.g004

Table 3. Mental disorders for each domain in social cognition.

Social Cognition Domain	
Mental Disorder	**Ref.**
Emotion Processing	
Schizophrenia Spectrum and Other Psychotic Disorders	P4, P10, P16, P30, P34, P45, P46, P47, P48, P59, P60, P61, P62, P63, P64, P65, P66, P67, P70, P79, P83, P84, P85, P86, P92, P94, P100, P101, P102, P103, P104, P109, P121, P122, P128, P130, P131, P132, P133, P136, P138, P140, P143, P144, P148, P153, P158, P159, P161, P162, P164, P165, P173, P177, P179, P180, P181, P182, P185, P188, P189, P191, P192, P202, P204, P209, P225, P226, P227, P228, P230, P237, P238
Autism Spectrum Disorder	P5, P7, P8, P11, P12, P26, P27, P41, P56, P93, P107, P115, P122, P123, P124, P125, P126, P175, P183, P190, P198, P201, P213, P214, P215, P219, P233, P235
Depressive Disorders	P6, P73
Feeding and Eating Disorders	P141, P212
Anxiety Disorders	P113
Attention Deficit / Hyperactivity Disorder	P43
Bipolar and Related Disorders, and Schizoaffective Disorder	P117
Disruptive, Impulse-Control, and Conduct Disorders	P51
Personality Disorders	P40
Theory of Mind	
Schizophrenia Spectrum and Other Psychotic Disorders	P9, P10, P14, P15, P16, P17, P28, P33, P39, P44, P45, P47, P60, P61, P62, P63, P64, P65, P66, P67, P70, P71, P79, P80, P83, P84, P86, P94, P98, P100, P103, P104, P108, P109, P121, P130, P133, P138, P142, P143, P144, P152, P153, P158, P159, P161, P162, P164, P177, P178, P179, P180, P181, P182, P185, P209, P220, P225, P227, P228, P230
Autism Spectrum Disorder	P2, P11, P13, P18, P19, P24, P42, P52, P69, P77, P81, P88, P99, P107, P110, P114, P115, P116, P123, P125, P126, P134, P135, P155, P168, P193, P194, P201, P213, P214, P215, P216, P219, P235, P239
Borderline Personality Disorder	P32, P232
Personality Disorders	P40, P57
Attention Deficit / Hyperactivity Disorder	P23
Bipolar and Related Disorders, and Schizoaffective Disorder	P117
Communication Disorders	P197
Delusional Disorder	P31
Disruptive, Impulse-Control, and Conduct Disorders	P51
Intellectual Disabilities	P1
Trauma- and Stressor-Related Disorders	P112
Attributional Bias	
Schizophrenia Spectrum and Other Psychotic Disorders	P4, P10, P45, P47, P70, P71, P79, P80, P86, P94, P103, P104, P130, P133, P143, P153, P158, P159, P161, P162, P177, P178, P179, P180, P181, P182, P209, P225, P228, P230
Anxiety Disorders	P72, P147, P203, P223, P224
Depressive Disorders	P106, P149, P160, P200, P229
Autism Spectrum Disorder	P56, P126, P219
Bipolar and Related Disorders, and Schizoaffective Disorder	P117
Delusional Disorder	P31
Feeding and Eating Disorders	P36

(*Continued*)

Table 3. (Continued)

Social Cognition Domain	
Mental Disorder	**Ref.**
Personality Disorders	P40
Social Perception	
Schizophrenia Spectrum and Other Psychotic Disorders	P4, P44, P60, P61, P62, P63, P64, P65, P66, P67, P74, P85, P86, P100, P103, P104, P109, P121, P137, P144, P158, P159, P161, P162, P172, P181, P182, P185, P206, P241
Autism Spectrum Disorder	P50
Intellectual Disabilities	P49

https://doi.org/10.1371/journal.pone.0218720.t003

Among targeted interventions, *Social Cognition and Interaction Training* (SCIT) was the focus of 16 publications, followed by *Training of Affect Recognition* (TAR) and *Conversation-Based Intervention*, both with 7 papers, Mind *Reading* and *SummerMAX* with 6 publications each, and *Mentalization-Based Therapy* (MBT), *Micro-Expression Training Tool* (METT) and *The Theory of Mind Training* with 4 publications each (see Table 4). The complete list of targeted interventions can be found as on-line material (S3 Table).

In the group of broad-based interventions, the most frequently studied therapy was *Cognitive Enhancement Therapy* (CET) with 11 publications, as shown in Table 5. The second most studied therapy was *Integrated Psychological Therapy* (IPT) with 4 articles. *Auditory Training with Cognitive Social Training plus Social Cognition Training* (AT + SCT) followed with 3 papers, and *Cognitive Pragmatic Treatment* (CPT) and *REHACOP* with 2 papers each. The rest of the papers on broad-based interventions are available in the supplementary material online (S3 Table).

Finally, in the group of non-specific interventions on social cognition (see S3 Table), the largest number of publications referred to *Cognitive and Behavioral Therapies* with 28 papers, followed by *Neurocognition Training* with 5 publications, and *Mindfulness* and *Art Therapy* with 4 papers each. The rest of the papers on non-specific interventions are available in the supplementary material online (see S3 Table).

Among the studies analyzed, 61 were based on computerized training versus 180 that used no new technologies, but rather interpersonal modality (see Table 6). It could be interesting to carry out studies comparing the effectiveness of these two types of intervention as future work.

Table 4. Targeted interventions in social cognitive remediation.

Targeted Interventions	**Refs**
Social Cognition and Interaction Training (SCIT) [67]	P10, P40, P45, P47, P94, P117, P126 (SCIT-A[a]), P153, P177, P179, P180, P209 (F-SCIT[b]), P211 (IFW-SCIT [c]), P219 (SCIT-A[a]), P228, P230
Training of Affect Recognition (TAR) [68]	P59, P92, P128, P191, P204, P237, P238
Conversation-Based Intervention [69]	P21, P22, P38, P118, P119, P120, P186
Mind Reading [70]	P88, P115, P116, P215, P216, P233
SummerMAX [71]	P123, P124, P125, P183, P213, P214
Mentalization-Based Therapy (MBT) [72]	P32, P221, P231, P232
Micro-Expression Training Tool (METT) [73]	P131, P132, P188, P189
The Theory of Mind Training [74]	P18, P19, P81, P99

[a] SCIT-A: Social Cognition and Interaction Training Modified for High Functioning Autism

[b] F-SCIT: Social Cognition and Interaction Training Modified for Family-Assisted

[c] IFW-SCIT: Social Cognition and Interaction Training Modified for Inpatient Forensic Wards

https://doi.org/10.1371/journal.pone.0218720.t004

Table 5. Broad-based interventions in social cognitive remediation.

Broad-Based Interventions	Refs
Cognitive Enhancement Therapy (CET) [75]	P60, P61, P62, P63, P64, P65, P66, P67, P100, P109, P121
Integrated Psychological Therapy (IPT) [76]	P74, P172, P206, P241
Auditory-Based Cognitive Training plus Social-Cognition Training (AT+ SCT) [77]	P101, P102, P192
Cognitive Pragmatic Treatment (CPT) [78]	P28, P76
REHACOP (*Programa de REHAbilitación COgnitiva en Psicosis*) [79]	P157, P158

https://doi.org/10.1371/journal.pone.0218720.t005

Discussion

This is the first systematic mapping review carried out on remediation interventions for the enhancement of social cognition deficits. The study included papers published over a period of eleven years (2006–2016). The results show the current situation of this field of knowledge, both with the areas that have received more attention, as well as those that show little research development. The present study adds to the recently published systematic mapping review on pharmacological interventions for social cognition improvement [22], providing a global overview of the current state of knowledge in the field of social cognition remediation interventions.

A total of 241 papers were selected from the initial 3229 non-repeated publications obtained from four databases (Scopus, PsycINFO, PubMed, Embase). The number of papers published per year on social cognition training and remediation interventions clearly increased throughout the studied period, especially in the last four years. This is an indicator of the growing interest in social cognition non-pharmacological treatment approaches, which may be related to the scant effectiveness of pharmacological treatments in improving social cognition deficits.

In terms of the level of scientific evidence as defined by the *US Agency for Healthcare Research and Quality Agency* [66], of the 241 selected papers, 106 were classified as having IB

Table 6. Computerized vs. in-person interventions.

Computerized interventions	
Targeted Interventions	P5, P26, P27, P41, P46, P48, P53, P56, P59, P88, P92, P97, P107, P115, P116, P128, P131, P132, P138, P144, P145, P160, P161, P162, P164, P165, P173, P181, P182, P185, P188, P189, P190, P191, P196, P198, P199, P202, P204, P208, P215, P216, P225, P233, P236, P237, P238
Broad-Based Interventions	P34, P70, P101, P102, P122, P192
Non-Specific Interventions	P12, P23, P39, P49, P93, P147, P149, P203
In-person interventions	
Targeted Interventions	P1, P2, P3, P10, P14, P16, P17, P18, P19, P20, P21, P22, P24, P25, P32, P33, P35, P36, P38, P40, P42, P43, P44, P45, P47, P51, P58, P69, P71, P72, P79, P80, P81, P82, P83, P84, P85, P86, P87, P90, P91, P94, P95, P96, P98, P99, P103, P104, P105, P108, P110, P117, P118, P119, P120, P123, P124, P125, P126, P127, P130, P133, P134, P137, P141, P150, P151, P152, P153, P154, P155, P156, P168, P169, P170, P171, P177, P178, P179, P180, P183, P186, P187, P194, P195, P197, P201, P209, P211, P212, P213, P214, P217, P218, P219, P220, P221, P222, P223, P224, P227, P228, P230, P231, P232, P234, P239, P240
Broad-Based Interventions	P15, P28, P60, P61, P62, P63, P64, P65, P66, P67, P74, P76, P100, P109, P121, P143, P157, P158, P172, P206, P241
Non-Specific Interventions	P4, P6, P7, P8, P9, P11, P13, P29, P30, P31, P37, P50, P52, P54, P55, P57, P68, P73, P75, P77, P78, P89, P106, P111, P112, P113, P114, P129, P135, P136, P139, P140, P142, P146, P148, P159, P163, P166, P167, P174, P175, P176, P184, P193, P200, P205, P207, P210, P226, P229, P235.

https://doi.org/10.1371/journal.pone.0218720.t006

level of evidence (evidence obtained from at least one randomized clinical trial) and 41 as IIA (obtained from at least one well-designed, non-randomized controlled prospective study). According to the social cognitive domain studied, studies with IB and IIA level of evidence were the most frequently found in the four domains of social cognition. IB was the highest level of evidence that could be found in our mapping review because we excluded papers with IA level of evidence (namely, meta-analyses of randomized clinical trials). Thus, publications with a high level of evidence were predominant, as an indicator of the quality of the research in the field. Moreover, given the high proportion of studies with IB level and their associated important economic costs, current interest in the subject is evident, both for researchers and different public and private funding agencies.

Referring to publication venues, it is interesting to note that most studies were disseminated in journals with a high impact factor. Journals with the highest number of papers on this topic were two journals in the first quartile of their area of knowledge: *Schizophrenia Research* with 19 papers (IF 3.986; Q1-Psychiatry), and *Journal of Autism and Developmental Disorders* with 10 papers (IF 8.321; Q1-Psychology, Developmental). Moreover, of the top eight most popular publication venues, five (comprising 42 of the 62 papers) were first-quartile journals. The fact that papers were published in high-impact journals may be related to the high level of scientific evidence previously indicated.

Regarding areas of medical knowledge and related disciplines with research on social cognition training and remediation, most publications belonged to the field of Medicine, especially to Adult Psychiatry, followed by Child and Adolescent Psychiatry and Psychotherapy. Psychology was the discipline with the second-greatest number of publications in social cognition remediation. The fact that impairments in social cognition frequently appear in numerous psychiatric disorders might explain why most studies belong to Adult and Child/Adolescent areas of Psychiatry and Psychology.

Concerning social cognition domains, most of the published papers targeted theory of mind, followed by emotional processing. Previously published reviews centered on schizophrenia and other related disorders showed that emotional processing was the focus of most publications [28–31,63]. Nevertheless, the fact that the present systematic mapping review included papers in disorders other than schizophrenia, such as autism spectrum disorders, might explain this difference. In fact, after schizophrenia and related disorders, autism spectrum disorders were the focus of most of the selected papers in this systematic mapping review. As deficits in theory of mind is a core problem in autism [80], a significant number of papers focused on this domain [64]. Much less frequent was the study of attributional bias, followed by research on social perception training. A feasible explanation for this may be related to the fact that assessment instruments for theory of mind and emotional processing may be considered more objective and less influenced by cultural aspects, as opposed to social perception assessment [81], and less influenced by some symptoms of the disorder itself, as opposed to, for example, attributional bias in patients with paranoid ideation. On the other hand, it has previously been suggested that improvements in attributional bias and social perception might be more difficult to achieve than in theory of mind and social perception [30,63]. More empirical work is needed to determine whether interventions on attributional bias and social perception can produce changes and whether these changes can be objectively measured.

The results regarding the types of social cognition training and remediation interventions show that the majority of publications refer to targeted interventions. This finding is in line with previous publications showing a greater number of papers related to targeted interventions compared to other types of interventions [31]. In the group of targeted interventions, the greatest number of papers were on *Social Cognition and Interaction Training* (SCIT). SCIT targets three domains of social cognition: theory of mind, emotional processing and attributional

bias [67]. Other targeted interventions were *Training of Affect Recognition* (TAR) [68], *Conversation-Based Intervention* [69], *Mind Reading* [70], *SummerMAX* [71], *Mentalization-Based Therapy* (MBT) [72], *Micro-Expression Training Tool* (METT) [73], and *The Theory of Mind Training* [74]. Among broad-based interventions, the therapy with the largest number of papers was *Cognitive Enhancement Therapy* (CET) [75]. CET consists of computer-assisted neurocognitive and social cognitive group training to improve theory of mind, social perception and emotional processing [82]. Other less frequently published broad-based interventions were *Integrated Psychological Therapy* (IPT) [76], *Auditory Training with Cognitive Social Training plus Social Cognition Training* (AT + SCT) [77] and *REHACOP* [79]. Finally, in the group of non-specific interventions, the largest number of publications was in *Cognitive and Behavioral Therapies*. Nevertheless, although publications on certain interventions were more numerous than others, the results show the existence of a considerable number of different interventions for improving social cognition. This may be partly due to the existence of different domains of social cognition, but also due to the limited number of comparative studies.

The present systematic mapping review has some risks and limitations. One of the risks implied in all systematic mapping reviews is related to selective reporting bias [83]. To minimize this risk, four different databases were used as the source for the search process: PsycINFO, PubMed, Embase and Scopus. These provide a comprehensive list of articles encompassing the different aspects of this mapping review. Nevertheless, we should acknowledge that the decision not to truncate search terms may have led to some important articles being overlooked. It is also worth noting that it was decided to exclude grey literature (e.g. theses, internal reports, etc.) from the study. This may have impinged on the validity of the study, but it should be stressed that grey literature is generally published without a rigorous review process. Another possible risk that could have affected this mapping review is the selection bias. This is related to the criteria used to select the articles to be analyzed during the study. In order to mitigate such a risk, both the inclusion and exclusion criteria were clearly defined.

Finally, the risk of likely inaccuracy in data extraction and misclassification was mitigated as classification and extraction data processes were performed independently by two researchers, and a consensus decision including the study coordinator was made in the event of no agreement between these two researchers.

Conclusions

To our knowledge, this is the first systematic mapping review describing social cognition remediation interventions. Our results show a growing interest in non-pharmacological treatments of social cognition, as can be demonstrated by the increase in the number of papers published over the studied period, their high level of scientific evidence, and their dissemination in journals with a high impact factor. Most studies are from the fields of psychiatry and psychology, with schizophrenia spectrum disorders and autism spectrum disorders being the two most studied conditions. Theory of mind was the most frequently studied domain of social cognition, followed by emotional processing. Targeted interventions were the most frequently studied, especially SCIT. Future research should be conducted on attributional bias and domains of social perception, with the comparative efficacy of different social cognition interventions also being an interesting future line of research.

Supporting information

S1 Table. Template for a Mapping Study Protocol.
(PDF)

S2 Table. Publication venues.
(PDF)

S3 Table. Cognitive rehabilitation programs.
(PDF)

S1 File. Selected papers.
(PDF)

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S1: Template for a Mapping Study Protocol

Section	Recommendation	Line #
1. Change Record		
	This should be a list or table summarizing the main updates and changes embodied in each version of the protocol and (where appropriate), the reasons for these.	**N/A**
2. Background		
	a) explain why there is a need for a study on this topic	**86-91**
	b) identify the topic that is to be 'scoped' in the study	**70-72**
	c) specify any research questions that will be addressed	**107-109; 117-118; 127; 150**
	d) if extending previous research on the topic, explain why a new study is needed	**N/A**
3. Search Strategy		
	a) specify and justify basic strategy: manual search, automated search, or mixed	**172-175**
	b) for automated searches, specify search terms and compounds of these (and record results of any prototyping of the search strings)	**176-190**
	c) for automated searches, identify resources to be used (digital libraries and search engines)	**172-175**
	d) for manual searches, identify the journals and conferences to be searched	**N/A**
	e) specify the time period to be covered by the review and any reasons for your choice	**195**
	f) identify any ancillary search procedures, e.g. asking leading researchers or research groups, or accessing their web sites; or checking reference lists of primary studies	**233-240**
	g) specify how the search process is to be evaluated (e.g. against a known subset of papers; or against the results from a previous systematic review or mapping study)	**233-240**

Section	Recommendation	Line #
4. Selection Criteria		
	a) identify the *inclusion* criteria for primary studies	**193-196; 208-214**
	b) identify the *exclusion* criteria	**197-207; 215-218**
	c) define how selection will be undertaken (roles of analysts)	**168-171**
	d) define how agreement among analysts will be evaluated	**221-237**
	e) define how any differences between analysts will be resolved	**221-237**
5. Data Extraction		
	a) design data extraction form (and check via a dry run)	**176-181**
	b) specify the strategy for extracting the data and the form (paper, on-line etc.)	**176-181**
	c) identify how the data extraction process is to be undertaken and validated, particularly any data that require numerical calculations, or are subjective	**N/A**
6. Synthesis		
	a) specify the categorization schemes to be used	**281; 287; 312; 328**
	b) assess the threats to validity (construct, internal, external), particularly constraints on the search process and deviations from standard practice	**422-433**
7. Study Limitations		
	Specify residual validity issues including potential conflicts of interest (i.e. that are inherent in the context of the study, rather than arising from the plan).	**426-438**
8. Reporting		
	Identify target audience, relationship to other studies, planned publications, authors of the publications.	**407-425**
9. Schedule		
	Provide time estimates for all of the major steps.	**N/A**

S2: Selected papers

P1 Adibsereshki, N., Abdolahzadeh, M., Karmilo, M., & Hasanzadeh, M. (2014). The effectiveness of theory of mind training on the adaptive behavior of students with intellectual disability. *Journal of Special Education and Rehabilitation*, *15*(1–2). https://doi.org/10.2478/jser-2014-0006

P2 Adibsereshki, N., Nesayan, A., Asadi Gandomani, R., & Karimlou, M. (2015). The effectiveness of theory of mind training on the social skills of children with high functioning autism spectrum disorders. *Iranian Journal of Child Neurology*, *9*(3), 40–49.

P3 Allen, J. R., & Kinsey, K. (2013). Teaching theory of mind. *Early Education & Development*, *24*(6), 865–876. https://doi.org/10.1080/10409289.2013.745182

P4 Álvarez, J. C., Tourinõ, R., Abelleira, C., Fernańdez, J., Baena, E., Giráldez, A., & Bordón, R. (2013). Social cognition and schizophrenia: Differences between users of psychosocial rehabilitation day center and from a supported employment program. *Rehabilitacion Psicosocial*, *10*(2), 4–9.

P5 Alves, S., Marques, A., Queirós, C., & Orvalho, V. (2013). LIFEisGAME prototype: A serious game about emotions for children with autism spectrum disorders. *PsychNology Journal*, *11*(3), 191–211.

P6 Babl, A., grosse Holtforth, M., Heer, S., Lin, M., Stähli, A., Holstein, D., … Caspar, F. (2016). Psychotherapy integration under scrutiny: investigating the impact of integrating emotion-focused components into a CBT-based approach: a study protocol of a randomized controlled trial. *BMC Psychiatry*, *16*(1), 423. https://doi.org/10.1186/s12888-016-1136-7

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P8 Baghdadli, A., Brisot, J., Henry, V., Michelon, C., Soussana, M., Rattaz, C., & Picot, M. C. (2013). Social skills improvement in children with high-functioning autism: a pilot randomized controlled trial. *European Child & Adolescent Psychiatry*, *22*(7), 433–442. https://doi.org/10.1007/s00787-013-0388-8

P9 Bargenquast, R., Schweitzer, R. D., & Drake, S. (2015). Reawakening reflective capacity in the psychotherapy of schizophrenia: A case study. *Journal of Clinical Psychology*, *71*(2), 136–145. https://doi.org/10.1002/jclp.22149

P10 Bartholomeusz, C. F., Allott, K., Killackey, E., Liu, P., Wood, S. J., & Thompson, A. (2013). Social cognition training as an intervention for improving functional outcome in first-episode psychosis: A feasibility study. *Early Intervention in Psychiatry*, *7*(4), 421–426. https://doi.org/10.1111/eip.12036

P11 Bauminger-Zviely, N., Eden, S., Zancanaro, M., Weiss, P. L., & Gal, E. (2013). Increasing social engagement in children with high-functioning autism spectrum disorder using collaborative technologies in the school environment. *Autism*, *17*(3), 317–339. https://doi.org/10.1177/1362361312472989

P12 Bauminger, N. (2007a). Brief report: Group social-multimodal intervention for HFASD. *Journal of Autism and Developmental Disorders*, *37*(8), 1605–1615. https://doi.org/10.1007/s10803-006-0246-3

P13 Bauminger, N. (2007b). Brief report: Individual social-multi-modal intervention for HFASD. *Journal of Autism and Developmental Disorders*, *37*(8), 1593–1604. https://doi.org/10.1007/s10803-006-0245-4

P14 Bazin, N., Passerieux, C., & Hardy-Bayle, M.-C. (2010). ToMRemed : une technique de remédiation cognitive centrée sur la théorie de l'esprit pour les patients schizophrènes. *Journal de Thérapie Comportementale et Cognitive*, *20*(1), 16–21. https://doi.org/10.1016/j.jtcc.2010.02.001

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P16 Bechi, M., Riccaboni, R., Ali, S., Fresi, F., Buonocore, M., Bosia, M., … Cavallaro, R. (2012). Theory of mind and emotion processing training for patients with schizophrenia: Preliminary findings. *Psychiatry Research*, *198*(3), 371–377. https://doi.org/10.1016/j.psychres.2012.02.004

P17 Bechi, M., Spangaro, M., Bosia, M., Zanoletti, A., Fresi, F., Buonocore, M., … Cavallaro, R. (2013). Theory of mind intervention for outpatients with schizophrenia. *Neuropsychological Rehabilitation*, *23*(3), 383–400. https://doi.org/10.1080/09602011.2012.762751

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P19 Begeer, S., Howlin, P., Hoddenbach, E., Clauser, C., Lindauer, R., Clifford, P., … Koot, H. M. (2015). Effects and moderators of a short theory of mind intervention for children with autism spectrum disorder: A randomized controlled trial. *Autism Research*, *8*(6), 738–748. https://doi.org/10.1002/aur.1489

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P23 Bigorra, A., Garolera, M., Guijarro, S., & Hervas, A. (2016). Impact of working memory training on hot executive functions (decision-making and theory of mind) in children with ADHD: a randomized controlled trial. *Neuropsychiatry*, *6*(5). https://doi.org/10.4172/Neuropsychiatry.1000147

P24 Biscaldi, M., Paschke-Müller, M., Rauh, R., & Schaller, U. M. (2016). Evaluation des Freiburger TOMTASS - Ein soziales Kompetenztraining mit Schwerpunkt auf Theory of Mind für Kinder und Jugendliche mit hochfunktionalen Autismus-Spektrum-Störungen. *Zeitschrift Für Psychiatrie, Psychologie Und Psychotherapie*, *64*, 269–275. https://doi.org/10.1024/1661-4747/a000288

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P36 Cardi, V., Esposito, M., Bird, G., Rhind, C., Yiend, J., Schifano, S., … Treasure, J. (2015). A preliminary investigation of a novel training to target cognitive biases towards negative social stimuli in anorexia nervosa. *Journal of Affective Disorders*, *188*, 188–193. https://doi.org/10.1016/j.jad.2015.08.019

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S3: Publication venues

Publication	Ref	# ref	Publication	Ref	# ref	Publication	Ref	# ref
Schizophrenia Research	**P45, P46, P47, P48, P59, P61, P63, P64, P86, P102, P103, P109, P121, P132, P140, P181, P189, P191, P226**	**19**	Biological Psychiatry	P73	1	Journal of Positive Behavior Interventions	P69	1
Journal of Autism and Developmental Disorders	**P11, P12, P18, P81, P107, P124, P125, P208, P216, P219**	**10**	BMC Research Notes	P193	1	Journal of Psychiatric and Mental Health Nursing	P232	1
Psychiatry Research	**P16, P40, P65, P70, P172, P179, P209, P230**	**8**	Body, Movement and Dance in Psychotherapy	P205	1	Journal of Psychiatric Research	P104	1
Behavioural and Cognitive Psychotherapy	**P178, P180, P211, P222, P224, P228, P229**	**7**	British Journal of Educational Psychology	P21	1	Journal of Research in Character Education	P54	1
PLoS ONE	**P68, P129, P142, P163, P203, P207**	**6**	Child and Family Behavior Therapy	P233	1	Journal of School Violence	P75	1
Schizophrenia Bulletin	**P122, P136, P143, P148, P237**	**5**	Child Development	P118	1	Journal of Special Education and Rehabilitation	P1	1
BMC Psychiatry	**P6, P133, P185, P212**	**4**	Chinese Mental Health Journal	P240	1	Journal of the International Neuropsychological Society	P170	1
Developmental Psychology	**P20, P82, P127, P234**	**4**	Clinical Case Studies	P51	1	Journal of the Society for Social Work and Research	P66	1
Autism	P13, P52, P116	3	Clinical Practice and Epidemiology in Mental Health	P227	1	Memory and Cognition	P29	1
Behaviour Research and Therapy	P72, P176, P184	3	Clinical Psychology and Psychotherapy	P152	1	Molecular Autism	P198	1
Clinical Neuropsychiatry	P32, P39, P164	3	Cognition	P195	1	Nervenheilkunde	P238	1
Clinical Schizophrenia and Related Psychoses	P83, P84, P192	3	Cognitive Behaviour Therapy	P149	1	NeuroImage: Clinical	P165	1
Frontiers in Psychiatry	P79, P112, P161	3	Cognitive Neuropsychiatry	P31	1	Neurology	P157	1
Frontiers in Psychology	P28, P38, P221	3	Community Mental Health Journal	P44	1	Neuropsychiatric Disease and Treatment	P93	1
Journal of Clinical Psychology	P9, P57, P98	3	Development and Psychopathology	P88	1	Neuropsychiatrie de l'Enfance et de l'Adolescence	P8	1
Journal of Experimental Child Psychology	P22, P119, P150	3	Early Child Development and Care	P78	1	Neuropsychiatry	P23	1
Journal of Head Trauma Rehabilitation	P76, P145, P171	3	Early Education and Development	P3	1	Neuropsychologia	P53	1
Neuropsychological Rehabilitation	P17, P108, P138	3	Early Intervention in Psychiatry	P10	1	Journal of Deaf Studies and Deaf Education	P218	1
Psychiatric Services	P60, P94, P100	3	Estudos de Psicologia	P182	1	NPJ Schizophrenia	P158	1
Psychological Medicine	P15, P67, P196	3	European Child and Adolescent Psychiatry	P7	1	Patient Education and Counseling	P25	1
Schizophrenia Research: Cognition	P144, P159, P225	3	European Journal of Developmental Psychology	P91	1	Progress in Neuro-Psychopharmacology and Biological Psychiatry	P113	1
Australasian Psychiatry	P130, P153	2	First Language	P210	1	Psychiatry Research - Neuroimaging	P101	1
British Journal of Clinical Psychology	P177, P188	2	Focus on Autism and Other Developmental Disabilities	P215	1	PsychNology Journal	P5	1
British Journal of Psychiatry	P26, P156	2	Frontiers in Human Neuroscience	P162	1	Psychological Research	P200	1
Chinese Journal of Clinical Psychology	P168, P239	2	Infancia y Aprendizaje	P187	1	Psychological Science	P58	1
Cognitive Development	P87, P217	2	Infancy	P90	1	Psychologie Française	P37	1

Computers in Human Behavior	P41, P56	2	Infant Mental Health Journal	P194	1	Psychology and Psychotherapy	P220	1
Journal of Affective Disorders	P36, P117	2	International Journal of High Risk Behaviors and Addiction	P146	1	Psychology in the Schools	P214	1
Journal of Behavior Therapy and Experimental Psychiatry	P80, P147	2	International Journal of Psychology and Psych. Therapy	P74	1	Psychosis	P206	1
Journal of Cognition and Development	P89, P105	2	International Journal of Rehabilitation Research	P174	1	Psychotherapy	P55	1
Journal of the American Academy of Child and Adolescent Psychiatry	P77, P201	2	International Journal of Telerehabilation	P236	1	Psychotherapy and Psychosomatics	P114	1
Personality and Individual Differences	P97, P166	2	Iranian Journal of Child Neurology	P2	1	Remedial and Special Education	P115	1
Psicothema	P35, P134	2	Iranian Journal of Psychiatry and Clinical Psychology	P110	1	Revista de Logopedia, Foniatría y Audiología	P197	1
Psychiatric Rehabilitation Journal	P30, P71	2	Journal de Therapie Comportementale et Cognitive	P14	1	Revista de Psicologia Social	P96	1
Rehabilitacion Psicosocial	P4, P173	2	Journal for Specialists in Group Work	P223	1	Revista de Psiquiatria Clinica	P202	1
Research in Autism Spectrum Disorders	P123, P155	2	Journal of Abnormal Psychology	P160	1	Science	P111	1
Social Development	P151, P169	2	Journal of Attention Disorders	P43	1	Shanghai Archives of Psychiatry	P34	1
Social Neuroscience	P92, P128	2	Journal of Child Psychology and Psychiatry and All. Disc.	P235	1	Social Cognitive and Affective Neuroscience	P135	1
Aging and Mental Health	P186	1	Journal of Clinical & Adolescent Psychology	P213	1	Spanish Journal of Psychology	P85	1
American Journal of Psychiatric Rehabilitation	P131	1	Journal of Consulting and Clinical Psychology	P106	1	Sport Psychologist	P154	1
Applied Neuropsychology	P137	1	Journal of Contemporary Psychotherapy	P33	1	Therapeutic Recreation Journal	P49	1
Archives of General Psychiatry	P62	1	Journal of Developmental and Physical Disabilities	P183	1	Topics in Language Disorders	P50	1
Archives of Gerontology and Geriatrics	P120	1	Journal of Experimental Psychology: General	P42	1	Trials	P99	1
Art Therapy	P175	1	Journal of Family Psychology	P167	1	Work	P126	1
Autism Research	P19	1	Journal of Forensic Psychiatry and Psychology	P231	1	World Health	P241	1
Behavior Therapy	P95	1	Journal of Health Psychology	P141	1	World Journal of Biological Psychiatry	P204	1
Behavioral and Brain Functions	P139	1	Journal of Nonverbal Behavior	P190	1	Zeitschrift fur Psychiatrie, Psychologie und Psychotherapie	P24	1
Behavioral Neuroscience	P27	1	Journal of Intellectual Disability Research	P199	1			

S4: Cognitive Rehabilitation Programs

Targeted Interventions		
Named Intervention Program	**Ref**	**#ref**
Social Cognition and Interaction Training (SCIT)	P10, P40, P45, P47, P94, P117, P153, P177, P179, P180, P228, P230	12
Training of Affect Recognition (TAR)	P59, P92, P128, P191, P204, P237, P238	7
Conversation-Based Intervention	P21, P22, P38, P118, P119, P120, P186	7
Mind Reading	P88, P115, P116, P215, P216, P233	6
summerMAX	P123, P124, P125, P183, P213, P214	6
Mentalization-Based Therapy (MBT)	P32, P221, P231, P232	4
Micro-Expression Training Tool (METT)	P131, P132, P188, P189	4
The Theory of Mind Training	P18, P19, P81, P99	4
Metacognitive Reflective and Insight Therapy (MERIT)	P33, P96, P98	3
Metacognitive Training (MCT)	P80, P170, P220	3
Social Cognitive Skills Training (SCST)	P86, P103, P104	3
Social Cognitive Training Program (PECS)	P83, P84, P85	3
Attentional Shaping Program	P46, P48	2
Cognitive Remediation and Emotion Skills Training (CREST)	P141, P212	2
Cognitive Remediation of Theory of Mind (ToMRemed)	P14, P108	2
Emotion and ToM Imitation Training (ETIT)	P138, P164	2
Frankfurt Test and Training of Facial Affect Recognition (FEFA)	P26, P27	2
Mental-State Reasoning Training for Social Cognitive Impairment (SoCog-MSRT)	P130, P133	2
Metacognitive and Social Cognitive Skills Program (MSCT)	P181, P182	2
Online Social Cognitive Program "SocialVille"	P144, P185	2
RC2S (Remédiation Cognitive de la Cognition Sociale) Program	P161, P162	2
Social Cognition and Interaction Training Modified for High Functioning Autism (SCIT-A)	P126, P219	2
Theory of Mind Intervention (ToMI)	P15, P17	2
Augmented Reality-based Video-Modeling with Storybook (ARVMS)	P41	1
Attributional Style Training "Positive Interpretation Training"	P95	1
Coaching and Rewarding Emotional Skills (CARES)	P51	1
Cognitive-Emotional Rehabilitation (REC)	P227	1
Emotional Management Training (EMT)	P43	1
Emotion Recognition Training (SoCog-ERT)	P133	1
E-Motional Training	P225	1
FaceGen	P202	1
Gaïa s-face program	P79	1
JeStiMulE	P198	1
Let's Talk about Emotions!	P151	1
LIFEisGAME	P5	1
Mary/Eddie/Bill (MEB)	P178	1
Metacognition-Oriented Social Skills Training (MOSST)	P152	1
Microexpression Recognition Training Tool (The MIX Program)	P190	1
Nonverbal communication, Emotion recognition, and Theory of mind Training (Seaver-NETT)	P201	1
Social Cognition and Interaction Training Modified for Family-Assisted (F-SCIT)	P209	1
Social Cognition and Interaction Training Modified for Inpatient Forensic Wards (IFW-SCIT)	P211	1
Social Cognition Enhancement Training (SCET)	P44	1
Theory-of-Mind based Social Skills Group Training for Children and Adolescents with ASD (TOMTASS)	P24	1
Understanding Social Situations (USS)	P71	1

(Unnamed) Intervention Focused on	**Ref**	**#ref**
Theory of Mind	P1, P2, P3, P15, P16, P20, P35, P42, P58, P69, P87, P90, P91, P105, P107, P110, P127, P134, P150, P155, P168, P169, P187, P194, P195, P197, P217, P218, P234, P239, P240	31
Attributional Bias	P36, P56, P72, P82, P154, P160, P203, P222, P223, P224	10
Emotional Processing	P15, P16, P25, P53, P56, P90, P91, P97, P107, P145, P150, P156, P165, P171, P173, P196, P199, P208, P236	19
Social Perception	P137, P107	2

Broad-Based Intervention	Ref	#ref
Cognitive Enhancement Therapy (CET)	P60, P61, P62, P63, P64, P65, P66, P67, P100, P109, P121	11
Integrated Psychological Therapy (IPT)	P74, P172, P206, P241	4
Auditory-Based Cognitive Training plus Social-Cognition Training (AT+ SCT)	P101, P102, P192	3
Cognitive Pragmatic Treatment (CPT)	P28, P76	2
REHACOP (Programa de REHAbilitación COgnitiva en Psicosis)	P157, P158	2
Computerized Drill Training (CDT) Program	P34	1
Mind Reading: Interactive Guide to Emotions (MRIGE)	P122	1
Integrated Neurocognitive Therapy (INT)	P143	1
Neuropersonal Trainer- Mental Health (NPT + MH)	P70	1

Non-Specific Treatment of Social Cognition	Ref	#ref
Cognitive and Behavioral Therapies	P6, P7, P8, P9, P11, P12, P13, P31, P50, P54, P57, P73, P75, P89, P93, P106, P113, P136, P146, P147, P149, P166, P176, P184, P200, P210, P226, P229	28
Neurocognition Training	P23, P30, P39, P140, P148	5
Art Therapy	P114, P142, P175, P205	4
Mindfulness	P52, P112, P139, P207	4
Physical activity	P37, P77, P148	3
Reading	P29, P111, P163	3
Films	P159, P235	2
Meditation	P129, P135	2
Other psychotherapies	P55, P78	2
Psychoeducation	P167, P174	2
Psychosocial and Employment Rehabilitation	P4, P49	2
Animal-Assisted Therapy	P193	1
Language Therapy	P68	1

3.1.2. Pharmacological Interventions in Social Cognition Deficits: A Systematic Mapping Review

Datos de la publicación

RESUMEN:
La cognición social es un campo de investigación importante en la psiquiatría debido a su relevancia en el funcionamiento y la calidad de vida de los pacientes. El objetivo de este trabajo es llevar a cabo una revisión de mapeo sistemático de las estrategias farmacológicas para mejorar los déficits de la cognición social. Se revisaron las publicaciones de 2006 a 2016 en Scopus, PsycINFO, PubMed y Embase. De las 1059 publicaciones iniciales obtenidas, se seleccionó un número final de 110. Los resultados muestran un creciente interés por los enfoques farmacológicos en diferentes campos de la medicina (especialmente la psiquiatría, la farmacología y la endocrinología, siendo la esquizofrenia y el autismo los trastornos más estudiados), como se puede observar en el progresivo aumento del número de publicaciones, el alto grado de evidencia científica y el alto factor de impacto de las publicaciones. Sin embargo, también se observa que la mayoría de los estudios se realizaron con oxitocina, psicoestimulantes y antipsicóticos (principalmente risperidona y olanzapina), siendo pocos los estudios en los que se utilizaron otros fármacos. En los diferentes dominios de la cognición social, la mayoría de las publicaciones se centraron en el procesamiento emocional o la teoría de la mente, con pocos estudios en otros dominios. Por lo tanto, esta revisión de mapeo sistemático muestra que, aunque hay un aumento en las actividades de investigación, existen algunas lagunas importantes que deben ser cubiertas en investigaciones futuras.

CITACIÓN:
P. Fernández-Sotos, E. Navarro, I. Torio, M. Dompablo, A. Fernández-Caballero, R. Rodriguez-Jimenez (2018) "Pharmacological Interventions in Social Cognition Deficits: A Systematic Mapping Review", *Psychiatry Research* 270:57–67; doi:10.1016/j.psychres.2018.09.012.

Datos de la publicación (cont.)

Reprinted from Publication "Pharmacological Interventions in Social Cognition Deficits: A Systematic Mapping Review, Psychiatry Research 270:57–67; doi:10.1016/j.psychres.2018.09.012", with permission from Elsevier.

ÍNDICES DE CALIDAD:

Índice de impacto 2018: 2,208.

Cuartil: Q2.

Rango (Categoría): 62/142 (Psychiatry).

Psychiatry Research 270 (2018) 57–67

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Pharmacological interventions in social cognition deficits: A systematic mapping review

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ARTICLE INFO

Keywords:
Pharmacological intervention
Social cognition
Emotional processing
Theory of mind
Social perception
Attributional bias
Systematic mapping review

ABSTRACT

Social cognition is an important research field in psychiatry due to its relevance in the functioning and quality of life of patients. The objective of this work is to conduct a systematic mapping review of pharmacological strategies for improving social cognition deficits. Publications from 2006 to 2016 were reviewed in Scopus, PsycINFO, PubMed, and Embase. From the initial 1059 publications obtained, a final number of 110 were selected. The results show an increasing interest in pharmacological approaches in different medical fields (especially psychiatry, pharmacology, and endocrinology, with schizophrenia and autism as the most studied disorders), as can be observed in the progressive increase in the number of publications, the high degree of scientific evidence, and the high impact factor of publications. However, it is also observed that most studies were conducted with oxytocin, psychostimulants, and antipsychotics (mainly risperidone and olanzapine), with few studies using other drugs. In the different social cognition domains, the majority of publications were focused on emotional processing or theory of mind, with few studies in other domains. Thus, this systematic mapping review shows that, even though there are increasing research activities, there are some important gaps to cover in future investigation.

1. Introduction

Social cognition refers to the set of mental operations that underlie social interactions, such as perceiving, interpreting, and generating responses to intentions, emotions, tendencies, and behaviors of others (Brothers, 1990; Fiske and Taylor, 1991; Green et al., 2008; Kunda, 1999; Ostrom, 1984). Social cognition is fundamental to the proper functioning and development of the life of humans as social beings. Numerous psychiatric disorders are deficient in social cognition, resulting in negative consequences. It has been shown that social cognition contributes to the functionality and quality of life of patients with psychiatric disorders (Couture et al., 2006; Fett et al., 2011; Green et al., 2008; Lahera et al., 2012; Schmidt et al., 2011).

Schizophrenia is one of the most studied disorders in psychiatry and is a good example of a disorder exhibiting an important deficit in social cognition. Schizophrenia is a serious mental disorder that presents a high personal, family, and social cost (Chong et al., 2016; Cloutier et al., 2016; Oliva-Moreno et al., 2006). In schizophrenia, pharmacological treatments have a partial efficacy (moderate-good for the so-called positive symptoms, such as hallucinations and delusions, and very little in so-called negative and cognitive symptoms) (Davis et al., 2014a,b; Fusar-Poli et al., 2015; Ibrahim and Tamminga, 2012; Keshavan et al., 2017; Rowe et al., 2015). Precisely, schizophrenia is one of the disorders in which social cognition deficits have been deeply studied. It has been clearly demonstrated that patients with schizophrenia have an important deficit in social cognition and that this deficit has a major relationship with their functionality and quality of life (Couture et al., 2006; Fett et al., 2011; Green et al., 2008).

During the past decade, there has been a major push in social cognition research, not only in the field of schizophrenia, but also in the

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https://doi.org/10.1016/j.psychres.2018.09.012
Received 17 March 2018; Received in revised form 8 August 2018; Accepted 7 September 2018
Available online 11 September 2018

field of other psychiatric disorders such as autism, bipolar disorder, and depressive disorders (Couture et al., 2010; Samamé, 2013; Weightman et al., 2014). Pharmacological approaches to psychiatric disorders gained a special thrust in the middle of the last century with the discovery of effective antidepressant and antipsychotic drugs. Until then, with exception of electroconvulsive therapy, no biological treatment had shown clear efficacy. Thus, drug research for depressive and anxious disorders focused on the monoaminergic systems (serotonergic, noradrenergic, GABAergic, fundamentally) and drug research for psychotic disorders concentrated on the dopaminergic system. During these decades, scarcely any changes to the original approach occurred, with subsequent developmental drugs presenting improvements in safety and tolerance rather than efficacy.

Following the therapeutic approaches, some authors focused in the relevance of functioning (Morrison et al., 1987; Bellack et al., 1990; Mueser et al., 1990). In this sense, in recent years, there has been a change from thinking about treatments that act on the mere symptomatic control toward therapies with more ambitious goals, such as improving the functioning and quality of life of the patients (Forray and Buller, 2017; Wykes et al., 2011). According to this, given its special relationship with functionality and quality of life, the use of several pharmacological strategies for the improvement of social cognition has been proposed.

Although many published works have studied the usefulness of different pharmacological approaches to social cognition as the main or secondary research objective, we are not aware of the existence of a systematic mapping review such as the one presented in this article. A systematic mapping review is a type of review that enables the contextualization of in-depth systematic literature reviews within wide literature and identification of the gaps in the scientific literature. It is a review that seeks to identify not results, but linkages (Cooper, 2016). Overall, a systematic mapping review could be a systematic approach to understanding the "map" of a research question or a clinical practice (Perryman, 2016). Systematic mapping review is an important tool in offering policymakers, clinical physicians, and researchers an explicit and transparent means of identifying narrower policy and practice-relevant review questions (Grant and Booth, 2009). In this sense, although in psychiatry publications of systematic mapping reviews are still scarce (Forsman et al., 2014; Evans-Lacko et al., 2014; Fernandez et al., 2015; Bantjes et al., 2016), their proliferation in other areas of medicine has been greater in recent years (Brennan et al., 2013; Coast et al., 2014; Booker et al., 2015a,b; Berg et al., 2016; Austvoll-Dahlgren et al., 2016; Chersich et al., 2016; Uttley et al., 2016; Kadi et al., 2017; Österberg et al., 2017; Witzel et al., 2017; Cree et al., 2017; Hillier-Brown et al., 2017; Hoseini et al., 2018; Law et al., 2018). Thus, the objective of the present work is to offer such a systematic mapping review to provide a vision that will help clinicians and researchers to have a clear and global idea of what the current state of the art is in pharmacological approaches to the improvement of social cognition in psychiatric and other medical pathologies.

The remainder of this paper is structured as follows. Section 2 introduces the systematic mapping review methodology, research questions, study search strategy, data extraction and analysis, and the data collection efforts and offers the answers to the research questions. Section 3 discusses the study results and limitations. Section 4 introduces the discussion, whereas Section 5 presents the main risks that may have affected the quality of the study and how they were mitigated or avoided. Finally, Section 6 shows the main conclusions of the paper.

2. Methods

2.1. Research methodology

2.1.1. Research interest

There are some reasons to carry out the present systematic mapping review. The first is to perform a broad analysis of the literature related to pharmacological interventions in social cognition deficits, with the aim of providing summaries of the existing proposals according to some classification criteria. The second is, if possible, to identify which current gaps exist in pharmacological interventions in social cognition deficits to help clinicians and academicians plan future research in this area. The third reason is to look for identifying topics and areas for future systematic literature reviews that will cover smaller research areas after analyzing the literature in depth.

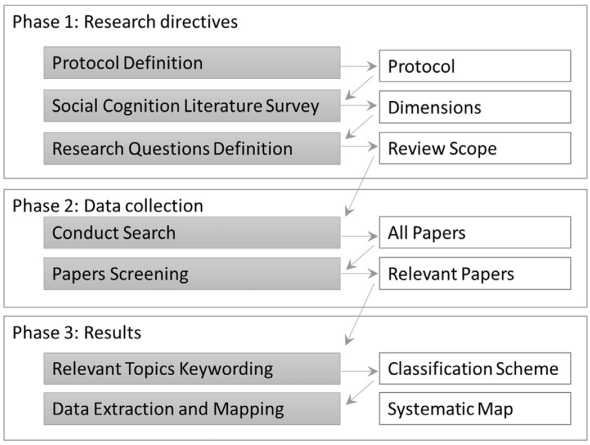

Fig. 1. Systematic mapping review process applied in this work.

To conduct this empirical study, the steps described in the "Template for a Mapping Study Protocol" (EBSE-RG, 2009) were observed. As shown in Fig. 1, the protocol holds three phases: (1) *Research directives* define the protocol applied for this study, identify which dimensions should be analyzed, and then determine which research questions should be answered throughout the work. (2) *Data collection* identifies relevant papers, according to the inclusion and exclusion criteria defined in the protocol. (3) The *Results* phase conducts the mapping of the existing literature, according to the criteria defined and its analysis to answer the posed research questions.

2.1.2. Research directives

In this section, the first phase of the systematic mapping review process, which defines the research protocol and questions, is introduced.

The protocol includes the study topic (pharmacological interventions in social cognition deficits); its justification (previously explained); preliminary research questions; and search strategy, selection criteria, and data extraction form. Also, an overview of the selected papers in terms of their empirical evaluation approaches is indicated. The overview of empirical evaluation approaches indicates the level of empirical evidence. Finally, the protocol includes an overview of the selected papers in terms of their publication venues and years.

The four research questions (RQ) for this study and their rationale are:

RQ1. How many papers have been published on pharmacological treatment of social cognition deficits? Is there any temporal trend?

As discussed in the Introduction section, deficits in social cognition are widespread in the field of psychiatric disorders and are of especial importance in some disorders due to their high prevalence and/or severity, such as depressive disorders, bipolar disorders, and schizophrenia (and related psychotic disorders). From this context, a first step seems to be to determine the number of papers that have been published on pharmacological treatment of social cognition deficits and, second, whether there is a temporal trend (growing or decreasing) in publication output.

RQ2. What medical knowledge areas investigate pharmacological

treatment of social cognition deficits? What types of disorders are investigated?

In addition to being present in psychiatric disorders such as those mentioned earlier, deficits in social cognition occur in neurological disorders such as frontotemporal dementia (Bora et al., 2016; Ibañez and Manes, 2012), Parkinson's disease (Palmeri et al., 2017), and other medical disorders that may have repercussions in the central nervous system such as some genetic-based diseases, for example, fragile X syndrome, Prader-Willi syndrome, and Klinefelter syndrome (Kennedy and Adolphs, 2012). At this point, it is interesting to study in which areas of medical research this field has been developed and, beyond medicine, in related disciplines such as psychology or neuroscience. It is also important to know what types of disorders are investigated in relation to pharmacological treatment of social cognition deficits.

RQ3. What specific domains of social cognition deficits are investigated in pharmacological interventions?

Social cognition is not a single construct, but is rather composed of several domains or dimensions that together make up what we call social cognition. There is some consensus in dividing social cognition into four domains (Pinkham et al., 2014,2016):

1 *Theory of mind*, which is defined as the ability to infer intentions, tendencies, and beliefs of others (Baron-Cohen et al., 2001; Frith, 1992). Several measures in this area were initially developed for use in children with generalized developmental disorders, and the study of theory of mind was subsequently extended to schizophrenia and other disorders (Brune, 2005; Corcoran et al., 1995; Leitman et al., 2006).
2 *Social perception*, which consists of the ability to identify social roles, social rules, and social context (Penn et al., 2002; Sergi and Green, 2003; Toomey et al., 2002). In tests that assess the ability of social perception, the subject must interpret verbal or nonverbal cues to infer interpersonal characteristics of a situation such as intimacy, social status, mood, or the nature of relationships between people (Green et al., 2008).
3 *Attributional bias*, which refers to how people infer the causes of positive or negative concrete events. There are external (to others) or internal (to oneself) attributions. For example, research in schizophrenia has focused on biases of attributing hostility or the tendency to attribute hostile intentions to others (Combs et al., 2007).
4 *Emotional processing*, which can be defined as so-called emotional intelligence and includes identifying, facilitating, understanding, and managing emotions (Mayer et al., 2001; Salovey and Sluyter, 1997).

RQ4. What drugs are used in treatment of social cognition deficits?

Finally, it is of special interest to describe the drugs and substances studied as potential enhancers of social cognition. On the one hand, this study is intended to investigate the utility of psychotropic drugs that have already been used in psychiatric disorders for improving social cognition. On the other hand, molecules or drugs used in other contexts, but which could improve social cognition from a rational or empirical basis, are also engaging.

2.2. Data collection

The study search strategy must lead to inclusion of relevant and exclusion of irrelevant papers. The search strategy of this study involves querying reference databases with customized search strings, followed by manual filtering of the query results, using predefined inclusion and exclusion criteria. Five researchers were involved in executing the search strategy.

2.2.1. Source selection and search string

Because using only one reference database might miss some relevant papers on pharmacological treatment of social cognition deficits, four reference databases in the area were queried: Scopus (Elsevier), PsycINFO (American Psychological Association), PubMed (American Psychological Association), and Embase (Elsevier).

Starting from our research questions, we identified the keywords for the search string. We identified relevant synonyms for the initial keywords and we considered variations of such keywords. All the items in our search string are connected with or/and statements to make sure that all relevant papers are retrieved. The final search string was: ("affect perception" OR "affect recognition" OR “attributional bias” OR "attributional style" OR “emotional processing” OR "emotion recognition" OR "mentalizing" OR "theory of mind" OR "social cognition" OR “social perception”) AND (“rehabilitation” OR “remediation” OR “therapy” OR “treatment” OR “training” OR “enhancement”).

The first part of the search string is composed of words related to social cognition; the second part includes treatment and its synonyms. In each reference database, this string was searched in title, abstract, and keywords fields. Depending on the options offered by each reference database, results were refined by the selected keyword possibilities.

2.2.2. Inclusion and exclusion criteria

We formulated inclusion and exclusion criteria for filtering papers as follows:

- The inclusion criteria were as follows:

  I1. Papers focusing on the topic of social cognition deficits and their treatment.
  I2. Papers published between January 1, 2006, and December 31, 2016.
  I3. Papers focusing on pharmacological interventions.

- The exclusion criteria were as follows:

  E1. Gray literature, because of their unclear peer review process: editorials, extended abstracts, tutorials, tool demos, doctoral symposium papers, research abstracts, book chapters, proceedings, keynote talks, workshop reports, and technical reports.
  E2. Systematic reviews (including meta-analyses) and survey papers not considered in this systematic mapping review. We were interested only in experimental research works, that is, in primary studies.
  E3. Papers from venues other than medicine, psychology, neuroscience, and/or biomedicine (e.g., agriculture, environmental sciences, business, physics, earth sciences, economy, energy).
  E4. Papers that did not relate to humans.

2.2.3. Search process

As shown in the search process described in Fig. 2, the search string was used on each of the four reference databases, and we obtained various numbers of papers from each database. After merging the references and implementing the filters on the papers obtained from the four databases (according to inclusion and exclusion criteria), we got 1059 papers.

Two researchers filtered the 1059 papers in an independent manner by reading the abstract of each paper. In addition, if a researcher was not sure about keeping a specific paper, the researcher read the introduction and conclusion sections of the full content paper. If the researcher was still not sure about including or excluding a paper, or there was no agreement between the classifications of both researchers, the paper was presented in a session to the other researchers and the clinical coordinator of the study for discussion and a consensus decision. This step resulted in 197 references.

Finally, the full content of all 197 papers was read independently by the two researchers to make the final decision about each article. Again,

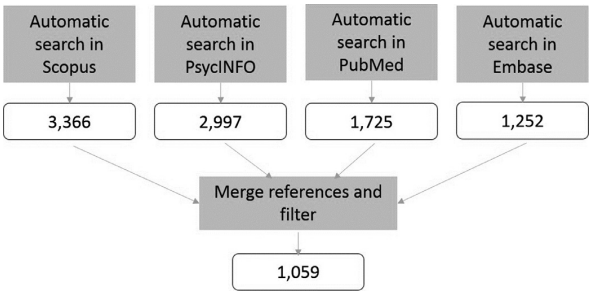

Fig. 2. Search process. Automatic search considers criteria I1 and I2 and exclusion criteria E1, E2, E3, and E4. Merge references and filter considers inclusion criterion I3.

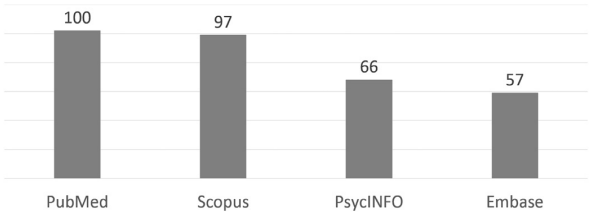

Fig. 3. Database sources in terms of number of references found.

when a researcher was unsure about keeping or removing a paper, or there was no agreement between both classifications, the paper was presented in another session to take a final decision. Overall, this step produced a final set of 110 references. In terms of database source of the 110 references, Fig. 3 shows the number of articles found per database. As can be seen, searching in only one database could cause some papers to be missed, which justified the necessity of combining databases.

3. Results

Finally, 110 papers (see Appendix 1, in Supplemental Materials) were extracted according to the previously described process. Next, we used descriptive statistics and frequency analysis to answer the research questions. An overview of the papers and the answers to the four research questions are presented as follows:

3.1. Overview of selected papers

The overview of the selected papers was presented in terms of the empirical evaluation approach followed and publication venues or years.

3.1.1. Empirical evaluation approach

According to the definition of levels of scientific evidence used by the U.S. Agency for Healthcare Research and Quality, 89 papers presented a IB level of evidence, which is equivalent to "Scientific evidence obtained from at least one randomized clinical trial." Sixteen papers presented a IIA level that is equivalent to "Scientific evidence obtained from at least one well-designed, non-randomized controlled prospective study." Four studies were level IIB, that is, "Scientific evidence obtained from at least one well-designed, quasi-experimental study." Finally, only one paper had evidence level III ("Scientific evidence obtained from well-designed observational studies, such as comparative studies, correlation study, or case-control studies").

3.1.2. Publication venues and years

Fig. 4 shows the journals in which more articles have been published on the utility of drugs for the improvement of social cognition. At the top of the ranking were 16 papers in the journal *Psychoneuroendocrinology*, followed by nine articles in *Biological Psychiatry* and *Psychopharmacology*, seven papers published in *Schizophrenia Research*, and five publications in *European Neuropsychopharmacology*. The complete list of publications appears in Appendix 2 (in Supplemental Materials).

At this point, it is important to highlight that these journals hold a high impact factor. That is, most of the articles analyzed in this systematic mapping review were disseminated in journals with high impact factor according to the Index Journal Report from the Web of Science. In year 2016, the impact factors and quartiles of the five top venues were: *Psychoneuroendocrinology* (4.788; Q1-Endocrinology & Metabolism; Neurosciences; Psychiatry); *Biological Psychiatry* (11.412; Q1–Neurosciences; Psychiatry); *Psychopharmacology* (3.308; Q2–Neurosciences; Pharmacology & Pharmacy; Psychiatry); *Schizophrenia Research* (3.986; Q1-Psychiatry); *European Neuropsychopharmacology* (4.239; Q1–Clinical Neurology; Neurosciences; Pharmacology & Pharmacy; Psychiatry).

In terms of publication years, from 2006 to 2016, there is a growing trend throughout the period, as can be seen in Fig. 5.

3.1.3. RQ1. How many papers have been published on pharmacological treatment of social cognition deficits? Is there any temporal trend?

In the period of study between January 1, 2006, and December 31, 2016, a total of 110 published works about pharmacological treatment of social cognition deficits were found. A temporal trend was observed for a larger number of publications, most of them with a IB level of evidence as can be seen in Fig. 6.

3.1.4. RQ2. Which medical knowledge fields investigate pharmacological treatment of social cognition deficits? What types of disorders are investigated?

The field of knowledge of publications is mostly in medicine (94 papers), and there are also publications in the field of psychology (9 papers) and neuroscience (7 papers). The complete list of 94 references in medicine in relation to European Union of Medical Specialists (UEMS) medical specialties is shown in Fig. 7. Psychiatry is the medical field with the highest number of publications (38 papers), followed by pharmacology and endocrinology with 24 and 19 articles, respectively. Fig. 8 shows the number of references according to UEMS medical specialties crossed with the level of scientific evidence. The intersections with the highest number of publications are UEMS medical specialties psychiatry, pharmacology, and endocrinology and level of evidence IB.

The types of disorders investigated regarding pharmacological treatment of social cognition deficits appear in Table 1. There are 56 references not specifically related to a concrete disorder (for example, those carried out in healthy volunteers). According to our data, schizophrenia and autism spectrum disorder are the most studied disorders.

3.1.5. RQ3. What specific domains of social cognition deficits are investigated in pharmacological interventions?

Within the different domains of social cognition, the most studied in relation to its likely improvement by using pharmacological strategies is emotional processing, with 80 papers, followed by 32 articles in theory of mind, and 13 of social perception. Only one publication was found on the usefulness of pharmacological approaches in attributional bias. Some studies used measures of two or three domains of social cognition, as depicted in Fig. 9, showing all the works found in the bibliography (see Appendix 1, in Supplemental Materials) grouped by social cognitive domains.

Finally, Fig. 10 shows the number of references according to the levels of scientific evidence and the domains of social cognition. The largest number of published works was on emotional processing with a IB level of evidence, followed by publications about theory of mind at the same IB level.

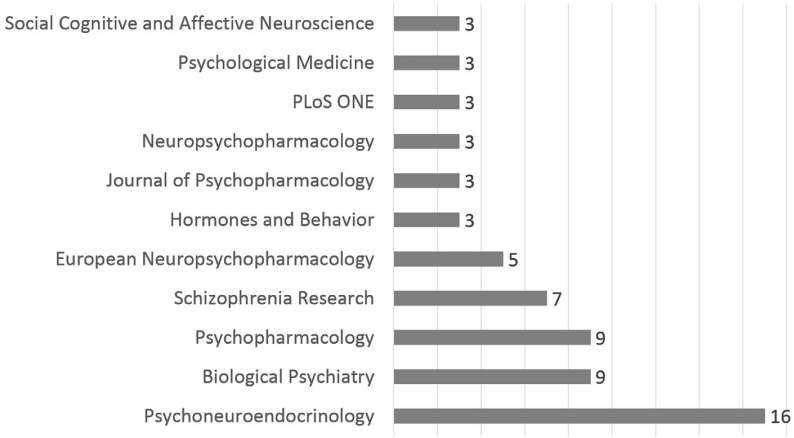

Fig. 4. Number of papers published in the top 11 publication venues.

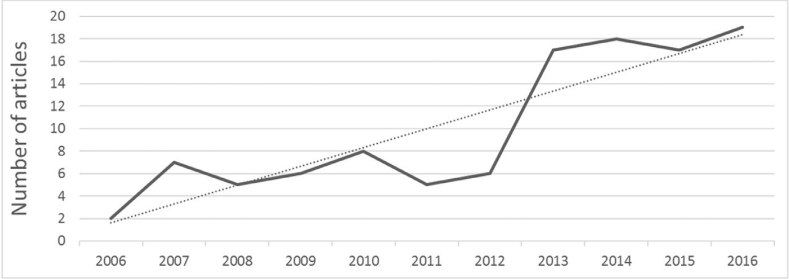

Fig. 5. Number of selected papers over the publication years.

3.1.6. RQ4. Which drugs are used to treat social cognition deficits?

As shown in Fig. 11, the category of drugs with the highest number of publications refers to treatments with hypothalamic hormones, remotely followed by antipsychotic drugs, amphetamines and other psychostimulants, and sex hormones.

In Table 2, the categories of pharmacological treatment are divided by specific drugs. Thus, the 59 articles on hypothalamic hormones refer primarily to oxytocin (56 references only to oxytocin and 1 to oxytocin and vasopressin). In the category of antipsychotics, the most studied were olanzapine and risperidone; in the category of psychostimulants are methylphenidate and methylenedioxyamphetamine; and in the category of sex hormones the most studied are estrogen and testosterone. Given the high presence of oxytocin studies, a comparison of the number of references to oxytocin versus other drugs used across the time in treatment of social cognition deficits is shown in Fig. 12. This figure also shows the number of papers (n = 39) in which oxytocin produces any change in variables directly related to social cognition.

4. Discussion

In the present work, a systematic mapping review of pharmacological approaches for improvement of social cognition deficits that have been presented in different disorders published in past years (2006–2016) has been produced. The results obtained are important and show a global view of the current state of knowledge in this area; both the points of greater study and those that show little developed research are highlighted.

Regarding the empirical evaluation approach, 89 (89/110) have a IB level of evidence, according to the U.S. Agency for Healthcare Research and Quality definition of levels of scientific evidence. This

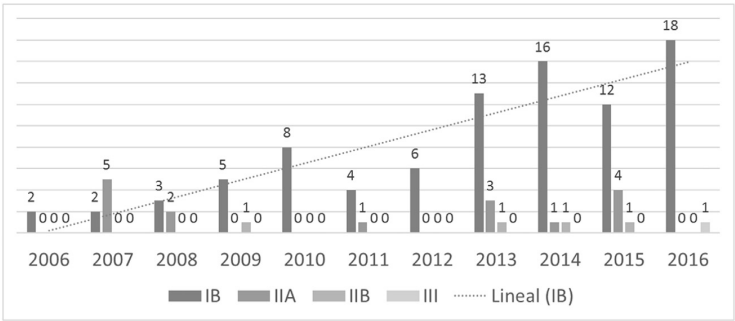

Fig. 6. Number of references per year and level of scientific evidence.

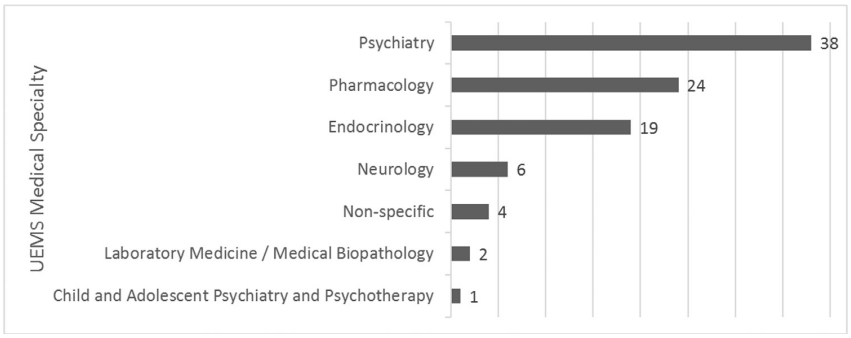

Fig. 7. Number of references in relation to UEMS medical specialties.

corresponds to studies with evidence obtained from at least one randomized controlled clinical trial. It is the highest degree of evidence that can be found in papers included in this systematic mapping review. It is worth noting that level IA corresponds to evidence obtained from meta-analysis, which belongs to one of the exclusion criteria.

The predominance of publications with a high level of evidence is especially useful for the clinical application of the results, which could point to an important degree of maturity in the state of the art. Thus, studies with a low level of evidence, such as single cases, case series, and so on, tend to predominate in the initial stages of therapeutic research. Later, when the potential possibilities of some approaches have been published, the researchers conduct controlled studies with a higher level of evidence. Given the high proportion of studies with IB level and the high economic cost of this type of study, the current interest in this subject is evident, not only for researchers and clinicians but also for industry as well as for different funding agencies, both public and private.

In relation to publication venues, it is interesting to highlight that most works were disseminated in journals with high impact factor. Almost all venues are in the first quartile of their field of knowledge. For instance, the journal with the highest number of published works—*Psychoneuroendocrinology*, with 17 papers—has an impact factor of 4,788 in 2016. The fact that the publications appear in journals with a high level of impact is in clear correlation with the high level of scientific evidence previously indicated.

With respect to the temporal evolution of the number of publications over the past ten years, a progressive increase has become more evident in the past four years, mainly in IB level of evidence. This fact is related to the progressive scientific interest in the study of social cognition and its deficits and, increasingly, in potential pharmacological strategies to alleviate such deficits and their impact on the patients' functionality and quality of life.

Regarding areas of knowledge, it is evident from the results that the greatest number of publications are connected to medicine, and within medicine they belong to the UEMS medical specialties of psychiatry, pharmacology, and endocrinology (in that order). The presence of studies in the area of psychiatry is easy to understand because social cognition deficits frequently appear in numerous psychiatric disorders. Similarly, when talking about pharmacological approaches, it is logical that the specialty of pharmacology would be another area with an important number of publications. A priori, it may be striking that the specialty of endocrinology is in third position, because the alteration in social cognition is not usually a symptom of endocrine disorders. However, as mentioned in the Results section of the present systematic mapping review, there are numerous studies on the usefulness of oxytocin hormone to improve social cognition, which explains the important presence of publications in the specialty of endocrinology. There is a manifest predominance of IB level of evidence in all three specialties, following the lines discussed previously. Regarding specific disorders, schizophrenia and autism spectrum disorder are the most studied disorders. This could be due to the important deficits in social cognition among these disorders and social cognition's important relationship with functionality and quality of life for these patients (Couture et al., 2006, 2010; Fett et al., 2011; Green et al., 2008).

According to the Social Cognition Psychometric Evaluation (SCOPE) study (Pinkham et al., 2014, 2016), there are four domains within social cognition. Of these, in this systematic mapping review, emotional processing has been detected as the most reported domain, followed by theory of mind. There are fewer publications on social perception, and only one paper was found in the domain of attributional bias. These results are similar to those observed in systematic reviews of interventions to improve social cognition (pharmacological and

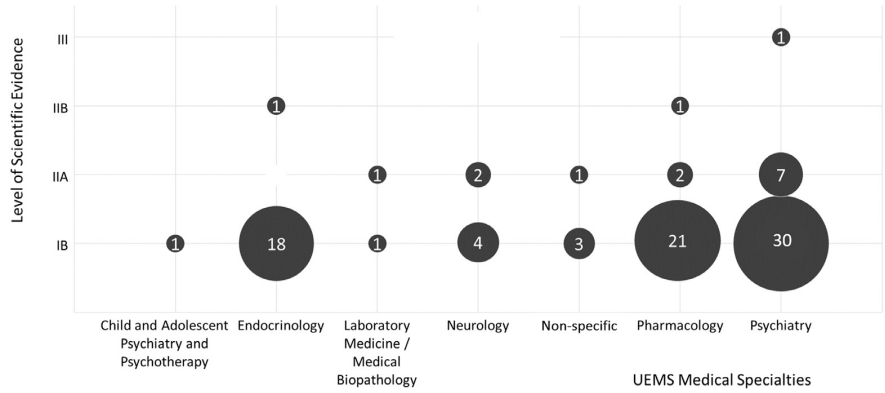

Fig. 8. Number of references according to UEMS medical specialties and level of scientific evidence.

Table 1
Category of disorders regarding pharmacological treatment of social cognition deficits.

Category of disorders	Number of references	Disorder	Number of references	References
Schizophrenia spectrum and other psychotic disorders	27	Schizophrenia	26	P2, P14, P17, P21, P22, P28, P29, P32, P34, P42, P48, P54, P61, P64, P67, P70, P76, P77, P80, P81, P88, P90, P93, P96, P98, P110
		Schizophreniform disorder	2	P17, P76
		Schizoaffective disorder	2	P17, P76
		Schizotypal (Personality) disorder	1	P45
Neurodevelopmental disorders	12	Autism spectrum disorder	8	P3, P4, P5, P20, P25, P38, P43, P47
		Attention-deficit/hyperactivity disorder	3	P12, P72, P108
		Other neurodevelopmental disorders	1	P92
Bipolar and related disorders	3	Bipolar disorder	3	P19, P44, P56
Depressive disorders	3	Major depressive disorder	2	P35, P71
		Persistent depressive disorder (dysthymia)	1	P27
Neurocognitive disorders	3	Major or mild frontotemporal neurocognitive disorder	2	P55, P79
		Major and mild neurocognitive disorders	1	P74
Substance-related and addictive disorders	3	Alcohol use disorder	2	P75, P109
		Cocaine use disorder	1	P8
		Opioid use disorder	1	P109
Feeding and eating disorders	1	Anorexia nervosa	1	P59
		Bulimia nervosa	1	P59
Disruptive, impulse-control, and conduct disorders	1	Conduct disorder	1	P58
Somatic disorders	1	Secondary adrenal insufficiency	1	P16

psychosocial treatments) in patients with schizophrenia (Tan et al., 2016). A feasible explanation for these results may be related to the fact that the evaluation instruments of emotional processing and theory of mind domains can be considered more objective and less influenced by cultural aspects, as in the case of social perception (Hong et al., 2003). On the other hand, it has previously been pointed out that the possibilities of improvement in social perception and attributional bias domains could be lower than in the domains of social perception and theory of mind (Kurtz and Richardson, 2012), which could lead to more studies in domains with greater margins of improvement.

The results obtained in the present systematic mapping review on pharmacological treatment of social cognition deficits show that many publications use treatments with hypothalamic hormones, followed at a distance by other substances such as antipsychotic drugs, amphetamines, and sex hormones. In this sense, it is necessary to emphasize the high number of studies with oxytocin hormone. This hormone is involved in the regulation of complex social cognition and behavior (Meyer-Lindenberg et al., 2011). Its participation in the processes of cognition and social behavior, as well as the possibility of intranasal administration, has nominated oxytocin as a firm candidate for studies of social cognition improvement. Thus, as shown in Fig. 12, after initial studies there has been a significant increase in oxytocin publications in recent years. However, although the results show an increase in the number of publications, this is not necessarily related to the efficacy of the approach. As shown in Fig. 12, not all oxytocin studies have found changes in social cognition. This is in accordance with a recent meta-analysis (Keech et al., 2018) that has not found robust evidence of the efficacy of oxytocin to improve social cognition.

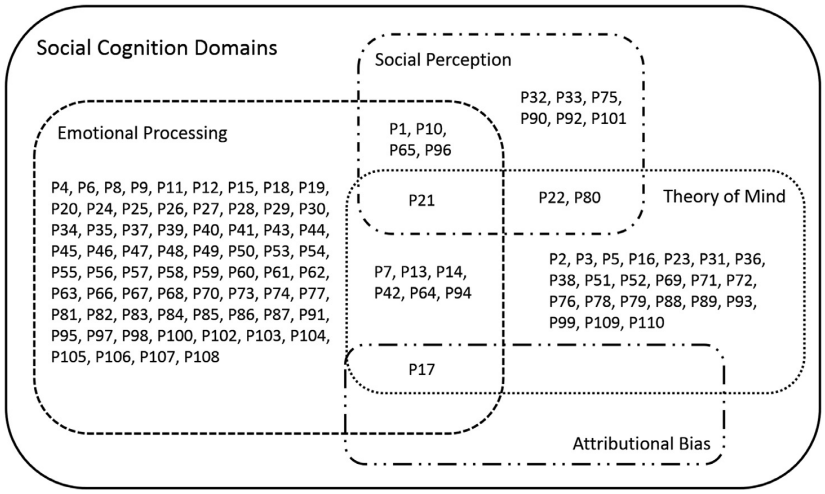

Fig. 9. Categorization of papers (see Appendix 1 in Supplemental Materials) in terms of social cognition domains.

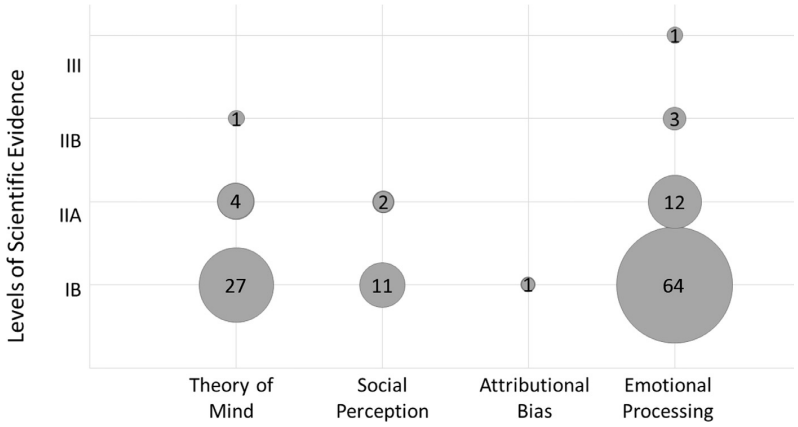

Fig. 10. Number of references according to the levels of scientific evidence and the domains of social cognition.

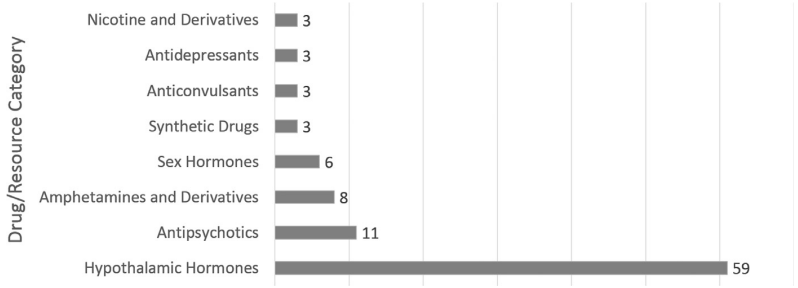

Fig. 11. Number of references and drug categories (top 8) used in the treatment of social cognition deficits.

Table 2
Number of references by category and drug used in the treatment of social cognition deficits.

CATEGORY	DRUG/COMPONENT	References	CATEGORY	DRUG / COMPONENT	References
Adrenal hormones	Corticoid therapy	2	Cannabis and derivatives	Cannabidiol	1
Amino acids	Tryptophan	1		Tetrahydrocannabinol	1
Amphetamines and derivatives	Methylenedioxymethamphetamine	4	Cholinesterase inhibitors	Donepezil	1
	Methylphenidate	4		Galantamine	1
	Amphetamine	1	Diuretics	Bumetanide	1
	Methamphetamine	1	Drugs	Carbidopa/Entacapone/Levodopa	1
Analgesics	Buprenorphine	1		Cocaine	1
Anticonvulsants	Lamotrigine	2	**Hypothalamic hormones**	**Oxytocin**	57
	Divalproex sodium	1		Vasopressin	3
Antidepressants	Citalopram	1			
	Escitalopram	1	Neurotoxins	Botulinum Toxin-A	1
	Fluoxetine	1	Neurotrophic peptides	Davunetide	1
	Paroxetine	1	Nicotine and derivatives	Nicotine	2
Antioxidant drugs	Ebselen	1		Varenicline	1
Antipsychotics	Olanzapine	6	Nutraceuticals	Souvenaid	1
	Risperidone	6	Opioid antagonists	Naltrexone	1
	Haloperidol	4	Plant resources	Withania somnifera	1
	Clozapine	3	Psychoactive drugs	Diazepam	1
	Quetiapine	3	Sex hormones	Estrogen	2
	Perphenazine	2		Testosterone	2
	Aripiprazole	1		Androgen	1
	Chlorpromazine	1		Androstadienone	1
	Emonapride	1	Synthetic drugs	Gamma-hydroxybutyrate	1
	Flupenthixol decanoate	1		Ketanserin	1
	Loxapine	1		Lysergic acid diethylamide	1
	Perospirone	1		Psilocybin	1
	Ziprasidone	1			

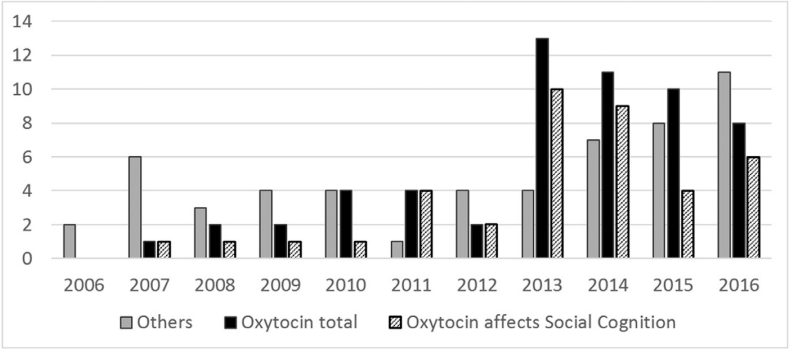

Fig. 12. Comparison of the number of references to oxytocin used in the treatment of social cognition deficits versus other drugs. A third type of bar has been added that represents the number of papers in which oxytocin produced any change in variables directly related to social cognition.

5. Assessment of risk of bias

One of the risks that may affect a systematic mapping review is related to selective reporting bias (Higgins and Altman, 2008), because analyses with statistically significant differences are more frequently published. To minimize such risk, we used four databases as sources for the search process: PsycINFO, PubMed, Embase, and Scopus. These provide a comprehensive list of articles that cover the different aspects of this systematic mapping review. It is worth noting that gray literature (e.g., theses, internal reports, etc.) should be excluded from the study as an exclusion criterion. This may threaten the validity of our study, but it must be emphasized that gray literature is mostly published without such a rigorous review process as the one followed by journals. Another possible risk that could have affected this study is the *selection bias*. This is related to the criteria used to select the articles to be analyzed during the study. To mitigate such risk, both the inclusion and exclusion criteria were clearly defined. Finally, another possible risk is related to the likely *inaccuracy in data extraction and misclassification*, that is, the chance of classifying a study in different ways. This risk was mitigated because classification and extraction data processes were made in an independent manner by two researchers, and when a researcher had any doubts or when there were discrepancies between the two researchers' classifications, the papers were revised by the other researchers and the clinical coordinator of the study for discussion in a dedicated session.

6. Conclusions

The present systematic mapping review demonstrates an increasing interest in the research of pharmacological approaches that aim to improve social cognition according to publications in different medical areas (especially psychiatry, pharmacology, and endocrinology). Proof of this is the progressive increase in the number of publications (more evident in the past four years), the high degree of scientific evidence of most of them, and the high impact factor in the categories of such publications.

However, it was also observed that most studies were conducted with the oxytocin hormone, with psychostimulants and antipsychotics (mainly risperidone and olanzapine) and few studies administering other drugs, which leaves open an important field of research. On the other hand, the research work has focused on the study of two domains of social cognition, namely emotional processing and theory of mind, with few studies on social perception and only one on attributional bias, which also leaves open new future research routes. Finally, it must be pointed out that, in parallel with the pharmacological studies reviewed in the present work, there is important research in nonpharmacological social cognition remediation interventions that have an important complementarity with pharmacological treatments.

Funding/support

This work was partially supported by the Spanish Instituto de Salud Carlos IIIunder a PI16/00359 grant, and the Spanish Ministerio de Economía, Industria y Competitividad, Agencia Estatal de Investigación (AEI)/European Regional Development Fund (FEDER, UE) under DPI2016-80894-R and TIN2015-72931-EXP grants; by the Madrid regional government (R&D activities in Biomedicine S2017/BMD-3740 [AGES-CM 2-CM]) and Structural Funds of the European Union, and by the Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM) of the Instituto de Salud Carlos III.

Authorship contributions

AFC, EN, PFS, and RRJ designed the study and wrote the protocol. PFS, EN, IT, and MD managed the literature searches. PFS and IT reviewed the papers. In cases of doubt or no agreement, AFC, MD, and RRJ (clinical coordinator) participated in the final decision. AFC, MD, and EN undertook the statistical analysis and made the tables and figures. PFS, EN, AFC, and RRJ made the first draft of the manuscript. All authors contributed to and approved the final manuscript.

Declaration of interest

Dr. R. Rodriguez-Jimenez has been a consultant for, spoken in activities of, or received grants from: the Instituto de Salud Carlos III; Fondo de Investigación Sanitaria (FIS); Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM); Madrid regional government (S2010/ BMD-2422 AGES); and Janssen-Cilag, Lundbeck, Otsuka, Pfizer, Ferrer, Juste. The other authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Acknowledgments

Instituto de Salud Carlos III, Agencia Estatal de Investigación (AEI)/ European Regional Development Fund (FEDER, UE), Madrid Regional Government, and CIBERSAM. These funding sources were not involved in study design; collection, analysis, and interpretation of data; writing of the report; or in the decision to submit the paper for publication.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2018.09.012.

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Supplementary data. Appendix 1: Selected papers

P1 (aan het Rot et al., 2006)
P2 (Abu-Akel et al., 2014)
P3 (Anagnostou et al., 2012)
P4 (Andari et al., 2016)
P5 (Aoki et al., 2014)
P6 (Baumeister et al., 2016)
P7 (Bedi et al., 2010)
P8 (Bedi et al., 2016)
P9 (Bernaerts et al., 2016)
P10 (Bershad et al., 2016)
P11 (Besnier et al., 2010)
P12 (Beyer von Morgenstern et al., 2014)
P13 (Bosch et al., 2015)
P14 (Brambilla et al., 2016)
P15 (Brunnlieb et al., 2013)
P16 (Werumeus Buning et al., 2015)
P17 (Cacciotti-Saija et al., 2015)
P18 (Cardoso et al., 2014)
P19 (Chengappa et al., 2013)
P20 (Dadds et al., 2014)
P21 (Davis et al., 2014)
P22 (Davis et al., 2013)
P23 (DeSoto et al., 2007)
P24 (Dolder et al., 2016)
P25 (Domes et al., 2013)
P26 (Domes et al., 2010)
P27 (Domes et al., 2016)
P28 (Drusch et al., 2013)
P29 (Fakra et al., 2009)
P30 (Feeser et al., 2014)
P31 (Feeser et al., 2015)
P32 (Fischer-Shofty et al., 2013a)
P33 (Fischer-Shofty et al., 2013b)
P34 (Fischer-Shofty et al., 2013c)
P35 (Fu, 2007)
P36 (Gallup and Church, 2015)
P37 (Guastella et al., 2009)
P38 (Guastella et al., 2010a)
P39 (Guastella et al., 2010b)
P40 (Guastella et al., 2008a)
P41 (Guastella et al., 2008b)
P42 (Guastella et al., 2015)
P43 (Hadjikhani et al., 2015)
P44 (Haldane et al., 2008)
P45 (Hindocha et al., 2015)
P46 (Hirosawa et al., 2015)
P47 (Hollander et al., 2007)
P48 (Horta de Macedo et al., 2014)
P49 (Hu et al., 2015)
P50 (Hummer and McClintock, 2009)
P51 (Hurlemann et al., 2010)
P52 (Hysek et al., 2012)
P53 (Hysek et al., 2014)
P54 (Jarskog et al., 2013)
P55 (Jesso et al., 2011)
P56 (Jogia et al., 2008)
P57 (Kalafatakis et al., 2016)
P58 (Khanzode et al., 2006)
P59 (Kim et al., 2015)
P60 (Kis et al., 2013)
P61 (Kohler et al., 2007)
P62 (Kometer et al., 2012)
P63 (Korb et al., 2016)
P64 (Kucharska-Pietura et al., 2012)
P65 (Kumar et al., 2015)
P66 (Leknes et al., 2013)
P67 (Lindenmayer and Khan, 2011)
P68 (Lischke et al., 2012)
P69 (Luminet et al., 2011)
P70 (Maat et al., 2014)
P71 (MacDonald et al., 2013)
P72 (Maoz et al., 2014)
P73 (Masaki et al., 2016)
P74 (McGregor et al., 2016)
P75 (Mitchell et al., 2016)
P76 (Mizrahi et al., 2007)
P77 (Olivier et al., 2015)
P78 (Olsson et al., 2016)
P79 (Pardini et al., 2015)
P80 (Pedersen et al., 2011)
P81 (Penn et al., 2009)
P82 (Perry et al., 2013)
P83 (Perry et al., 2010)
P84 (Prehn et al., 2013)
P85 (Pringle et al., 2016)
P86 (Quintana et al., 2016)
P87 (Quintana et al., 2015)
P88 (Quisenaerts et al., 2014)
P89 (Riem et al., 2014)
P90 (Roberts et al., 2010)
P91 (Rock et al., 2016)
P92 (Samango-Sprouse et al., 2015)
P93 (Savina and Beninger, 2007)
P94 (Schmid et al., 2014)
P95 (Schulze et al., 2011)
P96 (Sergi et al., 2007)
P97 (Sripada et al., 2013)
P98 (Sumiyoshi et al., 2009)
P99 (Tabak et al., 2015)
P100 (Theodoridou et al., 2013)
P101 (Theodoridou et al., 2009)
P102 (Thienel et al., 2014)
P103 (Tse et al., 2014)
P104 (Voorthuis et al., 2014)
P105 (Wardle et al., 2016)
P106 (Wardle et al., 2012)
P107 (Weigand et al., 2013)
P108 (Williams et al., 2008)
P109 (Woolley et al., 2016)
P110 (Woolley et al., 2014)

Supplementary data. Appendix 2: Publication venue

Journal	Papers	References
Psychoneuroendocrinology	(Bernaerts et al., 2016); (Bershad et al., 2016); Quintana et al., 2016); (Bosch et al., 2015); (Werumeus Buning et al., 2015); (Feeser et al., 2015); (Tabak et al., 2015); (Thienel et al., 2014); (Woolley et al., 2014); (MacDonald et al., 2013); (Perry et al., 2013); (Lischke et al., 2012); (Schulze et al., 2011); (Domes et al., 2010); (Perry et al., 2010); (Guastella et al., 2009)	16
Biological Psychiatry	(Domes et al., 2013); (Kometer et al., 2012); (Bedi et al., 2010); (Guastella et al., 2010a); (Guastella et al., 2010b); (Guastella et al., 2008a); (Guastella et al., 2008b); (Williams et al., 2008); (Hollander et al., 2007); (Luminet et al., 2011)	10
Psychopharmacology	(Masaki et al., 2016)(Pringle et al., 2016); (Woolley et al., 2016); (Feeser et al., 2014); (Quisenaerts et al., 2014); (Weigand et al., 2013); (Hysek et al., 2012); (Wardle et al., 2012); (Besnier et al., 2010)	9
Schizophrenia Research	(Guastella et al., 2015); (Davis et al., 2013); (Fischer-Shofty et al., 2013a); (Lindenmayer and Khan, 2011); (Pedersen et al., 2011); (Penn et al., 2009); (Savina and Beninger, 2007)	7
European Neuropsychopharmacology	(Brambilla et al., 2016); (Hindocha et al., 2015); (Maat et al., 2014); (Tse et al., 2014); (Haldane et al., 2008)	5
Hormones and Behavior	(Korb et al., 2016); (Hummer and McClintock, 2009); (Theodoridou et al., 2009)	3
Journal of Psychopharmacology	(Bedi et al., 2016); (Maoz et al., 2014); (Schmid et al., 2014)	3
Neuropsychopharmacology	(Dolder et al., 2016); (Davis et al., 2014); (Jarskog et al., 2013)	3
PLoS ONE	(Hirosawa et al., 2015); (Kim et al., 2015); (Theodoridou et al., 2013)	3
Psychological Medicine	(Olivier et al., 2015); (Abu-Akel et al., 2014); (Mizrahi et al., 2007)	3
Social Cognitive and Affective Neuroscience	(Hysek et al., 2014); (Fischer-Shofty et al., 2013b); (Leknes et al., 2013)	3
American Journal of Psychiatry	(Fu, 2007); (Sergi et al., 2007)	2
Brain	(Aoki et al., 2014); (Jesso et al., 2011)	2
Brain Research	(Voorthuis et al., 2014); (Brunnlieb et al., 2013)	2
Emotion	(Olsson et al., 2016); (Cardoso et al., 2014)	2
International Journal of Neuropsychopharmacology	(Kumar et al., 2015); (Sripada et al., 2013)	2
Psychiatry Research	(Horta de Macedo et al., 2014); (Roberts et al., 2010)	2
Acta Neuropsychiatrica	(Beyer von Morgenstern et al., 2014)	1
American Journal of Medical Genetics, Part C	(Samango-Sprouse et al., 2015)	1
Autism	(Hadjikhani et al., 2015)	1
BMC Psychiatry	(Domes et al., 2016)	1
British Journal of Psychiatry	(Jogia et al., 2008)	1
Child Psychiatry and Human Development	(Khanzode et al., 2006)	1
Clinical Schizophrenia and Related Psychoses	(Kucharska-Pietura et al., 2012)	1
Cognitive Neuropsychiatry	(Kohler et al., 2007)	1
Cortex	(Andari et al., 2016)	1
European Arch. Psychiatry and Clin. Neuroscience	(Drusch et al., 2013)	1
Frontiers in Neuroscience	(Fischer-Shofty et al., 2013c)	1
Frontiers in Psychology	(Kis et al., 2013)	1
Human Brain Mapping	(Hu et al., 2015)	1
Journal of Addiction Medicine	(Mitchell et al., 2016)	1
Journal of Autism and Developmental Disorders	(Dadds et al., 2014)	1

Journal of Clinical Psychiatry	(Chengappa et al., 2013)	1
Journal of Neuroscience	(Hurlemann et al., 2010)	1
Journal of Psychiatry and Neuroscience	(aan het Rot et al., 2006)	1
Journal of Psychopharmacology	(Rock et al., 2016)	1
Molecular Autism	(Anagnostou et al., 2012)	1
Neurodegenerative Diseases	(Pardini et al., 2015)	1
Neuropsychiatric Disease and Treatment	(McGregor et al., 2016)	1
Neuroscience Letters	(Gallup and Church, 2015)	1
North American Journal of Psychology	(DeSoto et al., 2007)	1
Progress in Neuro-Psychopharm. & Biol. Psychiatry	(Riem et al., 2014)	1
Psychiatry Research - Neuroimaging	(Sumiyoshi et al., 2009)	1
Psychophysiology	(Prehn et al., 2013)	1
Schizophrenia Bulletin	(Cacciotti-Saija et al., 2015)	1
Social Neuroscience	(Wardle et al., 2016)	1
Toxicon	(Baumeister et al., 2016)	1
Translational Psychiatry	(Quintana et al., 2015)	1
Trials	(Kalafatakis et al., 2016)	1
World Journal of Biological Psychiatry	(Fakra et al., 2009)	1

3.2. Uso de las tecnologías digitales por parte de los pacientes psicóticos

Digital Technology for Internet Access by Patients With Early Stage Schizophrenia in Spain: Multicenter Research Study

Los resultados de este estudio de investigación multicéntrico indicaron que una gran proporción de pacientes con esquizofrenia en estadio temprano tienen acceso a diferentes dispositivos digitales y los usan con frecuencia. Tanto los pacientes como los controles sanos emparejados coincidieron en el orden de preferencia y el propósito de uso de los dispositivos tecnológicos. Sin embargo, se detecta una menor frecuencia de uso de la mayoría de los dispositivos de tecnología digital en pacientes en comparación con los participantes sanos. Para algunos dispositivos (como las gafas de RV), esto se debe a la imposibilidad de acceso y no a la falta de interés.

3.2.1. Digital Technology for Internet Access by Patients With Early-Stage Schizophrenia: Multicenter Research Study

Datos de la publicación

RESUMEN:

Antecedentes: La tecnología digital y las redes sociales forman parte de la vida cotidiana en la actual era de Internet, especialmente entre los jóvenes. Hasta la fecha, se han publicado pocos estudios en todo el mundo sobre el patrón de uso de los dispositivos y aplicaciones de la tecnología digital en pacientes con esquizofrenia en etapa temprana, y aún menos los que los comparan con participantes sanos (que no utilizan datos de encuestas de la población general) de las mismas áreas demográficas. En España no se ha realizado ningún estudio de este tipo.

Objetivo: El objetivo de este estudio fue analizar cómo los pacientes con esquizofrenia en etapa temprana utilizan Internet y las redes sociales en comparación con los participantes sanos emparejados por edad y sexo y también examinar qué dispositivos se utilizan para acceder a los recursos de Internet.

Métodos: Se realizó un estudio transversal y multicéntrico mediante una entrevista semiestructurada en la que se preguntó sobre el uso de los dispositivos de tecnología digital e Internet. La muestra estuvo compuesta por 90 pacientes y 90 participantes sanos. La entrevista semiestructurada se realizó a 30 pacientes ambulatorios y 30 sujetos sanos en cada una de las 3 ciudades diferentes (Madrid, Alicante y Cuenca). Se utilizó el test t Student para las variables continuas y el test chi-cuadrado para las variables categóricas. En el caso de las variables ordinales, se realizaron pruebas no paramétricas de Mann-Whitney U y Kruskal-Wallis H para muestras independientes para comparar los grupos.

Datos de la publicación (cont.)

Resultados: Los resultados indicaron que una gran proporción de los pacientes con esquizofrenia en etapa temprana tienen acceso a diferentes dispositivos digitales y los usan con frecuencia. Además, ambos grupos coinciden en el orden de preferencia y en el propósito con el que utilizan los dispositivos. Sin embargo, se detectó una menor frecuencia de uso de la mayoría de los dispositivos de tecnología digital en los pacientes en comparación con los participantes sanos. En el caso de algunos dispositivos, esto se debió a la imposibilidad de acceso y no a una falta de interés.

Conclusiones: Se trata del primer estudio que analiza los patrones de acceso a Internet y el uso de dispositivos y aplicaciones de tecnología digital en pacientes españoles con esquizofrenia en fase inicial, en comparación con participantes sanos de las mismas áreas demográficas. Los resultados sobre el acceso y uso significativo de la tecnología digital e Internet que se muestran en este estudio transversal permitirán que se planifiquen estrategias de tratamiento mejoradas y más eficientes, utilizando dispositivos de tecnología digital, para los pacientes con esquizofrenia en fase temprana.

CITACIÓN:

P. Fernández-Sotos, A. Fernández-Caballero, P. González, A.I. Aparicio, I. Martínez-Gras, I. Torio, M. Dompablo, L. García-Fernández, J.L. Santos, R. Rodriguez-Jimenez (2019) "Digital Technology for Internet Access by Patients With Early-Stage Schizophrenia in Spain: Multicenter Research Study", *Journal of Medical Internet Research* 21(3):e11824; doi:10.2196/11824; https://www.jmir.org/2019/4/e11824/.

Datos de la publicación (cont.)

ÍNDICES DE CALIDAD:

Índice de impacto 2019: 5,034.

Cuartil: Q1 (D1).

Rango (Categoría): 2/27 (Medical Informatics); 5/102 (Health Care Sciences & Services).

Original Paper

Digital Technology for Internet Access by Patients With Early-Stage Schizophrenia in Spain: Multicenter Research Study

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Abstract

Background: Digital technology and social networks are part of everyday life in the current internet age, especially among young people. To date, few studies have been published worldwide on the pattern of use of digital technology devices and applications in patients with early-stage schizophrenia and even fewer comparing them with healthy participants (not using data from general population surveys) from the same demographic areas. In Spain, no such study has been carried out.

Objective: The aim of this study was to analyze how patients with early-stage schizophrenia use internet and social networks compared with healthy participants matched by age and gender and also to examine which devices are utilized to access internet resources.

Methods: A cross-sectional, multicentric study was carried out through a semistructured interview asking about the use of digital technology devices and internet. The sample comprised 90 patients and 90 healthy participants. The semistructured interview was conducted on 30 outpatients and 30 healthy subjects in each of the 3 different cities (Madrid, Alicante, and Cuenca). Student *t* test was used for continuous variables and chi-square test for categorical variables. In the case of ordinal variables, nonparametric Mann-Whitney *U* and Kruskal-Wallis *H* tests for independent samples were performed to compare groups.

Results: The results indicated that a large proportion of patients with early-stage schizophrenia have access to different digital devices and use them frequently. In addition, both groups coincide in the order of preference and the purpose for which they use the devices. However, a lower frequency of use of most digital technology devices was detected in patients compared with healthy participants. In the case of some devices, this was due to the impossibility of access and not a lack of interest.

Conclusions: This is the first study to analyze patterns of internet access and use of digital technology devices and applications in Spanish patients with early-stage schizophrenia compared with healthy participants from the same demographic areas. The results on significant access and use of digital technology and internet shown in this cross-sectional study will allow enhanced and more efficient treatment strategies to be planned, utilizing digital technology devices, for patients with early-stage schizophrenia.

(J Med Internet Res 2019;21(3):e11824) doi:10.2196/11824

KEYWORDS

information technology; computers; internet; schizophrenia

Introduction

Digital Technology

As indicated in a very recent report by the International Telecommunication Union (ITU) and the United Nations Educational, Scientific and Cultural Organization, the growth in information and communication technologies and the massive use of internet in the last 20 years have influenced the development of human activity in multiple areas such as education and health [1]. In this sense, internet access has increased worldwide over the last 10 years, reaching 48% of the population in 2017; in the case of Europe, the ITU reports a statistic of 79.6%. Facebook seems to be the favorite application throughout the world, surpassing 2 billion active users per month and reaching 1320 million active users per day in June 2017 (of whom, approximately 91% access Facebook via mobile technologies). WhatsApp and YouTube follow closely with around 1 billion users in June 2017 [1].

Moreover, in 2017, according to the Instituto Nacional de Estadística (INE; Spanish National Institute of Statistics), 78.4% of households with at least one member, aged between 16 and 74 years, had a computer and 97.4% of households had a landline or mobile phone [2]. In addition, 8 out of 10 participants between the ages of 16 and 74 years had used the internet in the previous 3 months and 2 out of every 3 had done so daily, with the use being even more frequent among young people. In the previous 3 months, 98% of young people aged between 16 and 24 years had used the internet, 91.3% on a daily basis and 49% for Web-based purchase. The products and services most commonly acquired were holiday accommodation (54.1%), sports equipment, clothing (53.5%), tickets for shows (47.6%), and other services for trips (44.7%). When analyzing the types of activities carried out on the internet by the Spanish population in 2017, those that were most frequently performed were receiving or sending emails; reading news, newspapers, or Web-based news magazines; searching for information about services; looking for information about health issues; and participating in social networks [2].

According to the same statistics by the INE, the device most commonly used to connect to the internet was by far the smartphone (90.4% of internet users in the last 3 months), followed by laptop (39.3%), desktop computer, and tablet. Smart television (TV), other mobile devices, and game consoles were also mentioned (12%). Regarding participation in social networks, during the previous 3 months, 67.6% of internet users had participated in general nature social networks such as Facebook or Twitter, creating a user profile or sending messages and other contributions, with greater participation by women than by men. The most participative subjects were students (90.4%) and people aged between 16 and 24 years (90.0%).

The fact that technology is rapidly changing society, and many activities now require the ability to use digital technology, potentially poses new problems for several population groups, including older adults, the economically disadvantaged, and people with severe mental illness [3]. Moreover, despite the clear potential of digital technology to connect people and health data in new ways, a key challenge is to ensure that patients and their needs remain at the center of technology development and implementation [4,5].

Use of Digital Technology in Health Care

In the last 10 years, the development and use of mobile devices devoted to health has increased significantly. The main advantage of these devices is that they increase access to medical care, reduce costs, and offer new options for control, prevention, detection of diseases, and basic diagnosis [6].

The literature at the time of this study reports positive effects derived from the use of mobile apps for health in relation to improving hygienic dietary habits such as stopping smoking, losing weight, dieting, and physical activity, as well as increasing therapeutic adherence and preventing and treating sexually transmitted diseases [7-9].

Use of Digital Technology in Mental Health

The impact of psychological interventions on mental disorders is unquestionable. However, owing to the limited resources of medical and psychological care and availability of interventions, their enormous potential is restricted [10-11]. Using internet and mobile-based interventions for mental disorders offer an accessible, innovative, and personalized option that addresses several of the devastating effects of mental illness, including associated stigma and the chronic nature and symptoms of these disorders. Patients are thus empowered to participate actively in their recovery [12]. Although digital exclusion among people with mental illness is still present, especially in older individuals with severe mental disorders, patients' access to internet-enabled technology is growing [13]. Internet and mobile-based studies or interventions have been shown to be effective in understanding and managing different mental disorders such as substance use disorder [14], depression [15], anxiety [16,17], and schizophrenia [18].

Use of Digital Technology in Schizophrenia and Related Disorders

Schizophrenia is a chronic psychiatric disorder that affects approximately 1% of the population and severely limits the social and occupational functioning of patients [19]. Symptoms of schizophrenia include positive symptoms (hallucinations, delusions, and disorganization of language and behavior), negative symptoms (including abulia, associability, anhedonia, and alogia or affective flattening), alterations in mood, and deficits in cognition [20].

Schizophrenia is a mental disorder for which mobile health (mHealth) offers a tremendous opportunity to provide personalized, innovative, and accessible solutions. A recent systematic review concluded that internet and mobile-based interventions for psychosis seem to be cost-effective, accessible, acceptable, feasible, and have the potential to improve clinical and social outcomes [21]. A subsequent review including studies

carried out in 12 different countries supported the feasibility and acceptability of emerging mHealth and electronic health (eHealth) interventions among people with serious mental illness (including schizophrenia, schizoaffective disorder, and bipolar disorder) [22]. Recently, the need for individuals with schizophrenia to engage themselves in Web-based activities was demonstrated [23].

At the time of this study, there was limited information on the access and use of digital technology by psychotic patients. Several previous studies have investigated the prevalence of use of technological devices and applications through surveys. In the United States, 2 studies were conducted in patients diagnosed with schizophrenia and schizoaffective disorder. The first interviewed 457 participants by means of a Web-based survey [12] and the second surveyed 80 patients in Georgia [24]. In addition, 2 other studies were carried out to compare access and the use of internet in persons with different mental disorders, the first in France [25] and the second in Australia [26]. In Europe, 2 other studies examined access and purpose of internet use in patients with schizophrenia. The first study compared patients from Greece and Finland [27] and the second, patients from 2 psychiatric units in Finland [28].

To our knowledge, only 2 studies have been conducted in patients with early-stage schizophrenia. The first study included 71 patients at different stages of their 5-year treatment in a therapeutic program in Montreal (Canada). The patients completed a survey on their access and use of technology and related activities. The authors concluded that a significant proportion of patients with early-stage schizophrenia had access to and were using different technological devices in their daily lives [29]. The second study, carried out in Valencia (Spain), compared access, use, and interest in new technologies and eHealth interventions through a survey on internet use conducted on 65 patients with early psychosis compared with 40 patients with chronic psychosis [30].

It should be noted that in the previously mentioned publications, the use of digital technology for internet access was compared with data of use from general population surveys, but not with a sample of controls matched in age, gender, and place of residence. The lack of a control group, as well as a nonmulticentric study design, could be an important source of bias in these publications.

Objectives

To date, no multicentric studies have been carried out that provide information about the use of digital technology to access the internet by patients with early-stage schizophrenia compared with a sample of control participants matched in age, gender, and place of residence. Hence, we conducted a cross-sectional, multicentric study to analyze the use of digital technology in patients with early-stage schizophrenia and to compare the responses with regard to healthy participants matched by age, gender, and place of residence through a semistructured interview. The following 3 main questions were analyzed:

1. Which digital technology devices are most frequently used by patients with early-stage schizophrenia to access the internet? Is there any difference in use by gender, age, education level, or location? And, primarily, is use similar in healthy participants?
2. What is the main purpose of the use of digital technology devices in early-stage schizophrenia patients? Moreover, is there any difference in the purpose of use between patients and healthy participants?
3. Which are the applications more frequently used when patients access the internet? Is their use similar in healthy participants?

Methods

Study Design

This was a cross-sectional, multicentric study of 6 months' duration (June to November 2017). The design included 3 recruitment centers: *Hospital Universitario 12 de Octubre* (Madrid), *Hospital Virgen de la Luz* (Cuenca), and *Hospital Universitario de San Juan* (Alicante). The study was approved by the Clinical Research Ethics Committee.

The psychiatric service of the *Hospital Universitario 12 de Octubre* serves a population of about 450,000 inhabitants and has an integrated psychosis assistance program, including an intensive program for first psychotic episodes. The psychiatric service of the *Hospital Virgen de la Luz* serves a population of 150,000 inhabitants and also offers an integrated psychosis program. Finally, the psychiatric service of the *Hospital de San Juan* serves a population of 300,000 inhabitants and manages a program for first psychotic episodes.

Participants

The patient sample size was established as 90 patients (30 patients from each of the centers). All met the Diagnostic and Statistical Manual of Mental Disorders, fifth edition, (DSM-5) diagnostic criteria for schizophrenia assessed with the Structured Clinical Interview for DSM-5 [31]. All the patients were at an early stage of the disorder (5 years or less since their first episode). The mean time of evolution of the disorder was 2.6 years (SD 1.3). A total of 90 healthy participants were recruited (30 from each center), matched with patients for age and gender.

Table 1. Sociodemographic data of the samples.

Participants	Patients (n=90)	Healthy participants (n=90)	Statistics		
			Student *t* test (df)	Chi-square test	*P* value
Age (years), mean (SD)	28.1 (SD 8.6)	27.9 (SD 8.7)	0.189 (179)	—[a]	0.85
Gender (%)					
Men	53	57	—	0.2	0.65
Women	47	43	—	0.2	0.65
Educational level (%)					
Basic	29	22	—	8.4	0.02
Medium	50	37	—	8.4	0.02
High	21	41	—	8.4	0.02

[a]: not applicable.

Inclusion and Exclusion Criteria

The following inclusion criteria were established for patients:

1. Meeting DSM-5 diagnostic criteria for schizophrenia.

2. Staying clinically stabilized during the 3 months before the semistructured interview, according to criteria already used by our group [32].

3. Being an outpatient.

4. Being aged between 18 and 55 years.

5. Speaking fluent Spanish.

6. Providing signed, informed consent.

The following exclusion criteria were considered:

1. Other Axis I major mental disorders of DSM-5.

2. Intellectual disability (IQ <70).

3. Suffering somatic pathology that might interfere with accessing the internet.

The patients were screened by their psychiatrist to determine whether they met the inclusion/exclusion criteria and were thus suitable to participate in the study.

Table 1 shows the sociodemographic data of patients and controls. As expected, there were no differences in age or gender; the only differences were in educational level.

Data Collection Procedure

The patients were recruited consecutively at the clinical appointments of their respective first-episode programs. After the clinical evaluation, the psychiatrist assessed the inclusion and exclusion criteria and proposed their participation in the study on the frequency and purpose of using a series of digital technology devices. Multimedia Appendix 1 includes all the information on the data collection procedure considering the 32-item checklist of the Consolidated Criteria for Reporting Qualitative Research [33]. The healthy participants were recruited from areas of similar sociocultural status as the patients, mainly from similar cultural and social groups.

Statistical Analysis

Statistical analysis of all data was conducted using SPSS version 23.0 (IBM Corp). The means and SDs were used to describe continuous variables whereas percentages and chi-square tests were used for categorical variables. Student *t* test was used for continuous variables with a normal distribution. For variables found not to be normally distributed after using Levene test (of homogeneity of variance or homoscedasticity) and ordinal variables, nonparametric tests for independent samples were performed.

The tables described in the section on frequency of use include variables that are considered ordinal variables as they are clearly ordered from *never* (0), including both *never, but would like to* and *never, and would not like to*; *rarely* (1); *once a week* (2); *twice a week* (3); and *every day* (4). Therefore, the *P* value of nonparametric tests for independent samples is presented as a result. The Mann-Whitney *U* test (also called Mann-Whitney-Wilcoxon test or Wilcoxon rank sum test) is performed when we have 2 groups of variables whereas the Kruskal-Wallis *H* (Kruskal-Wallis one-way analysis of variance) test is conducted for more than 2 (in our case, always 3) groups of variables.

Results

The results for the technological devices used by patients and how they used them are presented. We analyze whether there were any differences for several features such as gender, age, education level, and place of residence. In addition, the use of these digital technology devices by patients with early-stage schizophrenia and healthy participants is compared. Subsequently, the purpose of use of these devices is shown, analyzing 4 different domains: entertainment, work, socialization, and shopping. In addition, the websites used to access these internet services and the main applications used for socialization are studied. Finally, the favorite videogames played by both groups are analyzed.

Frequency of Use of Digital Technology Devices

A first analysis studied the frequency of use by patients with early-stage schizophrenia of several technological devices that are useful for internet access. In this selection, some devices

frequently used for this task such as computers or smartphones and other more novel or not so widely used devices (tablet, game console, or smart TV) were included. The inclusion of these latter devices allows possible trends in use to be evaluated. Moreover, this variety of devices was included to cover different domains and usages.

Table 2 shows the frequency of use of these devices by patients with early-stage schizophrenia. In this table, not only the real frequency of use was included, taking values *every day*, *twice a week*, *once a week,* and *rarely*, but also in the case of *never* for a specific device, an analysis of patients' interest in their use (*never, but would like* and *never, and would not like*) was included. This variable reveals the actual motivation of low use of a specific device.

Considering the results shown in Table 2, the use of *smartphone* clearly prevails over other devices. More than 80% of patients (75 out of 90 participants) use this device *every day* and it is very popular among patients. The other type of device most frequently used is the computer. In this case, use is not so frequent but the general use of these devices by patients is similar to that of smartphones.

In contrast to the devices previously analyzed, the other 3 are used less frequently, but as can be seen in Table 2, patients' interest in their use is high.

Comparison Between Patients and Controls

First, we analyzed whether the frequency of use of these devices is similar between schizophrenic patients and healthy participants. As can be seen in Table 3, the frequency of use of most digital technology devices under study is higher in healthy participants than patients.

As can be seen, there is a significant statistical difference in almost all devices. Only the use of *game console* has a *P* value higher than .05.

Table 4 shows that there are no statistically significant differences between female and male patients in the use of digital technology devices. However, in general, females used *smartphone* and *computer* more frequently and, more remarkably, *game console* is used by a proportional number of each gender. In contrast, males were more frequent users of *smart TV* and *tablet* use was similar between genders.

Table 2. Frequency of use of digital technology devices in patients with early-stage schizophrenia (N=90).

Device	Every day, n (%)	Twice a week, n (%)	Once a week, n (%)	Rarely, n (%)	Never, but would like to, n (%)	Never, and would not like to, n (%)
Computer	50 (56)	17 (19)	9 (10)	7 (8)	5 (6)	2 (2)
Tablet	8 (9)	2 (2)	8 (9)	17 (19)	33 (37)	22 (24)
Smartphone	75 (83)	9 (10)	0 (0)	0 (0)	4 (4)	2 (2)
Game console	9 (10)	11 (12)	19 (21)	15 (17)	21 (23)	15 (17)
Smart TV	18 (20)	4 (4)	6 (7)	10 (11)	31 (34)	21 (23)

Table 3. Comparison between patients with early-stage schizophrenia (N=90) and healthy participants (N=90) using the Mann-Whitney U test on the frequency of use of digital technology devices.

Devices	Patients, mean (SD)	Healthy participants, mean (SD)	*P* value [a]
Computer	3.04 (1.306)	3.72 (0.750)	<.001
Tablet	0.79 (1.250)	1.22 (1.322)	.006
Smartphone	3.63 (1.022)	3.96 (0.422)	<.001
Game console	1.36 (1.376)	1.63 (1.532)	.23
Smart TV	1.18 (1.619)	1.97 (1.757)	.002

[a]Significance *P*<.05.

Table 4. Use of digital technology devices in patients with early-stage schizophrenia divided by gender using the Mann-Whitney *U* test (N=90).

Digital device	Gender		*P* value [a]
	Female (47%), mean (SD)	Male (53%), mean (SD)	
Computer	3.17 (1.305)	2.94 (1.311)	.30
Tablet	0.76 (1.306)	0.81 (1.283)	.97
Smartphone	3.81 (0.671)	3.48 (1.238)	.22
Game console	1.36 (1.376)	1.35 (1.391)	.93
Smart TV	0.88 (1.468)	1.44 (1.712)	.10

[a]Significance *P*<.05.

In terms of age (see Table 5), this study only found a slight statistically significant difference in the use of *smart TV*. Participants aged 30 years or above used *smart TV* less than younger adults. Although not statistically significant, a trend of greater use of most devices for the age range between 25 and 29 years can be observed across all participants. Nevertheless, it is worth highlighting that the age range in the last interval (≥30) is greater (30 to 53 years), which could affect the results.

For educational level (see Table 6), the only significant difference in terms of statistics is found for *computer*; the higher the educational level, the more frequent is the use. In general, participants with a high educational level used the analyzed devices more.

Table 7 shows some key details about the influence of the location where patients live. In this case, 2 different locations were analyzed, namely *rural* and *urban*. In general, the use of digital technology devices is greater in *urban* than in *rural* areas. There is, however, a statistically significant difference in the use of *game console*.

Table 5. Use of digital technology devices in patients with early-stage schizophrenia divided by age using the Kruskal-Wallis *H* test (N=90).

Digital device	Age (years)			*P* value [a]
	18-24 (37%), mean (SD)	25-29 (38%), mean (SD)	≥30 (25%), mean (SD)	
Computer	2.88 (1.386)	3.35 (0.884)	2.83 (1.642)	0.51
Tablet	0.67 (1.109)	0.97 (1.403)	0.70 (1.222)	0.53
Smartphone	3.58 (1.001)	3.82 (0.716)	3.43 (1.376)	0.26
Game console	1.18 (1.185)	1.74 (1.543)	1.04 (1.296)	0.16
Smart TV	1.30 (1.590)	1.53 (1.780)	0.48 (1.201)	0.03

[a]Significance *P*<.05.

Table 6. Use of digital technology devices in patients with early-stage schizophrenia divided by educational level using the Kruskal-Wallis *H* test (N=90).

Digital device	Educational level			*P* value [a]
	Basic (29%), mean (SD)	Medium (50%), mean (SD)	High (21%), mean (SD)	
Computer	2.50 (1.503)	3.04 (1.278)	3.79 (0.535)	.004
Tablet	0.77 (1.275)	0.62 (0.936)	1.21 (1.751)	.74
Smartphone	3.38 (1.299)	3.64 (1.026)	3.95 (0.230)	.14
Game console	1.23 (1.423)	1.24 (1.282)	1.79 (1.376)	.35
Smart TV	0.73 (1.218)	1.42 (1.764)	1.21 (1.686)	.37

[a]Significance *P*<.05.

Table 7. Use of digital technology devices in patients with early-stage schizophrenia divided by rural versus urban place of residence using the Mann-Whitney *U* test (N=90).

Digital device	Place of residence		*P* value [a]
	Rural (21%), mean (SD)	Urban (79%), mean (SD)	
Computer	3.11 (1.370)	3.03 (1.298)	.77
Tablet	0.47 (0.964)	0.87 (1.309)	.29
Smartphone	3.37 (1.499)	3.70 (0.852)	.93
Game console	0.89 (1.487)	1.48 (1.329)	.048
Smart TV	0.74 (1.522)	1.30 (1.634)	.08

[a]Significance *P*<.05.

Table 8. Comparison between patients with early-stage schizophrenia (N=90) and healthy participants (N=90) using the Mann-Whitney U test on the purpose of use of digital technology devices.

Participants	Patients, mean (SD)	Healthy participants, mean (SD)	*P* value [a]
Entertainment			
Computer	0.76 (0.430)	0.71 (0.457)	>.99
Tablet	0.74 (0.443)	0.80 (0.404)	.07
Smartphone	0.82 (0.385)	0.91 (0.288)	.02
Game console	0.74 (0.442)	0.95 (0.218)	.02
Smart TV	0.82 (0.393)	0.92 (0.281)	.003
Work			
Computer	0.63 (0.487)	0.81 (0.395)	.001
Tablet	0.23 (0.426)	0.16 (0.373)	.19
Smartphone	0.71 (0.454)	0.79 (0.412)	.10
Game console	0.04 (0.191)	0.07 (0.250)	.41
Smart TV	0.18 (0.393)	0.15 (0.363)	.60
Socialization			
Computer	0.58 (0.566)	0.61 (0.491)	.27
Tablet	0.23 (0.426)	0.20 (0.404)	.66
Smartphone	0.88 (0.326)	0.98 (0.149)	.003
Game console	0.52 (0.947)	0.25 (0.434)	.27
Smart TV	0.18 (0.393)	0.08 (0.281)	.11
Shopping			
Computer	0.47 (0.502)	0.69 (0.467)	.001
Tablet	0.11 (0.323)	0.22 (0.417)	.34
Smartphone	0.42 (0.496)	0.55 (0.500)	.05
Game console	0.02 (0.136)	0.07 (0.250)	.17
Smart TV	0.05 (0.226)	0.07 (0.254)	.71

[a]Significance $P<.05$.

Purpose of Use of Digital Technology Devices

The purpose of use was classified into 4 domains: entertainment, work, socialization, and shopping.

We analyzed the responses of participants who reported using a specific device. Again, an ordinal variable was assigned to the responses with the following Boolean values: NO=0 and YES=1. This means that the answers of participants who reported never using a specific device were not considered.

Table 8 shows the results based on the number of patients and healthy individuals who used the devices: *computer* was used by 83 patients versus 89 healthy individuals, *tablet* by 35 patients versus 55 healthy individuals, *smartphone* by 84 patients versus 89 healthy individuals, *game console* by 54 patients versus 61 healthy individuals, and *smart TV* by 38 patients versus 59 healthy individuals.

As can be seen, *shopping* is the least used domain for all devices. The data show that patients do not frequently shop on the internet. Another relevant result is that the more versatile devices are *computer* and *smartphone*, whereas the others are mainly used for *entertainment*. Regarding *socialization*, the high value associated with *game console* is curious. This outcome may show that the games played by patients involve relevant social activity. As expected, the use of *smartphone* is also noteworthy in this domain.

However, are there any differences between patients and healthy participants in the purpose of use? Table 8 also shows the results of a case-control study using the Mann-Whitney *U* test for nonparametric variables.

Regarding *entertainment*, the mean of healthy participants is higher in general terms and there are significant differences in terms of statistics in the case of *smartphone*, *game console,* and *smart TV*, where healthy participants used these devices for *entertainment* more than patients.

In the case of *work*, *computer* was also used more by healthy participants. It is noticeable, although not from a statistical point of view, that *tablet* was used by patients more than by healthy participants. Nevertheless, the use of this technology was very low for both groups.

The purpose of *socialization* should be treated carefully. In fact, *smartphone* was used for *socialization* by a high number of patients and healthy participants, although healthy subjects prevail and there is statistical significance. However, on the contrary, *game console* was much more frequently used by patients than healthy participants.

For *shopping*, the difference in the use of *computer* is statistically significant in favor of healthy participants. Moreover, all other devices were found to be less used by patients for this purpose.

As noted before, both patients and healthy participants used most devices for the same purpose. Thus, the main purpose for using *smartphone* in both groups was *socialization*, followed by *entertainment*. Similarly, both *game console* and *smart TV* were used in both groups for the main purpose of *entertainment*. The main purpose of use of *tablet* was *entertainment* for both groups.

Regarding the purpose for using the *computer*, it is noticeable that patients used it preferentially for playing compared with healthy participants who primarily used it as a work tool.

Use of the Internet

Regardless of device, what type of website do patients and healthy participants use when they access the internet? Do they use the internet to search for information or socialize? Participants were asked to indicate a maximum of 3 search engines.

Table 9 shows the outcomes regarding the search engines used by participants. The search engines were classified into *general* (general purpose), *entertainment*, *knowledge* (knowledge sharing), *shopping*, and *work*. As can be seen, the percentages are quite similar for patients and healthy participants.

As expected, a great majority of participants use *Google* as a search engine and *YouTube* for entertainment purposes and the use of specific websites for work and shopping is very low. For *work* and *shopping*, the specific search engines were not included, as almost every participant uses a different website. Moreover, the difference in the use of Wikipedia is interesting: 11.1% (10 out of 90 participants) for patients and 3.3% for healthy participants (3 out of 90 participants). When analyzing the number of answers provided by participants, only 5.6% (5 out of 90 participants) of patients did not indicate any search engine, whereas all healthy participants indicated at least one search engine. In addition, the percentage of participants indicating 3 apps was higher for healthy participants than patients.

Table 10 analyzes the apps used for socialization. As in the previous study, a classification was established to choose the main purpose of each app used, although it was difficult to categorize them into only one class.

Use of Videogames

For videogames, Table 11 demonstrates that the participants were familiar with a great number of applications. Indeed, no single videogame was the most used by participants. The highest figures were for FIFA 17 in patients and for League of Legends in healthy participants.

Table 9. Use of search engines by patients with early-stage schizophrenia and healthy participants.

Participants	Patients		Healthy participants	
	Responses (N=163), n (%)	Individuals (N=90), n (%)	Responses (N=173), n (%)	Individuals (N=90), n (%)
General	96 (59)	—[a]	106 (61)	—
Google	—	86 (96)	—	89 (99)
Yahoo	—	9 (10)	—	9 (10)
Bing	—	1 (1)	—	8 (9)
Entertainment	49 (30)	—	51 (29)	—
YouTube	—	49 (54)	—	45 (50)
Spotify	—	—	—	6 (7)
Knowledge	10 (6)	—	3 (2)	—
Wikipedia	—	10 (11)	—	3 (3)
Shopping	5 (3)	5 (6)	6 (3)	6 (7)
Work	3 (2)	3 (3)	7 (4)	7 (8)

[a]: not applicable.

Table 10. App used for socialization by patients with early-stage schizophrenia and healthy participants.

Participants	Patients		Healthy participants	
	Responses (N=181), n (%)	Individuals (N=90), n (%)	Responses (N=223), n (%)	Individuals (N=90), n (%)
Messaging	95 (52)	—[a]	118 (539)	—
WhatsApp	—	65 (72)	—	72 (80)
Skype	—	12 (13)	—	9 (10)
Twitter	—	9 (10)	—	33 (37)
Snapchat	—	6 (7)	—	1 (1)
WeChat	—	2 (2)	—	0 (0)
Google Hangouts	—	1 (1)	—	0 (0)
Telegram	—	0 (0)	—	3 (3)
Social media	53 (29)	—	65 (29)	—
Facebook	—	53 (59)	—	65 (72)
Photo sharing	28 (15)	—	35 (16)	—
Instagram	—	28 (31)	—	35 (39)
Business and employment	3 (2)	—	3 (1)	6 (7)
Catalog of ideas	1 (1)	—	1 (0)	7 (8)
Dating	1 (1)	—	1 (0)	7 (8)

[a]not applicable.

Table 11. Use of videogames in patients with early-stage schizophrenia versus a control sample.

Videogames	Patients (N=75), n (%)	Healthy participants (N=95), n (%)
FIFA 17	12 (16)	7 (7)
League of Legends	5 (7)	10 (10)
Overwatch	2 (3)	8 (8)
Mario Kart 8	7 (9)	1 (1)
Grand Theft Auto V	6 (8)	1 (1)
The Elder Scrolls V: Skyrim	0 (0)	6 (6)
Call of Duty: Infinite Warfare	5 (7)	3 (3)
The Legend of Zelda: Breath of the Wild	1 (1)	5 (5)
Minecraft	4 (5)	2 (2)
Pokémon GO	0 (0)	4 (4)
Hearthstone: Heroes of Warcraft	0 (0)	3 (3)
The Sims 4	1 (1)	3 (3)
Others	36 (48)	42 (44)

Discussion

Principal Findings

This is the first multicentric study on the use of digital technology for internet access in patients with early-stage schizophrenia compared with a sample of control participants matched in age, gender, and place of residence. The smartphone is clearly the digital device most widely used by patients (84 out of 90 participants), reaching almost 95% of use at least twice a week. The second most used device is the computer, which reaches a use of almost 75% (67 out of 90 participants) at least twice per week. With regard to the other devices, the low usage indicated and the high number of *never, but would like to* responses is striking. This might be because these devices are not economically affordable for this group of the Spanish population despite there being outstanding interest in them.

In any event, although the use of all devices is lower in patients compared with healthy participants, the results indicate that a large proportion of patients with early-stage schizophrenia have access to different technological devices and use them

frequently. This finding is of great importance for designing intervention programs including the use of technological devices, especially smartphones and computers. The inclusion of technological devices is being investigated in several areas such as neurocognitive remediation [34], adherence to pharmacological treatment [35], social cognition remediation [36], treatment of refractory auditory hallucinations [37], or training in social skills [38].

Moreover, no statistically significant differences were found in the *frequency of* use of digital technology devices between male and female patients, which is interesting in terms of gender equality. In addition, no statistically significant differences were detected in terms of age, except for a lower use of smart TV in older adults. It was also found that frequency of use of computers increased significantly as educational level increased. Although not statistically significant, patients who lived in cities used most digital devices more frequently than those who lived in small towns. To sum up, healthy participants used all digital technology devices more frequently than patients, with this difference between the groups being statistically significant for all devices except for game console.

The main results in terms of *purpose of use of digital technology* when accessing the internet are described below. Patients and healthy participants coincided in that the main purpose of use for tablet, game console, and smart TV was entertainment and for smartphone, socialization. However, they differ in the purpose for using the computer, with entertainment being the principal motivation for patients and work for healthy participants. In general, most devices are less used by patients for this purpose. These data could indicate a lower interest of patients for this purpose.

Specifically, entertainment seems to be the main objective sought with most devices, both in patients and in healthy participants. For entertainment, patients use smart TV and smartphone more frequently, whereas healthy participants prefer the game console, with this difference being statistically significant. For work, there is a statistically significant difference in favor of healthy participants with respect to computer use. The devices most used to socialize are smartphone (with a statistically significant difference in favor of healthy participants) and computer in both groups. Another finding is that patients used the game console more frequently than healthy participants for socialization purposes. Web-based shopping seems to be the least common objective in both groups. Nevertheless, healthy participants engaged more in this type of activity, especially on the computer.

With regard to the most used *search tools*, the main finding is the lack of statistically significant differences between the 2 groups. Google is the most important search engine followed by YouTube. The access to social networks is quite similar in both groups, with WhatsApp and Facebook being the most important applications. As expected, the most frequently used domain of social activity was messaging, followed by social media and photo sharing. However, the use of Twitter, another well-known app in this domain, is slightly curious. Here, patients presented a lower use of this app than healthy participants, which was nevertheless mitigated through other messaging apps such as Snapchat and WeChat.

Regarding the number of answers provided by the participants, it is surprising that several patients with early-stage schizophrenia indicated no app, whereas this percentage was null for the other group. Moreover, the percentage of participants reporting a maximum of 3 apps was higher in the case of healthy participants.

In the case of *videogames*, both groups knew and played several video games, with FIFA 17 being the favorite for patients and League of Legends for healthy participants. Nonetheless, no single videogame was used by most participants. This means that an accurate analysis cannot be performed by just looking at the results provided in this table. Therefore, a deeper analysis, probably mining the most important features of the videogames, is necessary to give any concluding remarks in this regard.

Strengths and Limitations

There are several strengths and limitations in this study.

The main strength of this work is that it is the first multicentric study carried out on internet access through digital technology (with this degree of depth in terms of frequency of use, purpose of use, and type of digital technology) by patients with early-stage schizophrenia in Spain compared with a sample of controls matched in age, gender, and place of residence.

It should also be highlighted that the selection of a multicentric approach representing 3 typical, albeit different, cities is essential to generalize the results to the overall Spanish population. Indeed, this research study involved participants from 3 different recruitment centers (cities): *Hospital Virgen de la Luz* (Cuenca), *Hospital Universitario de San Juan* (Alicante), and *Hospital Universitario 12 de Octubre* (Madrid). The 3 centers of recruitment are related to 3 different types of settlements based on their number of inhabitants. The first could be classified as a *large town*, the second a *large city*, and the last a *metropolis*. Moreover, in terms of rural population, Cuenca has a high percentage, in Alicante the percentage is small, and in Madrid it is practically null.

In addition, regarding the statistical analysis, the size of the sample (180 participants) can be considered more than enough to extract important and useful considerations. In this sense, another strength of the study is having a control group of the same sociocultural environment, matched in age and gender.

There are some limitations to our study, mainly that socioeconomic status, ethnicity, culture, and working status of participants were not collected, which would have helped enhance the explanation of some results obtained.

Comparison With Prior Works

To the best of our knowledge, no other published multicentric studies have analyzed the access and use of digital technology devices and applications in patients with early-stage schizophrenia in comparison with a sample of healthy participants matched in age, gender, and place of residence.

The results of this study indicate that a large proportion of patients have access to different technological devices and use

them frequently, although the use of all devices is lower in patients compared with healthy participants. This lower use could be attributed to lower economical level of the patients [39], lower academic level [40], their cognitive dysfunction [41], unemployment rates [42], or the presence of negative symptoms [43]. Our results for access to different technological devices and use coincide with the results of a previous study, which concluded that more than 90% of the psychotic patients (not only the ones in early stage) surveyed owned more than one digital device and most of them used multiple devices habitually [12].

Both patients and healthy participants coincide in the preference for using smartphone over the other devices. The second most used device is the computer, followed by smart TV, game console, and tablet. The preference for the use of smartphone conforms to the Spanish population's access to this device, as well as the preference of its use to access the internet [1]. Considering this previous report, the smartphone seems to be the most used device by the Spanish population, both for healthy participants and patients, which coincides with the results obtained in our own study.

A recent meta-analysis on smartphone ownership in psychotic patients revealed that it was increasing rapidly, with 81.4% ownership among respondents between 2014 and 2015 in the United States [44]. Another study carried out in Georgia in 2015, with a sample of 80 patients with schizophrenia, concluded that there was greater access to smartphones compared with computers in the study sample (73% vs 54%), which would also be compatible with our results [24].

In addition, in a previous survey of access and use of technological tools carried out in 2012 in Montreal on 71 patients with a first psychotic episode [29], a greater use of computer (desktop or laptop) was reported in comparison with mobile phone or smartphone, reaching 96% versus 70% of frequency (defined as *from daily use up to 2 to 3 times per week*). This difference in the preference for computer compared with smartphone could be related to 2 circumstances. The first could be cultural difference, as in 2017, the device most frequently used to access the internet was smartphone (76%), followed closely by laptop computer (71%), according to the National Statistics Institute of Canada [45]. As can be concluded from these results, the Canadian population has no marked preference for the smartphone, with both having practically the same frequency of use. The second reason could be due to the fact that the study was carried out in 2012 and the pattern of use of digital technology is constantly changing and adapting to the needs of the population. Unlike other previously published studies, a greater use of game consoles in men was not observed [29].

Some years ago, an interesting study found that the internet is an influential source of illness-related information for patients with schizophrenia [46]. Moreover, the same report stated that many aspects of their behavior related to internet usage resembled those of individuals without mental illness. The following paragraphs support this statement.

Regarding the most visited search engines, the responses of both groups (patients and healthy participants) were quite similar. Google is the most named search engine by far (with close to 100% use in both groups), which shows the enormous expansion of this tool. The results (although not as overwhelming) were similar for YouTube, the main page visited by both groups for entertainment. It is striking that both patients and healthy participants named these search tools freely, that is, without a list provided by the interviewer. At the time of data collection, both groups coincided in the use of Wikipedia, the use being higher in patients than in healthy participants. With regard to other types of websites related to job searching, the response rate was low in both groups, although higher in the healthy participants, which could be related to the lower employment rates in the psychotic population.

With regard to the applications used for socialization, it is striking that around 12% of patients use no application. This is probably related to the difficulties these patients present when socializing. Nevertheless, the patients who responded did so similarly to the healthy participants, with WhatsApp being the favorite app, followed by Facebook and Instagram. As with Google and YouTube, it can be concluded that these applications have expanded enormously in recent years, reaching even young psychotic patients. Both groups agree on the low rate of responses in the use of dating websites, which could be related to inhibition when verbalizing this type of information.

Conclusions

This is the first multicentric study carried out that provides information about the access to the internet and use of digital technology devices and applications by patients with early-stage schizophrenia in comparison with healthy participants matched in age, gender, and place of residence.

In general terms, the results obtained in our study indicated that a large proportion of patients with early-stage schizophrenia have access to different digital devices and use them frequently. However, a lower frequency of use of most devices was found in patients compared with healthy participants. For some devices, this was due to a lack of access, not an absence of interest. Nevertheless, both groups coincide in the most used devices. In addition, the purpose of using the devices in relation to the internet is highly similar in both groups.

This study brings the scientific community closer to the patterns of internet access and use of digital technology in patients with early-stage schizophrenia compared with healthy participants from the same demographic areas. The analysis of this information will be useful to guide the future development of internet technology–based therapeutic applications [47].

Acknowledgments

This work was partially supported by Spanish Instituto de Salud Carlos III/European Regional Development Fund (FEDER, UE) under PI16/00359 grant and Spanish Ministerio de Ciencia, Innovación y Universidades, Agencia Estatal de Investigación (AEI)/FEDER, UE under DPI2016-80894-R and TIN2015-72931-EXP grants, by Madrid Regional Government (R&D activities in Biomedicine S2017/BMD-3740 (AGES-CM 2-CM)) and Structural Funds of the European Union, and by the Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM) of the Instituto de Salud Carlos III. These funding sources have not been involved in study design; collection, analysis, and interpretation of data; writing of the report; or in the decision to submit the paper for publication.

Authors' Contributions

RRJ, PFS, AFC, PG, and JLS designed the study. PG, AIA, IT, MD, JLS, IMG, and LFG managed the literature searches and analyses. PFS, AIA, PFS, IMG, and LFG selected the sample, interviewed participants, and contributed in some aspects of the study design and in the interpretation of results. AFC, IT, MDT, and PG undertook the statistical analysis. PFS, AFC, PG, and RRJ wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Conflicts of Interest

RRJ has been a consultant for, spoken in activities of, or received grants from Instituto de Salud Carlos III, Fondo de Investigación Sanitaria (FIS), Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM), Madrid Regional Government (S2010/BMD-2422 AGES), Janssen-Cilag, Lundbeck, Otsuka, Pfizer, Ferrer, Juste, and Takeda.

Multimedia Appendix 1

Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist.

[DOCX File, 46KB - jmir_v21i3e11824_app1.docx]

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Abbreviations

eHealth: electronic health
DSM-5: Diagnostic and Statistical Manual of Mental Disorders, fifth edition
INE: Instituto Nacional de Estadística
ITU: International Telecommunication Union
mHealth: mobile health

Edited by G Eysenbach; submitted 03.08.18; peer-reviewed by F Holl, K Mishina, A Daros; comments to author 12.10.18; revised version received 03.12.18; accepted 12.12.18; published 14.03.19

Please cite as:
Fernández-Sotos P, Fernández-Caballero A, González P, Aparicio AI, Martínez-Gras I, Torio I, Dompablo M, García-Fernández L, Santos JL, Rodriguez-Jimenez R
Digital Technology for Internet Access by Patients With Early-Stage Schizophrenia in Spain: Multicenter Research Study
J Med Internet Res 2019;21(3):e11824
URL: http://www.jmir.org/2019/3/e11824/
doi:10.2196/11824
PMID:

Multimedia Appendix 1.

Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist

No.	Item	Guide question	Response
Domain 1: Research team and reflexivity			
Personal characteristics			
1.	Interviewer/facilitator	Which author/s conducted the interview or focus group?	Patricia Fernández-Sotos carried out the interview in Madrid, Ana Isabel Aparicio in Cuenca and Lorena García-Fernández in San Juan, Alicante.
2.	Credentials	What were the researcher's credentials? *E.g. PhD, MD*	Please see affiliations.
3.	Occupation	What was their occupation at the time of the study?	Please see affiliations.
4.	Gender	Was the researcher male or female?	6 females and 4 males.
5.	Experience and training	What experience or training did the researcher have?	The researchers have years of experience in clinical research with patients with schizophrenia.
Relationship with participants			
6.	Relationship established	Was a relationship established prior to study commencement?	Patients were known in advance by the interview group. No previous relationship was established with healthy people.
7.	Participant knowledge of the interviewer	What did the participants know about the researcher? *e.g. personal goals, reasons for doing the research*	The participants knew that the interviewers were part of the clinical team of each center. They knew that our clinical groups are also research groups, with a common objective of improving the knowledge about schizophrenia disorder in order to improve the functioning of patients in real life.
8.	Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? *e.g. Bias, assumptions, reasons and interests in the research topic*	The interviewers provided information in this regard, especially about the interest in knowing the use and patterns of Internet access in patients compared to healthy participants.

<table>
<tr><td colspan="4">Domain 2: Study design</td></tr>
<tr><td colspan="4">Theoretical framework</td></tr>
<tr><td>9.</td><td>Methodological orientation and Theory</td><td>What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis</td><td>Grounded theory with one data collection episode in form of a semi-structured interview.</td></tr>
<tr><td colspan="4">Participant selection</td></tr>
<tr><td>10.</td><td>Sampling</td><td>How were participants selected? e.g. purposive, convenience, consecutive, snowball</td><td>Consecutive purposive sampling for patients and convenience sampling for healthy participants.</td></tr>
<tr><td>11.</td><td>Method of approach</td><td>How were participants approached? e.g. face-to-face, telephone, mail, email</td><td>Face-to-face approach.</td></tr>
<tr><td>12.</td><td>Sample size</td><td>How many participants were in the study?</td><td>90 patients and 90 healthy participants.</td></tr>
<tr><td>13.</td><td>Non-participation</td><td>How many people refused to participate or dropped out? Reasons?</td><td>10 patients and 23 healthy people. The main reason for not participating was that they did not have time or had no interest in the study.</td></tr>
<tr><td colspan="4">Setting</td></tr>
<tr><td>14.</td><td>Setting of data collection</td><td>Where was the data collected? e.g. home, clinic, workplace</td><td>At clinic, the usual workplace of the interviewers.</td></tr>
<tr><td>15.</td><td>Presence of non-participants</td><td>Was anyone else present besides the participants and researchers?</td><td>No, the interviewer and the participant were alone during the interview.</td></tr>
<tr><td>16.</td><td>Description of sample</td><td>What are the important characteristics of the sample? e.g. demographic data, date</td><td>
<table>
<tr><th></th><th>Patients (n=90)</th><th>Healthy participants (n=90)</th><th>Statistics (*) and significance</th></tr>
<tr><td>Age</td><td>28.1 ± 8.6 years</td><td>27.9 ± 8.7 years</td><td>t=0.189
p=0.850</td></tr>
<tr><td>Gender</td><td>Men: 53.3 %
Women: 46.7 %</td><td>Men: 56.7 %
Women: 43.3 %</td><td>X^2=0.202
p=0.653</td></tr>
</table>
</td></tr>
</table>

			Educational level Basic: 28.9 % Medium: 50.0 % High: 21.1 % Basic: 22.2 % Medium: 36.7 % High: 41.1 % X^2=8.414 p=0.015 * t: Student's t X^2: chi-square
Data collection			
17.	Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	The authors provided guides. A pilot study was carried out in the coordinator center (Madrid) with 5 patients and 5 healthy participants.
18.	Repeat interviews	Were repeat interviews carried out? If yes, how many?	No, each participant was only interviewed one.
19.	Audio/visual recording	Did the research use audio or visual recording to collect the data?	No, only a semi-structured questionnaire was filled out.
20.	Field notes	Were field notes made during and/or after the interview or focus group?	Yes, field notes were made during the interviews.
21.	Duration	What was the duration of the interviews or focus group?	Average duration of 20-30 minutes.
22.	Data saturation	Was data saturation discussed?	No.
23.	Transcripts returned	Were transcripts returned to participants for comment and/or correction?	At the end of the interview, data were revised with each participant.

Domain 3: Analysis and findings			
Data analysis			
24.	Number of data coders	How many data coders coded the data?	Three.
25.	Description of the coding tree	Did authors provide a description of the coding tree?	Yes.
26.	Derivation of themes	Were themes identified in advance or derived from the data?	Themes were identified in advance.
27.	Software	What software, if applicable, was used to manage the data?	The Statistical Package for the Social Sciences (SPSS) version 23.0 (IBM Corp) was employed for the statistical analysis of all usable data.
28.	Participant checking	Did participants provide feedback on the findings?	We will offer it when they were published.
Reporting			
29.	Quotations presented	Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? *e.g. participant number*	No. It was not necessary.
30.	Data and findings consistent	Was there consistency between the data presented and the findings?	Yes.
31.	Clarity of major themes	Were major themes clearly presented in the findings?	Yes.
32.	Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Yes.

3.3. Cognición social y realidad virtual

Virtual Reality for Psychosocial Remediation in Schizophrenia: A Systematic Review

En la presente revisión sistemática, que incluyó 7 estudios, cuatro de ellos se centraron en las habilidades sociales, dos estudios tuvieron como objetivo mejorar las habilidades de entrevista de trabajo y uno se centró en la cognición social. Las muestras fueron variables (de un informe de caso a 64 participantes). Tres estudios compararon la intervención con una condición de control y dos estudios especificaron el uso de la realidad virtual inmersiva. Todos ellos mostraron resultados positivos en el objetivo principal explorado.

3.3.1. Virtual Reality for Psychosocial Remediation in Schizophrenia: A Systematic Review

Datos de la publicación

RESUMEN:

Antecedentes y objetivo: El deterioro psicosocial en la esquizofrenia está relacionado con los déficits en el funcionamiento y la calidad de vida. La realidad virtual (RV) es una herramienta interesante que se ha empezado a utilizar en las terapias de rehabilitación. El objetivo de este estudio es realizar una revisión sistemática para describir el estado del arte de la RV para las intervenciones psicosociales en la esquizofrenia.

Métodos: Se revisaron las publicaciones desde el 1 de enero de 2000 hasta el 1 de julio de 2019 sobre las intervenciones basadas en la RV para la rehabilitación psicosocial en la esquizofrenia en cinco bases de datos: PubMed, Scopus, PsycINFO, IEEE Xplore y ACM Digital Library.

Resultados: Del conjunto inicial resultante de 144 publicaciones, se incluyó un número final de 7 publicaciones. Todas ellas mostraron resultados positivos en el principal objetivo explorado. Cuatro estudios se centraron en las habilidades sociales, dos estudios se dirigieron a mejorar las habilidades de entrevista de trabajo y uno se centró en la cognición social. Las muestras fueron variables (desde un informe de caso hasta 64 participantes). Tres estudios compararon la intervención con una condición de control y dos estudios especificaron el uso de la realidad virtual inmersiva.

Conclusiones: La RV ofrece una opción terapéutica interesante y prometedora para los pacientes que sufren esquizofrenia, aunque se necesitan más estudios para aclarar si las intervenciones basadas en RV son más efectivas que las intervenciones clásicas.

Datos de la publicación (cont.)

CITACIÓN:

P. Fernández-Sotos, A. Fernández-Caballero, R. Rodriguez-Jimenez (2020) "Virtual Reality for Psychosocial Remediation in Schizophrenia: A Systematic Review", *European Journal of Psychiatry* 34(1):1–10; doi:10.1016/j.ejpsy.2019.12.003.

ÍNDICES DE CALIDAD:

Índice de impacto 2019: 0,646.

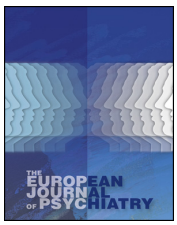
Cuartil: Q4.

Rango (Categoría): 130/141 (Psychiatry).

Eur. J. Psychiat. 2020;34(1):1–10

THE EUROPEAN JOURNAL OF PSYCHIATRY

www.elsevier.es/ejpsy



REVIEW ARTICLE

Virtual reality for psychosocial remediation in schizophrenia: a systematic review

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Received 8 October 2019; accepted 17 December 2019
Available online 9 January 2020

KEYWORDS
Virtual reality (VR);
Social cognition;
Psychosocial remediation;
Schizophrenia

Abstract
Background and objective: Psychosocial impairment in schizophrenia is related to deficits in functioning and quality of life. Virtual reality (VR) is an interesting tool that has been started to use in remediation therapies. The aim of this study is to carry out a systematic review to describe the state-of-the-art in VR for psychosocial interventions in schizophrenia.
Methods: Publications from 1st January 2000 to 1st July 2019 on VR-based interventions for psychosocial remediation in schizophrenia were reviewed in five databases: PubMed, Scopus, PsycINFO, IEEE Xplore and ACM Digital Library.
Results: From the initial resulting set of 144 publications, a final number of 7 publications were included. All of them showed positive results in the main target explored. Four studies focused on social skills, two studies were aimed at improving job interview skills and one focused on social cognition. Samples were variable (from a case report to 64 participants). Three studies compared the intervention with a control condition and two studies specified the use of immersive virtual reality.
Conclusions: VR offers an interesting and promising therapeutic option for patients suffering from schizophrenia, although more studies are needed to clarify if interventions based on VR are more effective than classical interventions.

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https://doi.org/10.1016/j.ejpsy.2019.12.003

Introduction

Functional impairment is one of the hallmarks of schizophrenia.[1,2] It has implications for the patient in terms of prognosis and quality of life.[3,4] Functional impairment is largely related to a deterioration in psychosocial functioning. Most theorists agree that psychosocial functioning is a complex construction that encompasses social cognition, social behaviour and social skills during interpersonal interactions.[5] It is essential for the development and maintenance of meaningful relationships and community participation and is indispensable for both physical health and psychological well-being.[6] Psychosocial impairment has been identified as one of the main characteristics of schizophrenia, including a deficit in social cognition and social behaviour/social skills.[7]

Social cognition has been defined as the ''mental operations that underlie social interactions, including perceiving, interpreting, and generating responses to the intentions, dispositions, and behaviours of others''.[8,9] Initiatives such as the Social Cognition Psychometric Evaluation (SCOPE) study have defined social cognition as a multidimensional construct which includes four core domains: emotional processing, social perception, attributional style/bias, and theory of mind.[10,11]

Researchers in many fields study social behaviour. It can be defined as all those interactions oriented towards other individuals, including social acts, actions and practices. A social act is any intention, objective, plan or purpose that encompasses another self. Examples of social events would be courtship or buying a gift. Social actions are directed towards the realization of a social act. While its purpose is a social act, the actions are social, whether they involve other beings or not. An example of social action would be that a person becomes beautiful for an appointment. Regardless of the act, the associated actions remain social if they are oriented to the feelings, beliefs or intentions of another, or if they anticipate the acts, actions or practices of another. Finally, there are social practices. These are rules, norms, customs and habits that encompass or anticipate the emotions, thoughts or intentions of another person. An example of social practice would be to shake hands.[12]

Social skills include a series of specific behavioural skills in social interactions, without involving the recognition, control and practice of skills to implement underutilised social cognitive processes.[13] A specific type of social skill is the job interview skill. Job interview is probably the most important tool when selecting candidates and making employment decisions. Therefore, the behaviour of a candidate during the interview can assume an important role in obtaining a desired position.[14] A study revealed that hiring commercial business officials rated the communication skills observed during the interview as the most important factor in the evaluation of a candidate for employment. This ability was ranked above the second factor, academic performance, and received more than twice as many points as the third factor, work experience.[15]

Previous studies have shown that psychosocial interventions in schizophrenia have positive effects on disease symptoms, treatment compliance, rehospitalisation rates, quality of life, social cognition, social functioning and employment.[16–21]

Psychosocial interventions can be classified into computerised and in-person remediations. Although both can point to the same social cognitive skills, their implementation is different[13,22] and there are no studies comparing the effectiveness of the two modalities. Among computerised interventions, the most recent interventions are based on virtual reality (VR). VR is a powerful tool that provides environments and situations almost similar to reality, dynamic avatars that allow social interaction with the participant and that can be managed to represent different emotional states.[23] VR enables real-time evaluation of emotions, thoughts, behaviours and physiological responses of individuals in a created environment that can be controlled, unlike in real life.[24,25] VR includes different modalities, such as immersive VR, non-immersive VR and augmented reality (AR). Immersive VR is linked to a three-dimensional computer-created environment that is manipulated through helmets, gloves or other devices that capture the position and rotation of different parts of the body. Non-immersive virtual reality allows real-time interaction with different people in spaces and environments that do not really exist without the need for additional devices to the computer. In augmented reality, unlike VR, the world moved by the user is the same surrounding him/her, and virtual objects are added to this world.

In recent years, there has been an exponential increase in the number of publications on the use of digital technology and VR in mental health.[26,27] The main fields of research in VR and psychosis are: studies on safety and acceptability of technology, symptom assessment studies (including: neurocognition, functional capacity, interview and employment skills, social cognition, social competence and positive symptoms) and treatment studies (including neurocognition, interview and employment skills, social cognition, social skills and positive symptoms).[28]

To date, there are no recent review studies hat specifically analyse the interventions based on VR for the improvement of psychosocial functioning in patients with schizophrenia. The aim of the present study is to conduct a systematic review of the interventions based on VR for psychosocial remediation in schizophrenia.

Material and methods

A systematic review on VR-based interventions for psychosocial remediation in schizophrenia.

Literature search

Five databases used were PubMed (American Psychological Association), Scopus (Elsevier), PsycINFO (American Psychological Association), IEEE Xplore (Institute of Electrical and Electronics Engineers) and ACM Digital Library (Association for Computing Machinery). Unpublished dissertations, conference proceedings and abstracts without full texts available were excluded. The search was limited to the publications available from the selected databases from 1st January 2000 to 1st July 2019.

Search criteria

Studies for review were identified following a keyword search for the terms ('virtual reality' OR 'VR' OR 'augmented reality' OR 'virtual character') AND ('social skills' OR 'psychosocial' OR 'social cognition' OR 'attributional bias' OR 'attributional style' OR 'social perception' OR 'theory of mind' OR 'emotional processing' OR 'emotion perception') AND ('schizophrenia').

Inclusion and exclusion criteria

Publications were included in the review if:

a) they were based on VR
b) the main purpose was the improvement of social cognition or social skills
c) they included patients diagnosed with schizophrenia, according to DSM-IV-TR[29], DSM-5[30] and ICD-10[31] criteria
d) they were written in English

Exclusion criteria:

a) Grey literature, due to their unclear peer review process: editorials, extended abstracts, tutorials, tool demos, doctoral symposium publications, research abstracts, book chapters, proceedings, keynote talks, workshop reports, and technical reports.
b) Systematic reviews, meta-analyses, and survey publications.

Search process

The steps described in Fig. 1 were followed for the article extraction and selection process. The search string was used on each of the five reference databases, providing a total number of 144 records. After removing duplicate references (n = 63), two researchers filtered the remaining 81 papers in an independent manner through screening the full content of papers. If the researcher was not sure about including or excluding a paper, or there was no agreement between both researchers, the paper was presented to the clinical coordinator of the study for discussion towards a consensus decision. This step resulted in 7 references.

In order to assess that no references were missed during the process, some review papers obtained in our search process were carefully studied.[28,32–34]

Results

A final number of 7 publications were extracted according to the previously described process. These are detailed in Table 1.

Description of VR therapies

Social skills training with virtual reality role-plays (SST-VR)[35] includes three consecutive workouts: five training sessions on conversation skills (ïntroduce yourself; ïnd a common concern and listen to the other person; ïtart a conversation; ïold a conversationänd ënd a conversation), three training sessions on assertiveness skills (mïake a demand; ïeject a demand from another personänd mïake a commitment), and two training sessions on emotional expression skills (ëxpress positive emotionsänd ëxpress negative emotions). Each session incorporates a therapist model followed by the participant's role play, and then positive and corrective comments from the therapists. The VR system allowed interacting with avatars in an immersive environment during role-playing sessions.

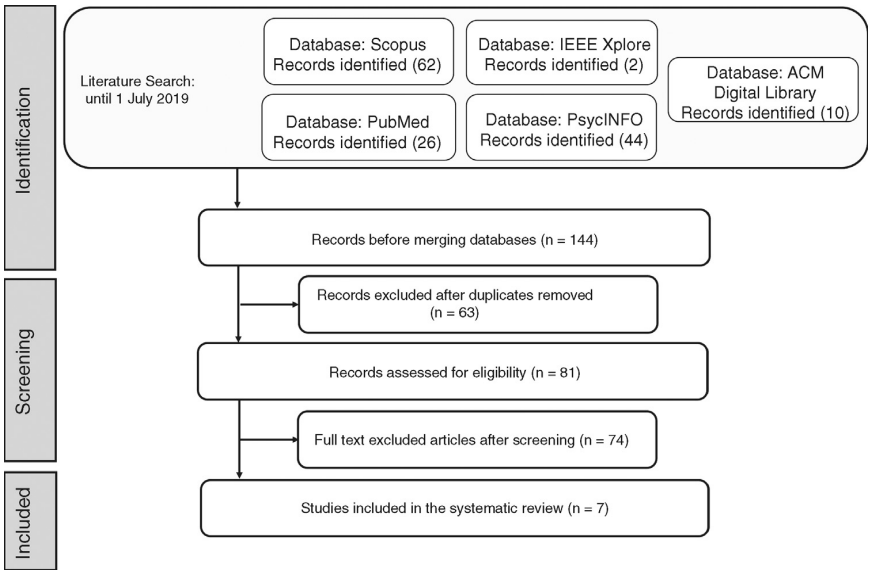

Figure 1 Steps followed for article extraction and selection process.

Table 1 VR-based interventions for psychosocial rehabilitation in schizophrenia.

Name of the therapy	Authors, Year	Sample	Duration and intensity	Type of study	Immersive/ non-immersive VR	Therapy targets	Evaluation instruments	Results
SST-VR[35] (Social skills training with virtual reality role-plays)	Park et al., 2011	64 patients diagnosed with schizophrenia	10 group sessions in 5 weeks	Randomised control trial Experimental condition: SST-VR (n = 33) Control condition: SST-TR (n = 31)	Immersive VR	Social skills and motivation	Psychopathology: PANSS Social skills: SBS RAS RCS SPSI-R Blind assessors rated vocal, non-verbal and conversational skills	During the training, the SST-VR group showed greater engagement with the training and generalisation of skills. After the training, the SST-VR group improved more in assertiveness and conversational skills, but less in nonverbal skills
Soskitrain36 (Social skills training)	Rus-Calafell et al., 2012	1 patient diagnosed with schizophrenia	16 individual one-hour sessions, twice a week over eight weeks	Pre-treatment, post-treatment	Not specified	Social skills and social functioning	Psychopathology: PANSS Social anxiety: SADS Social performance and anxiety: AI Social functioning: SFS	Improvement in facial emotion recognition, social anxiety, conversation time, interpersonal communication, assertiveness and negative symptoms
Soskitrain37 (Social skills training)	Rus-Calafell et al, 2014	12 patients diagnosed with schizophrenia or schizoaffective disorder	16 individual one-hour sessions, twice a week over eight weeks	Pre-treatment, post-treatment and four-month follow-up	Immersive VR	Social skills and social functioning	Psychopathology: PANSS Social performance and anxiety: AI SSIT SADS Social functioning: SFS	Improvement in negative symptoms, psychopathology, and social skills. Maintained at follow-up

Table 1 (*Continued*)

Name of the therapy	Authors, Year	Sample	Duration and intensity	Type of study	Immersive/ non-immersive VR	Therapy targets	Evaluation instruments	Results
Job interview[38] training with Molly Porter	Humm et al, 2014	26 patients diagnosed with ASD 37 patients diagnosed with schizophrenia and 33 patients diagnosed with PTSD	Molly Porter: 5 individual 2 hours sessions Control group: Treatment as usual	Randomised control trial Experimental condition (n = 64) Control condition: waitlist controls (n = 32)	Not specified	Job interview skills	Neurocognitive functioning: RBANS Social cognition: BLERT	Improvement in role-play interviews and self-evaluation
Job interview[39] training with Molly Porter	Smith et al., 2015	32 patients with schizophrenia or schizoaffective disorder	Molly Porter: 5 individual 2 hours sessions Control group: Treatment as usual	Randomised control trial Experimental condition (n = 21) Control condition: waitlist controls (n = 11) 6-month follow-up	Not specified	Job interview skills and employment	Role-playing performance, self-confidence, employment on the following 6 months	The VR group showed a larger improvement of job interview skills and self-confidence after the intervention. At 6-month follow-up participants in the VR groups had higher odds of receiving a job offer
RC2S[40] (Cognitive remediation of social cognition in schizophrenia)	Peyroux & Franck, 2016	2 patients diagnosed with schizophrenia	14 individual sessions of 1 hours 30 to 2 hours duration per week	Pre-treatment, post-treatment and six-month follow-up	Non-immersive VR	Social cognition and social functioning	Psychopathology: PANSS Daily functioning: SERS WEMWBS EAS Facial emotion recognition: TREF Theory of Mind: MASC-VF TOM-15 RMET Attribution style: AIHQ Social perception and knowledge: PerSo[a] Empathy: EQ QCAE	Improvement in the targeted social cognitive processes and positive changes in daily functioning in the long term

Table 1 (*Continued*)

Name of the therapy	Authors, Year	Sample	Duration and intensity	Type of study	Immersive/ non-immersive VR	Therapy targets	Evaluation instruments	Results
MASI-VR[41] (Multimodal adaptive social intervention in virtual reality)	Adery et al., 2018	16 patients diagnosed with schizophrenia	10 individual sessions scheduled approximately twice per week	Pre-treatment and post-treatment	Non-immersive VR	Social skills and social functioning	Severity of general psychiatric symptoms: BPRS Severity of positive and negative psychotic symptoms: SAPS SANS Social functioning: SFS	Improvement in general psychiatric symptoms and negative psychotic symptoms

AI: Assertion inventory; AIHQ: Ambiguous Intentions Hostility Questionnaire; ASD: Autism spectrum disorder; BLERT: Bell-Lysaker Emotion Recognition Task; BPRS: Brief Psychiatric Rating Scale; EAS: Social Autonomy Scale; EQ: Empathic quotient; MASC-VF: Movie for the Assessment of Social Cognition; PANSS: Positive and negative symptoms scale ; PTSD: Post-traumatic stress disorder; QCAE: Questionnaire of Cognitive and Affective Empathy; RAS: Rathus Assertiveness Schedule; RBANS: Repeatable Battery for the Assessment of Neuropsychological Status; RCS: Relationship Change Scale; RMET: Reading the Mind in the Eyes Test; SADS: Social avoidance and distress scale; SANS: Scale for the Assessment of Negative Symptoms; SAPS: Scale for the Assessment of Positive Symptoms; SBS: Trower's Social Behavior Scales; SERS: Self Esteem Rating Self; SFS: Social functioning scale; SPSI-R: Social Problem Solving Inventory- Revised; SSIT: Simulated social interaction test; TOM-15: Theory of Mind-15; TREF: Test de Reconnaissance des Emotions Faciales; WEMWBS: Warwick-Edinburgh Mental Well-Being Scale.

[a] PerSo: This test is currently under validation.

Soskitrain[36,37] is a social skills training aimed at everyday situations, such as going to the supermarket, dealing with an angry security guard in a museum or trying to negotiate with a friendly manipulator about who would drive a car to a party. The program consists of two phases. In the first phase, the difficulties of facial recognition of emotions and the processing of social information are addressed. The second phase is aimed at social anxiety and interpersonal skills. The program allows users to practise social interactions with virtual avatars, encourages progressive learning of the social skills repertoire and provides positive or negative reinforcement.

Job Interview Training with Molly Porter[38,39] is designed to teach, reinforce, and refresh job-interview skills to adults with mental illness who are actively seeking employment. The system incorporates user-driven educational materials, an interactive role play simulation and formative comments to create a training experience consistent with high fidelity simulations, successful job interviews and adult learning theory. The educational component includes approximately five hours of training materials designed to help students prepare for interviews and complete the other steps necessary to find a job. Some of the topics covered include creating a resume, researching a position, selecting a job that meets individualized needs, deciding what to wear to an interview, selecting appropriate questions to ask, deciding whether or not to disclose a disability, and taking appropriate follow- up steps. The therapy is based on interactive VR simulation of role-playing games combining videos and voice recognition software.

RC2S[40] is a comprehensive, individualized social cognitive remediation program that includes paper and pencil tasks and computerized exercises. Each session is divided into four parts. The first includes paper-and-pencil tasks for the patient to develop strategies to analyse social situations, focusing first on basic social cognitive processes and then on higher order social cognitive functions. The second part contains a VR scene in which the goal is to help a character named Tom in a particular social situation. In the third part, the specific social components such as context or non-verbal language are reviewed during the VR simulation scene. Finally, the fourth part includes the determination of a home-based task chosen by the patient in collaboration with the therapist and related to the concrete objectives defined at the beginning of the therapy.

MASI-VR[41] is a program that includes the training of nonverbal social skills such as eye contact, facial expression, social distance and more complex skills including how to start conversations, greet people and ask for help or information. For this, the therapy includes avatars in non-immersive VR in three different social contexts (bus stop, shop and cafeteria).

Samples

The sample size was very variable (from a case report[36] to 64 patients[35]). The study participants suffered from schizophrenia, except in two studies were included in which patients were diagnosed with schizophrenia and schizoaffective disorder.[37,39] One study included patients diagnosed with ASD and PTSD, in addition to patients with schizophrenia.[38] For the present review only the schizophrenia sample was considered.

Two studies specified that all included participants were clinically stable and had not been hospitalised in a psychiatric institution in the last 6 months.[36,37] One study noted that participants were treated with intensive psychiatric care during two to four weeks and stabilised enough to participate in the study.[35] Only one of the studies that included two participants clarified that one of them was stable after a 5-month hospitalisation.[40] Finally, three studies did not report information about clinical situation of the patients.[38,39,41]

Duration and intensity of therapies

The number of sessions was variable (5–16 sessions). The duration of the sessions was usually 1—2 hours with a twice a week frequency.

Type of study

According to the level of scientific evidence, three randomised control trials and four pre-post treatment studies were identified.

Among the three randomised studies, only one study included an intervention in social skills without VR as a control condition.[35] The main difference between the two interventions: Social skills training with virtual reality role-plays (SST-VR vs SST-TR) was the role-playing method. Virtual environments as simulators of the scenes and avatars as actors were used in VR role-plays, whereas verbal, writing, picture, and video supplies were used as simulators of the scenes and SST therapists as the actors in TR role-plays. Thus, except for the materials used in role-plays, there were no differences in the details of training, including time spent for instructions, orientation, and contact with the main therapist. Two randomized control trials compared the experimental condition with the control condition, which included patients on the waiting list to be admitted to the experimental condition.[38,39]

Four pre-post treatment studies were included. One of them included a post-intervention evaluation at 4 months[37] and another included an evaluation at 6 months.[40]

Immersive / non-immersive VR

Only two studies specified the use of immersive VR.[35,37] One study specified the use of non-immersive VR.[41] The rest did not specify it.[36,38–40]

Therapy targets

Social cognition interventions

One work had as its main objective the improvement of social cognition.[40]

Social skills interventions

Six studies were aimed at improving social skills.[35–39,41] Two articles focused on improving job interview skills[38,39] and one of them analysed the impact on neurocognitive

functioning and social cognition.[38] Three studies evaluated social functioning[36,37,41] and one of them also evaluated the impact on facial emotion recognition.[36]

Research teams and outcomes

A Korean research team was the pioneer in the design of a therapy for the improvement of social skills in patients with schizophrenia using VR. Park and colleagues designed a therapy called SST-VR, with positive results in assertiveness and conversational skills.[35]

A Spanish research team designed a therapy called Soskitrain, aimed at improving social skills. In 2012, they conducted a preliminary study with a patient diagnosed with schizophrenia.[36] Two years later, they expanded the sample to 16 patients with schizophrenia or schizoaffective disorder and added a follow-up evaluation after 4 months. It was described a significant improvement in negative symptoms, psychopathology, facial emotion recognition and social skills, maintained at follow-up.[37]

An American group has designed a job interview skills training program called ''Molly Porter''.[38,39] The intervention incorporates user-driven educational materials, an interactive role-play simulation, and formative feedback to create a training experience consistent with high-fidelity simulations, successful job interviews, and adult learning theory. In the first study, the improvement of job interview skills was evaluated, with positive results around this capacity and a superior self-assessment in the experimental condition. The second study also assessed the employment capacity during the next 6 months. The study again showed a greater improvement in job interview skills and self-confidence after the intervention in the experimental condition and, at 6 months of follow-up, participants in the VR groups had higher odds of receiving a job offer.

A French research team designed a therapy called RC2S. It is a comprehensive, individualised, and partly computerised social cognitive remediation program. Its main objective is the improvement of social cognition, evaluating the four cognitive domains (emotional processing, theory of mind, attributional style and social perception) and social functioning.[40] The therapy has been carried out in two patients diagnosed with schizophrenia, with immediate promising results in the targeted social cognitive processes and positive changes in daily functioning at 6 months follow-up.[40]

Another American group designed an intervention aimed at improving social skills and social functioning: MASI-VR. Significant improvement in general psychiatric symptoms and negative psychotic symptoms was shown.[41]

Tolerability

Only two studies evaluated the tolerability of interventions. Both indicated that the interventions were well tolerated, interesting and motivating for the patients.[35,37]

Discussion

To our knowledge, this is the first systematic review carried out specifically focused VR interventions for the improvement of psychosocial functioning in patients with schizophrenia.

The study included publications from 1st January 2000 to 1st July 2019. The results show the current situation of this field of knowledge. A total number of 7 papers were selected from the initial 81 non-repeated publications obtained from five databases (PubMed, Scopus, PsycINFO, IEEE Xplore, and ACM Digital Library).

Nowadays, the works are scarce, very recent and the samples are heterogeneous in quantity and quality, without specifying the level of stability of the patients included in the studies. Regarding the level of scientific evidence defined by the US Agency for Healthcare Research and Quality Agency,[42] from the total number of 7 selected papers only 2 papers were classified as having an IB level of evidence (evidence obtained from at least one randomised clinical trial) and 3 references presented an IIB level (scientific evidence obtained from at least one well-designed, quasi-experimental study). Studies that specified the use of immersive virtual reality are limited, probably because immersion is a step beyond the common studies that use VR. Most studies could be classified as social skills interventions, including job interview skills.

The low number of articles can be related to several facts. Today VR is expensive due to the cost of technological means and personnel specialised in the design of scenarios and avatars. In other pathologies such as specific phobias the works are in a more advanced state, partly because they require a simpler VR (e.g. a spider) than for social interaction.[43] In addition, there is an initial reluctance to work with VR in patients with schizophrenia, despite the studies that have been carried out in relation to safety and acceptability of technology, which indicated that VR was found to be easy to use, funny, motivating, interesting and did not generate anxiety in the participants.[28,35,37,44] Finally, publication bias in the face of negative results could be influencing the results obtained.

Despite the low number of publications, all studies obtained promising results around the improvement of social skills and / or social cognition in short-term. Some studies also noted an improvement in general psychopathology, negative symptomatology and daily functioning.

The present review throws new information around the available VR-based therapies for the improvement of psychosocial functioning in schizophrenia. Three studies[36,40,41] that had not been included in other previous reviews[36,40,41] were analysed in our review. Also, the present study provides extra information regarding previous reviews. Each therapy was described and classified considering the level of evidence, the type of VR used (immersive and non-immersive VR) and the content (social cognition, social behaviour and social skills), considering the definition of psychosocial functioning.

The present systematic review has some risks and limitations. One possible limitation in all systematic reviews is related to the selective reporting bias.[45] To minimise such risk, five different databases were used as the source for

the search process: PubMed, Scopus, PsycINFO, IEEE Xplore and ACM Digital Library. These provide a comprehensive list of articles that cover the distinct aspects of this review. In addition, two researchers independently reviewed the article selection process. It is worth noting that it was established that grey literature (e.g., theses, internal reports, etc.) should be excluded from the study. This could threaten the validity of the study, but it must be highlighted that grey literature is mostly published without a rigorous review process.

In summary, VR seems to offer an interesting and motivating therapeutic option for patients suffering from schizophrenia. The possibility of creating ecological environments and avatars that interact with patients and whose expressions and behaviours can be modified in real time, represents a great progress for mental health, especially interesting in the area of psychosocial remediation. In the coming years, the research will shed light on the limitations that exist today.

Financial disclosure

This work was partially supported by Spanish Ministerio de Ciencia, Innovación y Universidades, Agencia Estatal de Investigación (AEI)/European Regional Development Fund (FEDER, UE) under RECOVER (PID2019-106084RB-I00) EmoBioFeedback (DPI2016-80894-R) and HA-SYMBIOSIS (TIN2015-72931-EXP) grants, by the Instituto de Salud Carlos III (grant PI16/00359; Fondo de Investigaciones Sanitarias/FEDER), by the European Development Regional Fund'' A way to achieve Europe'' (ERDF), by Madrid Regional Government (R&D activities in Biomedicine S2017/BMD-3740 (AGES-CM 2-CM)) and Structural Funds of the European Union.

Conflict of interest

We have read the journal's policy and the authors of this manuscript have the following competing interests: Dr. R. Rodriguez-Jimenez has been a consultant for, spoken in activities of, or received grants from: Instituto de Salud Carlos III, Fondo de Investigación Sanitaria (FIS), Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM), Madrid Regional Government (S2010/ BMD-2422 AGES), Janssen-Cilag, Lundbeck, Otsuka, Pfizer, Ferrer, Juste, Exeltis. The other authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Acknowledgements

Spanish Ministerio de Ciencia, Innovación y Universidades, Agencia Estatal de Investigación (AEI) / European Regional Development Fund (FEDER). Instituto de Salud Carlos III. Madrid Regional Government and Structural Funds of the European Union. European Development Regional Fund'' A way to achieve Europe'' (ERDF).

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3.4. Diseño y validación de expresiones faciales humanas virtuales

Design of Reliable Virtual Human Facial Expressions and Validation by Healthy People

En este artículo, dedicado a la descripción del diseño de expresiones faciales humanas virtuales y su validación por parte de personas sanas, la precisión general en la identificación de emociones con los humanos virtuales diseñados fue del 88.25 %. Los estudios por género, edad e intensidad de la emoción muestran que el género y la edad no tienen influencia significativa en la tasa de reconocimiento, pero la intensidad de la emoción representada por el humano virtual ha demostrado ser significativo.

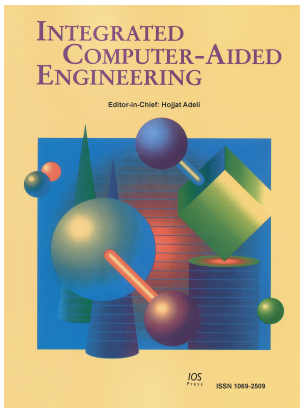
Validation of Dynamic Virtual Faces for Facial Affect Recognition

Los resultados de este otro estudio de validación de expresiones facilaes humanas virtuales, ahora con un mayor dinamismo, mostraron que los humanos virtuales eran tan válidos como los rostros naturales estandarizados para recrear con precisión las expresiones faciales de emociones humanas. La precisión general en la identificación de las emociones fue mayor para el estímulo virtual (el 88.25 % en nuestra propuesta frente al 82.60 % para ER-40). El porcentaje de éxitos de cada emoción fue alto, especialmente para la expresión neutral y la felicidad. La identificación del asco fue sorprendentemente alta, mayor que en estudios previos. No se encontraron diferencias estadísticamente significativas en términos de género. Tampoco se encontraron diferencias significativas entre adultos y adultos mayores de 60 años. La intensidad de la emoción, la presentación de frente (en comparación con la presentación de perfil) y los niveles educativos más altos han demostrado ser estadísticamente significativos.

3.4.1. Design of Reliable Virtual Human Facial Expressions and Validation by Healthy People

Datos de la publicación

RESUMEN:
El nivel de realismo que han alcanzado los humanos virtuales en tiempo real en los últimos años permite su uso como alternativa a las imágenes y vídeos en los tratamientos de los déficits de cognición social. Este trabajo presenta el procedimiento de diseño de expresiones faciales en humanos virtuales para reproducir emociones básicas. La propuesta se basa en el Sistema de Codificación de Acciones Faciales que permite representar fácilmente las expresiones faciales. A continuación, se describe cómo las emociones faciales de los humanos virtuales diseñados han sido evaluadas por personas sanas. Para ello, 204 participantes sanos han participado en un experimento en el que han tenido que reconocer las seis emociones básicas (cada una de ellas con dos niveles de intensidad) representadas por los humanos virtuales. La precisión global de la tarea de identificación de emociones fue del 88,25 %, lo que supera la mayoría de los resultados obtenidos por otros autores utilizando humanos virtuales y/o imágenes. Las emociones mejor reconocidas fueron las neutras, la alegría y la ira. Notablemente llamativo fue el alto índice de éxito obtenido para el disgusto, muy superior a los estudios previos basados en la realidad virtual. A diferencia de otros trabajos, no se encontraron diferencias significativas entre mujeres y hombres en el reconocimiento de las emociones, probablemente debido a un mayor dinamismo y realismo de los rostros humanos diseñados. Sin embargo, se encontraron diferencias relacionadas con la edad para algunas emociones a favor de los participantes más jóvenes. Además, se detectaron mayores tasas de identificación de emociones para las representaciones de mayor intensidad de cada emoción, para los avatares más dinámicos y para los rostros mostrados frontalmente en comparación con los laterales. Por lo tanto, los resultados del experimento de evaluación han demostrado que los humanos virtuales transmiten perfectamente las emociones utilizando expresiones faciales.



Datos de la publicación (cont.)

CITACIÓN:

A.S. García, P. Fernández-Sotos, M.A. Vicente-Querol, G. Lahera, R. Rodriguez-Jimenez, A. Fernández-Caballero (2020) "Design of Reliable Virtual Human Facial Expressions and their Validation by Healthy People", *Integrated Computer-Aided Engineering* 27(3): 287-299; doi:10.3233/ICA-200623

ÍNDICES DE CALIDAD:

Índice de impacto 2019: 4,706.

Cuartil: Q1.

Rango (Categoría): 10/91 (Engineering, Multidisciplinary); 15/109 (Computer Science, Interdisciplinary Applications); 25/136 (Computer Science, Artificial Intelligence).

Integrated Computer-Aided Engineering 27 (2020) 1–13
IOS Press

Design of reliable virtual human facial expressions and validation by healthy people

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Abstract The level of realism that real-time virtual humans have reached in the last years enables their use as an alternative to pictures and videos in the remediation of social cognition deficits. This paper presents the engineering principles and tools used to design facial expressions on virtual humans to play basic emotions. The proposal is based on the Facial Action Coding System that makes it possible to easily represent facial expressions. Then, the paper describes how the designed virtual human facial emotions have been assessed by healthy people. For that purpose, 204 healthy participants have taken part in an experiment in which they had to recognize the six basic emotions (each of them with two levels of intensity) depicted by the virtual humans. The overall accuracy of the emotion identification task was 88.25%, which outperforms most results obtained by other authors using virtual humans and/or pictures. The best recognized emotions were neutral, happiness and anger. Remarkably striking was the high success rate gotten for disgust, far superior to previous studies based on virtual reality. Unlike other works, no significant differences were found between women and men in the recognition of emotions, probably due to an enhanced dynamism and realism of the designed human faces. However, age-related differences were found for some emotions in favor of the younger participants. In addition, higher emotion identification rates were detected for higher intensity representations of each emotion, for more dynamic avatars and for faces shown frontally compared to lateral ones. Therefore, the results of the evaluation experiment have demonstrated that virtual humans perfectly convey emotions using facial expressions.

Keywords: Virtual human, Facial expression, Facial affect recognition, Virtual reality, Validation

1. Introduction

Modeling social interactions is becoming increasingly important in the creation of interactive systems that apply Biomedical Engineering (BME) principles and design concepts [1,2,3]. BME pursues to close the gap between engineering and medicine to advance health care, including diagnosis, monitoring, and therapy [4]. Non-verbal communication (gaze, facial movements, gesture, interpersonal distance, etc.) is an essential dimension in the interaction of humans with humans and machines [5]. In this context, facial emotion (affect) recognition is the capacity to distinguish and perceive essential types of affective expressions in faces [6]. This daily life ability is critical for social interaction [7].

Indeed, the way an individual perceives emotional states in others influences his/her social success, which is important for assimilation to the community [8]. There is steady proof that patients with various neuropsychiatric disorders have noteworthy trouble in perceiving emotions communicated by others in a precise

way. This creates a distortion of social circumstances that supports the presence of psychotic symptoms and a decrease of social functioning [9]. This deficit in facial affect recognition has been widely observed in psychotic disorders, particularly in schizophrenia and related disorders [10]. The disability is by all accounts stable throughout the disorder, not identified with psychopathology or pharmacological treatment, and autonomous of general cognitive deficits [11,12,13].

This is the reason why different mental interventions have been designed to improve facial affect recognition in patients with schizophrenia. In fact, recent meta-analyses have demonstrated promising results of psychotherapeutic methodologies improving facial affect recognition and functionality [9]. For this purpose, computer-based treatments appear to be fitting to date. Indeed, access to digital technology and the Internet to individuals experiencing mental disorders [14] empowers new ways to deal with their illness. Precisely, frameworks for emotion detection [15,16,17] and facial emotion detection [18] have been at the focal point of our research. The generation of frameworks based on virtual humans (VHs) for facial affect recognition [19,20] is one of our current primary interests. In the most recent years, a few works on building multimodal virtual characters for social cognition remediation programs [21,22] and proposing the utilization of VHs to describe auditory hallucinations in schizophrenia patients [23,24] have been presented.

The primary effort to reproduce human faces in 3D using computer graphics imagery is probably over 45 years old [25]. From that point forward, 3D human faces have been widely used in computer games and films. Current advances in graphics technologies are moving out of the uncanny valley, as real-time rendered virtual characters turn out to be increasingly realistic. Hence, an absence of human-like facial expressions portrayed by virtual characters increases the dimension of strangeness felt despite physical authenticity [26]. Additionally, physical authenticity ought to be accompanied by social realism [27], as the individuals' assumptions regarding realistic movements or behaviors are raised by the level of physical authenticity [28].

A few physical models depicting facial expressions have been proposed from the perspective of muscle activation and can be used to accomplish a higher level of authenticity. One of the most popular models in the literature is the one by Ekman and colleagues [29]. Notwithstanding, conveying emotions using virtual characters is not a simple task, and this might be identified with the absence of knowledge about the time course of facial movements and the affective content felt from those developments [30].

The present paper introduces the engineering principles and tools used to design facial expressions on virtual humans for showing basic emotions. At that point, an investigation is done with healthy individuals to assess that the designed facial emotions are accurately interpreted by people who have no social cognitive shortfalls. Thus, the objective of the present paper is the description of the design process of virtual human facial expressions and their validation by 204 healthy participants. The novelty of the article lies, first, in the description of the virtual human design process that combines several techniques and commercial software packages. Secondly, in the large sample size to validate the design, and finally, the designed facial expressions are shown to each participant with two levels of intensity (low and high), two levels of dynamism (low and high), and from different perspectives (frontal and lateral views). Should the outcomes be concluding, our virtual human emotional faces could be used as correlation with patients with schizophrenia. Conversely, if healthy people are not able to correctly detect facial expressions on virtual humans with a high accuracy, it would be nonsense to use the avatars in further studies with real patients. The current paper must be considered as an initial move towards planning a complete therapy to upgrade facial affect recognition in these patients.

2. Design of Facial Expressions in Virtual Humans

2.1. Facial Action Coding System

People are social creatures who need to convey emotions in order to socialize. Individuals express emotions in various ways and the face assumes a significant role in how emotions are transmitted both in verbal and non-verbal communication. Affect has been contemplated in the field of Psychology and Psychiatry. For example, Ekman and Friesen [31] concluded that there exist six universal basic emotions (*Anger*, *Disgust*, *Fear*, *Happiness*, *Sadness*, and *Surprise*). Facial muscles are used to demonstrate these emotions, changing that way the appearance in the face. A few studies attempted to discover a framework to evaluate the various changes in the face providing a few approximations [32].

To reproduce the adjustments in the face, our proposal is not situated in an exact representation and investigation of the muscles, but in the well-known Facial Action Coding System (FACS). We picked this framework since it is the most generally used and has demonstrated its adequacy through a psychometric evaluation for assessing spontaneous expressions [33]. Subsequently, it gives more information, such as intensity, than other systems about the adjustments in the face [32]. In fact, FACS, designed in 1978 and modified and improved in 2002 [29], is a notable system that categorizes facial movements based on various Action Units (AUs), instructing how to perceive and score them.

Every AU characterizes a group of muscles that work together to provoke a modification on the facial appearance. The various AUs are gathered according to the location of the facial muscles that are separated in upper and lower face muscles. Upper face muscles incorporate eyebrows, forehead, eye cover fold, and upper and lower lids. The lower face incorporates the muscles around mouth and lips, and it is divided in different classifications as indicated by the muscles' movement directions. There are other AUs based on muscles that move the neck and the gaze direction.

2.2. Facial Expressions in FACS

Only fifteen AUs from the twenty-eight fundamental ones are required to describe the six basic emotions (*Anger*, *Disgust*, *Fear*, *Happiness*, *Sadness*, and *Surprise*) and the *Neutral* expression used in this research. The AUs used and their connection with every emotion is shown in Table 1.

The table shows that:

- Twelve animations were modelled.
- Two levels (1.2) of animations were designed for every emotion.
- No AU was needed to model the *Neutral* expression.
- Each level indicates the emotion intensity; a higher number shows greater emotional intensity, (2)>(1).
- New AUs were added for some emotions, indicating that more muscles are moved, and more facial changes appear.

2.3. Generation of Affective Virtual Humans

The work flow for the generation of the affective VHs is one of the novelties of this proposal. The contribution of our approach lies in the combination of several well-known techniques in the game development and VR fields, using different software packages in order to obtain the desired result. This work flow process is depicted in Figure 1 and described in the following paragraphs.

We began by choosing and tuning two predefined characters accessible in Adobe Fuse CC [35]. Adobe Fuse CC is a software tool principally aimed at video game developers to create 3D characters using an advanced character creation editor. The characters gotten by using this tool exploit numerous visual features that are typical in recent high-end video games, specifically high-resolution textures, normal maps, ambient occlusion maps, etc. Besides, they are completely configurable, from the face to the length of the arms, torso or the garments they wear. For this work, predefined VHs were chosen (using the option "Assemble") and not changed apart from picking garments and choosing a hair style (option "Clothing") that did not occlude significant parts of the face like forehead and eyes.

By clicking the "Send to Mixamo" button from inside Adobe Fuse CC, the characters were then exported to Mixamo [36], a web platform that provides autorigging of humanoid 3D models. Rigging is a technique used in skeletal animation for representing a 3D character model using a series of interconnected digital bones. It refers to the process of creating the bone structure of a 3D model, which enables manipulating the 3D model like a puppet for animation. At that point, an idle animation was chosen from the available ones. This platform likewise provides some basic form of facial animation that can be used in other programs. In any case, it did not depend on FACS so that there is no immediate correspondence between them.

From that point onward, the resulting 3D character is brought into the 3D Studio Max [37] authoring tool to generate the AUs, always starting from the *Neutral* facial expression. We used blend shapes, also known as morph animation targets, which consists in altering the mesh likewise and storing the vertex positions for every AU. At that point, these AUs are smoothly morphed and combined to shape the wanted facial animation by using a "Morph Modifier". Alternatives to implement AUs are the utilization of a muscle-based animation system or a hierarchy of bones to modify the geometry. A blend shape animation system was chosen because of its straightforwardness and the likelihood to combine AUs to generate complex facial expressions.

Once all the AUs were incorporated into the virtual human models, they were exported into Unity 3D [38],

Table 1
Action Units used to describe the six basic emotions (based on [32, 29,34]).

AU	Name	*Surprise*	*Fear*	*Happiness*	*Sadness*	*Disgust*	*Anger*
1	Inner Brow Raiser	(1.2)	(1.2)		(1.2)		
2	Outer Brow Raiser	(1.2)	(1.2)				
4	Brow Lowerer		(1.2)		(1.2)		(1.2)
5	Upper Lid Raiser	(1.2)	(1.2)				(1.2)
6	Cheek Raiser			(1.2)			
7	Lid Tightener						(1.2)
9	Nose Wrinkler					(1.2)	
12	Lip Corner Puller			(1.2)			
15	Lip Corner Depressor				(1.2)	(1.2)	
16	Lower Lip Depressor					(1.2)	
17	Chin Raiser				(2)		(1)
20	Lip Stretcher		(1.2)				
23	Lip Tightener						(1.2)
25	Lips Part						(2)
26	Jaw Drop	(1.2)	(1.2)				

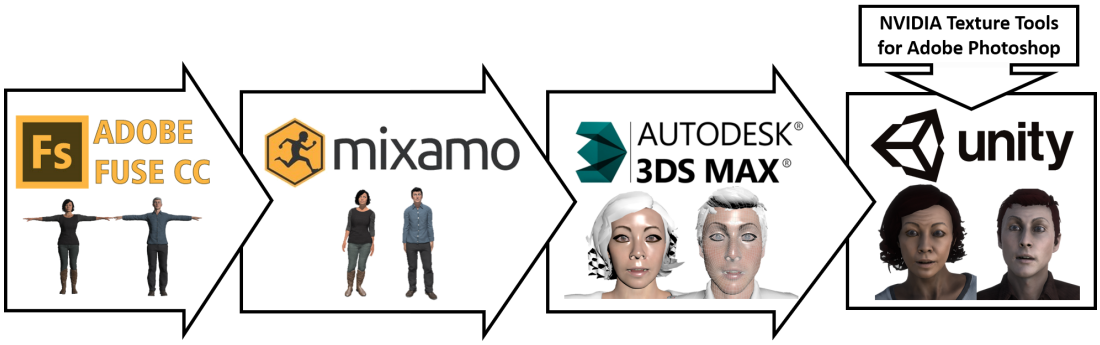

Figure 1. Work flow of the generation of affective virtual humans.

the real-time engine used to play the animations. Time is an essential information for the optimal planning and scheduling of interaction systems [39]. This software tool enables to use the initial idle animation incorporated into Mixamo in the same manner as the blend shapes included into 3D Studio Max. At that point, the facial expressions were upgraded by adding wrinkles to the models. For this, a custom surface shader using several "Normal map" textures was generated in Unity 3D and used as a material parameter. Normal maps are used to simulate subtleties in an object's surface by changing the vertices' normal and, therefore, affecting light calculation on the surface. Everyone incorporated an alternate wrinkle pattern related to each emotion. This shader described all the visual appearance of the virtual human's face, using textures for the skin color, normal mapping, reflections (specularity) and ambient occlusion. The standard lighting model was used, and shadows were enabled on all light types (fullforward-shadows option).

The textures generated by Adobe Fuse CC were used in the surface shader. For each facial expression, the Nvidia Normal Map Filter for Adobe Photoshop [40] was used to generate the normal maps based on photos of individuals delineating the facial emotion and on the wrinkle descriptions provided by Ekman and Friesen [34]. We used 7 different normal maps per virtual human, one per each facial expression plus the *Neutral* one. At last, the custom surface shader smoothly interpolated between the *Neutral* normal map and the normal map of every facial expression, simulating a dynamic generation of wrinkles. This interpolation was synchronized with the blend shape animation of the facial expression in a way that

the wrinkles appeared gradually as the animation progressed. A value of 0 for a blend shape related to a given facial expression means that this facial expression is not displayed by the virtual human, while 100 means that the facial expression is completely displayed. This denotes that the vertices of the face depicting the expression have moved from the initial position (*Neutral*) to the final position for the given expression. Similarly, this numeric value ranging from 0 to 100 was used to blend the normal maps from the *Neutral* normal map to the corresponding normal map for the target facial expression. These two actions happening together gave the impression that the wrinkles are generated by the motion of the face when depicting each expression. For instance, Figure 2 shows how the *Surprise* and *Disgust* facial expressions are enhanced by using wrinkles.

Figure 2. Male virtual human demonstrating the *surprise* emotion (top images) and female virtual human showing *disgust* (bottom). Both pairs of pictures show how they look without (left) and with (right) normal maps. Please pay attention on the wrinkles on the forehead and on both sides of the mouth in the male VH, and the wrinkles around the nose and the mouth in the female.

As the fine-tuning of most parameters related to the AUs has been done by hand, the way decisions have been taken should be highlighted. Two engineers designed the avatars from scratch to a first version. Then, the other engineer and the psychiatrists discussed about the likeness of the virtual human's emotions to the human's ones. The final version of the avatars was obtained in an iterative manner.

2.4. Improvements in Facial Expressions Over a Previous Version

In a previous experiment [41], we detected troubles with some facial expressions. Originally, *Happiness* included a third variation of lower intensity, a very subtle smile which was mainly confused with the *Neutral* expression. It seems that the participants did not consider it to be a sign of happiness, even when they noticed the smile. Therefore, that variation was excluded from the present study. There were also some identification problems for *Disgust* and *Sadness*, which lead to their redesign.

3. Validation of Facial Expressions by Healthy People

A validation of the system was performed to assess its suitability to propose a future clinical therapy for enhancing facial affect recognition in people with schizophrenia. Therefore, in first term it was determined as mandatory to evaluate if healthy people are capable of recognizing the virtual facial expressions generated. In addition, the acceptance and use of such avatar-based proposal has been positively assessed by 41 therapists in a recent previous work [42].

3.1. Participants

The sample size was 204 healthy volunteers. The single inclusion criterion was to be aged between 20 and 79 years. The mean age of the participants was $M = 47.21$ ($SD = 15.64$). The participants were recruited from Madrid and Albacete (Spain). Exclusion criteria included having a diagnosis of mental illness, a personal history of medical illness, and a first-degree family history of psychosis. The sample was stratified by gender (50% male, 50% female). All the participants were volunteers and did not receive any compensation for their participation.

3.2. Experimental Procedure

As explained before, this experiment aims at examining whether the emotions shown by the designed virtual humans convey the same emotional meaning as real human expressions. Two variations of each of the original VHs previously used by our research team [41] were designed. This made a total amount of six VHs (see Figure 3). Four were Caucasian (two

male and two female) and two African (one male and one female). All six VHs were designed with two age representations, namely adult of about 30 years and old age. As said, seven emotions were portrayed for this experiment based on the FACS system: the six basic emotions and the *Neutral* expression. Two different intensities were implemented for each basic emotion, giving a total of thirteen intensity emotions, labeled as *neutral*, *surprise1*, *surprise2*, *fear1*, *fear2*, *anger1*, *anger2*, *disgust1*, *disgust2*, *happiness1*, *happiness2*, *sadness1*, and *sadness2* (written in lower case).

Each facial expression was presented to the participants four times (two frontal and two lateral views, one from each side). This made a total of fifty-two facial expression representations. Thirty-two of them were shown using the younger adult versions of the Caucasian VHs, eight using the aging adult version of the Caucasian VHs and eight using the African VHs. These fifty-two facial representations using different variations were randomly presented to the participants. Half of them were presented with less dynamism (only the most characteristic facial features presented movement, i.e. the AUs described in Table 1) and the other 50% with more dynamism, including movement of the head and the neck in order to bring more realism to the expressions.

The validation process is depicted in Figure 4. It starts by requiring the participant to complete two questionnaires. The first one includes a collection of social, demographic and clinical data. The second is the Spanish version of the positive and negative affect schedule (PANAS [43]), which is a 20-item self-report questionnaire that measures the individual's positive and negative affect. This schedule is included in order to control the participant's mood state or non-specific depression symptoms. After completing the questionnaires, the participant starts the evaluation test.

A short tutorial describing the task is presented to the participant. He/she must press a button to start the experiment. The validation process starts by displaying the first facial expression. Each time a new facial expression is shown, the character's face is faded-in from a black background. A transition is made from the *neutral* expression to the new emotion (lasting 0.4 seconds), which is held for 1.5 seconds. Then, there is a new transition to the *neutral* expression (again, 0.4 seconds). This is in accordance with transition times studied in well-known works [44], as expression time lasts between 0.5 and 4 seconds.

Once this process has finished, a panel is presented to the participant asking him/her for the expression just offered by the VH. This panel also includes a button for each of the six basic emotions and the *Neutral* expression. Once the participant has selected an option, the character face is faded-out. This process is repeated for each of the fifty-two facial expressions. The experiment finishes once the system has presented all the facial expressions to the participant.

The same idle animation is used for all virtual humans. This animation is subtle enough not to distract the participant, while it adds a slight swing that provides more realism to the character. Similarly, a blinking animation is also added, but only during the time the system is waiting for a participant's response, not during the actual visualization of the emotion.

4. Results and Discussion

4.1. Accuracy in Facial Expression Recognition

The number of correct answers did not follow a normal distribution (Kolmogorov-Smirnov test: $Z = 0.165$, $p < 0.001$). Therefore, non-parametric tests were used to compare the results.

As shown in Table 2, the percentage of successful recognition for each face expressing an emotion is high, all well above random chance (set at 14%), and all above 80% except *fear1* and *fear2*. These results are consistent with previously published studies in which *Fear* and *Disgust* were the least identified emotions [45,46]. In our study, although *Fear* is the least recognized emotion, it obtained a percentage of hits similar to previous studies [46,20].

A closer look at the table shows that *fear1* was confused with *Surprise* and *Sadness*, while *fear2* was mainly confused with *Surprise*. This is astonishing as it differs from the results of our previous experiment using the same facial expressions [41], especially for *Fear*. With regards to *disgust2* and *sadness2*, a great improvement is noticeable, as they improve from 68.5% to 89.6% for *disgust2* and from 31.5% to 82.6% in the case of *sadness2*.

Regarding the rest of the emotions, the only one with a confusion percentage above 10% is *disgust1*, which was mainly confused with *Anger*. Remarkably, this is also consistent with previous literature [45, 47]. Nevertheless, the high percentage of successes around *Disgust* is striking in relation to previous outcomes [20,45,46,47]. Previous studies have reported a limitation in the recognition of *Disgust* through virtual reality. This phenomenon may be due to the difficulty

Figure 3. Different variations of the virtual humans used in the emotion recognition evaluation.

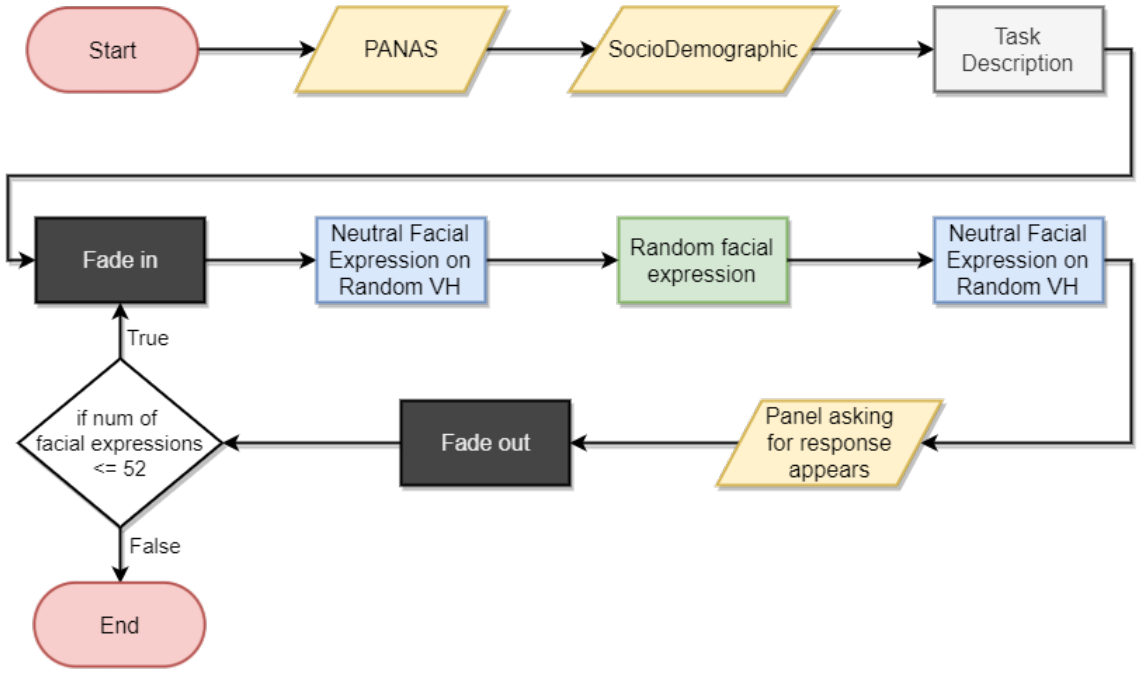

Figure 4. Several variations of the virtual humans used in the emotion recognition evaluation.

Table 2
Emotion recognition rates for each of the 13 animations. Average successful recognition rate: 88.25%.

	Neutral	Surprise	Fear	Anger	Disgust	Happiness	Sadness
neutral	96.3%	0.4%	0.1%	0.2%	0.5%	0.0%	2.45%
surprise1	0.5%	92.6%	6.3%	0.0%	0.1%	0.0%	0.5%
surprise2	0.5%	90.0%	9.2%	0.0%	0.2%	0.1%	0.0%
fear1	1.0%	9.9%	74.4%	0.1%	1.1%	0.0%	13.5%
fear2	0.9%	18.9%	79.5%	0.2%	0.4%	0.0%	0.1%
anger1	1.1%	1.8%	2.3%	87.7%	4.8%	0.0%	2.2%
anger2	1.0%	1.0%	1.2%	92.9%	3.7%	0.1%	0.1%
disgust1	1.5%	1.8%	1.1%	12.9%	82.0%	0.0%	0.7%
disgust2	0.2%	0.4%	1.3%	8.3%	89.6%	0.0%	0.1%
happiness1	2.7%	0.6%	0.2%	0.2%	0.1%	96.1%	0.0%
happiness2	2.8%	0.7%	0.1%	0.6%	0.4%	95.2%	0.1%
sadness1	5.4%	3.2%	2.0%	0.1%	0.7%	0.2%	88.4%
sadness2	1.7%	3.8%	6.7%	1.0%	4.2%	0.0%	82.6%

of authenticity recreating the nasolabial area [48]. For this reason, we paid special attention to this region during the redesign of emotions.

In general terms, the average percentage of successful recognition is high (88.25%), in this way improving in more than 5% our previously reported results (83.56%) [41]. This degree of accuracy is superior to that obtained in previous works with classical stimuli (natural faces) like the Ekman-60 Faces Test [49] or the Penn Emotion Recognition Test-96 Faces version [50]. With the first stimulus, the general percentage of success in two different populations was approximately 82% [49,51]. With the second stimulus, a general percentage of success close to 70% was obtained [20]. In the latter study, the classic stimulus was compared with a set of virtual faces. With the virtual stimulus the overall accuracy was over 73%.

Similar studies based on virtual faces obtained an average percentage of success ranging from 62 to 78% [45,47,46,19]. The last two papers included more emotions, namely contempt, embarrassment and pride. Thus, the results obtained in our study are in line with previous studies using virtual humans for the recognition of emotions. Only one previous study obtained a percentage of success superior to all other studies (91.7% [52]). Nonetheless, this study was only applied to 41 participants. Moreover, other findings of our experiment are consistent with previous studies using virtual humans to recognize emotions, where the *Neutral* expression and the *Happiness* emotion were the most easily recognized, followed by *Anger* and *Surprise*.

4.2. Influence of Gender, Age and Emotion Intensity

There was no significant difference in the overall number of correct answers for all emotions per gender (Mann-Whitney: $U = 5085, p = 0.781$). We also tested the difference for individual emotions, showing all of them non-significant results in a similar way. Curiously, previous studies have reported differences in the recognition of facial emotions in terms of gender in favor of women. While most studies used static stimuli and/or stimuli that represent extreme examples of facial emotions [51], recent studies with more subtle and dynamic facial expressions have obtained similar results to ours [53].

Regarding age, we created two groups (younger and older adults) using the median (47 years) to split the two classes. Similarly, no significant differences were found in the total number of correct answers. However, there were differences for some individual emotions. The results for *anger1*, *joy2* and *sadness1* were significantly better for the younger group ($U = 4405.5, p = 0.017$, $U = 4656, p = 0.041$, and $U = 4329.5, p = 0.012$, respectively). In this regards, some authors have reported that there is a decline in facial emotion recognition ability as people grow older [54,55], suggesting that older adults pay less attention to socially relevant areas such as eyes or mouth [56]. Another factor that could influence our results is the greater difficulty that older people present when using digital technological devices.

As discussed earlier, each emotion was depicted by the VHs with two different intensities. In this case, the Wilcoxon Signed Rank test revealed a significant difference for the intensity parameter ($Z = -2.317, p =$

0.020). As expected, higher intensity emotions obtained a higher number of correct answers. Again, this result is in line with a previous work [46].

A deeper study focusing on individual emotions revealed that *fear1*, *anger1* and *disgust1* obtained a higher number of correct answers for higher intensity emotions ($Z = 2.349-, p = 0.019$, $Z = -3.586, p < 0.001$, and $Z = -4.149, p < 0.001$), while it was the opposite for *surprise1* and *sadness1* ($Z = -1.994, p = 0.046$, and $Z = -3.165, p = 0.002$). *surprise2* and *sadness2* got fewer hits than *surprise1* and *sadness1*, respectively, because they were often confused with *Fear*. *Fear* is also often mistaken with *Surprise* in other studies [45]. Social psychology states that the expression of *Fear* and *Surprise* often occurs simultaneously, such as when *Fear* is suddenly felt due to an unexpected threat [34].

4.3. Influence of the Virtual Human Movement and the Camera Angle

A subtle movement of the VHs' head and upper body was included in 50% of the emotions presented to the participants in order to study its effect in the recognition rate. Our hypothesis was that it would increase the rates of successful recognition because the number of hints were increased. The Wilcoxon Signed Rank test ($Z = -5.666, p < 0.001$) confirmed the hypothesis. A further study of the impact on the individual emotions showed that the improvement was significant for *fear1*, *disgust1*, *sadness1* and *sadness2* ($Z = -3.817, p < 0.001$, $Z = -2.667, p = 0.008$, $Z = -2.168, p = 0.030$, and $Z = -1.993, p = 0.046$, respectively).

Table 3 shows the confusion matrices for both conditions. The average successful identification rate with movement was 90.12% while it was 85.03% for no movement. A general improvement is noticeable, for example, taking a look at *fear1*. Using the less dynamic virtual humans, this emotion was confused with *Sadness* almost one-fourth of the number of times it was presented to the participants. This was reduced to 3.7% when more dynamic VHs were used. It makes sense that a greater dynamism in the area of the neck and face is related to a better identification of emotions due to the increasing realism.

In addition, three different camera angles were randomly used to present the VHs to the participants (50% from the front and 50% from both sides). Our hypothesis was that front views would obtain a higher number of correct answers than lateral views. This was confirmed for the total number of correct answers by a Wilcoxon Signed Rank test ($Z = -2.829, p = 0.005$). Focusing on individual emotions, the test revealed that there was a significant difference for *sadness1* and *sadness2* ($Z = -3.166, p = 0.002$, and $Z = -2.129, p = 0.033$). In both cases, the results were better for frontal views in regards to lateral views. We could not find significant results for the other emotions. The average successful identification rate for front views was 89.06%, while for the lateral views it was 87.45%. This time, even though it is true that there is an improvement due to the use of frontal cameras only, this improvement is less ostensible. The most significant improvement is related to the confusion of *fear2* with *Surprise*, which experiences 5% reduction when only front cameras are used (see Table 4).

This confirmed that the combination of virtual human movement and frontal cameras obtains the best possible results. Table 5 shows this enhanced combination side-by-side with the worst combination, which does not use virtual human movement and only lateral cameras. This comparison maximizes the differences. Apart from the ones mentioned before (*fear1* and *fear2*), there are other noticeable differences between both tables. *sadness2* is confused with *Fear* 10% of the times it is presented to the participants in the worst combination (see left side of Table 5). This percentage is reduced to 5% for the best combination (see right side of Table 5). Moreover, this issue is of great importance, as there are no studies published to date that include different camera angles and compare the identification of emotions in the avatars presented with frontal and lateral views.

4.4. Errors per Participant

The average number of errors per participant (measured as the mistakes made when identifying an emotion performed by a virtual human) was 6.11 ($SD = 5.03$). It is a reduction from our previous study, where this number was 9.7 ($SD = 3.7$). The histogram in Figure 5 groups the participants by number of recognition errors. The largest group gathers those participants who made a total of 5 or less errors (115 volunteers). In addition, it is also apparent that the number of participants decreases as the intervals of errors get bigger, especially for the number of people making 15 or more mistakes, which is only 13 people. These results demonstrate that only a few participants made many recognition errors. The maximum number of er-

Table 3

Emotion recognition rate with (left) and without (right) VH movement. Average successful recognition rates are 90.12% and 85.03%, respectively.

	Surprise	Fear	Anger	Disgust	Happiness	Sadness
surprise1	92.1%	7.0%	0.0%	0.0%	0.0%	0.7%
surprise2	91.7%	7.3%	0.0%	0.3%	0.0%	0.0%
fear1	12.4%	82.5%	0.2%	0.9%	0.0%	3.7%
fear2	18.7%	79.5%	0.3%	0.3%	0.0%	0.0%
anger1	2.0%	2.5%	89.5%	3.0%	0.0%	1.5%
anger2	0.7%	1.2%	93.4%	2.8%	0.2%	0.0%
disgust1	2.0%	1.8%	3.5%	91.7%	0.0%	0.5%
disgust2	0.3%	1.8%	2.3%	95.2%	0.0%	0.3%
happiness1	0.5%	0.5%	0.3%	0.0%	96.3%	0.0%
happiness2	1.0%	0.3%	0.5%	0.0%	95.4%	0.0%
sadness1	4.6%	0.9%	0.2%	0.7%	0.0%	89.2%
sadness2	3.9%	4.4%	1.4%	3.7%	0.0%	84.9%

	Surprise	Fear	Anger	Disgust	Happiness	Sadness
surprise1	93.3%	5.5%	0.0%	0.3%	0.0%	0.3%
surprise2	88.4%	10.9%	0.0%	0.2%	0.2%	0.0%
fear1	7.2%	65.5%	0.0%	1.3%	0.0%	24.2%
fear2	19.0%	79.6%	0.2%	0.5%	0.0%	0.2%
anger1	1.7%	2.2%	86.1%	6.5%	0.0%	2.9%
anger2	1.3%	1.3%	92.3%	4.6%	0.0%	0.3%
disgust1	1.7%	0.5%	21.7%	72.8%	0.0%	1.0%
disgust2	0.5%	1.0%	14.1%	84.2%	0.0%	0.0%
happiness1	0.7%	0.0%	0.2%	0.2%	95.9%	0.0%
happiness2	0.5%	0.0%	0.7%	0.7%	95.0%	0.2%
sadness1	1.6%	3.1%	0.0%	0.8%	0.5%	87.4%
sadness2	3.6%	9.4%	0.5%	4.7%	0.0%	80.0%

Table 4

Emotion recognition rates for frontal (left) and lateral (right) views of the VHs. Average successful recognition rates are 89.06% and 87.45%, respectively.

	Neutral	Surprise	Fear	Anger	Disgust	Happiness	Sadness
neutral	97.1%	0.7%	0.0%	0.0%	0.0%	0.0%	2.19%
surprise1	1.0%	92.4%	5.9%	0.0%	0.2%	0.0%	0.5%
surprise2	0.2%	92.4%	7.4%	0.0%	0.0%	0.0%	0.0%
fear1	1.0%	8.5%	76.1%	0.2%	1.2%	0.0%	12.9%
fear2	0.7%	16.3%	81.7%	0.5%	0.5%	0.0%	0.2%
anger1	1.0%	1.7%	2.5%	87.1%	5.2%	0.0%	2.5%
anger2	1.0%	1.2%	1.4%	92.3%	3.9%	0.0%	0.2%
disgust1	1.5%	1.2%	1.0%	12.8%	82.5%	0.0%	1.0%
disgust2	0.2%	0.5%	2.2%	9.3%	87.5%	0.0%	0.2%
happiness1	2.9%	0.5%	0.0%	0.2%	0.2%	96.1%	0.0%
happiness2	3.0%	0.2%	0.0%	0.5%	0.2%	96.0%	0.0%
sadness1	3.7%	2.0%	1.5%	0.0%	0.2%	0.5%	92.2%
sadness2	1.2%	2.7%	6.3%	1.0%	4.4%	0.0%	84.5%

	Neutral	Surprise	Fear	Anger	Disgust	Happiness	Sadness
neutral	95.6%	0.0%	0.2%	0.5%	1.0%	0.0%	2.72%
surprise1	0.0%	92.9%	6.7%	0.0%	0.0%	0.0%	0.5%
surprise2	0.7%	87.6%	11.0%	0.0%	0.5%	0.2%	0.0%
fear1	1.0%	11.3%	72.7%	0.0%	1.0%	0.0%	14.0%
fear2	1.0%	21.4%	77.4%	0.0%	0.2%	0.0%	0.0%
anger1	1.2%	1.9%	2.2%	88.4%	4.4%	0.0%	1.9%
anger2	1.0%	0.7%	1.0%	93.5%	3.5%	0.2%	0.0%
disgust1	1.5%	2.4%	1.2%	12.9%	81.5%	0.0%	0.5%
disgust2	0.2%	0.2%	0.5%	7.3%	91.7%	0.0%	0.0%
happiness1	2.4%	0.7%	0.5%	0.2%	0.0%	96.1%	0.0%
happiness2	2.7%	1.2%	0.2%	0.7%	0.5%	94.4%	0.2%
sadness1	7.1%	4.4%	2.5%	0.2%	1.2%	0.0%	84.5%
sadness2	2.2%	5.0%	7.2%	1.0%	4.0%	0.0%	80.7%

Table 5

Emotion recognition rates with virtual human movement and using front cameras (left), and without virtual human movement and using lateral cameras (right). Average successful recognition rates are 91.18% and 84.42%, respectively.

	Surprise	Fear	Anger	Disgust	Happiness	Sadness
surprise1	92.6%	6.4%	0.0%	0.0%	0.0%	0.5%
surprise2	94.5%	5.5%	0.0%	0.0%	0.0%	0.0%
fear1	11.2%	83.6%	0.5%	0.5%	0.0%	3.7%
fear2	15.6%	81.9%	0.5%	0.5%	0.0%	0.0%
anger1	2.0%	3.1%	88.3%	4.1%	0.0%	1.0%
anger2	1.4%	1.4%	92.5%	3.3%	0.0%	0.0%
disgust1	1.0%	1.5%	2.0%	94.6%	0.0%	1.0%
disgust2	0.5%	3.0%	3.0%	92.9%	0.0%	0.5%
happiness1	0.0%	0.0%	0.0%	0.0%	97.8%	0.0%
happiness2	0.5%	0.0%	0.0%	0.0%	96.5%	0.0%
sadness1	2.8%	0.0%	0.0%	0.5%	0.0%	93.4%
sadness2	3.3%	4.7%	1.4%	3.7%	0.0%	85.6%

	Surprise	Fear	Anger	Disgust	Happiness	Sadness
surprise1	94.4%	5.6%	0.0%	0.0%	0.0%	0.0%
surprise2	86.0%	13.0%	0.0%	0.5%	0.5%	0.0%
fear1	8.9%	63.0%	0.0%	0.5%	0.0%	25.5%
fear2	20.8%	77.8%	0.0%	0.5%	0.0%	0.0%
anger1	1.9%	2.4%	86.1%	6.7%	0.0%	1.9%
anger2	1.6%	1.0%	92.7%	4.7%	0.0%	0.0%
disgust1	1.9%	0.5%	20.0%	74.9%	0.0%	0.9%
disgust2	0.5%	0.5%	13.0%	86.1%	0.0%	0.0%
happiness1	0.5%	0.0%	0.0%	0.0%	97.1%	0.0%
happiness2	0.9%	0.0%	0.5%	0.9%	94.5%	0.5%
sadness1	2.2%	3.2%	0.0%	1.6%	0.0%	83.8%
sadness2	5.3%	10.6%	0.5%	4.3%	0.0%	76.6%

rors per session registered is 26, which were made by a single participant.

4.5. *Influence of the Number of Faces Presented on the Number of Errors Made*

We wanted to study whether the number of emotion identification errors increased or decreased during the progression of the test. Figure 6 plots in the X axis the faces to be identified (from 1 to 52) by the participants,

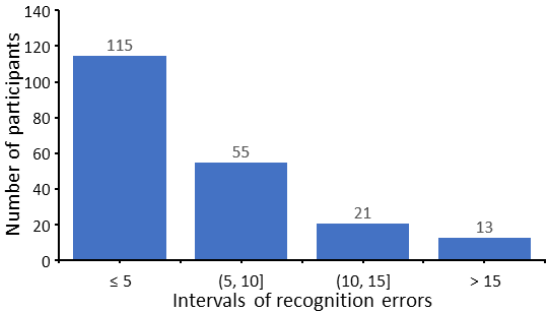

Figure 5. Histogram showing number of participants in terms of ranges of bad responses.

while the Y axis shows the number of people failing to recognize the emotion presented (from 0 to 204). Notice that the order of presentation of emotions differed from one participant to another.

Two situations would be possible: (1) more errors are made at the beginning, which would mean that the participants learn and improve along the test, or, (2) more errors are made at the end, which would mean that they become tired. The trend line (colored in red in Figure 6) shows a reduction in the number of errors as the test progresses. The slope of the line is -0.1781, which is a reduction of approximately 18% in the number of errors. This result enforces the hypothesis that the participants improve along the test.

The loss of progressive attention during the performance of a task is known, as well as the improvement in cognitive performance after the repetition of an instruction. However, no previous studies of facial recognition of emotions that evaluate the "fatigue effect" or "learning effect" have been published. Therefore, our results cannot be compared with any previous work.

5. Conclusions

The objective of this paper was twofold. On the one hand, it aimed at describing the complete engineering design process of virtual humans capable of expressing facial emotions. Following the Facial Action Coding System, six facial expressions with two levels of intensity were designed to convey the six basic emotions (*Anger*, *Disgust*, *Fear*, *Happiness*, *Sadness*, and *Surprise*), plus the *Neutral* one. On the other, this paper has described in detail the assessment by 204 healthy people of the avatar expressions designed.

The work described in this paper is a follow-up of a previous pilot study [41]. The current work has improved the design of the virtual humans, introducing variations for age and race, and increasing the number of participants in the evaluation from 23 to 204. This has enabled a further analysis of the results and allowed us to reach out wider and more precise conclusions.

The overall success recognition rate was 88.25%, which is consistent with (and mostly outperforms) the results obtained by other authors in previous works using virtual humans and/or pictures [19,20,46,53].

Moreover, age and gender were found to have no statistically significant influence on the overall recognition rate. However, the difference of two age groups proved to be significant for some emotions, being better for the younger group. Another interesting result is that the intensity of each emotion was found statistically significant, being the more intense emotional expression easier to recognize by the participants in respect to the less intense one. Other technical aspects have also been evaluated, such as the camera angle in which the faces were presented to the participants, and the level of dynamism of the VH. The results showed that frontal cameras (versus lateral cameras) and more dynamic VHs (in relation to less dynamic VHs) provided the best results in terms of overall successful recognition rates.

In summary, the results show that the virtual faces designed in the experiment are valid for accurately recreating human facial affect expressions. Current findings show that virtual reality environments allow the design of virtual faces that can be controlled externally and in real time, overcoming some of the limitations associated with the use of static faces. This has clinical implications, since the advances provided by virtual reality for sure help to design therapies for patients with difficulties in identifying basic emotions.

The next objective of our research team is the design of a facial affect recognition therapy for patients with schizophrenia. The lessons learned through the current research can also be used to adapt and personalize the therapies to each patient. For example, different camera angles and even more dynamic VHs can be used to increase or decrease the learning curve of emotion recognition tasks. In future work, the idea and methodology proposed in this paper could be easily extended to various science and engineering applications [57,58,59].

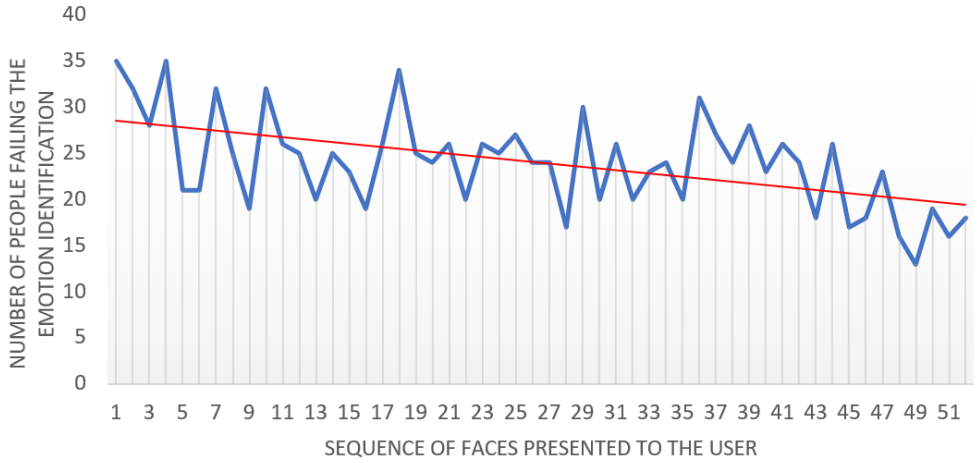

Figure 6. Identification errors per each of the 52 faces presented to the participants. The trend line shows a negative slope of 18%.

Acknowledgements

This work was partially supported by Spanish Ministerio de Ciencia, Innovación y Universidades, Agencia Estatal de Investigación (AEI) / European Regional Development Fund (FEDER, UE) under PID2019-106084RB-I00, DPI2016-80894-R and TIN2015-72931-EXP grants, and by Biomedical Research Networking Centre in Mental Health (CIBERSAM) of the Instituto de Salud Carlos III.

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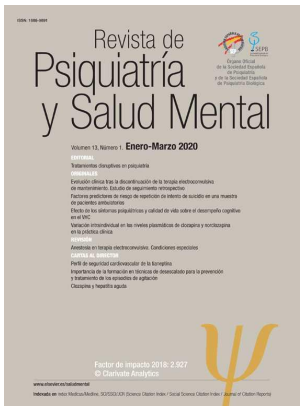
3.4.2. Validation of Dynamic Virtual Faces for Facial Affect Recognition

Datos de la publicación

RESUMEN:
La capacidad de identificar y reconocer emociones faciales es esencial para una interacción social exitosa. Algunos trastornos psiquiátricos como la esquizofrenia conllevan un deterioro en la capacidad de reconocer las emociones básicas, lo que interfiere en el funcionamiento diario. Los estímulos más comunes utilizados para evaluar esta capacidad son las fotografías. Aunque estos estímulos han demostrado ser válidos, no ofrecen el nivel de realismo que los humanos virtuales han alcanzado recientemente. El objetivo del presente trabajo es la validación de un nuevo conjunto de rostros virtuales dinámicos (DVF) que imitan las seis emociones básicas más la expresión neutra. Las caras están preparadas para ser observadas con bajo y alto dinamismo, y desde vistas frontales y laterales. Para ello, se reclutaron 204 participantes sanos, estratificados por sexo, edad y nivel educativo según la población española, para evaluar su reconocimiento de afecto facial con el conjunto de DVFs. La precisión de las respuestas se comparó con el ya validado Penn Emotion Recognition Test (ER-40). Los resultados mostraron que las DVFs eran tan válidas como las caras naturales estandarizadas para recrear con precisión las expresiones faciales similares a las humanas. La precisión general en la identificación de las emociones fue mayor para las DVFs (88,25 %) que para las caras ER-40 (82,60 %). El porcentaje de aciertos de cada emoción del DVF fue alto, especialmente para la expresión neutral y la emoción de alegría. La identificación del asco fue sorprendentemente alta, mayor que en estudios anteriores. No se descubrieron diferencias estadísticamente significativas en cuanto al género.



Datos de la publicación (cont.)

Tampoco se encontraron diferencias significativas entre los adultos más jóvenes y los adultos de más de 60 años. Por otra parte, hay un aumento de aciertos para las caras de los avatares que muestran un mayor dinamismo, así como para las vistas frontales de los DVFs en comparación con sus presentaciones de perfil. Por último, se derivan algunas implicaciones clínicas del uso de las DVFs en terapias dirigidas a pacientes con déficits en el reconocimiento de afectos faciales. Las DVF son tan válidas como las caras naturales estandarizadas para recrear con precisión las expresiones faciales de las emociones similares a las humanas y podrían ayudar a superar algunas de las limitaciones asociadas con el uso de caras estáticas en las terapias de remediación.

CITACIÓN:

P. Fernández-Sotos, A.S. García, M.A. Vicente-Querol, G. Lahera, A. Fernández-Caballero, R. Rodriguez-Jimenez (2020) "Validation of Dynamic Virtual Faces for Facial Affect Recognition", *Revista de Psiquiatría y Salud Mental* (enviado)

ÍNDICES DE CALIDAD:

Índice de impacto 2019: 2,630.

Cuartil: Q2.

Rango (Categoría): 45/141 (Psychiatry).

Validation of Dynamic Virtual Faces for Facial Affect Recognition

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Conflicts of interest

Dr. Roberto Rodriguez-Jimenez has been a consultant for, spoken in activities of, or received grants from: Instituto de Salud Carlos III, Fondo de Investigación Sanitaria (FIS), Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM), Madrid Regional Government, Janssen Cilag, Lundbeck, Otsuka, Pfizer, Ferrer, Juste, Takeda, Exeltis, Angelini. Dr.Lahera has been a consultant to or has received honoraria or grants from Janssen-Cilag, Otsuka-Lundbeck, Lilly, Astra-Zeneca, CIBERSAM and Instituto de Salud Carlos III. The other authors have no conflicts of interest to disclose.

Validation of Dynamic Virtual Faces for Facial Affect Recognition

Abstract

The ability to recognize facial emotions is essential for successful social interaction. The most common stimuli used when evaluating this ability are photographs. Although these stimuli have proved to be valid, they do not offer the level of realism that virtual humans have achieved. The objective of the present paper is the validation of a new set of dynamic virtual faces (DVFs) that mimic the six basic emotions plus the neutral expression. The faces are prepared to be observed with low and high dynamism, and from front and side views. For this purpose, 204 healthy participants, stratified by gender, age and education level, were recruited for assessing their facial affect recognition with the set of DVFs. The accuracy in responses was compared with the already validated Penn Emotion Recognition Test (ER-40). The results showed that DVFs were as valid as standardized natural faces for accurately recreating human-like facial expressions. The overall accuracy in the identification of emotions was higher for the DVFs (88.25%) than for the ER-40 faces (82.60%). The percentage of hits of each DVF emotion was high, especially for *neutral* expression and *happiness* emotion. No statistically significant differences were discovered regarding gender. Nor were significant differences found between younger adults and adults over 60 years. Moreover, there is an increase of hits for avatar faces showing a greater dynamism, as well as front views of the DVFs compared to their profile presentations. DVFs are as valid as standardized natural faces for accurately recreating human-like facial expressions of emotions.

Keywords: dynamic virtual faces, facial affect recognition, validation; social cognition

Introduction

The ability to identify and recognize emotions on others' faces is crucial for effective social interaction (1 , 3) . Classical studies report a close relationship between emotional recognition and social functionality (3, 4). Thus, the way an individual recognizes the emotional state in the other determines a large part of social success, which is relevant to his/her functioning in the community (5). Accuracy in facial emotion recognition has been studied in several neuropsychiatric conditions, such autism spectrum disorders (6), schizophrenia (7,8), depression (9) and Alzheimer's dementia (10).

In most emotional recognition studies, the experimental stimulus is presented through photographs or static images (11, 12). Some authors point out that this stimulus does not reflect the reality of the facial stimulus (13). Other studies use videos to present expressions in a genuine way (14, 15). The presentation of a dynamic facial expression generates a more intense emotional experience and facilitates successful emotional recognition (16-18). In this sense, virtual reality is a powerful tool that provides environments and situations similar to reality, dynamic avatars that allow social interaction with the participant, and that can be managed to represent different emotional states (19 - 21).

Most of the studies published in relation to the creation of avatar faces take as reference the Facial Action Coding System (FACS) developed by Ekman & Friesen (22). The basic element of this system is the Action Unit (AU), which represents muscular activity. This produces momentary changes in facial appearance so that expressions are encoded by detecting the presence of combinations of AUs in the face. Precisely, the complete design process of our new series of dynamic virtual faces (DVFs) that represent the six basic emotions starting from the *neutral* expression using AUs has been recently addressed from an engineering viewpoint (19). The DVFs can be presented frontally or laterally. Moreover, the presentation can be with a lower or higher dynamism. Lower dynamism involves movements only of the face, whereas higher dynamism incorporates the movement of neck and shoulders.

There is consistent evidence that patients with different neuropsychiatric disorders have notable difficulty to accurately recognize emotions expressed by others (25, 26). This deficit in facial affect recognition has been extensively studied in psychotic disorders, especially in schizophrenia and related disorders. In this group of disorders, the deficit can lead to a misinterpretation of social situations and, therefore, a significant deficit in social functioning (27). The design of interventions aimed at improving facial affect recognition in patients with schizophrenia has become a primary objective of current research (28).

Previous studies have explored the role that gender, age and education level have on facial affect recognition. In general, women show a more accurate and faster recognition of facial emotions compared to men (31). In turn, recent studies indicate that facial affect recognition from the age over 60 worsens with respect to younger adulthood (29-31). This would suggest that older adults pay less attention to socially relevant areas such as eyes or mouth (32). Another study identified a correlation between years of education and identification of the six basic emotions (33). These results are consistent with previously published works that support the general role of education in predicting cognitive performance in multiple neuropsychological tests (34).

The main objective of this work was to verify whether the emotions expressed by DVFs could be recognized as well as natural emotions in photographs of human faces. The accuracy in the responses provided by a large stratified sample of healthy controls to the set of DVFs was compared with the accuracy in the responses to the validated Penn Emotion Recognition Test (ER-40) (23, 26). The following hypotheses were established:

- H1. The number of hits (correct emotion identifications) and the reaction time (time calculated from the appearance of the stimulus to the participant's response) of the set of dynamic virtual faces (DVFs) will be similar to the face photos of the ER-40.

- H2. Within the set of DVFs, the participants will recognize more precisely the most dynamic as opposed to the less dynamic ones, obtaining a greater number of hits and a shorter reaction time.
- H3. Within the set of DVFs, the participants will recognize more accurately the faces presented in front view compared to the faces oriented laterally, obtaining a greater number of hits and shorter reaction time in frontal views.
- H4. Within the set of DVFs, there will be differences in the number of hits and reaction time regarding gender (in favor of women), age (in favor of participants younger than 60 years) and education level (in favor of higher educational levels).

Method

Participants

The study was carried out with healthy volunteers. The single inclusion criterion was that the participants had to be between 20 and 79 years old. Exclusion criteria included a diagnosis of mental illness, a personal history of medical illness (that could interfere with affect recognition), and a first-degree family history of psychosis. The sample was stratified by gender (50% men, 50% women), age (divided into 3 age ranges: 20-39, 40-59, 60-79), and education level (divided into the three educational strata; ≤ 2, basic level; 3-4, medium level; ≥ 5, high level). The stratification lead to the conclusion that an exact number of 204 participants had to be enrolled. Indeed, Table 1 was prepared considering the level of education of the Spanish population in 2017. 43% of men had basic level studies compared to 38.3% of women; 22.7% of men and women had medium level studies; 33.8% of men had high level studies compared to 38.9% of women.

Procedure

A data collection notebook was designed by the research team to annotate sociodemographic and clinical data. The sociodemographic data included age, gender and level of education, among others. The clinical data included personal somatic history (including neurological), toxic personal history, psychiatric personal history, and relevant family psychiatric history. The Mini International Neuropsychiatric Interview (35), Spanish version 5.0.0, was used for screening of psychiatric disorders. The Spanish version (36) of the Positive and Negative Affect Schedule (PANAS) (37) was also administered with the aim to exclude participants with altered mood state in the moment of performing the emotion recognition task. PANAS is a 20-item self-report questionnaire which measures an individual's positive and negative affect. If a participant had a positive affect score of less than 25 ($PA < 25$) or a negative affect score of more than 35 ($NA > 35$), he/she was excluded from the study, in line with a previous work (22).

Data collection was carried out in a single 60-minute individual session. The facial stimuli were presented in a random order in 2 separate blocks (classic Penn Emotion Recognition Test (ER-40) already validated versus the DVFs created by the research team). In the presentation block of the DVFs, the order of appearance of the avatar faces was also randomized for each participant.

The two main measures for each face presented are the hits and the response or reaction time. The reaction time for ER-40 is determined from the appearance of the emotion photograph. In the case of DVFs, as a transition is made from the *neutral* expression to the target emotion (and back to *neutral*), it makes no sense for the participant to answer before the transition is initiated, so the reaction time is counted from that precise moment. The study was approved by the Clinical Research Ethics Committee.

Novel Dynamic Virtual Faces

All participants were shown 52 DVFs on a 27'' computer screen. They had to identify all basic emotions presented (*happiness*, *sadness*, *anger*, *fear*, *disgust* and *surprise*) plus the *neutral* expression. Each exhibited emotion started from and ended in the *neutral* expression, with a total presentation time

of 2 seconds. The participants had to identify each emotion expressed by a DVF among the seven options offered. Of these 52 faces, 50% were interspersed with less dynamism (the movement zone includes only the most characteristic facial features of each emotion) and 50% revealed more dynamic faces (the movement zone added movements of the neck and shoulders that should bring more realism and naturalness to the scene). Moreover, both the most and least dynamic faces were shown 50% in frontal view, 25% in right side face and 25% in left side face. A video demonstrating the two levels of dynamism and several views of a same DVF is available as Supplementary Material.

The set of DVFs included 2 Caucasian avatars around 30 years old, holding different features in terms of eye color, skin tone and hair. Additionally, 2 avatars were designed of the African race, about 30 years old and 2 avatars of old age. Of the 52 avatars presented, 8 were of African race and 8 were of old age.

Classical Penn Emotion Recognition Test

The Penn Emotion Recognition Task (ER-40) (38) contains forty color photographs of faces of different ethnicity, expressing the four basic feelings *happy*, *sad*, *angry* and *fearful*, as well as the *no emotion* expression. It includes eight photographs of each expression (four high-intensity and four low-intensity ones). This test has strong psychometric properties and has been identified by some authors as recommended when used in clinical trials (24).

Statistical Analysis

IBM SPSS Statistics (version 24) was used to conduct the statistical analyses. Since the data (hits and reaction time) did not follow a normal distribution, mainly non-parametric tests were used for hypothesis testing. A p-value < .05 was considered to be statistically significant.

Regarding the statistical tests, the Kruskal-Wallis test was used to determine if there were statistically significant differences in the number of correct answers (hits) and reaction time between more than two different groups of participants (the case of age and education groups). In the cases in which this test found differences, the Dunn's post-hoc test together with a Bonferroni correction for pair-wise comparisons was applied in order to find out which groups was different. When only two groups were compared, the Mann-Whitney test was used instead. Finally, in the cases in which we wanted to find differences in the performance of the same group of participants using two techniques (i.e. DVF with lower versus higher dynamism), the Wilcoxon Signed Ranks test was used.

Results

As mentioned before, non-parametric tests were used to compare the results since the number of correct answers did not follow a normal distribution (Kolmogorov-Smirnov test: $Z = 0.165$, $p < .001$).

Accuracy in Emotional Expression Recognition

With regards to the accuracy in emotional expression recognition using the ER-40 image dataset, the percentage of successful recognition is high (82.6%) as shown in Table 2. The *no emotion* expression has the lowest recognition percentage (70.6%) and *fearful* the highest one (94.0%).

In respect to the DVFs, as shown in Table 3, the percentage of successful recognition for each DVF expressing an emotion is even higher, all above 85% except for *fear*. A closer look shows that *fear* was mainly confused with *surprise* and *sadness*. Regarding the rest of the emotions, the only one with a quite high confusion percentage is *disgust*, which was mainly confused with *anger*. Apart from *neutral* expression, *happiness* is the emotion that obtained a higher recognition percentage.

H1. On the Presentation of ER-40 Static Photos and Dynamic Virtual Faces

Regarding the number of hits, the DVFs obtained better results than the ER-40 faces (88.2% and 82.6%, respectively), although participants had a greater number of emotional options with the DVFs compared to the natural ones (7 versus 5). The Wilcoxon Signed Ranks test (Z = -9.145, p < .001) confirmed that the difference in the number of hits is statistically significant. All emotions were better recognized with DVFs except for *fear* and *sadness*.

With regards to the reaction time, there was a significant difference in the average reaction time per participant (Wilcoxon Signed Ranks test: Z = -8.965, p < .001). The reaction time using ER-40 was significantly lower than the reaction time using DVFs (M = 2.05 s, SD = 0.78, for ER-40; M = 2.43 s, SD = 0.85 for DVFs).

Figure 1 shows the average reaction time of the participants during the progression of the test for the DVF and ER-40 conditions. It also visualizes the difference in the reaction time in both parts of the study. The slopes of the trend lines are -0.011 and -0.019 for the DVF and ER-40 conditions, respectively, which in both cases implies a slight reduction in the reaction time during the progression of the test.

H2. On the Dynamism of the Dynamic Virtual Faces

The confusion matrices for both levels of dynamism are shown in Table 4. The average successful identification percentage was 90.14% for more dynamic DVFs compared to 85.05% for less dynamic ones. Using the less dynamic DVFs, the percentage of confusion was 11.7%, while it was reduced to 2% when more dynamic DVFs were reproduced. All emotions were better recognized with more dynamic DVFs, being the most obvious improvements for *disgust* (15%) and *fear* (8.2%). The Wilcoxon Signed Ranks test (Z = -5.666, p < .001) confirmed the hypothesis. A further study of the impact on the individual emotions showed that the increase in the success recognition rate was significant for *disgust* and *sadness* (Z = -2.563, p = .010 and Z = -3.399, p = .001, respectively).

Regarding the reaction time, there was a significant difference in the average reaction time depending on the level of dynamism of the DVFs (Wilcoxon Signed Ranks test: Z = -5.973, p < .001). The average reaction time using the most dynamic DVFs (M = 2.34 s, SD = 0.84) was significantly lower than the one obtained using the least dynamic ones (M = 2.50 s, SD = 0.89).

H3. On the Orientation of the Dynamic Virtual Faces

Three different orientations (angles) were randomly used to present the DVFs (50% frontal, 25% right profile and 25% left profile). A significant difference was perceived in the total number of correct answers (Wilcoxon Signed Ranks test: Z = -2.829, p = .005). Focusing on individual emotion identification, the test revealed that there was a significant difference for *fear* and *sadness* (Z = -1.996, p = .046 and Z = -3.605, p = .001) in favor of the frontal faces' presentation. We did not find significant results for the other emotions. The average successful identification percentage for frontal views was 89.63%, compared to 88.02% for lateral views (see Table 5). Although not statistically significant, a better recognition of *disgust* and *anger* in profile DVFs is observed. As shown in the table, these two emotions present a higher success rate in the profile condition, in part because they are less confused with each other.

H4. On the Issues Related to Gender, Age and Education Level of the Dynamic Virtual Faces

The Mann-Whitney test did not find any significant difference in the total number of correct answers by gender (U = 5085, p < .781, with M = 45.78, SD = 5.47 for women, and M = 46.01, SD = 4.58 for men). After having looked at the individual emotions, the only significant difference was with *disgust* (U = 4325, p = .029), which was better identified by women (M = 7.06, SD = 1.15 for women, and M = 6.66, SD = 1.37 for men). No difference was detected regarding reaction time. The average reaction time for women was M = 2.49 s, SD = 0.87, and M = 2.37 s, SD = 0.82 for men.

Regarding age groups, the Kruskal-Wallis test observed significant differences in the total number of hits ($\chi^2_{(2)}$ = 9.659, p = 0.008). There was significant difference between age groups 40-59 and 20-39 (p = .002). The number of correct answers for age group 20-39 (M = 47.21, SD = 4.08) was significantly higher than the number of hits for age group 40-59 (M = 44.69, SD = 5.43). No more significant differences became aware for any other combination. Focusing on individual emotions, significant differences were found for *anger* ($\chi^2_{(2)}$ = 6.574, p = .037) and *disgust* ($\chi^2_{(2)}$ = 7.463, p = .024). In both cases, the differences coincide with the study of the total number of correct answers. The results for age group 20-39 (M = 7.54, SD = 1.06 for *anger* and M = 7.12, SD = 1.02 for *disgust*) were significantly better than those for age group 40-59 (M = 7.13, SD = 1.35 for *anger* and M = 6.50, SD = 1.46 for *disgust*) (p = .015 and p = .011, respectively).

Moreover, we studied the reaction time in the different age groups. The Kruskal-Wallis test revealed significant differences ($\chi^2_{(2)}$ = 34.014, p < .001). There was a significant difference between age groups 20-39 and 40-59 (p < .001 with M = 1.99 s, SD = 0.76 and M = 2.51 s, SD = 0.82, respectively), and 20-39 and over 60 (p < .001 with M = 2.78 s, SD = 0.78 for over 60), meaning that the reaction time was significantly lower for age group 20-39 than for age groups 40-59 and over 60.

Regarding education levels, significant differences were discovered in the total number of hits ($\chi^2_{(2)}$ = 10.435, p = .005). A post-hoc pairwise comparison revealed significant differences between basic (0-2) and medium (3-4) education levels (p = .016, with M = 45.49, SD = 5.50 and M = 47.29, SD = 4.99, respectively), and high (5-8) and medium levels (p = .002, with M = 44.38, SD = 4.36 for the high level). The number of hits for medium education level was significantly higher than the number of correct answers for the other education levels. An in-depth study of individual emotions revealed that there was a significant difference between education levels for *surprise* ($\chi^2_{(2)}$ = 13.515, p = .001), *disgust* ($\chi^2_{(2)}$ = 10.200, p = .006) and *sadness* ($\chi^2_{(2)}$ = 6.685, p = .035). For *surprise*, high education level obtained better results than basic education level (p = .001, with M = 7.60, SD = 0.66 and M = 7.04, SD = 1.08, respectively),

while for *disgust* and *sadness* medium education level obtained better results than high education level (p = .001 with M = 7.31, SD = 0.96 and M = 6.56, SD = 1.37 for *disgust*, and p = .010 with M = 7.22, SD = 1.34 and M = 6.56, SD = 1.75 for *sadness*).

Discussion

The main objective of this work was to verify whether the emotions expressed by DVFs could be recognized as well as natural emotions in photographs of human faces. As we firstly hypothesized, the results confirmed that DVFs are as valid as photographs of the ER-40 for assessing emotion recognition skills. In fact, not only was the accuracy similar between DVFs and the ER-40 faces, but a statistically significant difference was obtained in favor of DVFs.

The percentage of general success was higher for the condition of DVFs compared to the natural ER-40 faces. For the natural photo faces, the mean of hits was similar to that obtained in previous studies (28). All emotions were better recognized with DVFs, except for *fear* and *sadness*. The reason why *fear* emotion is recognized worse on DVFs may be that there is no *surprised* condition in ER-40. Precisely, it is the one that generates a good piece of the mistakes done when using DVFs. Adding the percentage of answers for *surprise* to *fear* when using DVFs would raise the recognition percentage of *fear* to 91.4%, very close to 94% obtained in ER-40 for *fearful*. The difference in the number of hits around *sadness* in the two conditions is not as striking as for *fear* (2.4%).

The overall accuracy in emotion identification with our DVFs was consistent with similar studies using virtual faces (22, 23, 41 - 43). In this sense, *neutral* expression and *happiness* emotion were the most easily recognized, followed by *anger* and *surprise*. In our study, although *fear* was the worst identified emotion, it obtained a percentage of success like previous studies (20, 21).

In line with previous literature, *fear* was mainly confused with *surprise* and *sadness* (39, 40). This is striking as it differs from the result of our previous study using the same facial expressions in a pilot

study (42). The difference could probably be explained as two emotional expressions (*disgust* and *sadness*) were redesigned following the results obtained in the previous study. The recognition of *disgust* improved from 69.6% to 85.8%, and *sadness* from 62% to 85.5%. To sum up, the average percentage of successful recognition using this new set of DVFs is very high (88.2%) in comparison to our previously reported high result (83.6%) (42).

For the case of *disgust*, our results differ from those previously published by other groups. While most previous works have reported a worse recognition rate of *disgust* compared to other emotions (20, 21, 39, 40), in our study the high success rate is striking. This is probably due to the redesign of the emotion that our team carried out from previous results (42), considering the difficulty of authenticity to recreate the nasolabial area (43).

Contrarily to what was hypothesized, the reaction time using ER-40 is significantly lower compared to DVFs. The most plausible explanation for this result is that the presentation of each emotion began and ended with the *neutral* expression in the DVF condition, with a total presentation speed of 2 seconds. It is worth noting that, in both cases, the participant could click on an option right after the face was presented, even if it was in the middle of the animation for DVFs. However, the participants normally waited for the emotional transition to end before answering, something that did not happen for ER-40, as there was no transition at all. Another possible explanation for this result is that the number of choices was lower in the ER-40 study. Thus, the participants had less options to consider before responding.

The second hypothesis was confirmed. The most dynamic virtual faces were recognized better and faster than the less dynamic. It makes sense that a greater dynamism in the area of the neck and face is related to a better identification of emotions due to a notably increasing realism. As proposed by previous authors, a dynamic presentation of emotional facial expressions can evoke a better subjective emotional experience (18).

Following our third hypotheses, we could only confirm a significant improvement in the recognition of emotions with frontal views compared to lateral ones for *fear* and *sadness*. No significant differences were detected in the reaction time using the different orientations. As far as we know, this is the first work that has studied the effect that the face orientation has on the recognition of emotions. In real-life situations, facial expressions are not always presented frontally. Working with increasingly realistic stimuli will help assessing and remediating the identification of emotions in the everyday environment.

In relation to the fourth hypothesis, we found significant gender differences in emotion recognition in relation to the number of hits for *disgust* in favor of women, but not for the other emotions. Although it is widely believed that females outperform males in the ability to recognize other people's emotions, this conclusion seems not well supported by the extant literature. A recent study provides evidence for the presence of gender differences in emotion recognition ability but show that these differences are modest in magnitude and appear to be limited to facial disgust (44), what is congruent with our results. Indeed, some meta-analyses and literature reviews have reported that females outperform males in facial emotion recognition (45, 46) but small effect sizes are generally reported.

The present study has some limitations and strengths. Among the limitations, it should be mentioned that the ER-40 test incorporates only four emotions plus neutral, whereas our DVFs have six emotions plus the neutral expression. But the main objective was not to study differences between accuracy in the two tasks, but to study if the set of created DVFs represented adequately the emotions and that they would be recognized by the participants, as well as the ER-40 photographs of real faces. Perhaps, the strongest aspects of our study are the size and, especially, the stratification of the sample by gender, age and education level. As far as we know, this is the first study with DVFs designed for emotional recognition validated in a representative sample of the general population. Other strengths are related to some the evaluated aspects, such as the orientation view and the level of dynamism of the DVFs.

The design of this set of DVFs will allow their future use in social cognition remediation therapies. The advances obtained thanks to virtual reality can help overcome some of the limitations associated with the use of static faces. The incorporation of valid ecological environments will allow simulating real-life social interactions, enabling the therapists to control and manipulate the behavior of avatars for the training and evaluation of emotion recognition skills.

Funding

This work was partially supported by grants from Spanish Ministerio de Ciencia, Innovación y Universidades, Agencia Estatal de Investigación / European Regional Development Fund (DPI2016-80894-R, PID2019-106084RB-I00), Biomedical Research Networking Center in Mental Health (CIBERSAM) of the Instituto de Salud Carlos III, Instituto de Salud Carlos III (PI16/00359; PI19/00766), Madrid Regional Government (S2017/BMD-3740).

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Table 1

Number of Participants Stratified by Gender, Age and Education Level

	Age and Gender					
	20-39		40-59		60-79	
	Men	Women	Men	Women	Men	Women
Basic education level (0-2)						
Men = 45 (43.5 %); Women = 39 (38.3 %)	15	13	15	13	15	13
Medium education level (3-4)						
Men = 24 (22.7 %); Women = 24 (22.7 %)	8	8	8	8	8	8
High education level (5-8)						
Men = 33 (33.8 %); Women = 39 (38.9 %)	11	13	11	13	11	13

Note: Total number of participants = 204

Table 2

Emotion Recognition Confusion Matrix for Each Category of Emotion Included in the ER-40 Dataset

		Emotions recognized				
		No emotion	Fearful	Angry	Happy	Sad
Emotions presented	No emotion	**70.6 %**	2.5 %	8.3 %	18.3 %	0.4 %
	Fearful	3.2 %	**94.0 %**	0.9 %	0.9 %	1.1 %
	Angry	3.0 %	14.0 %	**78.6 %**	4.1 %	0.3 %
	Happy	1.1 %	10.4 %	4.1 %	**81.9 %**	2.5 %
	Sad	0.1 %	1.2 %	1.0 %	9.8 %	**87.9 %**

Table 3

Emotion Recognition Confusion Matrix for Each Emotion Depicted by DVFs.

		Emotions recognized						
		Neutral	Surprise	Fear	Anger	Disgust	Happiness	Sadness
Emotions presented	Neutral	**96.3 %**	0.4 %	0.1 %	0.2 %	0.5 %	0.0 %	2.5 %
	Surprise	0.5 %	**91.3 %**	7.7 %	0.0 %	0.2 %	0.1 %	0.2 %
	Fear	0.9 %	14.4 %	**77.0 %**	0.2 %	0.7 %	0.0 %	6.8 %
	Anger	1.0 %	1.4 %	1.8 %	**90.3 %**	4.2 %	0.1 %	1.2 %
	Disgust	0.9 %	1.1 %	1.2 %	10.6 %	**85.8 %**	0.0 %	0.4 %
	Happiness	2.8 %	0.7 %	0.2 %	0.4 %	0.2 %	**95.6 %**	0.1 %
	Sadness	3.6 %	3.5 %	4.4 %	0.6 %	2.5 %	0.1 %	**85.5 %**

Table 4

Emotion Recognition Using High and Low Dynamism in the DVFs when expressing the emotions.

		Emotions recognized using high dynamism					
		Surprise	Fear	Anger	Disgust	Happiness	Sadness
Emotions presented	Surprise	**91.9 %**	7.1 %	0.0 %	0.1 %	0.0 %	0.4 %
	Fear	15.4 %	**81.1 %**	0.2 %	0.6 %	0.0 %	2.0 %
	Anger	1.3 %	1.8 %	**91.5 %**	2.9 %	0.1 %	0.7 %
	Disgust	1.1 %	1.8 %	2.9 %	**93.5 %**	0.0 %	0.4 %
	Happiness	0.8 %	0.4 %	0.4 %	0.0 %	**95.9 %**	0.0 %
	Sadness	4.3 %	2.7 %	0.8 %	2.2 %	0.0 %	**87.1 %**
		Emotions recognized using low dynamism					
		Surprise	Fear	Anger	Disgust	Happiness	Sadness
Emotions presented	Surprise	**90.7 %**	8.3 %	0.0 %	0.2 %	0.1 %	0.1 %
	Fear	13.4 %	**72.9 %**	0.1 %	0.9 %	0.0 %	11.7 %
	Anger	1.5 %	1.7 %	**89.1 %**	5.6 %	0.0 %	1.6 %
	Disgust	1.1 %	0.7 %	17.9 %	**78.5 %**	0.0 %	0.5 %
	Happiness	0.6 %	0.0 %	0.5 %	0.5 %	**95.4 %**	0.1 %
	Sadness	2.6 %	6.3 %	0.3 %	2.7 %	0.3 %	**83.7 %**

Note: The average successful recognition percentages are 90.14% and 85.05% for higher and lower dynamism, respectively.

Table 5

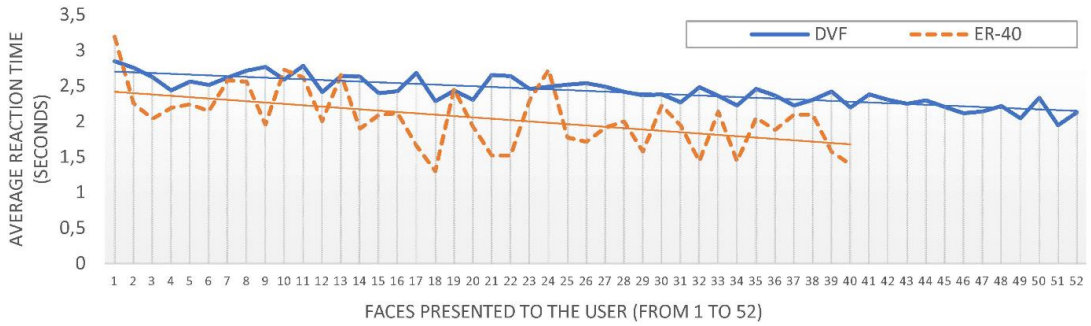
Emotion Recognition Using Frontal and Profile Views of the DVFs.

		Emotions recognized using frontal views						
		Neutral	Surprise	Fear	Anger	Disgust	Happiness	Sadness
Emotions presented	Neutral	**97.1 %**	0.7 %	0.0 %	0.0 %	0.0 %	0.0 %	2.2 %
	Surprise	0.6 %	**92.4 %**	6.6 %	0.0 %	0.1 %	0.0 %	0.2 %
	Fear	0.9 %	12.4 %	**78.9 %**	0.4 %	0.9 %	0.0 %	6.6 %
	Anger	1.0 %	1.5 %	2.0 %	**89.7 %**	4.5 %	0.0 %	1.3 %
	Disgust	0.9 %	0.9 %	1.6 %	11.1 %	**85.0 %**	0.0 %	0.6 %
	Happiness	3.0 %	0.4 %	0.0 %	0.4 %	0.2 %	**96.1 %**	0.0 %
	Sadness	2.4 %	2.3 %	3.9 %	0.5 %	2.3 %	0.2 %	**88.3 %**
		Emotions recognized using profile views						
		Neutral	Surprise	Fear	Anger	Disgust	Happiness	Sadness
Emotions presented	Neutral	**95.6 %**	0.0 %	0.2 %	0.5 %	1.0 %	0.0 %	2.7 %
	Surprise	0.4 %	**90.2 %**	8.8 %	0.0 %	0.2 %	0.1 %	0.2 %
	Fear	1.0 %	16.4 %	**75.1 %**	0.0 %	0.6 %	0.0 %	7.0 %
	Anger	1.1 %	1.3 %	1.6 %	**90.9 %**	3.9 %	0.1 %	1.0 %
	Disgust	0.9 %	1.3 %	0.9 %	10.1 %	**86.6 %**	0.0 %	0.2 %
	Happiness	2.6 %	1.0 %	0.4 %	0.5 %	0.2 %	**95.2 %**	0.1 %
	Sadness	4.7 %	4.7 %	4.8 %	0.6 %	2.6 %	0.0 %	**82.6 %**

Note: Average successful recognition percentages are 89.63% and 88.02% for frontal and profile views, respectively.

Figure 1

Average Reaction Time for Each Face Presented to the Participants Using DVFs (in blue) and the ER-40 dataset (in orange)



Note. The figure plots in the X axis the faces to be identified (from 1 to 52 for the DVFs, and from 1 to 40 for ER-40) for the participants.

3.5. Aceptación de avatares emocionales por parte de los profesionales de Salud Mental

Acceptance and Use of a Multi-modal Avatar-based Tool for Remediation of Social Cognition Deficits

A la luz de los resultados obtenidos de 41 terapeutas sobre la intención de uso de la herramienta basada en avatares para la rehabilitación de los déficits en cognición social, la afirmación más importante es que su interés por este tipo de herramientas es elevado (un 75 % tendría interés en su uso y un 90 % valora de manera positiva este tipo de intervención). Sin embargo, hay algunos factores que afectan negativamente su intención de comportamiento, como la influencia social y las condiciones facilitadoras. No se encontraron diferencias entre la opinión de terapeutas más jóvenes y mayores.

Mental Health Professionals' Intention to Adopt Virtual Humans in Affect Recognition Training

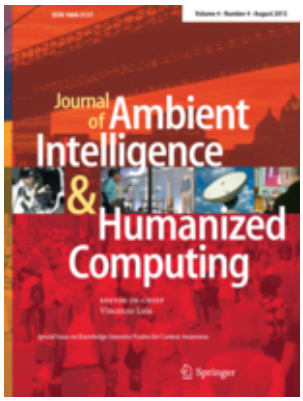
En este artículo, una vez ampliada la muestra a 124 terapeutas, se mantiene una elevada intención de uso, sin encontrarse factores que hayan afectado negativamente a la intención de comportamiento. La relación entre la variable condición facilitadora e intención de comportamiento parece ser más fuerte para el grupo de edad más joven mientras que la relación entre motivación hedónica e intención de comportamiento parece ser más fuerte en el grupo de mayor edad. No se encontraron diferencias significativas en términos de género, experiencia previa o profesión.

3.5.1. Acceptance and Use of a Multi-modal Avatar-based Tool for Remediation of Social Cognition Deficits

Datos de la publicación

RESUMEN:
El presente trabajo se centra en la validación de una herramienta diseñada para mejorar el reconocimiento de emociones, un aspecto fundamental de la cognición social, ya que afecta en gran medida a la funcionalidad y la calidad de vida de los pacientes con trastornos mentales. La herramienta presentada facilita la generación de terapias multimodales basadas en avatares por parte de los profesionales de la salud mental en este importante dominio clínico. Además, la herramienta para remediar los déficits cognitivos sociales puede ser personalizada según el deterioro de cada paciente. Este artículo describe cómo la herramienta fue evaluada por los terapeutas después de ver un vídeo que explica sus aspectos más relevantes. Se pidió a los participantes que rellenaran un cuestionario basado en el UTAUT2 para el estudio de la aceptación y el uso de esta tecnología. A la luz de los resultados obtenidos de 41 terapeutas sobre su intención de uso, la afirmación más importante es que su interés por este tipo de herramientas es alto. No obstante, hay algunos factores que afectan negativamente a su intención conductual.

CITACIÓN:
A.S. García, P. Fernández-Sotos, A. Fernández-Caballero, E. Navarro, J.M. Latorre, R. Rodriguez-Jimenez, P. González (2019) "Acceptance and Use of a Multi-Modal Avatar-Based Tool for Remediation of Social Cognition Deficits", *Journal of Ambient Intelligence and Humanized Computing*; doi:10.1007/s12652-019-01418-8.



Datos de la publicación (cont.)

ÍNDICES DE CALIDAD:

Índice de impacto 2019: 4,594.

Cuartil: Q1.

Rango (Categoría): 26/136 (Computer Science, Artificial Intelligence); 27/156 (Computer Science, Information Systems); 18/90 (Telecommunications).

Journal of Ambient Intelligence and Humanized Computing
https://doi.org/10.1007/s12652-019-01418-8

ORIGINAL RESEARCH

Acceptance and use of a multi-modal avatar-based tool for remediation of social cognition deficits

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Received: 30 November 2018 / Accepted: 1 August 2019

Abstract
This paper focuses on the validation of a tool designed to improve affect recognition, a fundamental aspect of social cognition as it greatly affects the functionality and quality of life of patients with mental disorders. The presented tool facilitates the generation of multi-modal avatar-based therapies by mental health professionals in this important clinical domain. Moreover, the tool for remediation of social cognitive deficits may be customised to each patient's impairment. This paper describes how the tool was assessed by therapists after viewing a video explaining its most relevant aspects. The participants were asked to fill in a questionnaire based on UTAUT2 for the study of the acceptance and use of this technology. In light of the results obtained from 41 therapists about their intention of use, the most important statement is that their interest for this kind of tools is high. Nonetheless, there are some factors that negatively affect their behavioural intention.

Keywords Social cognition · Affect recognition · Virtual reality · Avatar

1 Introduction

Social cognition refers to cognitive processes involved in social interactions, which incorporates processes of perceiving, interpreting and generating responses to the intentions, dispositions, and behaviours of others (Pinkham et al. 2014; Brothers 1990). Moreover, it is fundamental to the proper functioning and development of humans as social beings as it greatly affects the functionality and quality of life of patients with deficits related to social cognition (Lahera et al. 2012). In fact, social cognition deficits affect social relations and work environments because people are not able to accurately interpret social stimuli during interactions with others. Therefore, the development of home therapies that help to alleviate the effects of social cognition deficits is highly demanded as several diseases such as schizophrenia (Gottesman 1991), autism spectrum disorders (Baron-Cohen et al. 2001), and acquired brain injury (Rosenberg et al. 2014) are associated with them.

Social cognition is usually described as multidimensional, incorporating four principal domains: emotional processing, social perception, attributional bias and theory of mind (Fernández-Sotos et al. 2018, 2019; Pinkham et al. 2016). One of them, emotional processing, is related to the ability to perceive, recognise and manage emotions (Krishnappa Babu

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s12652-019-01418-8) contains supplementary material, which is available to authorized users.

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Published online: 06 August 2019

and Lahiri 2019; Samara et al. 2019; Mendoza-Palechor et al. 2018; Lozano-Monasor et al. 2017; Castillo et al. 2016; Fernández-Caballero et al. 2016, 2014; Green et al. 2008). Some nonverbal behaviours play an important role in emotional processing, including facial expressions and body movements (Tracy et al. 2015; Cerezo et al. 2012).

One of the most frequent therapies to improve emotion recognition is by training people using photographs that show a specific facial affect. However, the main criticism to the use of images is associated to its low ecological validity (Garrido et al. 2016; Roark et al. 2003). Indeed, they are static stimuli, whilst temporal aspects of facial/gestural motion are also relevant to the recognition of expressions. Thus, it is paramount to include not only static images but also dynamic ones to improve such process (Garrido et al. 2016). An important drawback is that a huge database of expressions is necessary to include different race, age and gender. The growth of the database is even higher when facial images or videos are considered from different angles.

Virtual humans (VH) can be used to overcome the limitations of using images or videos. VH are depicted as human representations inside a virtual world. They are either computer-controlled agents or avatars controlled by a real person. The main motivation for the design of future therapies based on remotely-controlled avatars is that they provide the therapist with a practically unlimited set of avatars. They are modelled and animated to match any combination of race, age and gender, being observed from any angle, under any lighting condition and in any social context.

Therefore, the selection of the right type of person to interact with the patients is also beneficial to engage and encourage them. VH even speak in accordance with their physical representation and express any emotion at any time. They can be used to have a fluent conversation with the observer. Moreover, the fact of having patients inside a controlled virtual environment opens the door to monitor them. For example, it is possible to keep track of eye gaze to identify whether not recognising facial affect is a result of an inability to correctly explore a face.

There have been some VH-based promising approaches for facial affect recognition up to date, mainly targeting people affected by autism (Abirached et al. 2011; Beer et al. 2009). However, to date there are only a few papers about the use of remotely-controlled avatars (Fernández-Caballero et al. 2017), and technological approaches to treat social cognition deficits are scarce (Adery et al. 2018; Souto et al. 2018; Yang et al. 2017; Rus-Calafell et al. 2014; Kandalaft et al. 2013). In most cases, they are limited to research and do not reach a majority of patients affected by this problem. We recently presented a distributed virtual reality (VR) software framework aimed at supporting therapists to conduct social cognition therapies through the use of remotely-controlled avatars (García et al. 2018). Our argument is that technology is mature enough to reach its application with real patients, increasing ecological validity, but it is still far from being used because therapists are not aware of it, neglect the tremendous capabilities or do not have access to it.

In our attempt to bring this kind of technology closer to real therapies, this paper investigates the key factors that influence the behavioural intention of therapists, mainly psychiatrists and clinical psychologists, to adopt it. This is why we presented them a video showing our multi-modal avatar-based tool for treatment of social cognition deficits (see the video provided as Supplementary Material). After watching the video, the participants were asked to fill in a questionnaire based on the Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) (Venkatesh et al. 2012) to investigate which factors affect the adoption of our proposal. UTAUT2 was selected over other alternatives because it integrates the dominant constructs of eight prior prevailing models which are theory of reasoned action, technology acceptance model (TAM), motivational model, theory of planned behavior (TPB), combined TAM and TPB, model of PC utilization, innovation diffusion theory, and social cognitive theory.

This paper is organised as follows. Section 2 introduces the multi-modal avatar-based tool proposed for the implementation of social cognitive deficit therapies. Then, Sect. 3 presents the design of the research based on the UTAUT2 model. This section describes the video created to evaluate the acceptance of the proposed technology, as well as the data collection procedure and the participants who evaluated the tool. Section 4 offers the most important results derived from the data captured. Afterwards, Sect. 5 discusses the factors that have influence on the adoption of such VR tool, the validity of using a video to evaluate the intention of use and some limitations of the present research. Lastly, Sect. 6 presents remarkable conclusions.

2 Multi-modal avatar-based tool

The multi-modal avatar-based tool is designed as a generic test-bed for the implementation of therapies for the remediation of social cognitive deficit. With this aim, the program conveys the voice, facial expressions and body movements of a therapist through an avatar so that he/she interacts remotely with a patient to carry out several therapies without meeting face-to-face. The appearance of the avatar is selected according to the needs of the patient. In the design of the tool, we have considered some proposals that identify which awareness information is needed to improve user experience during a general-purpose use of virtual environments (García et al. 2008) and specific rehabilitation systems (Teruel et al. 2017). For example, considering social awareness (García

et al. 2008), conversation and gestures have been included to allow the user to know the emotional state of the avatar by the tone of voice and the body language, respectively. In addition, as will be seen later, a specific control of the user gaze has been included to take advantage of another awareness element (Present-Where-Gaze: Where are they looking?) (Teruel et al. 2017).

The designed system architecture is based on distributed layers with three main elements: Therapist System; Networking Software; and Patient System (see Fig. 1). Therapist System is composed of three main components. The first one, Capture Hardware, includes the devices that allow gathering body movements (a Kinect v2), facial expressions (a camera) and voice (a microphone). This component provides the information captured by each one of these devices to the Software Processing component. Within this component, the Voice Modulator module takes the therapist's voice stream as input and supplies a modulated voice matching age and gender of the avatar selected. The Emotion Recognition module takes the video feed as input and generates one of 13 different emotions identified as output. Finally, the body posture is computed by the Posture Estimation module by using the information provided by a Kinect v2 device. In addition, there is a Display Hardware in Therapist System that allows the therapist to control the therapy. The gestures carried out and the voice emitted by the patient are as in a normal therapy session, but our system also provides relevant information related to the patient's eye gaze. Thus, a live video stream of the patient is included in the therapist's user interface, as well as the point where the patient is looking at inside the virtual environment. The gaze is represented by a semi-transparent red sphere that is only visible to the therapist.

The next component, Networking Software, is in charge of controlling all communications between therapist and patient systems. It sends each specific information to the Patient System in order to handle the avatar as a puppet. Moreover, it forwards to the Therapist System all the feedback information needed for controlling the therapy execution. Finally, the Patient System has three modules. The Avatar Representation Software implements the final avatar characterisation by mapping the received information to the avatar's expressions as well as to its voice and body and lip movements. Within the Avatar Representation Software, the LipSync module is used to animate the avatar's mouth, the Facial Animation module controls its facial expression and the Body Animation module handles its posture. The avatar is shown using the patient's Display Hardware. All patient-generated data are managed by the Capture Hardware. It provides the voice signal, a video stream of the camera and the eye gaze data that are sent through the network to the Therapist System where it is displayed and reproduced.

The architecture is implemented under Unity 3D (https://www.unity3d.com) by using a set of different assets for acquisition, processing, transmission and avatar representation. These are Affectiva (McDuff et al. 2016) for emotion recognition using a web cam, Kinect v2 Examples with MS-SDK for body posture capture using Kinect v2, Voice Changer Filter for adapting the therapist's voice to the avatar's age and gender, UNET for network transmission of Kinect and emotion data, Photon Voice for network transmission of voice, and Salsa with RandomEyes for animation of the avatar's eyes and mouth. The emotions are modelled using blend shape interpolation so that when an emotion is selected by the therapist, a message is sent to the patient system which establishes appropriate values for the blend shapes defined in the avatar 3D model. FOVE (https://www.getfove.com/), a head-mounted display (HMD) incorporating an eye tracker used in the patient system. Thus, it works both as an output (display) and input (eye-tracking information) device.

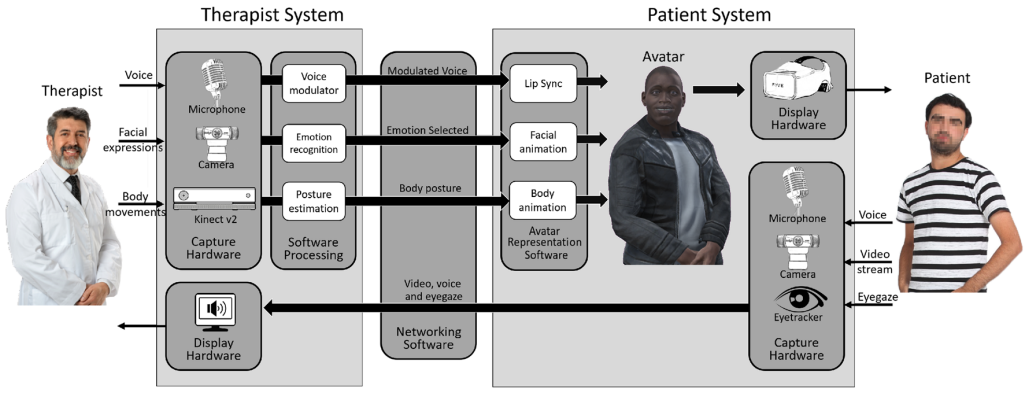

Fig. 1 System architecture to convey voice, facial expression and body posture

3 Research design

This research is based on the the Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) model (Venkatesh et al. 2012). The original UTAUT model (Venkatesh et al. 2003) was created as a synthesis of eight different technology use theories. It was however extended to produce a substantial improvement in variance of behavioural intention and technology use. UTAUT2 is a comprehensive theoretical framework describing seven constructs that play a decisive role in Behavioural Intention and Use Behaviour of a new technology: Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation, Price Value and Habit. This model also considers the influence that gender, age and/or experience have on these constructs. The constructs are defined in the following way:

- Performance Expectancy is the extent to which an individual believes that the use of technology will upgrade his/her performance in the execution of a task.
- Effort Expectancy is the degree of ease associated with the use of a particular technology.
- Social Influence is the degree to which an individual perceives how important it is for other people that he/she uses the technology.
- Facilitating Conditions refer to the degree to which a user believes that the environment supports the use of the technology under study.
- Hedonic Motivation refers to the fun or pleasure derived from the use of the technology.
- Price Value refers to the users' cognitive trade-off between the perceived benefits of using the technology and the monetary cost of using it.
- Habit is the extent to which people tend to automatically perform behaviours due to learning, which creates a preference for the use of a particular technology.

In addition, Behavioural Intention and Use Behaviour are defined as:

- Behavioural Intention refers to the intention to use a certain technological product or service.
- Use Behaviour refers to the user's current use of the technology.

Price Value and Use Behaviour were not included in our model as their measurement is not feasible in this particular case. It would not be easy for the professional therapists to evaluate the cost of the avatar-based tool presented as it is not yet in the market, or their use as they have not used it in practice. Table 1 summarises the questions asked to the therapists for each construct.

UTAUT2 includes age, gender and experience as individual differences that may moderate the effects of the seven constructs on Behavioural Intention and User Behaviour. We hypothesise that age is an important factor for the behavioural intention of the VR tool because younger therapists are likely to be more open to the use of new technologies in their therapies, such as the one proposed in this paper. This is in line with the opinion of several researchers like Venkatesh et al. (2003), who indicate that younger generations value technology usefulness more than older generations when deciding on usage intention. In the VR domain, they point out that "the older the consumer the less likely they will perceive VR hardware easy to use" (Manis and Choi 2018). Thus, this hypothesis is tested in the Data and Results section. We did not formulate any hypothesis about the gender and experience of the participants (in our case it refers to their years of experience practicing their speciality).

3.1 Video to evaluate technology acceptance

In the evaluation described in our previous work (García et al. 2018), five expert therapists were invited to evaluate our first tool after managing the system and analysing all the features proposed. The participants pointed out that the system provides new possibilities of interaction that would improve the treatment of social cognitive deficits. Since bringing therapists to our lab for a live presentation was difficult and considering we tried to gather the opinion of as many of them possible, we followed a different approach to conduct a new experiment. In this experiment, a video presenting the main features of our tool was used to provide a common view to the participants. In this case, our goal is not to analyse the usability but the acceptance of a tool that has the features showcased in the video. Moreover, the video is based on the experience gained in our initial validation. It does not show a real therapy; no real therapist or patient is featured, but members of our lab have participated as actors trying to describe how a therapist may use our tool for conducting a novel therapy.

This manner of showcasing the tool was selected because we reckoned that a video is a powerful tool to catch people's attention, especially in the case of new technological tools. An example of the success of this approach is the hundreds of new products and ideas that are supported in kick-starter-like sites. This is an example of how a video is able to drag people to an idea and even make them support it financially without testing a product that has not yet been developed. Moreover, during the last years this approach is being used more and more in the evaluation of technology acceptance in several technological fields, such as social robotics (Akalin et al. 2017), cognitive tele-rehabilitation (Oliver et al. 2018), use of near field communication for mobile payment

Table 1 UTAUT2 survey items

Performance expectancy
PE1. The use of the VR tool presented in the video would be useful in my daily work with patients
PE2. Using this VR tool would increase the chances of making progress in patient's emotion recognition
PE3. Using this VR tool would help me to achieve the objectives of the therapies quicker
PE4. Using this VR tool would increase my productivity
Effort expectancy
EE1. Learning how to use this VR tool is easy
EE2. The interaction with this VR tool is clear and understandable
EE3. I find this VR tool easy to use
EE4. It would be easy for me to become skillful at using this VR tool
Social influence
SI1. People who are important to me think that I should use this kind of VR tools
SI2. People who influence my behaviour think that I should use this kind of VR tools
SI3. People whose opinions I value prefer that I use this kind of VR tools
Facilitating conditions
FC1. I have the resources necessary to use this kind of VR tools
FC2. I have the knowledge necessary to use this kind of VR tools
FC3. This VR tool is compatible with other tools or ways of designing therapies that I know
FC4. I could get help from others if I have difficulties using this kind of VR tools
Hedonic motivation
HM1. The VR tool presented in the video looks funny
HM2. The VR tool presented in the video looks enjoyable
HM3. The VR tool presented in the video looks very entertaining
Behavioural intention
BI1. I would intend to use the VR tool presented in the video with my patients
BI2. I would use this VR tool in my daily work with patients
BI3. I would use this VR tool frequently

(Khalilzadeh et al. 2017), or recommender systems (Laumer et al. 2018; Oechslein et al. 2014), among others.

The video lasts around 7.5 min and is divided into four main sections: introduction, configuration of the pre-therapy session, execution of the therapy, and post-therapy. The introduction lasts about 1.5 min and provides a brief overview of the motivation and capabilities of the multi-modal avatar-based tool. The pre-therapy section of the video shows how to set up a session and select the appropriate avatar. Since the therapist is a woman (in the video), a male avatar is selected to show the system's voice modulation capabilities. Moreover, the video describes the user interface, how to start controlling the avatar and the functioning of the eye-tracking panel. This panel is shown on the top-right corner of the left screen shot in Fig. 2. It also shows how the patient should put on the head-mounted display

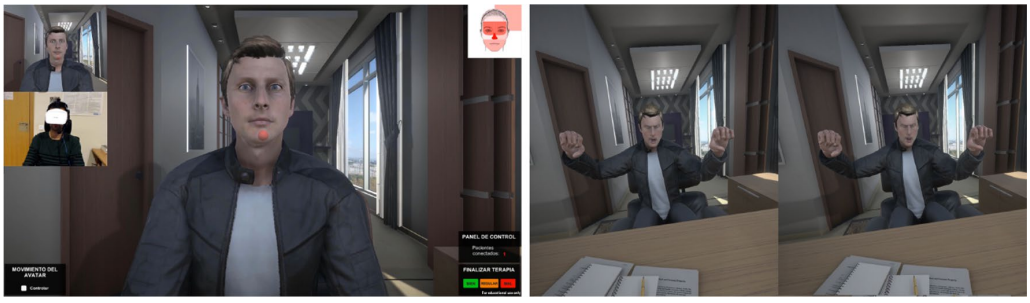

Fig. 2 Screen shots taken during the therapy. Left: the therapist's screen. Right: the patient's screen when looking at an angry avatar

(HMD). This section lasts around 2.5 min. The execution of the therapy takes about 3 min to show a possible way of using the avatar in a made-up social cognition therapy in which the patient has to identify the behaviour of the avatar by paying attention to its facial expression, body movements, and voice.

The therapist makes use of her own facial expression and body movements to demonstrate two different behaviours. In first place, he/she opts for a cheerful avatar that tries to involve the patient in a friendly conversation, while in the second he/she uses a threatening avatar that tries to intimidate the patient (see the right side of Fig. 2). This also shows the practical use of the eye-tracking technology since the patient is scared of the avatar and looks away from it. This is noticed by the therapist who tries to bring the patient's attention back to her. A red sphere (only visible to the therapist) represents the point in the 3D space where the patient is looking at (see the left side of Fig. 2), right on the avatar's chin. Finally, she interviews the patient about the behaviours tested at the end of the session. The post-therapy section of the video shows the capability to review the session at any time, including the video feedback of the user, and both the patient and therapist screens. This final section lasts about 30 s.

From the patient's point of view, the pre-therapy stage includes the connection to the session created by the therapist. In this prototype, it can be done either by introducing the IP address of the therapist computer, or by automatically discovering the session inside the same local network. During the therapy, the patient experiences the virtual environment with an HMD or using a standard screen. The HMD is preferable as it provides higher levels of immersion and allows an easy change of the viewpoint (as the perspective is associated with the patient's head position and orientation), as can be seen in the right side of Fig. 2. At this stage, the interaction with the therapist is reduced to the live video stream and the audio link, as the patient is not aware of the eye-tracking capabilities of the system. Finally, when the therapist concludes the session, a summary screen provides feedback about the performance of the patient, always using positive messages to encourage them to improve and avoid to demotivate.

3.2 Data collection

A recruitment email was sent out in order to invite therapists to participate in the study. This email included a short text providing the therapists with instructions about what they had to do. Essentially, they were asked to follow a link to YouTube to watch the video and then another link to a web-based questionnaire. This questionnaire was developed using Google Forms and was divided into several parts. The first one provided a brief introduction to the purpose of the study and the participation agreement. The second aimed at gathering demographic information of the participants, while the third one gathered the technology usage intention, measured on a 7-point Likert scale (from 1-Strongly Disagree to 7-Strongly Agree).

3.3 Participants

The recruitment email was sent randomly to 100 therapists, including psychiatrists (51%), clinical psychologists (12%) and residents (38%) working in Spanish hospitals. A resident is a therapist practicing his/her specialty in a postgraduate training program under the direct or indirect supervision of a senior therapist. All addressees were members of the Biomedical Research Networking Centre in Mental Health (CIBERSAM), a Spanish virtual research centre to which some of the authors of this paper belong to. Only 41 responded to the questionnaire ($N = 41$), being 12 men (29%) and 29 women (71%). The mean age of the respondents was $M = 35.44$ ($SD = 9.82$).

4 Data and results

In order to test the reliability and internal consistency of the data gathered, Cronbach's alpha, composite reliability and average variance extracted (AVE) coefficients were computed. Table 2 summarises the values obtained for all constructs. The reliability of the responses to the questionnaire are confirmed as the values of the coefficients are above the minimum acceptable levels for all cases (≥ 0.70 for Cronbach's alpha and composite reliability, and ≥ 0.50 for AVE). Moreover, discriminant validity of the model is confirmed by Heterotrait–Monotrait (HTMT) ratio (Henseler et al. 2015).

Partial least squares structural equation modelling (PLS-SEM) is a popular multivariate analysis technique that is commonly employed to study the relationships between the constructs when using UTAUT2. Even though one of the advantages of this technique is that it can be applied having

Table 2 Reliability analysis of the constructs

Construct	Cronbach alpha	Composite reliability	AVE
PE—performance expectancy	0.91	0.94	0.79
EE—effort expectancy	0.92	0.95	0.81
SI—social influence	0.98	0.98	0.95
FC—facilitating conditions	0.87	0.91	0.71
HM—hedonic motivation	0.95	0.91	0.77
BI—behavioural intention	0.96	0.97	0.92
Recommended values	≥ 0.70	≥ 0.70	≥ 0.50

a relatively small sample size, several studies have identified that such size cannot be randomly selected. The ten-times rule (Barclay et al. 1995) establishes that the minimum sample size should be ten times the largest number of structural paths directed at a particular construct in the model. In our case, that would make 50 as the minimum sample size.

However, this rule has been criticised because this minimum sample size is not sufficient for detecting small effects in the model. Other alternatives have been proposed over time. Marcoulides and Saunders (2006) suggest a minimum sample size based on the number of relationships specified in the model. Following this approach, the minimum sample size for our study would be 91. More recently, an alternative, namely R-squared method (Hair et al. 2014), has been proposed. The sample size is determined by power analyses based on the part of the model with the largest number of predictors (maximum number of arrows pointing at a construct). In our case, we would need 70 observations to achieve enough statistical evidence.

As already mentioned, from the 100 invitations sent to our contact network, only 41 people accepted to participate. Therefore, our sample size does not meet the criteria of any of the reviewed methods to estimate the minimum sample size. This led us to use other statistical techniques to infer the relationship of the constructs, especially in regard to Behavioural Intention.

Two age groups were determined to test our initial hypothesis and, thus, to assess whether age has an influence in the Behavioural Intention of this type of VR tools. The sample was divided into therapists over and under 33 years (the median of the population's age), yielding 22 and 19 professionals, respectively. The normality of the data was checked to select the appropriate hypothesis testing technique. The data collected did not meet the requirements for normality according to the Shapiro–Wilk test, which was selected over the Kolmogorov-Smirnov test due to the sample size ($p < 0.05$). Therefore, the non-parametric Mann–Whitney U test with 95% significance was used. The results showed no difference between the impact of the two different age groups on *Behavioural Intention* ($U = 194.5$, $p = .696$ for BI1, $U = 206.5$, $p = .947$ for BI2 and $U = 195.5$, $p = .719$ for BI3), thus rejecting our initial hypothesis.

An in-depth study of the Behavioural Intention tries to infer some information from the answers provided by the respondents. Table 3 provides the descriptive statistics for the three indicators that form this construct. Medians are provided because the values for standard deviation (SD) are relatively high and this statistic is not affected by extreme values. For the three indicators, the mean and the median indicate a relatively high agreement from the respondents which can also be interpreted as a positive interest in the use of a VR tool similar to the proposed one.

The left side of Fig. 3 shows the boxplot diagram depicting the distribution of the data set. 75% responses lie within the range 4–7 for BI1 and BI2 (50% in the range 6–7 for BI1), indicating that most of the respondents would have the intention to use the tool if it was available to them. This

Table 3 Descriptive statistics of Behavioural Intention indicators

Indicator	Mean	SD	Median	IQR
Behavioural Intention	5.04	1.87	6	3
BI1. I would intend to use the VR tool presented in the video with my patients	5.22	1.82	6	3
BI2. I would use this VR tool in my daily work with patients	5.00	1.86	5	3
BI3. I would use this VR tool frequently	4.90	1.96	5	4

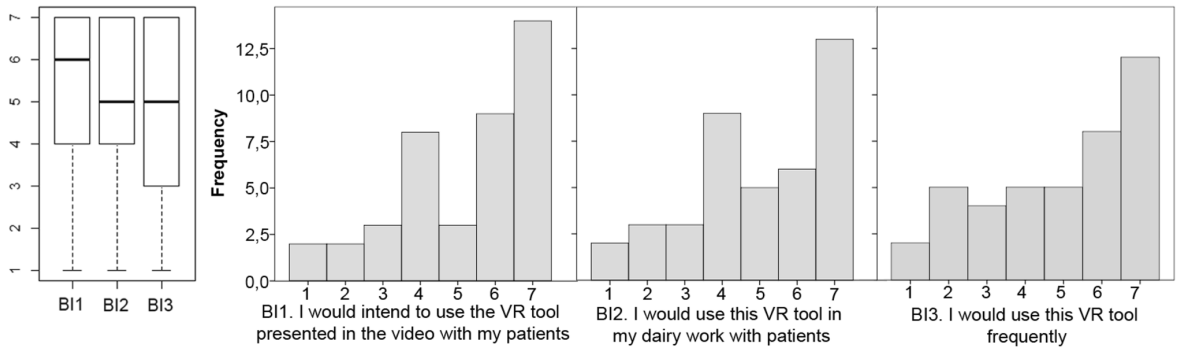

Fig. 3 Boxplot (left) and histograms (right) of Behavioural Intention values

clearly shows the interests in the technological solution proposed.

5 Discussion

5.1 Influencing factors for adoption of VR-based tools

Even though we cannot use PLS-SEM to analyse the relationship between the constructs and extract conclusions about their influence on Behavioural Intention, they can be studied individually to gain further insight into their potential impact (see Table 4).

Figure 4 depicts a boxplot diagram for all the indicators analysed. At first glance it reveals that most of the indicators were rated about 4, which means that the participants agreed with them. However, it is worth analysing them in more detail. The Performance Expectancy indicators (PE) show a similar distribution to Behavioural Intention, most of the responses lie within the range 4–7, with median values between 5 and 6. This suggest that most of the respondents thought that a tool using VR avatars could be useful in their work. This is important as PE indicators, in general, and the expectancy of making progress with the patients (PE2) and

Table 4 Grouped descriptive statistics for the constructs

Indicator	Mean	SD	Median	IQR
Performance expectancy	5.24	1.74	5	3
PE1	5.56	1.25	6	1
PE2	5.56	1.25	6	1
PE3	5.37	1.36	6	1
PE4	4.83	1.79	5	2
Effort expectancy	5.71	1.19	6	1
EE1	5.76	1.14	6	2
EE2	5.76	1.18	6	2
EE3	5.61	1.20	6	1
EE4	5.71	1.27	6	2
Social influence	4.31	1.90	4	3
SI1	4.44	2.04	4	3
SI2	4.20	1.74	4	3
SI3	4.29	1.94	4	3
Facilitating conditions	4.77	2.04	6	3
FC1	3.88	2.47	3	5
FC2	4.51	2.00	5	3
FC3	5.61	1.46	6	2
FC4	5.08	1.90	6	2
Hedonic motivation	5.40	1.45	6	3
HM1	5.44	1.48	6	3
HM2	5.39	1.36	6	1
HM3	5.37	1.55	6	3

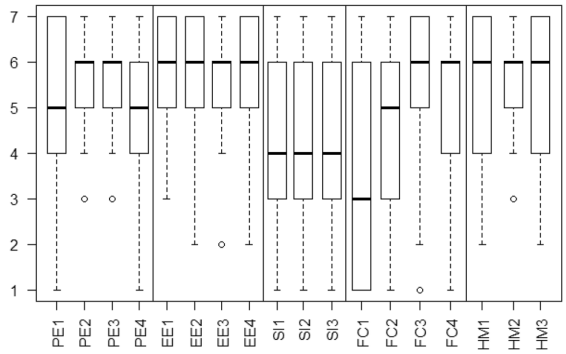

Fig. 4 Boxplot for Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), Facilitating Conditions (FC) and Hedonic Motivation (HM) indicators

increasing the productivity (PE4), in particular, may have a profound impact in the Behavioral Intention. However, they are not enough on their own, so the rest of the indicators should be analysed as well.

Similar conclusions are extracted for Effort Expectancy (EE). This time the positive answers to the questions are even clearer, as 84% of the responses lie within the range 5–7. This indicates that the respondents found the use of the tool easy to learn (EE1 and EE4) and use (EE3), and the interaction with the system was clear (EE2). It is worth reminding that these results are based on a video-based evaluation rather than on the participants' experience with the actual tool. Therefore, the estimation of the effort that the use of the tool would require should be further investigated in order to extract more robust conclusions.

A closer look to Social Influence (SI) shows a different situation. The median for the indicators of this construct is significantly lower than the previous ones ($Mdn = 4$). This indicates that the social environment of the experts consulted is not demanding this kind of avatar-based tools. This may be due to several reasons such as the lack of tools available, their apparent complexity of interacting in 3D environments, and the refusal to interact with other people by using a virtual character. We therefore consider this a key factor for the adoption of VR tools for the treatment of social cognition deficits. Even if the therapist found that this kind of tools would improve their performance with a moderate effort, the lack of perceived positive attitude of relevant people in the professional and social context may prevent them from taking the first step and starting using it.

Similarly, Facilitating Conditions (FC) indicate whether the therapists consider they have or may have the resources (FC1), knowledge (FC2) someone to help them in case they need it (FC4), and whether this is compatible with their current therapies (FC3). The results for the indicators are not homogeneous. As might be expected, FC1 is badly

valued ($M = 3.88$, $SD = 2.47$), which negatively affects in their behavioural intention. This can be explained by the low penetration of VR in the field, limiting the availability of the hardware needed for its application. Interestingly, the respondents consider that they have the knowledge to use this kind of tools ($M = 4.51$, $SD = 2.00$) and it is compatible with their current therapies ($M = 5.61$, $SD = 1.46$), which can be considered to positively influence in their intention to use the technology. This is interesting since considering this kind of tools to be compatible with their current therapies makes room for using them as a complement, something easy to integrate, not as something disruptive that would require a major change in the way they normally work.

Finally, the values for the Hedonic Motivation (HM) indicators show that the respondents found the tool funny (HM1 $M = 5.44$, $SD = 1.48$), enjoyable (HM2 $M = 5.39$, $SD = 1.36$) and entertaining (HM3 $M = 5.37$, $SD = 1.55$). The respondents answered with different levels of agreement (values between 5 and 7) in 72% of the cases for the three questions. In light of these results we can conclude that HM probably contributed positively to their answers to the Behavioural Intention.

5.2 Validity of a video to evaluate intention of use

The final section of the questionnaire was intended to evaluate the respondents' impression on how the capabilities of avatar-based VR tools were presented through a video.

Three questions were asked:

- "V1. Do you agree with the use of a video to evaluate the usage intention of avatar-based VR tools?"
- "V2. The video provided enough information to answer the questions."
- "V3. The video was useful to spark your interest in using avatar-based VR tools."

Their descriptive statistics are $M = 6.05$, $SD = 1.05$, $Mdn = 6$ for V1, $M = 5.49$, $SD = 1.53$, $Mdn = 6$ for V2 and $M = 5.54$, $SD = 1.45$, $Mdn = 6$ for V3, and the boxplot and the histograms are depicted in Fig. 5. For the three questions, at least 65% of the respondents selected the highest possible values of agreement (6-Agree or 7-Strongly Agree), with 90% selection between 4 and 7. Only 10% of the respondents did not agree with the use of a video. Therefore, these results support our decision to use a video as a tool to catch the therapists' attention.

5.3 Limitations of the proposal

Despite the reasonably good acceptance shown by the participants, we are aware of some limitations of our proposal. Here, the most relevant drawbacks to be considered in future works are briefly described.

The first limitation is related to the sample size. Only 41 therapists took part in the video-based evaluation, preventing us from using more powerful statistical techniques to analyse the results of the evaluation. Therefore, the involvement of a higher number of therapists would be necessary in order to reach further conclusions.

The use of a video for the technology acceptance assessment of the avatar-based tool proposed could be considered another limitation. As it has already been mentioned, the participants in the evaluation did not have the chance to use the actual tool. This decision was aimed at increasing the number of participants. Therefore, we used an online questionnaire so that they could access it at their own convenience. We tried to keep the video as short as possible and, at the same time, provide the therapists with enough information to understand the capabilities of the tool. Even though a previous work could not find significant differences between video-based and live evaluations (Woods et al. 2006), a face-to-face validation process is probably necessary, but at the expense of evaluating the tool in a much longer period of time.

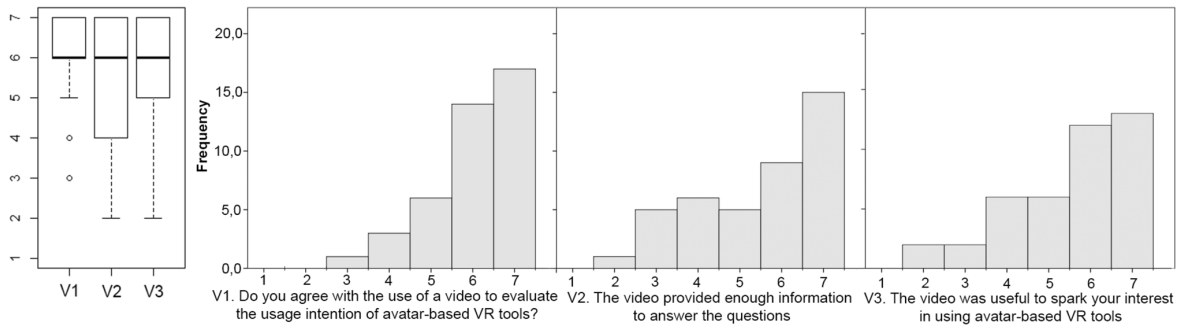

Fig. 5 Boxplot (left) and histograms (right) for the questions regarding the use of a video to present the tool

Moreover, the tool evaluated in this paper is intended for patients suffering from severe mental diseases in stages that need to be monitored by psychiatrists or clinical psychologists, so their physical presence is mandatory. However, there are patients in lower severity stages who would allow the application of therapies that do not require the presence of a mental health professional. This would provide an opportunity to use a similar tool in a home environment. This tool would be aimed at exploiting the communication among groups of patients to improve social interaction skills. Nonetheless, the results of the therapy should always be transmitted to the therapist with the aim of controlling and modifying the treatment, if necessary.

In addition, although the initial evaluation presented in this paper only gathers the opinions of the therapists, it will be interesting to collect the judgements of the patients, since they are the outstanding counterpart aimed at using the multi-modal tool. Although it is out of the scope of the current paper, this will provide in a close future a complete picture of the acceptance of the technology by all people involved.

Finally, the tool proposed is to a certain extent linked to some specific hardware requirements (HMD, Kinect, and so on), but other technologies and devices could be used in a similar setup. For example, a standard screen with eye-tracking capabilities could be used instead of using an HMD. There are consumer devices that, placed under a regular screen, are capable of capturing the user's eye gaze in a reliable way. This solution would be less intrusive and reduce the maintenance costs of the system, as an HMD is still a delicate equipment, especially when used at home.

6 Conclusions

This paper has presented the evaluation process of a tool designed to improve affect recognition in patients with social cognition deficits. The therapists' intention to use our multi-modal avatar-based VR tool for the treatment of affect recognition disorders has been examined. A video was created to showcase the capabilities of our distributed tool for the creation of multi-modal avatar-based therapies and was sent to 100 professional therapists together with a questionnaire based on UTAUT2. This questionnaire was aimed at collecting their Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions and Hedonic Motivation, and investigate the influence in their Behavioural Intention.

The results show that 75% of the respondents would have the intention to use the tool. They also confirmed that although therapists do not consider new VR tools to be difficult to use or understand (they even find them funny and entertaining), the lack of resources and their social environment, which is not pushing them to include new tools in their therapies, may be limiting its adoption. The use of a video as a tool to demonstrate the capabilities of the VR tool was also tested by the questionnaire. The results show that 90% of the respondents found that the use of such a multi-modal avatar-based tool for remediation of social cognition deficits is positive.

Nonetheless, the hypothesis stating that age would be a factor influencing technology adoption was tested and rejected for two age groups (under and below 33 years old). This indicates that the interest of younger and older generations of therapists for the use of VR tools in affect recognition therapies is similar.

Finally, the sample size of this study was a limitation for the application of multivariate analysis in this research. This statistical analysis can be used to extract the influence and correlations of the UTAUT2 constructs on the Behavioural Intention. Thus, we plan to reach a larger population of therapists so that further conclusions will be drawn.

Acknowledgements This work was partially supported by Spanish Ministerio de Ciencia, Innovación y Universidades, Agencia Estatal de Investigación (AEI)/European Regional Development Fund (FEDER, UE) under EmoBioFeedback (DPI2016-80894-R), Vi-SMARt (TIN2016-79100-R) and HA-SYMBIOSIS (TIN2015-72931-EXP) Grants, and by Biomedical Research Networking Centre in Mental Health (CIBERSAM) of the Instituto de Salud Carlos III.

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3.5.2. Mental Health Professionals' Intention to Adopt Virtual Humans in Affect Recognition Training

Datos de la publicación

RESUMEN:

Antecedentes: Las terapias dirigidas a los déficits de cognición social son muy demandadas debido a que varias enfermedades neuropsiquiátricas como la esquizofrenia, los trastornos del espectro autista, los trastornos afectivos o la lesión cerebral adquirida muestran déficits en esta área que se relacionan con una pérdida de funcionamiento y calidad de vida. Los humanos virtuales pueden superar las limitaciones del uso de imágenes o vídeos para entrenar a los pacientes a mejorar el reconocimiento de las emociones.

Objetivo: Este artículo investiga los factores clave que influyen en la intención conductual de los profesionales de la salud mental de adoptar a los humanos virtuales como forma de entrenamiento en el reconocimiento de emociones.

Métodos: Se contactó por correo electrónico con 350 profesionales de la salud mental para participar en este estudio. 124 aceptaron que se les proporcionara un vídeo que mostrara las principales características de un sistema basado en humanos virtuales. A continuación, se les pidió que rellenaran un cuestionario basado en la Teoría Unificada Ampliada de Aceptación y Uso de Tecnología (UTAUT2) para investigar qué factores pueden afectar a la adopción de esta tecnología, analizándose las respuestas mediante el modelo de ecuaciones estructurales de mínimos cuadrados parciales (PLS-SEM).

Resultados: El modelo de medición se probó confirmando su fiabilidad, validez convergente y validez discriminante. El modelo estructural fue evaluado confirmando el efecto sustancial y la relevancia de los constructos en la intención conductual de los profesionales de la salud mental para adoptar esta tecnología.

Conclusiones: Los resultados confirmaron que los profesionales de la salud mental muestran una intención positiva de utilizar las herramientas de realidad virtual para entrenar el reconocimiento de emociones, ya que permiten manipular la interacción social con los pacientes. Se deberían realizar estudios adicionales con terapeutas de otros países para llegar a más conclusiones.

Datos de la publicación (cont.)

CITACIÓN:

A.S. García, P. Fernández-Sotos, P. González, E. Navarro, R. Rodriguez-Jimenez, A. Fernández-Caballero (2020) "Mental Health Professionals' Intention to Adopt Virtual Humans in Affect Recognition Training", *Health Informatics Journal* (enviado)

ÍNDICES DE CALIDAD:

Índice de impacto 2019: 2,932.

Cuartil: Q2.

Rango (Categoría): 29/102 (Health Care Sciences & Services); 12/27 (Medical Informatics).

Health Informatics Journal
26(1):1–10

DOI: 10.1177/ToBeAssigned
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Mental health professionals' intention to adopt virtual humans in affect recognition training

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Abstract

This paper investigates the key factors that influence the behavioral intention of mental health professionals to adopt virtual humans as a way for training affect recognition. Therapies aimed at social cognition deficits are highly demanded since these deficits are related to a loss of functioning and quality of life in several neuropsychiatric diseases such as schizophrenia, autism spectrum disorders, affective disorders and acquired brain injury. Virtual humans (VHs) can overcome the limitations of using images or videos to train patients for improving affect recognition. 124 mental health professionals participated in this study. They were provided with a video showcasing the main features of a software tool based on virtual humans. Then, they were asked to fill in a questionnaire based on the Extended Unified Theory of Acceptance and Use of Technology to investigate which factors may affect the adoption of this technology being the answers analyzed using the partial least square structural equation modeling. The results confirmed that mental health professionals show a positive intention to use virtual reality tools for training affect recognition as they allow to manipulate the social interaction with the patients. Additional studies should be conducted involving therapists from other countries to reach further conclusions.

Keywords

Affect recognition, Mental health, Social cognition, Technology acceptance, UTAUT2, Virtual humans

Introduction

Social cognition focuses on how people process, store, and apply information about other people and social situations (Pinkham et al. 2014; Brothers 1990). Deficits in social cognition, which are present in several neuropsychiatric diseases, negatively affect relations and work environments (Lahera et al. 2012; Wingfield et al. 2019) and produce a loss of functioning and quality of life (Couture et al. 2006). One important domain of social cognition is emotional processing (Anon 01, 02; Pinkham et al. 2016; Myrick and Willoughby 2019), which is the ability associated to perceiving, recognizing and managing emotions. Traditionally, therapies aimed at remediating impairments in emotional processing used photographs demonstrating a series of emotions. Nonetheless, movements in face and gestures are important cues for the recognition of affect (Garrido et al. 2016; Roark et al. 2003).

Virtual humans (VHs) solve many limitations of using static images by providing animation, or even of videos as they offer an unlimited set of designs (avatars and social context) to professionals (Anon 03, 04; Johnson et al. 2018). Therefore, we have designed a software tool, controlled by therapists, for the remediation of affect recognition deficits (Anon 05). This paper studies the influential factors on behavioral intention of mental health professionals to adopt the proposed technology (Marler et al. 2006) through showing them a video describing the tool. For this sake, the therapists had to complete a questionnaire based on the Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) (Venkatesh et al. 2012).

Material and methods

This study was grounded on the UTAUT2 model as an alternative to another relevant acceptance model used in healthcare like the Technology Acceptance Model (TAM) (Ketikidis et al. 2012; Tao et al. 2019). UTAUT and UTAUT2 are also being widely utilized in the last years in healthcare (Ljubicic et al. 2018; Kuek and Hakkennes 2019; Jaana et al. 2019; Sezgin et al. 2018). UTAUT2

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is a framework describing seven constructs –performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), hedonic motivation (HM), price value (PV), and habit (H)– that play a decisive role in behavioral intention (BI) and use behavior (UB) to adopt a new technology. PV, H and UB were not included in our model as their measurement is unclear in this domain. Table 1 shows the questions asked for all analyzed constructs.

124 mental health professionals, including psychiatrists, clinical psychologists and clinical nurses specialized in mental health participated in the study. All were members of the Spanish Biomedical Research Networking Center in Mental Health. Table 2 summarizes the demographic data of the participants. The participants were asked to access YouTube to watch the video and then to a web-based questionnaire developed using Google Forms. The first section provided a brief introduction to the purpose of the study and a participation agreement. The second collected demographic information of the participants, while the third gathered the technology usage intention, measured on a 7-point Likert scale (1 = strongly disagree, 2 = quite disagree, 3 = slightly disagree, 4 = neither agree nor disagree, 5 = slightly agree, 6 = quite agree and 7 = strongly agree).

The hypotheses analyzed in this work are:

- H1: PE of the VH tool for the remediation of affect recognition deficits will positively influence therapists' BI to use the technology.
- H2: EE of the use of the VH tool will not affect the therapists' BI to use it.
- H3: SI will not affect the therapists' BI to use the VH tool for their affect recognition therapies.
- H4: FC will positively affect the therapists' BI to use the technology.
- H5: HM will positively affect the therapist's BI to use VH tool.

This list of hypotheses will be expanded in the following section when considering the moderation effects of age and experience.

Results

As shown in Table 3, results both for constructs and items were very positively rated by the professionals.

SmartPLS v.3.2.8 was employed to run the partial least square structural equation modeling (PLS-SEM) algorithm using the data collected in the questionnaire. The guidelines provided by other authors were followed for the interpretation of the results and the evaluation of the model (Hair et al. 2019; Henseler et al. 2016; F. Hair Jr et al. 2014; Hair et al. 2013, 2011). This included the evaluation of the measurement model, the structural model and the moderation effects.

Measurement model

Being it a reflective model in this case, the factors' reliability, internal consistency reliability, convergent validity and discriminant validity were tested.

In general, the larger the factor loadings, the stronger and more reliable the measurement model. The factors loadings are depicted in the diagonal of Table 4. As can be observed, every standardized factor loading was greater than the threshold 0.70, suggesting reliable scales. The square of the factor loadings was also above 0.5 for all items.

The reliability and the internal consistency of the constructs were tested using composite reliability and Cronbach's alpha (see Table 5). Both coefficients were also above threshold 0.70. AVE (average variance extracted) confirmed convergent validity, being greater than 0.50. Thus, at least 50% of variance is explained by the constructs' items.

Discriminant validity refers to the extent to which a construct is empirically distinct from other constructs in the structural model. Fornell-Larcker criterion has traditionally been used for assessing the discriminant validity. This criterion compares the square root of the AVE values with the latent variables' correlations, which should be greater than its highest correlation with any other construct (see Table 6).

However, the use of this criterion has declined, as it has been demonstrated that the heterotrait-monotrait (HTMT) ratio performs better (Henseler et al. 2015). Therefore, the latter approach was applied to confirm the discriminant validity, which is accepted if this statistic is different from 1. $HTMT_{.90}$ confirmed that there were no discriminant validity issues between any pair of constructs other than BI and HM, and BI and PE (see Table 7). In this case, the HTMT ratios were slightly above the threshold established by $HTMT_{.90}$ (0.926 and 0.942, respectively). Nevertheless, the more conservative $HTMT_{inference}$ approach has been suggested for technology acceptance models (Henseler et al. 2015). Attending to this criterion, the confidence interval (CI) did not include value 1 and thus confirmed the discriminant validity of these pairs of constructs ($CI_{.95}$ [0.877;0.961] for BI and HM, and $CI_{.95}$ [0.904;0.969] for BI and PE).

Table 1. UTAUT2 survey items.

	Performance Expectancy
PE1.	The use of the VH tool presented in the video would be useful in my daily work with patients.
PE2.	Using this VH tool would increase the chances of making progress in patient's affect recognition.
PE3.	Using this VH tool would help me to achieve the objectives of the therapies quicker.
PE4.	Using this VH tool would increase my productivity.
	Effort Expectancy
EE1.	Learning how to use this VH tool is easy.
EE2.	The interaction with this VH tool is clear and understandable.
EE3.	I find this VH tool easy to use.
EE4.	It would be easy for me to become skillful at using this VH tool.
	Social Influence
SI1.	People who are important to me think that I should use this kind of VH tool.
SI2.	People who influence my behavior think that I should use this kind of VH tool.
SI3.	People whose opinions I value prefer that I use this kind of VH tool.
	Facilitating Conditions
FC1.	I have the resources necessary to use this kind of VH tool.
FC2.	I have the knowledge necessary to use this kind of VH tool.
FC3.	This VH tool is compatible with other systems or ways of designing therapies that I know.
FC4.	I could get help from others if I have difficulties using this kind of VH tool.
	Hedonic Motivation
HM1.	The VH tool presented in the video looks funny.
HM2.	The VH tool presented in the video looks enjoyable.
HM3.	The VH tool presented in the video looks very entertaining.
	Behavioral Intention
BI1.	I would intend to use the VH tool presented in the video with my patients.
BI2.	I would use this VH tool in my daily work with patients.
BI3.	I would use this VH tool frequently.

Table 2. Demographic and descriptive statistics.

	Freq.	%
Gender		
Male	27	21.77%
Female	97	78.23%
Age		
23–35	66	53.23%
36–61	58	46.77%
Experience in social cognition		
Yes	40	32.26%
No	84	67.74%
Profession		
Psychiatrist	61	49.19%
Clinical Psychologist	17	13.71%
Mental Health Nurse	46	37.10%

Table 3. Descriptive statistics for the constructs and items.

	Mean	SD	Median	IQR
Performance Expectancy	5.31	1.48	6	1
PE1	5.24	1.55	6	1
PE2	5.51	1.20	6	1
PE3	5.32	1.44	6	1
PE4	5.16	1.65	6	2
Effort Expectancy	5.67	1.10	6	1
EE1	5.69	1.13	6	1
EE2	5.61	1.05	6	1
EE3	5.65	1.13	6	1
EE4	5.75	1.12	6	1
Social Influence	4.12	1.99	4	4
SI1	4.12	1.99	4	4
SI2	4.03	1.89	4	4
SI3	4.12	1.95	4	3.25
Facilitating Conditions	5.07	1.73	6	2
FC1	4.56	2.15	6	3
FC2	4.99	1.70	6	2
FC3	5.40	1.37	6	1
FC4	5.35	1.49	6	1
Hedonic Motivation	5.50	1.52	6	1
HM1	5.50	1.46	6	1
HM2	5.51	1.37	6	1
HM3	5.48	1.50	6	1
Behavioral Intention	5.51	1.66	6	2
BI1	5.50	1.74	6	2
BI2	5.26	1.84	6	3
BI3	5.23	1.82	6	1

Structural model

As the measurement model was valid and reliable, the next step focused on assessing the structural model. This included calculating the coefficient of determination (R^2), path coefficients, effect size (f^2) and the predictive relevance of the model (Q^2), which are standard assessment criteria for evaluating the inner structural model.

Collinearity inflates standard errors, makes significance tests of independent variables unreliable, and prevents the researcher from assessing the relative importance of one independent variable compared to another (Hair Jr et al. 2016). In order to test collinearity, the variance inflation factors (VIF) were computed. All of them were less than 4, the cut-off value (Garson 2016) (see Table 8). This discarded collinearity as a critical issue of the model, allowing the assessment and interpretation of the structural relationships.

The path coefficients are depicted in Fig. 1 and summarized in Table 9. The greater the path coefficient, the more the substantial effect of the exogenous construct on the endogenous latent construct. EE $\rightarrow$ BI (0.125, $p <$

Table 4. Factors loadings and cross-loadings.

	BI	EE	FC	HM	PE	SI
BI1	0.97	0.64	0.69	0.86	0.87	0.57
BI2	0.97	0.61	0.71	0.87	0.88	0.55
BI3	0.98	0.61	0.71	0.84	0.88	0.58
EE1	0.47	0.88	0.47	0.43	0.38	0.41
EE2	0.58	0.92	0.53	0.56	0.52	0.42
EE3	0.57	0.93	0.54	0.53	0.46	0.37
EE4	0.66	0.89	0.59	0.63	0.53	0.50
FC1	0.68	0.46	0.90	0.65	0.67	0.58
FC2	0.67	0.64	0.90	0.65	0.64	0.52
FC3	0.54	0.44	0.76	0.55	0.51	0.38
FC4	0.57	0.48	0.84	0.55	0.51	0.46
HM1	0.82	0.54	0.66	0.92	0.74	0.53
HM2	0.83	0.56	0.66	0.95	0.77	0.52
HM3	0.85	0.60	0.67	0.95	0.79	0.48
PE1	0.87	0.47	0.64	0.76	0.93	0.56
PE2	0.72	0.43	0.51	0.69	0.87	0.46
PE3	0.82	0.49	0.65	0.74	0.93	0.56
PE4	0.88	0.53	0.70	0.77	0.92	0.54
SI1	0.56	0.46	0.55	0.52	0.57	0.98
SI2	0.54	0.45	0.52	0.49	0.54	0.97
SI3	0.60	0.47	0.61	0.57	0.59	0.97

0.05), HM → BI (0.356, $p > 0.001$) and PE → BI (0.509, $p > 0.001$) were found significant using the bootstrapping procedure (10000 sub-samples). Therefore, it could also be stated that the effects of EE on BI were lower than the ones of HM and PE.

The predictive accuracy of the model is measured by the coefficient of determination R^2. There was only one endogenous variable in this model, so R^2 for BI was 0.889 (ranging from 0 to 1). Even though the interpretation of R^2 depends on the discipline under study, the rule of thumb is that its effects are described as substantial, moderate or weak for values of 0.75, 0.50 and 0.25, respectively (Hair et al. 2011). Therefore, it was concluded that the model explains 88.9% of the variance in BI. We rerun the PLS-SEM algorithm with only significant paths in the model to examine the change in R^2, which decreased by less than 7%.

The f^2 statistic measures the importance (or relative impact) of the exogenous constructs in explaining the endogenous construct. 0.02 represents a small f^2 effect size, 0.15 a medium one, and 0.35 represents a high effect size (Cohen 1988). Therefore, the effect of dropping PE from the model was high (0.691, $p > 0.05$), it was medium to drop HM (0.316, $p > 0.05$) and not significant effect for dropping EE was found, as shown in Table 10.

A cross-validated redundancy Q^2 value larger than 0 means that the exogenous constructs have predictive relevance for the endogenous construct under consideration (Hair et al. 2011). In other words, the model is relevant to predicting that factor. The value of Q^2 was 0.779. Values higher than 0, 0.25 and 0.5 depict small, medium and large predictive accuracy, respectively, of the PLS path model (Hair et al. 2019). Here, both R^2 and Q^2 values demonstrated that the model had substantial predictive precision and relevance in relation to the BI construct.

Moderation

We rerun the tests including moderation to test the remaining hypotheses. Multi-group analysis was discarded due to the difference in the groups' sizes and the low sample size for some of them (see demographic information on Table 2). Therefore, a two-stage moderation approach was followed. Indeed, we wanted to prioritize the detection of a significant interaction, and the sample size made us focus on statistical power (Hair Jr et al. 2016). Moreover, dummy variables were added as in previous works (Henseler and Fassott 2010; Hair Jr et al. 2016). Fig. 2 shows the inclusion of the moderator variables in the model.

We expected age (AGE) to moderate the effect that all exogenous constructs have on BI. Age was divided into two groups delimited by the median of the participant's age, which was 35. Similarly, we expected experience (EXP) to moderate the effect of PE, SI and FC on BI. This led us to have 8 new hypotheses (see Table 11).

H6 Age moderation We studied the moderation effects of the categorical dummy variable representing the two age groups, as we expected differences between the younger and older groups (interaction effects of age on the relationships of the constructs). The left side of Table 12 shows that this hypothesis was false, as no significant paths could be found. To explore the possible interaction of age, we replaced the categorical dummy variable by a continuous one. In this case, the results were different (see the right side of Table 12), as the paths for the moderation of the relationships FC→BI and HM→BI were found to be significant ($-0.133, p < 0.05$ and $0.141, p < 0.05$).

This suggested that the relationship of FC→BI becomes stronger with low levels of age, supporting H6(d). However, it was not the case for HM→BI, as it became stronger with high levels of age, not supporting H6(e). H6(c) was confirmed, as we did not expect age to moderate the relationship of SI with BI. The rest of the H6 groups of hypotheses were not supported because paths were not significant.

H7 Experience moderation Similarly, we coded the experience of the participants in a dummy variable (yes/no) to perform the moderation analysis. Again, the results showed no interaction effects of experience in the

Table 5. Internal consistency, construct reliability and convergent validity.

	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
BI. Behavioral Intention	0.97	0.98	0.94
EE. Effort Expectancy	0.93	0.95	0.82
FC. Facilitating Conditions	0.87	0.91	0.73
HM. Hedonic Motivations	0.94	0.96	0.89
PE. Performance Expectancy	0.93	0.95	0.83
SI. Social Influence	0.97	0.98	0.94
Thresholds	≥ 0.70	≥ 0.70	≥ 0.50

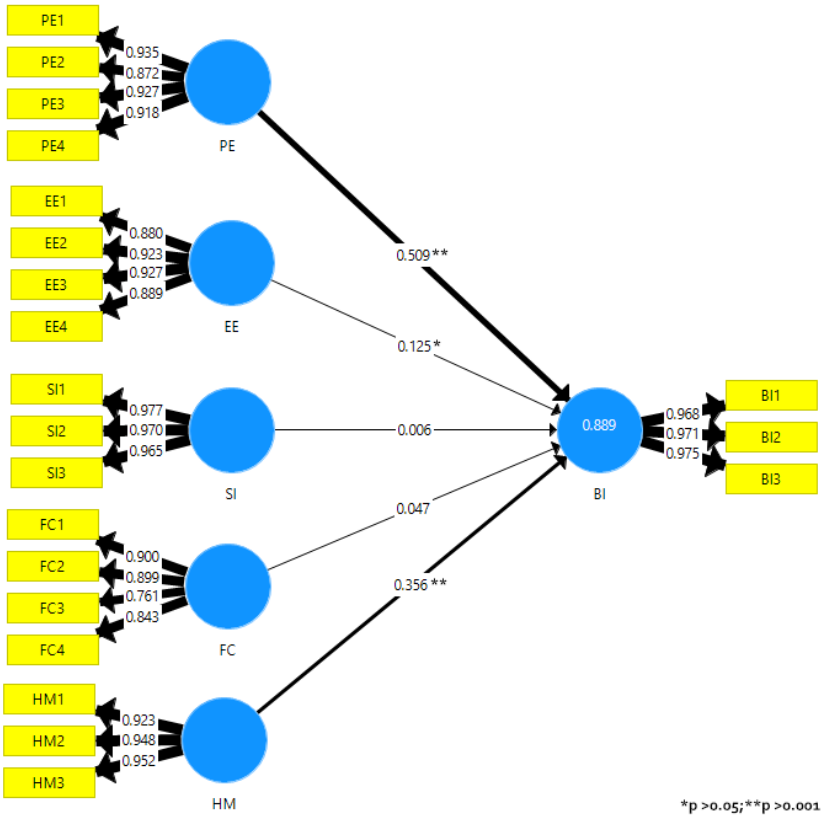

Figure 1. Results of the structural model.

Table 6. Fornell-Larcker criterion table. The square root of AVE is shown in the diagonal cells and the correlation are presented just below.

	BI	EE	FC	HM	PE	SI
BI	0.971					
EE	0.639	0.905				
FC	0.726	0.593	0.853			
HM	0.882	0.603	0.707	0.941		
PE	0.901	0.528	0.688	0.815	0.913	
SI	0.583	0.473	0.576	0.543	0.584	0.971

Table 7. Heterotrait-monotrait ratio (HTMT) values.

	BI	EE	FC	HM	PE	SI
BI						
EE	0.664					
FC	0.785	0.651				
HM	0.926	0.637	0.780			
PE	0.942	0.558	0.752	0.871		
SI	0.599	0.494	0.618	0.569	0.610	

relationship of the constructs with BI (see Table 13), rejecting the group of hypotheses H8.

Discussion and conclusion

The main objective of this work was to investigate the impact that some key factors have on adopting a software

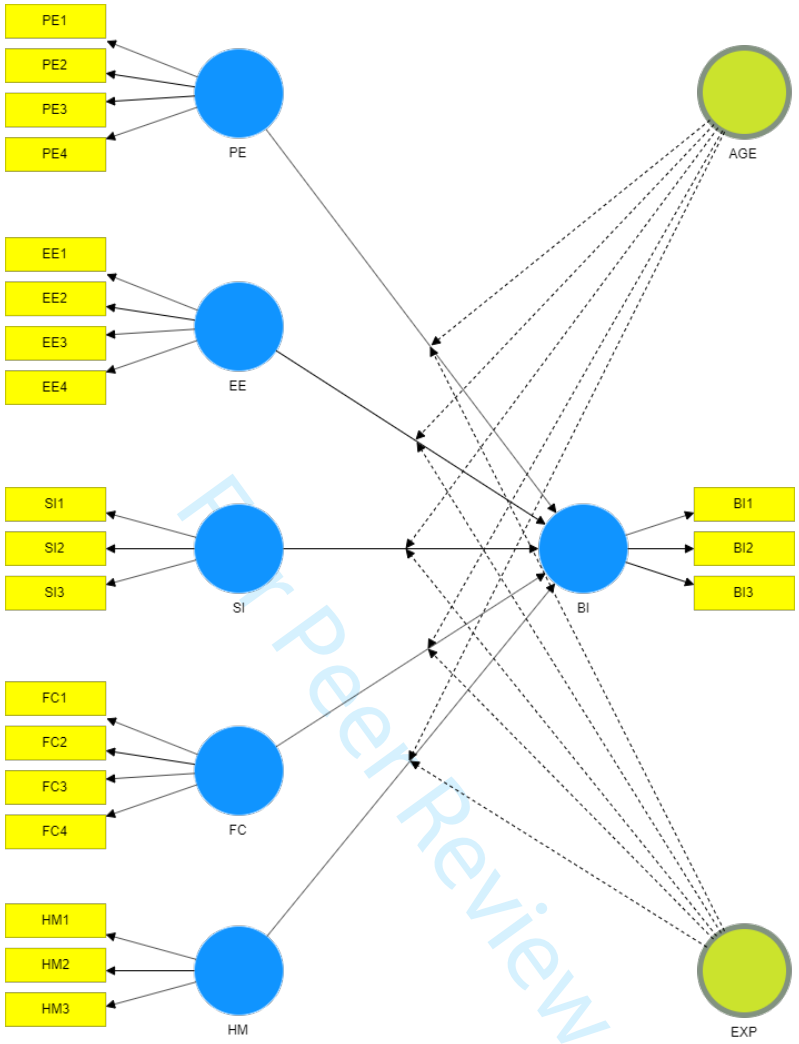

Figure 2. Structural model including age and experience as moderator variables. The image has been adapted to show which relationships are expected to be affected by which moderating variable.

Table 8. Collinearity. Assessment of variance inflation factors (VIF) of the constructs.

	BI
BI	
EE	1.75
FC	2.47
HM	3.62
PE	3.39
SI	1.70

Table 9. Path coefficients.

	Path coeff.	T Statistics	P Values
EE → BI	0.125*	2.325	0.020
FC → I	0.047	0.770	0.441
HM → BI	0.356**	5.120	0.000
PE → BI	0.509**	6.422	0.000
SI → BI	0.006	0.159	0.874

$*p > 0.05; **p > 0.001$.
Bootstrapping 10,000 sub-samples.

tool controlled by therapists for the remediation of affect recognition deficits. A video was developed, showcasing the features of our tool to 124 therapists. After watching the video, they were asked to fill in a questionnaire based on the UTAUT2 model. The data gathered were analyzed using PLS-SEM to evaluate the model and test nine hypotheses.

Table 10. f-square.

	F Square	T Statistics	P Values
EE → BI	0.080	1.040	0.298
FC → BI	0.008	0.254	0.799
HM → BI	0.316*	2.368	0.018
PE → BI	0.691*	2.573	0.010
SI → BI	0.017	0.017	0.987

*$p > 0.05$. Bootstrapping 10,000 sub-samples.

Table 11. Moderation hypotheses.

#	Influence	Type of effect expected
H6 (a)	AGE*PE → BI	Stronger for the younger group
H6 (b)	AGE*EE → BI	Stronger for the younger group
H6 (c)	AGE*SI → BI	No moderation effect expected
H6 (d)	AGE*FC → BI	Stronger for the younger group
H6 (e)	AGE*HM → BI	Stronger for the younger group
H7 (a)	EXP*PE → BI	Stronger for the experienced group
H7 (b)	EXP*SI → BI	Stronger for the not experienced group
H7 (c)	EXP*FC → BI	Stronger for the experienced group

Hypotheses

The first five hypotheses dealt with the influence that the five exogenous constructs had on the endogenous construct of our model, the BI of the therapists.

The results confirmed the first hypothesis, as we could find a positive influence of PE on BI. In recent years, different rehabilitation therapies have been developed aimed at improving facial affect recognition, mainly in the area of schizophrenia. Many of them used virtual reality (VR) as a basic training tool, because it provides environments and situations practically similar to reality, using dynamic avatars that allow social interaction with the participant and are manipulated to represent different emotional states (Gutiérrez-Maldonado et al. 2014). Recent meta-analyses have shown promising results of psycho-therapeutic approaches in terms of facial recognition of emotions and functionality (Bordon et al. 2017; Kurtz and Richardson 2011). More specifically in the area of VR and psychosis, a recent review indicates that interventions based on VR are not only effective but also well tolerated by patients (Rus-Calafell et al. 2018).

Contrarily to what was hypothesized on the second hypothesis, EE had a positive influence on BI, although the coefficient of this path was not very high ($0.125, p = 0.02$). The effect was not that strong compared to PE ($0.509, p < 0.001$). In fact, in the last 10 years society uses new technologies in a standardized manner, which reduces the fear of its complexity and the rejection of its use. In addition, we consider that the tool proposed in the paper is effortless.

The third hypothesis expected SI not to affect BI. At present, mental health professionals do not feel that the most influential social environment expects them to use this technology in clinical practice. The hypothesis was fulfilled since the result showed no impact. The non-existence of standardized therapies aimed at improving social cognition probably influences the results obtained.

Similarly, FC have no influence on BI. We expected to reject the fourth hypothesis mainly because of the general lack of availability of VR equipment in Spanish hospitals. However, the positive answers to questions FC2 and FC3 about the knowledge needed to use VR tools and its compatibility with other ways of designing therapies, may have counteracted.

Finally, the fifth hypothesis was confirmed. As expected, the therapists found the use of this technology enjoyable and entertaining, which is positive as it may turn out to be enjoyable for the patients as well, turning therapy into something they do not consider a hard work.

The rest of the hypotheses dealt with the moderation effects that age and experience might have on the relationship of exogenous with endogenous constructs. Younger participants thought that they had the knowledge to use a tool like the one described in the video, while the older believed that they would enjoy more using such tool. As expected, age did not have an influence in the relationship of SI and BI.

Regarding the moderation effect that the therapists' experience in social cognition remediation had on the relationships in our model, we hypothesized that the impact of PE and FC on BI would be stronger for the experienced group, while the impact of SI on BI of the not experienced group would be stronger. No interaction effects could be found and, thus, these three hypotheses were discarded. In recent years, social cognition in schizophrenia has taken a relevant role in the area of mental health. This probably has to do with its close relationship with functionality and quality of life (Fett et al. 2011; Schmidt et al. 2011). Similarly, VR has recently developed with promising results into an important alternative in the area of psychosis (Rus-Calafell et al. 2018). A plausible explanation of the results obtained could have to do with the fact that a large part of mental health professionals considers these deficits relevant and are aware of the development of therapies aimed at their treatment, including VR-based therapies.

Limitations of the proposal

The results of this study suggest clinical implications in the use of this new technology in affect recognition training, as can be concluded from the therapists' intention of use. Nevertheless, several potential limitations need to be

Table 12. (Left) Moderation for age using a categorical variable with two categories (≤ 35 and ≥ 36) and (Right) moderation for age as a continuous variable

$R^2 = 0.897$	Path coeff.	T Stat.	P Val.
AGE → BI	0.001	0.043	0.966
AGE*EE → BI	-0.067	1.270	0.204
AGE*FC → BI	-0.083	1.394	0.163
AGE*HM → BI	0.098	1.470	0.142
AGE*PE → BI	0.004	0.052	0.958
AGE*SI → BI	0.031	0.792	0.428

$R^2 = 0.904$	Path coeff.	T Stat.	P Val.
AGE → BI	-0.016	0.467	0.641
AGE*EE → BI	-0.068	1.041	0.298
AGE*FC → BI	-0.133*	2.020	0.043
AGE*HM → BI	0.141*	2.221	0.026
AGE*PE → BI	0.046	0.517	0.605
AGE*SI → BI	0.024	0.567	0.571

*$p > 0.05$. Bootstrapping 10,000 sub-samples

Table 13. Moderation for experience using a categorical variable with two categories (*Yes* and *No*).

R2 = 0.893	Path coeff.	T Statistics	P Value
EXP → BI	0.000	0.003	0.997
EXP*EE → BI	-0.035	0.516	0.606
EXP*FC → BI	0.028	0.304	0.761
EXP*HM → BI	-0.051	0.438	0.661
EXP*PE → BI	0.053	0.463	0.643
EXP*SI → BI	0.038	0.847	0.397

Bootstrapping 10,000 sub-samples.

considered in the interpretation of the results and addressed in future work.

The first limitation is related to the sample size. 124 therapists took part in the video-based evaluation and, even though it is a representative number of practitioners of several regions of Spain, the involvement of a higher number of therapists would be necessary in order to reach further conclusions. Moreover, it would be interesting to extend this study to different countries to provide a bigger picture on the acceptance of VH-based tools in affect recognition training.

Regarding the statistical evaluation, PLS-SEM was used to evaluate the results of the UTAUT2 model, but three-way and four-way interactions were not studied. Such analyses would provide information on the impact that two or three combined moderator variables may have on the relationship of the exogenous constructs on the endogenous one. However, this type of interactions is hard to compute and interpret (Hair et al. 2013). Future studies could employ other statistical techniques to draw additional conclusions about the findings of this study.

Another limitation may be the use of a video for showcasing the tool instead of having a hands-on experience. Based on our previous experience (Anon 06), we decided to use a video and an on-line questionnaire to reach a higher number of therapists instead of focusing just on a few to evaluate the tool. Although a previous research was not able to find significant differences between video-based and live evaluations (Woods et al. 2006), it seems reasonable to undergo a face-to-face validation process.

This research focused on one of the two parties potentially interested in using a tool like the one described in this paper. Therefore, it will be interesting to collect the judgements of the patients, since they are the outstanding counterpart aimed at profiting from the tool. This will provide in a close future a whole picture of the acceptance of the technology by all stakeholders involved.

Finally, we would like to remark that this work is an extension of a previous work (Anon 05). The number of participants of the present study was 124, while the previous had only 41. This increase has facilitated the use of multivariate analysis techniques, improving the statistical power. Other aspects as the influence of age and experience of the constructs regarding BI are a contribution of the current paper, as they were not considered in the previous.

Funding

Removed for blind review.

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Anon (03) Anonymized reference.

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Anon (05) Anonymized reference .

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Capítulo 4. Discusión

Los trabajos que componen esta tesis abordan diferentes cuestiones que siguen una misma línea argumental, con el objetivo de responder a la hipótesis principal planteada: La investigación y el desarrollo de nuevas intervenciones psicoterapéuticas basadas en RV, dirigidas a la mejora de los déficits en cognición social de los pacientes con esquizofrenia abre un novedoso y prometedor camino para abordar este problema.

Consideramos que la hipótesis planteada ha sido confirmada en el presente trabajo. Esta conclusión general se basa en los resultados de los ocho estudios que forman parte de trabajo.

En las revisiones de mapeo sistemáticas (Fernández-Sotos y cols., 2018, 2019) se observó un creciente interés en las intervenciones diseñadas para la mejora de la cognición social, especialmente en el área de la esquizofrenia. En los últimos cuatro años analizados (2013 a 2016), el número de publicaciones aumentó de manera llamativa con respecto a los años previos, tanto en las intervenciones farmacológicas como en las psicoterapéuticas. La mayoría de los estudios publicados, además, presentaron un alto nivel de evidencia y fueron publicados en revistas con un elevado factor de impacto. Este interés puede tener que ver con que los profesionales de la salud mental conocen la relación estrecha entre cognición social y funcionalidad. En los últimos años se aboga por un tratamiento integral del paciente con esquizofrenia, prestando una especial atención a su funcionamiento diario y calidad de vida (Vita y Barlati, 2018). Por otra parte, concretamente en el caso de las intervenciones psicoterapéuticas, se añade el hecho de

que existe un gran número de publicaciones que han obtenido resultados positivos en términos de mejora de la cognición social, las habilidades sociales y el funcionamiento social (Kurtz y cols., 2016).

El trabajo sobre acceso y uso de nuevas tecnologías por parte de pacientes con esquizofrenia (Fernández-Sotos y cols., 2019) hipotetizó que los pacientes tendrían acceso y utilizarían las nuevas tecnologías, con un patrón de uso similar a la población sana. En el caso particular de los pacientes con diagnóstico de esquizofrenia en estadio inicial de la enfermedad, parece existir una elevada frecuencia de uso de los dispositivos y aplicaciones tecnológicas, que si bien, es menor que en la población sana comparada, continúa siendo elevada. El hecho de que la finalidad de uso de los dispositivos y aplicaciones analizadas sea muy parecida a la de la población sana comparada, nos acerca un poco más al conocimiento que guiará el desarrollo futuro de aplicaciones terapéuticas basadas en nuevas tecnologías. En el caso concreto de la RV, en nuestro estudio, se objetivó una menor frecuencia de uso en los pacientes en comparación con los controles sanos, que se relacionó con la falta de acceso a este tipo de dispositivos, más que con una falta de interés. Del estudio se desprende que los pacientes con esquizofrenia en estadios iniciales utilizan las nuevas tecnologías con frecuencia, las disfruta y las utilizan con la misma finalidad que la población general. Estos resultados resultan muy positivos de cara a desarrollar intervenciones basadas en nuevas tecnologías, ya que este tipo de herramientas pueden favorecer la adherencia de los pacientes a terapias de rehabilitación para mejorar aspectos de su enfermedad mental, que quizás, sin este tipo de soporte resultaría más complicado.

A la luz de los resultados de la revisión de intervenciones de rehabilitación psicosocial basadas en RV en pacientes con esquizofrenia (Fernández-Sotos, Fernández-Caballero, y Rodriguez-Jimenez, 2020), podemos señalar que la RV se está abriendo paso en el tratamiento de la esquizofrenia, con resultados muy positivos, tanto en términos de tolerabilidad como de eficacia. Los pacientes con esquizofrenia parecen disfrutar de las nuevas tecnologías y lo que es más importante, parecen mejorar en los objetivos

propuestos en las diversas terapias de intervención diseñadas (sintomatología positiva, habilidades sociales, cognición social, neurocognición, funcionalidad, etc.). Se prevé que, en los próximos años, las nuevas intervenciones basadas en RV continúen desarrollándose de manera llamativa, resultando una opción accesible, divertida, innovadora y personalizada para rehabilitar los déficits en cognición social. Además, la combinación del abordaje tecnológico con sesiones interpersonales a nivel individual y grupal resulta compatible y favorece el vínculo terapéutico y la relación entre participantes. Bajo nuestro punto de vista, este tipo de abordaje integral promueve la participación activa de los pacientes en su recuperación funcional.

Si bien los resultados obtenidos hasta el momento resultan prometedores, no disponemos de información suficiente sobre eficacia comparada entre las terapias basadas en RV, las terapias interpersonales y terapias mixtas. Además, resulta necesaria la evaluación de cuestiones importantes como el beneficio y la adherencia a largo plazo y los posibles efectos adversos de este tipo de terapias.

En relación a los resultados obtenidos en los trabajos de creación y validación de expresiones emocionales faciales con HV (García, Fernández-Sotos, Vicente-Querol, y cols., 2020) y DHV (Fernández-Sotos, García, y cols., 2020), la herramienta de creación de avatares demostró ser tan válida como la herramienta clásica en papel para recrear con precisión las expresiones faciales de emociones humanas en población sana. En comparación con otros estímulos virtuales, la tasa de reconocimiento de cada una de las emociones fue similar a la obtenida en otros estudios, y superior para la emoción "asco". Algunas fortalezas del estudio fueron: la estratificación de la muestra por género, edad y nivel educativo; la presentación de cada una de las emociones básicas con dos niveles de intensidad y la evaluación del ángulo de la cámara en el que se presentaron los rostros a los participantes. A diferencia de otros estudios no encontramos diferencias estadísticamente significativas en términos de género. Tampoco se encontraron diferencias estadísticamente significativas entre los participantes adultos y los participantes adultos mayores de 60 años. Sí se encontraron diferencias estadísticamente significati-

vas entre los grupos de edad 1 (20-39 años) y 2 (40-59 años), a favor del grupo más joven, para la tasa de aciertos. Encontramos diferencias estadísticamente significativas con respecto al nivel educativo, a favor de los niveles más altos. Hubo una mayor tasa de aciertos a favor de las emociones de mayor intensidad y a favor del ángulo de cámara frontal.

Los avances obtenidos gracias a la RV pueden ayudar a superar algunas de las limitaciones asociadas al uso de caras estáticas. El uso de entornos ecológicos válidos permitirá simular interacciones sociales similares a la realidad, permitiendo el control y la manipulación de las emociones y los comportamientos de los avatares.

Los resultados obtenidos en los trabajos sobre la aceptación de avatares emocionales por parte de los profesionales de salud mental (García y cols., 2019; García, Fernández-Sotos, González, y cols., 2020) parecen indicar que existe un interés por el uso de herramientas de rehabilitación en cognición social basadas en RV. Los profesionales encuestados valoran este tipo de herramientas como útiles y estarían dispuestos a utilizarlas en la práctica clínica. Esta aceptación puede estar relacionada con que en los últimos diez años la sociedad utiliza nuevas tecnologías de manera frecuente, lo que reduce el miedo a su complejidad y el rechazo a su uso. Otra explicación plausible de los resultados obtenidos podría tener que ver con el hecho de que una gran parte de los profesionales de la salud mental considera que los déficits en la cognición social de los pacientes con esquizofrenia son relevantes y conocen el desarrollo de terapias dirigidas a su tratamiento, incluidas las terapias basadas en RV.

Hoy en día, no existe un tratamiento estandarizado para abordar los déficits en cognición social de los pacientes con esquizofrenia. Muchas cuestiones siguen sin quedar aclaradas, incluyendo cuál es el tipo de intervención más eficaz en términos de contenido y formato, qué durabilidad tienen los resultados obtenidos para cada terapia o cuál es la tolerancia de las terapias a medio-largo plazo. Por todo ello, se requieren mayores esfuerzos a la hora de investigar este tipo de intervenciones.

Aplicabilidad

Los resultados de este trabajo pueden aplicarse al ámbito de la investigación y de la práctica clínica en la esquizofrenia. Los estudios ofrecen una visión general del estado del arte en torno a los tratamientos farmacológicos y psicoterapéuticos diseñados para la mejora de la cognición social. A su vez, ofrecen una visión en profundidad de las intervenciones psicosociales basadas en RV y diseñadas para pacientes con esquizofrenia, arrojando luz sobre la tolerancia y eficacia de este tipo de terapias.

El trabajo aporta información sobre el patrón de uso de las nuevas tecnologías (incluida la RV) en pacientes con esquizofrenia, lo que permitirá diseñar nuevas intervenciones que entrenen la cognición social de una forma accesible, apetecible, bien tolerada y, en definitiva, adaptada a las necesidades de esta población.

Los resultados apoyan el uso de avatares dinámicos para el entrenamiento del reconocimiento facial de emociones frente al uso de estímulos naturales, lo que tiene implicaciones clínicas. Los avances obtenidos gracias a la RV podrían ayudar a superar algunas de las limitaciones asociadas al uso de caras estáticas. El uso de entornos ecológicos válidos permitirá simular interacciones sociales parecidas a la realidad, lo que permitirá a los terapeutas controlar y manipular el comportamiento de los avatares para evaluar y entrenar el reconocimiento emocional básico.

De los resultados se desprende información de interés sobre la opinión que los terapeutas tienen acerca de las herramientas basadas en RV para el entrenamiento de la cognición social. Esto resulta esencial a la hora de poner en marcha este tipo de terapias en la práctica clínica habitual.

Limitaciones

En los trabajos de revisión existen una serie de limitaciones que son intrínsecas a todas las revisiones. La primera limitación está relacionada con el sesgo de informe selectivo. Para minimizar este riesgo, se utilizaron cuatro bases de datos diferentes como fuente para el proceso de búsqueda: PsycINFO, PubMed, Embase y Scopus. Una

segunda limitación es el posible sesgo de selección, que está relacionado con los criterios utilizados para seleccionar los artículos que se analizarán durante el estudio. Para mitigar dicho riesgo, se definieron claramente los criterios de inclusión y exclusión. Un tercer riesgo es el relacionado con la posible inexactitud en la extracción y/o clasificación errónea de datos y clasificación errónea que se mitigó con el trabajo independiente de dos investigadores, y una decisión consensuada que incluyó al coordinador en caso de no haber acuerdo entre ambos investigadores.

En el estudio sobre acceso y uso de nuevas tecnologías por parte de pacientes con esquizofrenia la principal limitación identificada tuvo que ver con la falta de información recogida, incluyendo la situación socioeconómica, la etnia, el nivel cultural y la situación laboral de los participantes, lo que habría ayudado a explicar mejor algunos resultados obtenidos.

En el artículo "Design and validation of virtual human facial emotions", la principal limitación fue la diferencia en la proporción de participantes de diferentes razas que no permitió un análisis en profundidad del papel de la raza en el reconocimiento facial de emociones.

A continuación, se incluyen las principales limitaciones del trabajo "Validation of virtual dynamic faces for future utilization in facial affect recognition". En primer lugar, resulta difícil comparar un estímulo natural (fotografías) con un estímulo virtual. Estudios anteriores han indicado que las expresiones faciales se procesan neurológicamente de manera diferente cuando el estímulo es estático y dinámico. Sin embargo, el objetivo del estudio fue validar el estímulo virtual, no explorar el mecanismo neural subyacente. En nuestra opinión, el estímulo virtual resultó ser mejor que el estímulo natural, a pesar de que había más opciones de respuesta con el estímulo virtual. Esta limitación podría haberse eliminado parcialmente con el uso de una versión extendida del ER-40 (The Penn Emotion Recognition Test) que incluye las siguientes emociones: alegría, tristeza, enfado, miedo, neutra y asco. La razón por la que decidimos usar el estímulo ER-40 es que incluía 40 caras en lugar de 96 caras, lo que hizo que la administración de la prueba

fuera más sencilla. Una limitación compartida con el quinto estudio fue la diferencia en la proporción de participantes de diferentes razas.

La limitación principal de los estudios acerca de la aceptación de avatares emocionales por parte de profesionales de la Salud Mental tiene que ver con el tamaño de muestra utilizada. Si bien en el último estudio la muestra se amplía a 124 terapeutas, la participación de un mayor número sería necesario para llegar a conclusiones adicionales. Además, sería interesante extender este estudio a diferentes países para proporcionar una visión más amplia de la aceptación de la herramienta. Con respecto a la evaluación estadística, se utilizó PLS-SEM para evaluar los resultados del modelo UTAUT2, pero las interacciones de tres y cuatro vías no fueron estudiadas. Tal análisis proporcionaría información sobre el impacto que dos o tres variables moderadoras combinadas pueden tener en la relación de las construcciones exógenas sobre la endógena. Sin embargo, este tipo de interacciones son difíciles de calcular e interpretar. Futuros estudios podrían emplear otras técnicas estadísticas y paquetes de software para extraer más conclusiones sobre los resultados de este estudio. Por último, otra limitación puede ser el uso de un vídeo para mostrar la herramienta en lugar de tener una experiencia práctica con él. Se utilizó un vídeo con el objetivo de llegar a un mayor número de terapeutas. Se intentó hacer un vídeo lo más corto posible y, al mismo tiempo, brindar a los terapeutas información suficiente para comprender las capacidades de la herramienta.

Líneas futuras

El trabajo de investigación desarrollado pretende contribuir a despejar algunas incógnitas sobre el tema tratado, pero, de forma simultánea, y teniendo en cuenta que el tema abordado es muy amplio, genera nuevas preguntas, nuevas ideas y abre nuevas líneas de trabajo. En este apartado se presentan algunas líneas de investigación que pueden ser objeto de interés.

Las revisiones de mapeo sistemáticas ofrecen una visión amplia del tema, buscando descubrir temas y áreas para futuras revisiones sistemáticas de la literatura que

deberían cubrir áreas de investigación más pequeñas. A su vez, este tipo de estudio busca identificar las brechas existentes que se deberán cubrir en el futuro. Una brecha identificada tiene que ver con las intervenciones farmacológicas y psicoterapéuticas dirigidas a los dominios de la cognición social menos estudiados: estilo atribucional y percepción social. En el caso de la revisión con tratamientos farmacológicos, también se observa que la mayoría de los estudios se han llevado a cabo con la hormona oxitocina, con psicoestimulantes y antipsicóticos y pocos estudios han utilizado otro tipo de drogas, lo que deja abierto un importante campo de investigación. Otra línea futura de investigación debería comparar la eficacia de los diferentes tratamientos farmacológicos e intervenciones en cognición social. El estudio sobre acceso y uso de nuevas tecnologías por parte de pacientes con esquizofrenia abre nuevas líneas de trabajo. En primer lugar, resultaría interesante investigar el patrón de uso de nuevas tecnologías en pacientes con esquizofrenia en los próximos años y valorar si ha habido cambios con respecto a la actualidad. Se podría ampliar el tamaño muestral utilizado, incluir a pacientes con esquizofrenia de más de cinco años de evolución de la enfermedad o incluir otras variables sociodemográficas y clínicas relevantes como el nivel socioeconómico, la situación laboral, la raza o el tratamiento psicofarmacológico que toman en la actualidad, recoger el número de ingresos, etc.

En relación a los resultados de la revisión de intervenciones de rehabilitación psicosocial basadas en RV en pacientes con esquizofrenia, la RV parece ser una opción terapéutica interesante y motivadora para los pacientes con esquizofrenia. La posibilidad de crear ambientes ecológicos y avatares que interactúen con los pacientes y cuyas expresiones y comportamientos puedan modificarse en tiempo real, representa un gran progreso para la salud mental, especialmente interesante en el área de la rehabilitación psicosocial. De cara a investigaciones futuras, se ha señalado la importancia de llevar a cabo más estudios para aclarar si las intervenciones basadas en la RV son más efectivas que las intervenciones clásicas. A su vez se deberá aclarar si este tipo de herramientas son aceptadas y bien toleradas por los pacientes.

La conclusión de que el uso de avatares dinámicos que representan estados emocionales tiene una validez similar a los estímulos clásicos utilizados abre un campo de investigación enorme en torno al desarrollo de intervenciones basadas en RV dirigidas a la mejora del reconocimiento facial de emociones en pacientes con diferentes trastornos psiquiátricos como la esquizofrenia, el trastorno bipolar o el trastorno depresivo mayor.

En los próximos años, nuestro equipo investigador tiene como objetivo principal el diseño y la aplicación de un nuevo programa de entrenamiento en reconocimiento facial de emociones llamado AFRONTA (AFfect RecOgnitioN Through Avatars). La terapia incluirá los avatares creados y validados por el grupo de investigación, juegos de ordenador y actividades grupales dirigidas por terapeuta. Dicha intervención se organizará en seis módulos. En cada módulo se trabajará una de las emociones básicas (alegría, tristeza, ira, miedo, asco y sorpresa). El programa será diseñado para adaptarse a las necesidades de cada participante, individualizando el contenido, la duración y frecuencia de la terapia para cada una de las seis emociones básicas. A su vez, el programa incorporará elementos que favorecerán la colaboración, la superación personal y la ayuda entre participantes.

En relación a los resultados extraídos de los estudios sobre la aceptación de avatares emocionales por parte de los profesionales de Salud Mental, consideramos que quedan algunas incógnitas por despejar, pero la principal tiene que ver con el tamaño muestral utilizado. Investigaciones futuras dirigidas al aumento del tamaño muestral proporcionará una visión más amplia de la aceptación de la herramienta en terapeutas.

Capítulo 5. Conclusiones

En la presente tesis se ha investigado el desarrollo de las intervenciones basadas en RV dirigidas a la mejora de la cognición social en esquizofrenia. De los estudios se concluye que:

1. La investigación y el desarrollo de nuevas intervenciones psicoterapéuticas basadas en RV dirigidas a la mejora de los déficits en cognición social de los pacientes con esquizofrenia abre un novedoso y prometedor camino para abordar este problema.

2. Existe un interés creciente en las intervenciones psicoterapéuticas dirigidas a la mejora de la cognición social, especialmente en el área de la esquizofrenia.

3. Existe un interés creciente en las intervenciones farmacológicas dirigidas a la mejora de la cognición social, especialmente en el área de la esquizofrenia.

4. Una gran proporción de pacientes con esquizofrenia en estadio temprano tienen acceso y utilizan con frecuencia los dispositivos tecnológicos, presentando un patrón de uso de nuevas tecnologías parecido a la población sana.

5. La RV ofrece una opción terapéutica interesante y prometedora para pacientes que sufren esquizofrenia, aunque se necesitan más estudios para aclarar si las intervenciones basadas en la RV son más efectivas que las intervenciones clásicas, así como para evaluar su tolerancia.

6. La RV ha permitido diseñar expresiones faciales que representan las emociones básicas de forma precisa.

7. Los humanos HV son tan válidos como las caras naturales estandarizadas para recrear con precisión las expresiones faciales de emociones humanas.

8. Los profesionales de la salud mental consideran que las herramientas de rehabilitación en cognición social basadas en RV son útiles y estarían dispuestos a utilizarlas.

Anexos

Anexo 1. Consentimiento informado - Tecnología digital para el acceso a Internet

CONSENTIMIENTO INFORMADO

Título del estudio:

TECNOLOGÍA DIGITAL PARA EL ACCESO A INTERNET EN PACIENTES CON ESQUIZOFRENIA EN ESTADIO TEMPRANO EN ESPAÑA: UN ESTUDIO DE INVESTIGACIÓN MULTICÉNTRICO.

Lugar de realización:

Hospital Universitario 12 de Octubre (Madrid), Hospital Virgen de la Luz (Cuenca), Complejo Hospitalario Universitario de Albacete, Hospital de San Juan (Alicante).

Propósito del estudio:

Le proponemos participar en un estudio para determinar el uso de las nuevas tecnologías en pacientes con trastornos psicóticos.

Las nuevas tecnologías se han introducido en la vida cotidiana de la población general en los últimos años. Existe bibliografía que señala los beneficios relativos al uso de programas terapéuticos apoyados en nuevas tecnologías aplicados a los trastornos psicóticos. Actualmente existe una información limitada acerca del acceso y uso de nuevas tecnologías en pacientes psiquiátricos y más concretamente en pacientes con trastornos psicóticos en España.

Lo que le solicitamos es que nos de su consentimiento informado para utilizar sus datos sociodemográficos y clínicos, de manera absolutamente anonimizada, así como responder a una encuesta de 15-20 minutos de duración, con el fin de realizar un estudio acerca del uso de las nuevas tecnologías en personas que padecen un trastorno psicótico en España.

Procedimientos/explicación del estudio:

Si usted presenta un trastorno psicótico, se le realizarán las evaluaciones clínicas y tratamientos dentro de la práctica clínica habitual.

El contestar a esta encuesta no le llevará más de 15-20 minutos.

La encuesta se llevará a cabo en las consultas habituales de seguimiento, sin que esta suponga un desplazamiento extra a los dispositivos de Psiquiatría y Salud Mental.

Riesgos/beneficios:

No existe ningún riesgo asociado al presente estudio, ya que tanto su tratamiento como sus evaluaciones forman parte de la práctica clínica habitual.

El estudio no supone ningún beneficio directo para usted. El beneficio que se obtendrá de su participación es que ayudará a conocer el uso de las nuevas tecnologías en pacientes con trastornos psicóticos.

Confidencialidad:

Sus datos personales (nombre, dirección, etc. seguirán siendo confidenciales, y en ningún caso se utilizarán). Los datos relativos a su historia clínica serán consultados exclusivamente por las personas que participan en la investigación, en colaboración con su psiquiatra. Todos los datos serán manejados de manera estrictamente confidencial de acuerdo con la normativa vigente de protección de datos de carácter personal.

Así, el estudio se realizará siguiendo la Ley Orgánica de Protección de Datos 3/2018, de 5 de diciembre y el Real Decreto 1720/2007. Ni los nombres, ni cualquier otro dato que pueda llevar a la identificación de los pacientes que participen en el estudio serán publicados en ninguno de los trabajos que se deriven de esta investigación. Los datos estarán en todo momento anonimizados y se trabajará con ficheros de datos disociados. Todo ello con el fin de garantizar la confidencialidad de los datos. Los datos no se cederán a personas ajenas a la investigación.

Tiene derecho a ejercer los derechos ARCO (Acceso, Rectificación, Cancelación y Oposición) regulados en la Ley Orgánica de Protección de Datos 15/1999 y en el Real Decreto 1720/2007.

Coste/compensación:

La participación en este estudio no le aportará ningún beneficio económico o material.

Consideraciones éticas:

Este proyecto respeta los principios éticos fundamentales establecidos en la Declaración de Helsinki, en el Convenio del Consejo de Europa relativo a los Derechos Humanos y la Biomedicina, así como cumple los requisitos establecidos en la legislación española en el ámbito de la investigación médica, la protección de datos de carácter personal y la bioética con la Ley 14/2007, de 3 de julio, de Investigación Biomédica, y demás requisitos legales al respecto.

Alternativas a la participación:

Su participación en este estudio es completamente voluntaria. Tanto si participa o no en el estudio, usted seguirá recibiendo las visitas regulares de su psiquiatra. Es decir, su tratamiento y atención psiquiátrica no se modificarán tanto si participa como si decide no participar.

Derecho al abandono del estudio:

Tiene derecho a abandonar el estudio en cualquier momento sin que ello suponga cambios en su tratamiento o cuidados recibidos por parte de su médico. Puede usted retirarse del estudio en el momento que así lo estime conveniente, tras haber avisado a su psiquiatra, sin tener que justificar su retirada. Su decisión no supondrá ningún cambio en la relación con su psiquiatra. Será informado sobre cualquier dato relevante del estudio que pudiera condicionar tu permanencia o abandono de este.

¿Con quién tengo que ponerme en contacto si necesito más información?

Su psiquiatra es la persona encargada de informarle de todo lo concerniente al estudio y está a su disposición para contestar a todas sus preguntas y dudas. En caso de urgencia relacionada con el estudio, es con su psiquiatra con quien debe contactar.

Si tiene alguna pregunta o duda sobre el estudio o sobre sus derechos como participante, o si desea notificar algún problema resultante de la investigación, póngase en contacto con:

Nombre del médico o del investigador responsable: (Según centro)

Número de teléfono: (Según centro)

CONSENTIMIENTO PARA PARTICIPAR EN ESTUDIO:

(Marcar con una X)

___ He leído la hoja de información que se me ha entregado.

___ He podido hacer preguntas sobre el estudio.

___ He recibido suficiente información sobre el estudio.

___ He hablado con: (nombre del/la psiquiatra)

___ Comprendo que mi participación es voluntaria.

___ Comprendo que puedo retirarme del estudio:

1- Cuando quiera.
2- Sin tener que dar explicaciones.
3- Sin que esto repercuta en mis cuidados médicos.

___ Presto libremente mi conformidad para participar en el estudio.

Nombre del participante (o tutor legal): Firma del participante (o tutor legal):

Nombre del Investigador: Firma del Investigador:

Fecha:

NOTA: Se harán tres copias del consentimiento informado: una será para el investigador principal, otra para la historia clínica del paciente y la última para el paciente o sus familiares.

Anexo 2. Cuaderno de recogida de datos (CRD)

CUADERNO RECOGIDA DE DATOS (CRD)

CÓDIGO DE IDENTIFICACIÓN	
FECHA DE NACIMIENTO	
EDAD	
GÉNERO	
RAZA	

ESTADO CIVIL	□ Soltero □ Casado □ Separado □ Divorciado □ Viudo
CONVIVENCIA	□ Familia propia □ Familia de origen □ Solo □ Pareja □ Compañeros □ Institución
LUGAR DE RESIDENCIA	□ Urbano □ Rural
CIUDAD DE RESIDENCIA	□ Madrid □ Cuenca □ Alicante □ Albacete □ Otra: _____

ESTUDIOS	ESTUDIOS PADRE	ESTUDIOS MADRE
□ No □ Primarios □ Medios □ Universitarios Tipo de estudios: _____ Años de escolarización: _____	□ No □ Primarios □ Medios □ Universitarios Tipo de estudios: _____ Años de escolarización: _____	□ No □ Primarios □ Medios □ Universitarios Tipo de estudios: _____ Años de escolarización: _____

SITUACIÓN LABORAL	SITUACIÓN LABORAL PADRE	SITUACIÓN LABORAL MADRE
□ Activo □ Parado □ ILT □ Pensionista □ Ama de casa □ Estudiante Profesión actual: _____	□ Activo □ Parado □ ILT □ Pensionista □ Ama de casa □ Estudiante Tipo de trabajo: _____	□ Activo □ Parado □ ILT □ Pensionista □ Ama de casa □ Estudiante Tipo de trabajo: _____

ANTECEDENTES PSIQUIÁTRICOS
□ Sí □ No En caso de afirmación, indicar cuáles: _____ Ingresos previos / Atenciones en urgencias _____ _____ _____ _____
ANTECEDENTES SOMÁTICOS
□ Sí □ No En caso de afirmación, indicar cuáles: _____

ANTECEDENTES FAMILIARES DE INTERÉS

□ Sí □ No
En caso de afirmación, indicar cuáles:

_____
_____
_____

TRATAMIENTO PSICOFARMACOLÓGICO ACTUAL COMPLETO

□ Antipsicóticos □ Estabilizadores □ Antidepresivos □ Benzodiazepinas □ Anticolinérgicos □ Otros

Indicar fármacos:

□ _____ □ Dosis: _____ □ Inicio: _____

□ _____ □ Dosis: _____ □ Inicio: _____

□ _____ □ Dosis: _____ □ Inicio: _____

□ _____ □ Dosis: _____ □ Inicio: _____

□ _____ □ Dosis: _____ □ Inicio: _____

□ _____ □ Dosis: _____ □ Inicio: _____

□ _____ □ Dosis: _____ □ Inicio: _____

ANTECEDENTES TÓXICOS

	No	Ocasional	Abuso	Dependencia	Edad de inicio Duración
Tabaco					
Café, colas					
Alcohol					
Cannabis					
Cocaína					
Anfetaminas					
Alucinógenos					
Opiáceos					
Consumo de tóxicos en el mes previo: Sí □ No □					

Anexo 3. Encuesta de acceso y uso de nuevas tecnologías

ENCUESTA DE ACCESO Y USO DE NUEVAS TECNOLOGÍAS

ENCUESTA (Parte 1): Uso de dispositivos								
Con qué frecuencia los utiliza… *(Marcar con una X en la casilla correspondiente)*	**ORDENADOR**		**TABLET**	**MÓVIL**		**CONSOLA DE VIDEOJUEGOS**		**TV INTELIGENTE (SMART TV)**
	PORTÁTIL	**FIJO**		**CLÁSICO**	**SMARTPHONE**	**PORTÁTIL**	**FIJA**	
Todos los días								
2-3 veces por semana								
1 vez por semana								
Raramente								
Nunca lo he utilizado, pero me gustaría hacerlo								
Nunca lo he utilizado y no me gustaría hacerlo								
Dónde los utiliza…	*Marcar con una X en la casilla correspondiente*							
En casa								
En casa de mis padres								
En casa de un amigo/a								
En el trabajo								
En cafeterías, bibliotecas…								
Por la calle								

ENCUESTA (Parte 2): Uso de dispositivos								
Para qué los utiliza… *(Marcar con una X en la casilla correspondiente)*	**ORDENADOR**		**TABLET**	**MÓVIL**		**CONSOLA DE VIDEOJUEGOS**		**TV INTELIGENTE (SMART TV)**
	PORTÁTIL	**FIJO**		**CLÁSICO**	**SMARTPHONE**	**PORTÁTIL**	**FIJA**	
Diversión								
Adquirir conocimientos Obtener información Herramienta de trabajo								
Socialización								
Realizar compras								

ENCUESTA (Parte 3): Uso de dispositivos						
Marcar con una X la frecuencia con la que lo utiliza **¿Utiliza alguno de los siguientes dispositivos?**						
	Todos los días	2-3 veces por semana	1 vez por semana	Raramente	Nunca lo he utilizado, pero me gustaría hacerlo	Nunca lo he utilizado y no me gustaría hacerlo
SMARTWATCH						
GAFAS DE REALIDAD VIRTUAL						

Comentarios (del paciente) relativos al uso de dispositivos

Si el paciente refiere alguna información adicional que el entrevistador considere relevante acerca del uso de dispositivos, anótela en las siguientes líneas.

……

……

……

……

ENCUESTA (Parte 4): Uso de aplicaciones									
Aplicaciones	**BUSCADORES**			**REDES SOCIALES**			**VIDEOJUEGOS**		
	Escribir los 3 buscadores más utilizados en orden de mayor a menor frecuencia de uso. Debajo, señalar con una X la frecuencia de uso de cada una o de ellos. 1…… Todos los días ☐ 2-3 veces por semana ☐ 1 vez por semana ☐ Raramente ☐ 2…… Todos los días ☐ 2-3 veces por semana ☐ 1 vez por semana ☐ Raramente ☐ 3…… Todos los días ☐ 2-3 veces por semana ☐ 1 vez por semana ☐ Raramente ☐			*Escribir las 3 aplicaciones para redes sociales más utilizadas en orden de mayor a menor frecuencia de uso.* *Debajo, señalar con una X la frecuencia de uso de cada una de ellas.* 1…… Todos los días ☐ 2-3 veces por semana ☐ 1 vez por semana ☐ Raramente ☐ 2…… Todos los días ☐ 2-3 veces por semana ☐ 1 vez por semana ☐ Raramente ☐ 3…… Todos los días ☐ 2-3 veces por semana ☐ 1 vez por semana ☐ Raramente ☐			*Escribir los 3 videojuegos más utilizados en orden de mayor a menor frecuencia de uso. Debajo, señalar con una X la frecuencia de uso de cada uno de ellos.* 1…… Todos los días ☐ 2-3 veces por semana ☐ 1 vez por semana ☐ Raramente ☐ 2…… Todos los días ☐ 2-3 veces por semana ☐ 1 vez por semana ☐ Raramente ☐ 3…… Todos los días ☐ 2-3 veces por semana ☐ 1 vez por semana ☐ Raramente ☐		
Marcar con una X el dispositivo que se utiliza para cada una de las anteriores aplicaciones *Los números 1, 2 y 3, se refieren a las aplicaciones ordenadas más arriba por categorías*									
ORDENADOR	1	2	3	1	2	3	1	2	3
TABLET	1	2	3	1	2	3	1	2	3
MÓVIL	1	2	3	1	2	3	1	2	3
CONSOLAS	1	2	3	1	2	3	1	2	3
SMART TV	1	2	3	1	2	3	1	2	3

Con respecto a la tarea anterior, lo ideal es que sea el propio paciente quien refiera de forma espontánea las aplicaciones que con más frecuencia utiliza. Si no es así, facilitaremos la tarea con ejemplos.

EJEMPLOS DE BUSCADORES	**EJEMPLOS DE REDES SOCIALES**
GENERALES Google, yahoo, bing ESPECÍFICOS Ocio Youtube, trivago, booking, tripadvisor, vimeo Búsqueda de domicilio Idealista, fotocasa Búsqueda de empleo Infoempleo, linkedin Buscador de redes sociales Social mention, spokeo, google plus	Whatsapp Telegram Skype Viber Snapchat Facebook Twitter Instagram Pinterest Tumblr Myspace LinkedIn Citas: Meetic, eDarling, Badoo, Grner, Tinder Foros de discusión

Anexo 4. Consentimiento informado - Validación de caras dinámicas con realidad virtual

CONSENTIMIENTO INFORMADO

Título del estudio:

VALIDACIÓN DE CARAS DINÁMICAS CON REALIDAD VIRTUAL COMO TAREA PARA EL RECONOCIMIENTO FACIAL DE EMOCIONES

Lugar de realización:

Hospital Universitario 12 de Octubre (Madrid), Hospital Virgen de La Luz (Cuenca), Complejo Hospitalario Universitario de Albacete.

Propósito y metodología del estudio:

Le proponemos participar en un estudio en el que se va a evaluar su capacidad para identificar las seis emociones básicas universales (alegría, tristeza, enfado, miedo, asco y sorpresa) + emoción neutra. Para ello, deberá sentarse delante de una pantalla de ordenador en la que aparecerán 52 caras virtuales; cada una representando una emoción básica. En caso de que sea usted control, se presentarán además 40 fotografías de caras que aparecerán en la pantalla del ordenador y que igualmente representarán una emoción básica. Usted podrá elegir la etiqueta de la emoción que considere que está viendo, entre varias opciones de etiqueta que aparecerán debajo de cada cara. El objetivo de la tarea es obtener el máximo número de aciertos en el menor tiempo posible. El objetivo es que estas caras sean integradas en un programa de entrenamiento en reconocimiento facial de emociones para personas con patología mental que presente dificultades a la hora de identificar emociones.

Si decide participar en el estudio, lo que le solicitamos es que nos dé su consentimiento informado para:

1. Utilizar sus datos sociodemográficos (edad, género, etc) y clínicos (diagnóstico, tratamiento, etc), de manera absolutamente anonimizada.

2. Tener una cita de unos 30-40 minutos para el reconocimiento de emociones en las caras presentadas.

3. *En caso de que sea usted control*, completar una escalas sobre su estado emocional antes del reconocimiento facial de emociones y permitirnos utilizar los resultados de manera absolutamente anonimizada. Esta escala le llevará 5 minutos.

4. *En caso de que sea usted caso*, ser evaluado a través de una escala de gravedad de su enfermedad mental antes del reconocimiento facial de emociones y permitirnos utilizar los resultados de manera absolutamente anonimizada. Esta escala le llevará 20 minutos.

Riesgos/beneficios:

No existe ningún riesgo conocido asociado al presente estudio, ya que tanto su tratamiento como la mayoría de sus evaluaciones forman parte de la práctica clínica habitual. Las evaluaciones añadidas no presentan molestia alguna, más allá del tiempo que tenga que invertir en realizarlas.

El beneficio de su participación en el estudio es que nos ayudará a validar la herramienta informática diseñada para ayudar al tratamiento futuro del reconocimiento facial de emociones en diversos trastornos mentales (trastorno bipolar, trastorno depresivo mayor y esquizofrenia).

Confidencialidad:

Sus datos personales (nombre, dirección, etc), seguirán siendo confidenciales, y en ningún caso se utilizarán. Los datos relativos a su historia clínica serán consultados exclusivamente por las personas que participan en la investigación, en colaboración con su psiquiatra. Todos los datos serán manejados de manera estrictamente confidencial de acuerdo con la normativa vigente de protección de datos de carácter personal.

Así, el estudio se realizará siguiendo la Ley Orgánica de Protección de Datos 3/2018, de 5 de diciembre y el Real Decreto 1720/2007, así como el Reglamento general de protección de datos (RGPD) de la UE aprobado el 6 de abril de 2016. Ni los nombres, ni cualquier otro dato que pueda llevar a la identificación de los pacientes que participen en el estudio serán publicados en ninguno de los trabajos que se deriven de esta investigación. Los datos estarán en todo momento anonimizados y se trabajará con ficheros de datos disociados. Todo ello con el fin de garantizar la confidencialidad de los datos. Los datos no se cederán a personas ajenas a la investigación.

Tiene derecho a ejercer los derechos ARCO (Acceso, Rectificación, Cancelación y Oposición) regulados en la Ley Orgánica de Protección de Datos 15/1999 y en el Real Decreto 1720/2007.

Coste/compensación:

La participación en este estudio no le aportará ningún beneficio económico o material.

Consideraciones éticas:

Este proyecto respeta los principios éticos fundamentales establecidos en la Declaración de Helsinki, en el Convenio del Consejo de Europa relativo a los Derechos Humanos y la Biomedicina, así como cumple los requisitos establecidos en la legislación española en el ámbito de la investigación médica,

la protección de datos de carácter personal y la bioética con la Ley 14/2007, de 3 de julio, de Investigación Biomédica, y demás requisitos legales al respecto.

Alternativas a la participación:

Su participación en este estudio es completamente voluntaria. Así, tanto si participa como si no en el estudio, seguirá recibiendo las visitas regulares de su psiquiatra, así como las evaluaciones clínicas, psicométricas, y neuropsicológicas habituales. Es decir, su tratamiento y atención psiquiátrica no se modificarán tanto si participa como si decide no participar.

Derecho al abandono del estudio:

Tiene derecho a abandonar el estudio en cualquier momento. El abandono del estudio no supondrá cambios en su tratamiento o cuidados recibidos por parte de su psiquiatra. Puede usted retirarse del estudio en el momento que así lo estime conveniente, tras haber informado a su psiquiatra, sin tener que justificar su retirada. Será informado sobre cualquier dato relevante del estudio que pudiera condicionar tu permanencia o abandono de este.

¿Con quién tengo que ponerme en contacto si necesito más información?:

Su psiquiatra es la persona encargada de informarle de todo lo concerniente al estudio y está a su disposición para contestar a todas sus preguntas y dudas. En caso de urgencia relacionada con el estudio, es con su psiquiatra con quien debe contactar.

Si tiene alguna pregunta o duda sobre el estudio o sobre sus derechos como participante, o si desea notificar algún problema resultante de la investigación, póngase en contacto con:

Nombre del médico o del investigador responsable: (Según centro)

Número de teléfono: (Según centro)

CONSENTIMIENTO PARA PARTICIPAR EN ESTUDIO:

(Marcar con una X)

___ He leído la hoja de información que se me ha entregado.

___ He podido hacer preguntas sobre el estudio.

___ He recibido suficiente información sobre el estudio.

___ He hablado con: (nombre del/la psiquiatra)

___ Comprendo que mi participación es voluntaria.

___ Comprendo que puedo retirarme del estudio:

1- Cuando quiera.
2- Sin tener que dar explicaciones.
3- Sin que esto repercuta en mis cuidados médicos.

___ Presto libremente mi conformidad para participar en el estudio.

Nombre del participante (o tutor legal): Firma del participante (o tutor legal):

Nombre del Investigador: Firma del Investigador:

_____

Fecha:

NOTA: Se harán tres copias del consentimiento informado: una será para el investigador principal, otra para la historia clínica del paciente y la última para el paciente o sus familiares.

Anexo 5. Escala de afecto positivo y negativo (PANAS)

ESCALA DE AFECTO POSITIVO Y NEGATIVO (PANAS)

A continuación, aparecen una serie de palabras que describen sentimientos. Lea cada palabra e indique con un círculo la intensidad con la que siente cada uno de los 20 sentimientos durante la última semana, incluido el día de hoy. Conteste lo más sinceramente posible.

1. Nada o casi nada
2. Un poco
3. Bastante
4. Mucho
5. Muchísimo

1. Interés	1	2	3	4	5	**11. Irritación**	1	2	3	4	5
2. Tensión	1	2	3	4	5	**12. Disposición**	1	2	3	4	5
3. Animación	1	2	3	4	5	**13. Vergüenza**	1	2	3	4	5
4. Disgusto	1	2	3	4	5	**14. Inspiración**	1	2	3	4	5
5. Energía	1	2	3	4	5	**15. Nerviosismo**	1	2	3	4	5
6. Culpa	1	2	3	4	5	**16. Decisión**	1	2	3	4	5
7. Susto	1	2	3	4	5	**17. Atención**	1	2	3	4	5
8. Enojo	1	2	3	4	5	**18. Intranquilidad**	1	2	3	4	5
9. Entusiasmo	1	2	3	4	5	**19. Actividad**	1	2	3	4	5
10. Orgullo	1	2	3	4	5	**20. Temor**	1	2	3	4	5

Anexo 6. Cuestionario demográfico y de aceptación e intención de uso de la tecnología

CUESTIONARIO DEMOGRÁFICO Y DE ACEPTACIÓN E INTENCIÓN DE USO DE LA TECNOLOGÍA

GÉNERO	
EDAD	
DATOS PROFESIONALES	PROFESIÓN: □ Psiquiatra □ Residente de Psiquiatría □ Psicólogo clínico □ Residente de psicología □ Enfermero especialista en salud mental □ Residente de enfermería en salud mental HOSPITAL / CENTRO _____
EXPERIENCIA EN DÉFICITS DE COGNICIÓN SOCIAL	EXPERIENCIA EN DÉFICITS DE COGNICIÓN SOCIAL □ Sí □ No En caso afirmativo, número de años ____ EXPERIENCIA EN TRATAMIENTO DE DÉFICITS DE COGNICIÓN SOCIAL UTILIZANDO NUEVAS TECNOLOGÍAS □ Sí □ No En caso afirmativo, número de años ____ En caso afirmativo, ¿qué tipo de tecnología o programa informático has utilizado? _____
EXPERIENCIA CON REALIDAD VIRTUAL	¿Sabes qué es la realidad virtual? □ Sí □ No En caso afirmativo, ¿la has usado alguna vez? □ Sí □ No

CUESTIONARIO DE ACEPTACIÓN DE LA TECNOLOGÍA (UTAUT2)

Después de haber visto el video debes marcar desde “1 = Completamente en desacuerdo” a “7 = Completamente de acuerdo” a cada una de las frases que te vamos a mostrar en relación con la herramienta de VR presentada.

Expectativas de rendimiento

PE1: El uso de la herramienta de realidad virtual mostrada en el video podría ser de utilidad en mi trabajo diario con pacientes
1 2 3 4 5 6 7

PE2. Usar esta herramienta de realidad virtual aumentaría las posibilidades de conseguir avances en el reconocimiento de emociones con los pacientes
1 2 3 4 5 6 7

PE3. Usar esta herramienta de realidad virtual ayudaría a conseguir más rápidamente los objetivos de las terapias
1 2 3 4 5 6 7

PE4. Usar esta herramienta de realidad virtual aumentaría mi productividad
1 2 3 4 5 6 7

Expectativas de esfuerzo

EE1. Aprender a usar la herramienta de realidad virtual mostrada en el vídeo es fácil
1 2 3 4 5 6 7

EE2. La interacción con esta herramienta de realidad virtual me resulta clara y comprensible
1 2 3 4 5 6 7

EE3. Encuentro esta herramienta de realidad virtual fácil de usar
1 2 3 4 5 6 7

EE4. Me resultaría fácil volverme hábil en el uso de esta herramienta de realidad virtual
1 2 3 4 5 6 7

Influencia social

SI1. Las personas que considero importantes en mi trabajo piensan que debería utilizar herramientas de realidad virtual tales como la mostrada en el video
1 2 3 4 5 6 7

SI2. Las personas con influencia sobre mi conducta en mi trabajo piensan que debería utilizar este tipo de herramientas de realidad virtual
1 2 3 4 5 6 7

SI3. Las personas cuyas opiniones valoro prefieren que use la realidad virtual en las terapias
1 2 3 4 5 6 7

Condiciones facilitadoras

FC1. Dispongo o podría disponer de los recursos necesarios para usar la herramienta de realidad virtual mostrada en el video
1 2 3 4 5 6 7

FC2. Tengo los conocimientos necesarios para usar esta herramienta de realidad virtual
1 2 3 4 5 6 7

FC3. Esta herramienta de realidad virtual es compatible con otras herramientas o modos de diseñar terapias que conozco
1 2 3 4 5 6 7

FC4. Podría obtener ayuda de otras personas cuando tenga dificultades para usar esta herramienta de realidad virtual
1 2 3 4 5 6 7

Motivaciones hedónicas

HM1. La herramienta basada en realidad virtual mostrada en el vídeo es divertida
1 2 3 4 5 6 7

HM2. Esta herramienta de realidad virtual es agradable
1 2 3 4 5 6 7

HM3. Esta herramienta de realidad virtual es muy entretenida
1 2 3 4 5 6 7

Intención de comportamiento

BI1. Tendría la intención de usar la herramienta de realidad virtual mostrada en el vídeo con mis pacientes
1 2 3 4 5 6 7

BI2. Intentaría utilizar esta herramienta de realidad virtual en mi trabajo diario con los pacientes
1 2 3 4 5 6 7

BI3. Me plantearía usar esta herramienta de realidad virtual con frecuencia
1 2 3 4 5 6 7

Cuestiones finales

¿Qué te ha parecido el uso de un vídeo para evaluar la expectativa de uso de la herramienta basada en realidad virtual?
1 2 3 4 5 6 7

¿El video ha sido suficiente para dar respuesta a las preguntas planteadas en el cuestionario?
1 2 3 4 5 6 7

¿El vídeo ha sido útil para despertar tu interés en usar esta herramienta de realidad virtual?
1 2 3 4 5 6 7

Expresa cualquier otro comentario acerca de la herramienta mostrada:

_____
_____

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