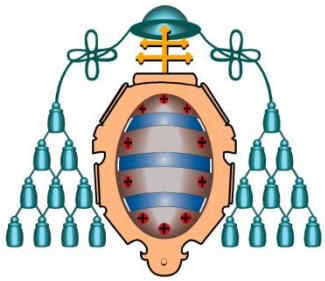

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«*Estudio del Perfil Diagnóstico del TDAH y sus Tipos de Presentación*»

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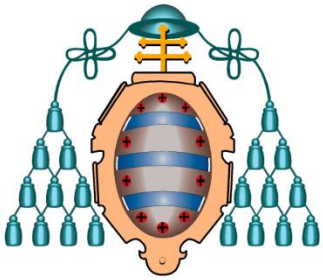
TESIS DOCTORAL

Autora

Paloma Cabaleiro Fernández



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Directoras

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Universidá d'Uviéu
University of Oviedo

RESUMEN DEL CONTENIDO DE TESIS DOCTORAL

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RESUMEN (en español)

El trastorno por déficit de atención con hiperactividad (TDAH) es considerado un desorden del neurodesarrollo que puede manifestarse en tres formas de presentación: presentación predominante con falta de atención, presentación predominante hiperactiva-impulsiva, y presentación combinada. En los últimos años, la evaluación e intervención en el TDAH es objeto de interés para investigadores y profesionales de la práctica clínica y educativa. Esta tesis doctoral se ha centrado en estos dos aspectos, evaluación e intervención en el TDAH. Concretamente, se plantearon tres objetivos principales que se desarrollaron en tres trabajos publicados en revistas incluidas en la Web of Science.

Con respecto a la evaluación, un aspecto clave es la detección inicial que realiza el profesorado de las diferentes etapas educativas. En este contexto, el primero de los objetivos, se situó en analizar el conocimiento y actitud de profesionales de la educación en torno al TDAH. Para alcanzar este objetivo se realizó un primer estudio publicado en la revista Psychology in the Schools (situada en el cuarto cuartil del área "psychology, educational" con un índice de impacto de 1.134 en la web of science). En este estudio se establecieron como objetivos específicos: (1) Analizar el conocimiento y actitud hacia el TDAH de estudiantes universitarios y profesores en activo; (2) Establecer en qué medida el conocimiento sobre el trastorno servía de predictor de las actitudes hacia el TDAH. Los resultados reflejaron que el conocimiento de estudiantes universitarios y profesionales en activo sobre el TDAH era moderado con diferencias significativas entre ambos grupos (los profesionales en activo mostraban un conocimiento superior) que sin embargo no se dieron en el caso de la actitud. Además, el conocimiento sobre el TDAH mostró valor predictivo de la actitud hacia el trastorno. Con todo ello, se concluyó la necesidad de fomentar el conocimiento de profesionales en el ámbito educativo sobre el TDAH, dada la implicación que ese conocimiento tiene sobre su labor en la detección e intervención en estudiantes con este trastorno y al mismo tiempo sobre su actitud hacia el TDAH.

En relación con la intervención, esta tesis se ha centrado en el estudio de la técnica de neurofeedback que en los últimos años ha sido objeto de diversas investigaciones. El segundo de los objetivos se centró en analizar la eficacia del entrenamiento en neurofeedback en los tipos de presentación de TDAH. Con este objetivo se realizó un estudio publicado en la revista Journal of Clinical Medicine (situada en el primer cuartil del área "medicine, general and internal" con un índice de impacto de 3.303 en la web of science). En este caso, se valoraron los beneficios del entrenamiento en neurofeedback a tres niveles: activación cortical, ejecución y

sintomatología observada. Tal y como se pudo ver, los resultados reflejaron que los tres tipos de presentación del TDAH mostraban una evolución favorable tras la intervención a los tres niveles. Además, eran los estudiantes con TDAH presentación combinada quienes obtenían un mayor beneficio. Los resultaron pusieron en relevancia la necesidad de que la intervención en personas con TDAH, y concretamente el entrenamiento con neurofeedback, se ajuste al perfil del estudiante.

En esta línea, el tercer objetivo que se recogió en un estudio publicado en la revista International Journal of Environmental Research and Public Health (situada en el primer cuartil del área "Public, environmental and occupational health" con un índice de impacto de 3.390 en la web of science), planteó analizar la eficacia del entrenamiento en neurofeedback en un caso concreto de TDAH (niña de 10 años) tipo de presentación predominante con falta de atención. Se analizó inicialmente el perfil de activación cortical con el MiniQ (EEG monopolar) y se ajustó en base a los datos recogidos en el protocolo intervención con neurofeedback. Los resultados reflejaron que el MiniQ permitía constatar la actividad cortical del sujeto para ajustar el protocolo de entrenamiento con neurofeedback. Dadas las características del caso evaluado, se pusieron en marcha dos protocolos de intervención, el protocolo SMR y el protocolo Theta/Beta. Tras la intervención, se pudo observar una evolución favorable a nivel de activación cortical con el aumento de activación de la onda beta que se reflejaría en un mejor nivel atencional. Nuevamente, en la línea con los hallazgos del segundo estudio, los resultados apuntan hacia la necesidad de establecer el protocolo de intervención ajustado al caso particular de TDAH.

Teniendo en cuenta los resultados alcanzados en los tres estudios descritos, es preciso hacer hincapié en la importancia de tener en cuenta los diferentes contextos que envuelven a niños y adolescentes con TDAH, tanto el contexto escolar para su detección e intervención, como el contexto personal sobre el que es preciso realizar un análisis exhaustivo y una intervención específica, entre cuyas opciones se encuentra el neurofeedback que puede aportar efectos positivos cuando se ajusta al perfil característico de la persona con TDAH.

RESUMEN (en Inglés)

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that has three primary presentations: predominantly inattentive, predominantly hyperactive-impulsive, and a combined presentation. In recent years, evaluation of ADHD and intervention have been the object of interest for researchers along with clinical and educational practitioners. This doctoral thesis focuses on these two aspects, ADHD evaluation of and intervention. More specifically, it pursued three main objectives through three studies published in journals included in the Web of Science.

The first of these objectives was to analyze what educational practitioners knew about ADHD and their attitudes towards it. To do that, a study was carried out which was published in the journal, Psychology in the Schools (in the fourth quartile of the "psychology, educational" area with in impact factor of 1.134 in the web of science). This study had the following specific objectives: (1) To analyze university students' and active teachers' knowledge of ADHD and attitudes towards it; (2) To determine how far the knowledge of ADHD served as a predictor of attitudes towards it. The results indicated that the two groups, university students and active teachers, had moderate knowledge of ADHD, with significant differences between them (working teachers demonstrated greater knowledge), differences which were not seen in attitude. Furthermore, knowledge of ADHD exhibited predictive value in terms of attitudes towards the disorder. Based on that, the conclusion of the study was the need to enhance educational practitioners' knowledge about ADHD, given the impact of that knowledge

on their work in detection and intervention for students with this disorder as well as the impact on their attitudes towards ADHD.

The second of the objectives focused on analyzing the effectiveness of neurofeedback training on the ADHD presentations. With this objective, a study was performed which was published in the Journal of Clinical Medicine (in the first quartile of the "medicine, general, and internal" area, with an impact factor of 3.303 in the web of science). The study assessed the benefits of neurofeedback training on three levels: cortical activation, execution, and observed symptomatology. The results showed that the three presentations of ADHD demonstrated favorable progress on the three levels following the intervention. Furthermore, the students with combined ADHD presentations exhibited the greatest benefits. The results highlighted the need for interventions for people with ADHD, specifically with neurofeedback, to be adjusted to fit students' profiles.

In this same context, the third objective was addressed in a study published in the journal, International Journal of Environmental Research and Public Health (in the first quartile of the "Public, environmental and occupational health" area, with an impact factor of 3.390 in the web of science), with the aim of analyzing the effectiveness of neurofeedback training in a specific ADHD case (a 10-year-old girl) with predominantly inattentive presentation. Initially, her cortical activation profile was analyzed with a MiniQ (monopolar EEG) and adjusted according to the data collected in the intervention with neurofeedback protocol. The results showed that the MiniQ allowed the subject's cortical activity to be used to modify the neurofeedback training protocol. Given the characteristics of the case, two intervention protocols were implemented, the SMR protocol and a Theta/Beta protocol. Following the intervention, there was encouraging progress in cortical activation, with increased beta-wave activation which was reflected in better levels of attention. In line with the findings from the second study, the results of this third study indicate the need to establish an intervention protocol that is adjusted to the particular ADHD case.

Bearing the results of the three studies in mind, it is essential to underscore the importance of considering the different contexts surrounding children and adolescents with ADHD, both the school context for detection and intervention, and the personal context which needs a thorough analysis and specific intervention, the options for which include neurofeedback, which can have positive effects when it is adjusted to the characteristic profile of the person with ADHD.

SR. PRESIDENTE DE LA COMISIÓN ACADÉMICA DEL PROGRAMA DE DOCTORADO EN EDUCACIÓN Y PSICOLOGÍA

Agradecimientos

Mi primer agradecimiento es para mis directoras de tesis, Paloma y Marisol, por su apoyo, su conocimiento, su constancia, por haberme animado cuando las fuerzas flaqueaban, por contagiarme su entusiasmo por el TDAH, por la escuela, por el profesorado, por el trabajo con el neurofeedbak. Porque con ellas he aprendido no solo conocimientos sino actitudes, tan importantes cuando tienes que equilibrarte entre la excitación y la inhibición, cuando tienes que seleccionar y mantener la atención tanto tiempo, años. Sin su empuje este trabajo no hubiera sido posible. Asimismo agradezco profundamente la colaboración y el apoyo a los compañeros y compañeras del Departamento de Psicología, y del área de Psicología Evolutiva y de la Educación de la Universidad de Oviedo.

No puedo dejar de agradecer y dedicar este trabajo, a mi compañero de vida, a mi marido Fernando, que fue el que me impulsó desde el primer momento a emprender este viaje. Sin él, me hubiera rendido, no lo hubiera conseguido y buscando motivación encontró una muy fuerte, la de mi abuelo, el Dr. Manuel Cabaleiro Goás, psiquiatra y gran estudioso de su tiempo. En muchos momentos de flaqueza fue su recurso para motivarme, y lo consiguió. No obstante, mi mayor motivación ha sido él, después de tantos años juntos, todo lo hemos construido entre los dos, nuestras carreras, nuestra casa, nuestros hijos, nuestra familia, así que este trabajo te lo dedico a ti, porque junto a ti, todo es más fácil. Gracias por haberme acompañado, motivado, empujado y sobre todo por tu generosidad, apoyo y tu amor incondicional.

Listado de Publicaciones

Cueli, M., Areces, D., Cabaleiro, P., & González-Castro, P. (2021). Differences between Spanish students' and teaching professionals' knowledge about and attitudes towards ADHD. Does knowledge influence attitude? *Psychology in the Schools*, 1-18. https://doi.org/10.1002/pits.22605

Cueli, M., Rodríguez, C., García, T., Cabaleiro, P., & González-Castro, P. (2019). Differential efficacy of neurofeedback in children with ADHD presentations. *Journal of Clinical Medicine*, *8*(2), Article e204. https://doi.org/10.3390/jcm8020204

Cabaleiro, P., Cueli, M., Cañamero, L. M., & González-Castro, P. (2022). A case study in attention-deficit/hyperactivity disorder: An innovative neurofeedback-based approach. *International Journal of Environmental Research and Public Health*, *19*(1), Article e191. https://doi.org/10.3390/ijerph19010191

Índice

Resumen

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Summary

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that has three primary presentations: predominantly inattentive, predominantly hyperactive-impulsive, and a combined presentation. In recent years, evaluation of ADHD and intervention have been the object of interest for researchers along with clinical and educational practitioners. This doctoral thesis focuses on these two aspects, ADHD evaluation of and intervention. More specifically, it pursued three main objectives through three studies published in journals included in the Web of Science.

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Bearing the results of the three studies in mind, it is essential to underscore the importance of considering the different contexts surrounding children and adolescents with ADHD, both the school context for detection and intervention, and the personal context which needs a thorough analysis and specific intervention, the options for which include neurofeedback, which can have positive effects when it is adjusted to the characteristic profile of the person with ADHD.

Introducción

El trastorno por déficit de atención con hiperactividad (TDAH) es considerado un desorden del neurodesarrollo que se presenta de forma cada vez más común en la población infantil y adolescente (Barkley, 2016). Greenway y Rees-Edwards (2020) señalan que las tasas de TDAH en las aulas han ido aumentando durante los últimos años. Los estudios en relación con la prevalencia han estimado que el trastorno aparece en un rango del 5.9 al 7.1% en niños y adolescentes, y en alrededor del 5% en adultos (Polanczyk et al., 2014; Thomas et al., 2015; Willcutt, 2012).

La Asociación Americana de Psiquiatría (American Psychiatric Association [APA], 2013) recoge que el TDAH es un patrón persistente, manifestado con anterioridad a los doce años, en el que se evidencian conductas de inatención y/o hiperactividad-impulsividad. Concretamente, en este manual de referencia se diferencian tres tipos de presentación del TDAH: presentación predominante con falta de atención, presentación predominante hiperactiva-impulsiva, y presentación combinada.

También, la Organización Mundial de la Salud (World Health Organization, 2018), en su Manual Internacional de Clasificación de Trastornos Mentales y del Comportamiento (International Statistical Clasification of Diseases and Related Health Problems; CIE-11), incluye el TDAH (en este manual presentado como “Trastorno por Hiperactividad y Déficit de la Atención”) dentro de los denominados Trastornos del Neurodesarrollo, considerando igualmente, una sintomatología desatenta e hiperactiva-impulsiva, aunque poniendo en evidencia que la manifestación de los síntomas, si bien tiene que mostrarse con anterioridad

a los doce años, tiene la puerta abierta a la posibilidad de una manifestación tardía por enmascaramiento de los mismos en etapas más tempranas. En definitiva, independientemente del sistema de clasificación de referencia, los principales síntomas asociados al TDAH son la inatención, la hiperactividad y la impulsividad.

Por otro lado, la comunidad científica que profundiza en la comprensión del TDAH parece mostrar cada vez mayor consenso en la idea de que, además de los síntomas principales asociados a este desorden, las personas con TDAH presentan alteraciones en las funciones ejecutivas, las cuales, llevan de la mano deficiencias en los procesos cognitivos de autocontrol, de autorregulación y de planificación en las tareas (Silverstein et al., 2020). Todo ello, condiciona el rendimiento académico del alumnado con TDAH, las relaciones con sus iguales, la interacción familiar, la autoestima y la calidad de vida (Harpin et al., 2016; Villalobos et al., 2004; Willoughby, 2003).

Teniendo en cuenta la repercusión que el TDAH tiene sobre los estudiantes, se pone de relevancia la importancia de una detección precoz y una intervención ajustada. Esta Tesis Doctoral se enmarca en estos dos aspectos, es decir, en el diagnóstico y tratamiento del TDAH. A nivel general, las preguntas iniciales de las que parte esta investigación son, ¿qué es relevante en el diagnóstico de TDAH? ¿qué intervenciones pueden resultar eficaces?

En relación con la detección, el diagnóstico del trastorno no suele sucederse con anterioridad a la etapa escolar (Arnett et al., 2013). Esto tiene evidentes implicaciones a nivel educativo puesto que el contexto personal de los niños y el contexto escolar conforman un binomio que es preciso tener en cuenta. Los déficits de autocontrol,

planificación, organización y ejecución de conductas complejas durante periodos prolongados de tiempo, es a nivel observable, lo que permite identificar a los niños susceptibles de presentar TDAH (Boonstra et al., 2005). Soroa et al. (2016) sugieren que la etapa escolar es decisiva para la identificación del TDAH, siendo los profesionales que detectan y trabajan en mayor medida el trastorno, los profesores, incluso con mayor frecuencia que las familias y los profesionales sanitarios (Sax y Kautz, 2003). En este contexto, el conocimiento y la actitud del profesorado acerca del TDAH ganan especial relevancia por lo que diversas investigaciones han profundizado en el análisis de estos dos aspectos (conocimiento y actitud hacia el TDAH) entre los profesionales de la educación. Sin embargo, hasta el momento, las investigaciones han mostrado diferentes resultados reflejando un alto conocimiento en algunas de ellas (p.e., Barbaresi y Olsen, 1998; Jerome et al., 1994) y un bajo conocimiento en otras (p.e,. Miranda et al., 2018; Perold et al., 2010) o una actitud más positiva en determinados trabajos y más negativa en otros (ver Greenway y Rees-Edwards, 2020).

El primer objetivo de esta Tesis Doctoral se enmarcaría en esta temática, y tratando de responder a la pregunta planteada inicialmente ¿qué es relevante en el diagnóstico de TDAH? Se focalizó en profundizar en el conocimiento y actitud de los profesionales de la educación hacia el TDAH.

Hasta aquí, hemos expuesto el foco de interés en aquello que determina la detección del TDAH, ahora bien, una vez que aparece el diagnóstico, se hace necesario tener en cuenta los diferentes tratamientos disponibles.

Diferentes metaanálisis publicados en los últimos años, han tratado de analizar la eficacia del tratamiento farmacológico, no farmacológico y combinado para la intervención en el TDAH (Catala-Lopez et al., 2017; Cortese et al., 2018; Yan et al., 2019). La evidencia respalda la eficacia de los tratamientos farmacológicos, al menos, a corto plazo (Castells et al., 2020; Caye et al., 2019). Sin embargo, los tratamientos no farmacológicos cuentan cada vez con un mayor número de estudios que apoyan la necesidad de incorporarlos al programa de intervención de niños y adolescentes con TDAH.

Caye et al. (2019) subraya que el tratamiento debe seleccionarse en cada caso particular teniendo en cuenta el perfil del individuo, su edad y gravedad del trastorno. La Academia Americana de Pediatría (American Academy of Pediatric) ha revisado recientemente las pautas para la intervención en niños y adolescentes con TDAH (Wolraich et al., 2019), clasificándolas en función de los grupos de edad. Para los niños en edad preescolar (4-5 años) se recomienda el tratamiento conductual con pautas para padres y las intervenciones comportamentales; para niños en educación primaria el tratamiento combinado (farmacológico y conductual); y para adolescentes el tratamiento farmacológico. Al mismo tiempo, cada vez más las investigaciones apuntan hacia los beneficios del tratamiento con neurofeedback (p.e., Arns et al., 2014; Moriyama et al., 2012; Yan et al., 2019), sobre todo, teniendo en cuenta que aproximadamente un tercio de las personas con TDAH, no responde adecuadamente o no tolera este tipo de tratamiento (Su et al., 2015).

Yan et al. (2019) han propuesto el tratamiento con neurofeedback como técnica efectiva y segura para la sintomatología asociada al trastorno. De acuerdo con Sitaram et al.

(2017), el neurofeedback persigue el propósito de modificar los patrones de actividad eléctrica cortical y, para ello, en el caso del TDAH, se utilizan protocolos centrados en la disminución de las ondas theta de baja frecuencia, relacionadas con bajos niveles de vigilancia, y el aumento de las ondas beta de alta frecuencia, relacionadas con altos niveles de concentración (Zuberer et al., 2015). El entrenamiento consiste en el registro, en tiempo real, de los niveles de actividad eléctrica cerebral (mediante electroencefalograma) mientras se observa un videojuego que va actuando como refuerzo en función del aumento de la actividad eléctrica del individuo. Los resultados de estos programas con neurofeedback indican que sus efectos son de moderados a grandes en la mejora de la sintomatología TDAH (p.e., Arns et al., 2014; Moriyama et al., 2012) y que pueden ser considerados "eficaces y específicos". En este nuevo contexto, y tratando de responder a la pregunta ¿qué intervenciones pueden resultar eficaces para el TDAH? Esta Tesis Doctoral se ha centrado en segundo lugar en el estudio de la eficacia del neurofeedback en los tipos de presentación del TDAH y en un caso concreto cuya sintomatología era predominante con falta de atención.

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Objetivos

De acuerdo con las cuestiones previamente planteadas a continuación, se detallan Objetivos

En esta tesis doctoral, se plantean tres objetivos principales que se desarrollan en tres estudios que conforman tres publicaciones en formato de art. Estos estudios se pueden encuadrar bien en la línea de detección del TDAH o en la línea de la intervención teniendo en cuenta dos contextos principales: El escolar (para su detección) y el personal (para su intervención).

1-Analizar el conocimiento y actitud de profesionales de la educación en torno al TDAH.

2-Analizar la eficacia del entrenamiento en neurofeedback en los tipos de presentación de TDAH.

3-Analizar la eficacia del entrenamiento en neurofeedback en un caso concreto de TDAH tipo de presentación predominante con falta de atención.

Publicaciones

Artículo 1

Primer estudio publicado en la revista: *Psychology in the Schools*

Differences Between Spanish Students' and Teaching Professionals' Knowledge About and Attitudes Towards ADHD. Does Knowledge Influence Attitude?

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Abstract

Knowledge about attention-deficit/hyperactivity disorder (ADHD) is essential for teachers' educational practice. This study aims to analyse knowledge and attitudes towards ADHD in university students (infant education, primary education, teaching, and psychology students) and teachers (elementary, primary and secondary school teachers, and university teachers). A total of 417 university students and 170 teachers took part in the study. All of the participants completed the Questionnaire for the Evaluation of Teachers' Knowledge of ADHD (four dimensions: General Information, Symptoms/Diagnosis, Aetiology, and Treatment) and a scale about specific attitudes towards ADHD (four components: Feelings; Beliefs; Knowledge, Training and Accommodations; and Desire for Training). The results indicated differences in knowledge between the teachers and the university students but no differences in attitudes. Teachers had deeper knowledge about ADHD in the four dimensions than the university students, with greater knowledge in the dimensions of Treatment and Symptoms/Diagnosis. Furthermore, levels of knowledge predicted attitudes, reflecting the importance of more educational training programmes (for students and professionals) providing information about ADHD, the main symptoms, specific interventions, and its aetiology.

Keywords: ADHD; teacher knowledge; teacher attitude; university student knowledge; university student attitude.

Differences Between University Students' and Working Teachers' Knowledge About and Attitudes Towards ADHD. Does Knowledge Influence Attitude?

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder that has a neurological basis and persists from childhood into adulthood (DSM-5; American Psychiatric Association [APA], 2013). More specifically, ADHD is characterized by a persistent pattern of inattention, hyperactivity, or impulsivity affecting at least two areas of a person's life (academic, work, family, or social life). The prevalence of ADHD makes it one of the most common disorders in school-age children, present in around 5% of this population group (APA, 2013; Polanczyk et al., 2014).

Considering the prevalence of ADHD, it is important for teachers in all educational stages to recognize the characteristic profile of the disorder and to be aware of the best measures and guidance in terms of intervention for this student group (Murtani et al., 2020). For example, teachers have been found to detect children with ADHD more frequently than parents or doctors (Arnett et al., 2013; Jarque et al., 2007). Furthermore, teachers' perceptions, whether positive or negative, affect students' performance in the classroom (Tsiplakides & Keramida, 2010). In this regard and considering teachers' roles in detecting students with ADHD and in interventions with those students, it is important to look more deeply into professionals' knowledge about ADHD and their attitudes towards it.

Knowledge About ADHD

Jarque et al. (2007) carried out a study with 193 teachers (68 infant education teachers, and 125 primary school teachers) using the questionnaire "Knowledge of Attention Deficit Hyperactivity Disorder" (KADDS; Sciutto et al., 2000). This

questionnaire was aimed at evaluating what teachers know about ADHD using three dimensions: general knowledge, knowledge of symptoms/diagnosis, and knowledge of treatment. The instrument assessed real knowledge, lack of knowledge, and false beliefs. The results indicated a moderate level of knowledge in teachers, with statistically significant differences between the three subscales, with the best results in the symptoms/diagnosis dimension. Similarly, Alshehri et al. (2020) carried out a study aimed at assessing school teachers' knowledge about ADHD. One hundred male teachers from southwest Saudi Arabia took part in this study, completing a self-report questionnaire (which included fundamental aspects of ADHD such as the nature of the disorder, age of onset, sex prevalence, the progression of the disorder, symptoms, etc.). The results showed that school teachers had insufficient knowledge about ADHD, with the worst results about its causes and aggravating factors.

Soroa et al. (2016) looked at Spanish teachers' knowledge of ADHD and the relationship with training and self-perception variables. Those authors analysed the responses of 1278 teachers (infants, primary, foreign language, music, physics, and special education teachers) from 108 schools to the "Questionnaire to Evaluate Teachers' Knowledge of ADHD" (Soroa et al., 2014). They found that teachers' knowledge about ADHD ranged from low to moderate. Furthermore, knowledge was related to training received and self-perceived understanding, along with perceived self-efficacy in relation to being a teacher of children with ADHD. Along similar lines, looking at the relationship between teacher knowledge about ADHD and previous training courses, Sciutto et al.

(2016) carried out a multinational study that analysed what teachers from nine countries knew. The results showed that knowledge about ADHD was predicted by previous training.

Considering the importance of previous training in knowledge about ADHD (e.g., Guerra et al., 2017; Sciutto et al., 2016; Soroa et al., 2016), some authors have proposed analysing what university students know, as future professionals. For example, Jarque and Tárraga (2009) used the KADDS questionnaire to compare the ADHD-related knowledge of active teachers and first- and third-year teaching students. The sample was made up of 193 active teachers, 275 first-year student teachers, and 130 third-year student teachers. The results indicated that the participants had low knowledge about ADHD, with the lowest levels being in the first-year student teachers. However, there were no statistically significant differences between active teachers and third-year student teachers.

In summary, research on knowledge about ADHD has produced different results with some studies reporting low levels of teacher knowledge and others indicating moderate or even high levels. The studies also differ in the dimensions that the teachers know the most or least about, with some results indicating greater knowledge about symptoms and others indicating greater knowledge about treatments. Some studies have concluded that the lowest levels of knowledge were about diagnosis and assessment, while others have indicated the lowest levels concerning the aetiology of ADHD (see Greenway & Edwards, 2020). At the same time, the literature is not clear about differences in what students and teachers know about ADHD. One reason for these differences may lie in cultural issues, in the educational systems each country, or in the differences in the training process required in universities to become a teacher.

In any case, teachers' knowledge about ADHD is a fundamental aspect in teacher training, considering both its influence on teacher behaviour and on attitudes towards children with ADHD (Ohan et al., 2008).

Attitudes Towards ADHD

Previous studies about the relationship between knowledge about and attitudes towards ADHD have also reported a variety of findings (see Greenway & Edwards, 2020). According to the tripartite model of attitudes (Eagly & Chaiken, 1993), an attitude is a tendency to evaluate something with some degree of favour or disfavour and includes three components: cognitive (thoughts and beliefs), affect (emotions and feelings), and behaviour (actions). Ohan et al. (2008) found that teachers with average to high knowledge about ADHD demonstrated better attitudes, characterized by more helpful behaviours towards children with ADHD and more favourable beliefs. In contrast, Liang and Gao (2016) did not find any relationships between knowledge and attitudes in secondary school teachers in Hong Kong. Greenway and Edwards (2020) found a significant association between knowledge about ADHD and attitudes towards it in teachers in the United Kingdom but not in teaching assistants (specialists in supporting children with educational needs and behavioural difficulties).

Along these lines, Amiri et al. (2017) performed a study to look more deeply at Iranian preschool teachers' attitudes and knowledge regarding ADHD. The sample was made up of 369 active infant education teachers who completed a questionnaire designed to evaluate their knowledge of ADHD and their attitudes towards it. Knowledge was assessed in terms of variables such as symptoms, aetiology, treatment, and consequences. The results

showed that teachers knew more about symptoms and treatment, but that their knowledge of the aetiology and consequences was relatively poor. The researchers also noted that overall knowledge, and knowledge about the aetiology of the disorder, was correlated with a more positive attitude towards ADHD.

In order to consider students' as well as teachers' attitudes, Anderson et al. (2012) carried out a study comparing knowledge and attitudes regarding ADHD in active teachers and university students (with and without previous teaching experience), using the "Knowledge About Attention Deficit Disorder Questionnaire" (KADD-Q; West et al., 2005). Attitude was assessed in terms of three components: beliefs (stereotypes and teaching), affect, and behaviour. The results showed that active teachers knew more about ADHD, especially about its characteristics and treatment. However, both teachers and students exhibited low levels of knowledge about treatment. Attitudes were generally slightly favourable in all groups, although stereotypical beliefs and teaching attitudes were unfavourable, without significant differences between the groups.

Although some studies in Spain have attempted to analyse what teachers know about ADHD (e.g., Soroa et al., 2016), we have not found any that have attempted to analyse what Spanish university students and teachers know about ADHD, assessing the combination of knowledge about ADHD and attitudes towards it in this population. In this context, and considering the previous findings, the present study aims to know in depth the knowledge of Spanish university students and teachers about ADHD, and more specifically, to examine the effect of knowledge over the attitude of education professionals towards ADHD. For these reasons, the three main objectives of the present study are the

following: (1) To analyse differences in knowledge about ADHD (in four dimensions: General Information, Symptoms/Diagnosis, Aetiology, and Treatment) in university students (studying infant education, primary education, teaching, and psychology) and teachers; (2) To analyse the differences in attitudes towards ADHD (in four components: Feelings; Beliefs; Knowledge, Training and Accommodations; and Desire for Training); and (3) To understand how knowledge predicts attitudes in order to determine whether those who know more about the disorder have more positive attitudes towards ADHD. The research questions posed were: Are there differences in knowledge about and attitudes towards ADHD between university students and teachers in the area of education? Has the knowledge about ADHD an impact over the attitudes?

Method

Sample

Participants were selected using a non-probability sampling method called snowball sampling (Elfil & Negida, 2017). The sample was made up of 587 Spanish participants (501 women and 86 men), of whom 170 were active teachers and 417 were university students. They were aged between 18 and 67 years old (M = 25.89, SD = 9.58). Table 1 shows information about the distribution of the sample in terms of: (a) years of teaching experience, (b) initial teacher training (in the case of teachers) or course of study (in the case of university students), (c) current professional role (teachers).

Table 1

Sample Characteristics

Demographic Information	Teachers		University Students	
	n	%	*n*	%
Gender				
Women	141	82.9%	360	86.3%
Men	29	17.1%	57	13.7%
Work experience				
More tan 10 years	60	35.3%	0	0%
5-10 years	26	15.3%	14	3.4%
2-5 years	25	14.7%	23	5.5%
0-2 years	21	12.4%	80	19.2%
No experience	38	22.4%	300	71.9%
Previous training / Course of study				
Infant education	45	26.5%	172	41.2%
Primary education	53	31.2%	59	14.1%
Teaching	12	7.1%	50	12%
Psychology	25	14.7%	111	26.6%
Other	35	20.6%	25	6%
Current teaching role				
Infant education	43	25.3%		
Primary education	56	32.9%		
Secondary school	38	22.4%		
University	9	5.3%		
Unknown	24	14.1%		

Note. $N = 587$ ($n = 170$ for teachers and $n = 417$ for university students).

For this study, we selected teachers from both state-funded and independent schools. The university students who participated came from various public universities in Spain.

Instruments

We used two instruments in this study: the "Questionnaire for the Evaluation of Teachers' Knowledge of ADHD" (Soroa et al., 2014), and the "ADHD-Specific Knowledge and Attitudes of Teachers"), part C "Scale for Specific Attitudes Towards

ADHD" (SASA; Mulholland, 2016). The first questionnaire has been used in Spanish population previously, and it has allowed to compare the present results with the previous findings reported by Soroa et al. (2014, 2016). The second questionnaire (in its Spanish version), aims to analyse the attitudes towards ADHD. This questionnaire it has been used in previous studies (Molinar-Monsivais & Cervantes-Herrera, 2020; Ordóñez-Ruiz, 2017) and currently it is the unique instrument available in Spanish language.

In addition, all of the participants answered questions related to their previous experience (0-2 years, 3-5 years, 5-10 years or more than 10 years), previous training (infant education, primary education, teaching, and psychology), course of study (infant education degree, primary education degree, teaching degree, psychology degree, other degree), and category (university student or teachers).

Questionnaire for the Evaluation of Teachers' Knowledge of ADHD (Soroa et al., 2014). The aim of this questionnaire is to analyse teachers' knowledge about ADHD in four dimensions or categories: (a) General Information (four items), (b) Symptoms/Diagnosis (eleven items), (c) Aetiology or causes (four items), and (d) Treatment (seven items). There is a total of 26 items (see Appendix 1) where participants are asked to respond to statements in one of three ways: (a) true, (b) false, or (c) I do not know. It is important to note that all but five of the items are true. The instrument assessed real knowledge (correct response variable), lack of knowledge (gap variable), and false beliefs (incorrect variable) in the four dimensions (correct responses, lack of knowledge and false beliefs for General Information, Symptoms/Diagnosis, Aetiology and Treatment) included in the questionnaire (Soroa et al., 2014; Soroa et al., 2016). The response was scored as (a) correct response (real

knowledge), (b) gap (lack of knowledge, when a participant responded explicitly: "I don't know"), or (c) incorrect response (false beliefs). The maximum possible scores are four correct responses in general information, eleven in symptoms/diagnosis, four in aetiology and seven in treatment. The questionnaire takes about ten minutes to complete. The original version had internal consistency between .83 and .91 for the four dimensions, and values of test-retest correlation between .62 and .79 (Soroa et al., 2014). In our sample, Cronbach's alpha was .767.

ADHD-Specific Knowledge and Attitudes of Teachers (Mulholland, 2016; Mulholland et al., 2015). This questionnaire originates from Australia and measures specific attitudes towards ADHD. It was adapted into Spanish by Ordóñez-Ruiz (2017). It is an up-to-date questionnaire, which includes the changes included in the DSM-5 (APA, 2013). The questionnaire has four parts (A, B, C, and D). Part A is demographic information, Part B measures teacher knowledge of ADHD, Part C measures teacher attitudes towards ADHD, and Part D measures how personal attitudes and feelings manifest in behaviour. In this study we only used part C, which has 29 items. The responses are on Likert-type scales from 1 to 6 (1 "completely disagree", 2 "disagree", 3 "disagree somewhat", 4 "agree somewhat", 5 "agree", and 6 "completely agree"). In this part, attitude is assessed in terms of four components (Murtani et al., 2015): (1) Feelings about teaching students with ADHD (four positive and five negative items); (2) Beliefs about ADHD and its associated behaviours (two positive and seven negative items); (3) Knowledge, Training and Accommodations about ADHD (four knowledge and training items, and four accommodations items); (4) Desire for Training about ADHD (three items). The responses

were coded according to the 6-point Likert scale from 0 to 5. For statistical analysis and optimal interpretation, items that were formulated negatively were converted into positive items. The maximum possible score for this part, the sum of the total responses of a participant in the questionnaire, is 174 points, which would indicate a positive attitude towards the disorder. This part takes about 10 minutes to complete. The internal consistency of each of the parts of the test was determined by Cronbach's alpha, which ranged between .774 and .893. Although previous studies (Molinar-Monsivais & Cervantes-Herrera, 2020; Ordóñez-Ruiz, 2017) have used the Spanish version of this questionnaire, they did not provide information regarding the validity of the instrument. In the present sample, part C produced a Cronbach's alpha of .691.

Procedure

The study was conducted in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki), which reflects the ethical principles for research involving humans (Williams, 2008). All procedures were performed in compliance with relevant laws and institutional guidelines. Participation in the study was voluntary, and the participants were assured that all of their responses would remain confidential and be used for research purposes only.

The questionnaires were completed online via a private website. The link for completing the questionnaires was sent to active professionals in the field of education who collaborate with the research team. These collaborators were instructed to distribute that link to their professional colleagues following the snowball sampling method. To preserve anonymity, we did not require any data that would allow us to identify the participant,

school, or university. Before completing the questionnaires, participants read the information about the study and gave their consent to participate in the study. The questionnaires were completed in approximately 15-20 minutes.

The website was open for 30 days, after which the collected data was processed and the results were interpreted.

Data Analysis

The first step was to produce a correlation matrix and examine the distribution of the variables.

We performed frequency analysis on responses to the Questionnaire for the Evaluation of Teachers' Knowledge of ADHD considering correct responses, incorrect responses and gaps (when a participant responded explicitly: "I don't know") in each item and in its four dimensions. In addition, following previous procedures (e.g., Greenway & Edwards, 2020; Sora et al., 2016), percentage scores were included for the university students' and teachers' responses in the two instruments used.

Addressing the first two aims of the study (analysing differences between what university students and teachers know about the disorder and their attitudes towards it), we performed two types of analysis: (1) The z statistic for the differences in the 26 items and the four dimensions of ADHD knowledge with 95% confidence intervals (differences were analysed for correct responses, incorrect responses and gaps); (2) Univariate analysis of variance (ANOVA) for the analysis of differences in the real knowledge for the four dimensions (General Information, Treatment, Symptoms/Diagnosis and Aetiology) and in

the attitudes towards the disorder considering the total score in the attitude variable and the four components: (1) Feelings; (2) Beliefs; (3) Knowledge, Training and Accommodations; (4) Desire for Training.

Finally, addressing the third aim of the study, we produced a hierarchical linear regression model. Attitude towards ADHD was taken as the dependent (predicted) variable and the independent variables were added in three blocks: block 1 (Model 1) had only the variables sex and age; block 2 (Model 2) included the variables Category (university students or teachers), and Experience in addition to the variables in Model 1; block 3 (Model 3) added the four knowledge variables (real knowledge or correct responses in General Information, Symptoms/Diagnosis, Aetiology, and Treatment).

The level of statistical significance was set at $p < .05$. Effect sizes were calculated using Cohen's d (Cohen, 1988): $d < .20$ indicates a minimal effect size; $d > .20 < .50$ indicates a small effect size; $d > .50 < .80$ indicates a medium effect size; and $d > .80$ indicates a large effect size. The Cohen's d statistic allows to control differences regarding the number of participants in the two groups analysed (university students vs. teachers; Cohen, 1988; Lakens, 2013).

All of the analyses were carried out using SPSS software version 22.0.

Results

Preliminary Analysis

The asymmetry and kurtosis values of the variables were within the intervals that denote a normal distribution (values below 3 for skewness and below 10 for kurtosis; Kline, 2015). As the correlation matrix shows (Table 2), knowledge in the four dimensions (correct responses in General Information, Symptoms/Diagnosis, Aetiology, and Treatment) was positively and significantly correlated with attitude towards the disorder, the greater the knowledge, the better the attitude. In terms of attitudes towards ADHD and the four knowledge dimensions, Feelings were significantly negatively correlated with Symptoms/Diagnosis and Aetiology, and positively correlated with Treatment; Beliefs correlated positively with General Information, Aetiology and Treatment; Knowledge, Training and Accommodations correlated positively with the four dimensions of knowledge; and Desire for Training only correlated with the Treatment dimension.

In addition, age was positively correlated with knowledge in the four areas and negatively correlated with attitude towards ADHD. More specifically, age was negatively correlated with Feelings, Beliefs and Desire for Training but positively correlated with the variable Knowledge, Training and Accommodations.

Table 2

Pearson Correlations

Variables	1	2	3	4	5	6	7	8	9	10
1.INF	—									
2.SYM	.434**	—								
3.AETI	.219**	.221**	—							
4.TRT	.337**	.447**	.212**	—						
5.Attitude	.173**	.160**	.174**	.250**	—					
6.Feelings	-.054	-.181**	-.003	.029	.716**	—				
7.Beliefs	.086*	.074	.153**	.180**	.642**	.307**	—			
8.KTA	.309**	.402**	.231**	.270**	.683**	.166**	.181**	—		
9.Desire	.020	.010	-.012	.168**	.510**	.420**	.251**	.104*	—	
10.Age	.160*	.249*	.164*	.217*	-.150*	-.300*	-.061	.048	-.118	—

Note. INF = General Information; SYM = Symptoms/Diagnosis; AETI = Aetiology; TRT = Treatment; KTA = Knowledge, Training and Accommodations; Desire = Desire for Training.

* $p < .01$. ** $p < .001$.

Table 3

Descriptive Statistics

	INF	SYM	AETI	TRT	Attitude	Feelings	Beliefs	KTA	Desire	Age
M US (*SD*)	1.89 (1.25)	7.31 (2.90)	1.61 (1.51)	6.08 (1.29)	101.06 (9.43)	32.32 (4.20)	33.09 (3.64)	22.13 (5.22)	13.51 (1.67)	22.41 (5.11)
M TC (*SD*)	2.29 (1.23)	8.41 (2.71)	2.21 (1.53)	6.34 (0.98)	99.75 (12.46)	30.35 (5.20)	32.89 (4.22)	23.34 (5.91)	13.16 (2.19)	34.66 (12.26)
Skewness	-0.004	-0.722	0.223	-2.189	-0.327	-0.396	.0.228	0.140	-1.805	1.964
Kurtosis	-1.036	-0.266	-1.451	6.383	2.102	2.229	0.361	-0.585	6.794	3.459
Minimum	0	0	0	3	40	5	19	9	0	18.124
Maximum	4	11	4	7	129	45	45	38	15	67.107

Note. INF = General Information; SYM = Symptoms/Diagnosis; AETI = Aetiology; TRT = Treatment; KTA = Knowledge, Training and Accommodations; Desire = Desire for Training; *M* = Mean; *SD* = Standard Deviation; US = University students; TC = Teachers.

Differences Between What University Students and Working Teachers Know About ADHD

Table 4 shows the numbers and percentages of correct responses, gaps (when a participant responded explicitly: “I don’t know”), and incorrect responses from the university students and teachers in each item in the four dimensions in the Questionnaire for the Evaluation of Teachers’ Knowledge of ADHD.

Table 4

Number and Percentages of Correct Responses, Gaps and Incorrect Responses

Variables	University Students (n = 417)						Teachers (n = 170)					
	n CR	% CR	*n* Gaps	% Gaps	*n* IR	% IR	*n* CR	% CR	*n* Gaps	% Gaps	*n* IR	% IR
Information												
4	207	49.6	120	28.8	90	21.6	100	58.8	37	21.8	33	19.4
7	196	47.0	201	48.2	20	4.8	93	54.7	69	40.6	8	4.7
11	203	48.7	189	45.3	25	6.0	97	57.1	65	38.2	8	4.7
17	182	43.6	207	49.6	28	6.7	99	58.2	59	34.7	12	7.1
Symptoms												
1	312	74.8	28	6.7	77	18.5	145	85.3	5	2.9	20	11.8
3	298	72.5	73	17.5	46	11.0	140	82.4	12	7.1	18	10.6
6	291	69.8	86	20.6	40	9.6	133	78.2	23	13.5	14	8.2
8	213	51.1	157	37.6	47	11.3	122	71.8	34	20	14	8.2
12	332	79.6	70	16.8	15	3.6	151	88.8	13	7.6	6	3.5
15	260	62.4	106	25.4	51	12.2	120	70.6	32	18.8	18	10.6
18	256	61.4	127	30.5	34	8.2	126	74.1	28	16.5	16	9.4
20	266	63.8	127	30.5	24	5.8	108	63.5	39	22.9	23	13.5
21	277	66.4	90	21.6	50	12.0	127	74.7	23	13.5	20	11.8
23	333	79.9	68	16.3	16	3.8	145	85.3	18	10.6	7	4.1
25	211	50.6	161	38.6	45	10.8	113	66.5	41	24.1	16	9.4
Aetiology												
2	226	54.2	135	32.4	56	13.4	113	66.5	37	21.8	20	11.8
9	156	37.4	150	36	111	26.6	84	49.4	53	31.2	33	19.4
16	151	36.2	175	42	91	21.8	98	57.6	51	30	21	12.4
24	139	33.3	139	33.3	89	21.3	81	47.6	57	33.5	32	18.8
Treatment												
5	371	89	41	9.8	5	1.2	160	94.1	6	3.5	4	2.4
10	395	94.7	18	4.3	4	1.0	166	97.6	0	0	4	2.4
13	375	89.9	36	8.6	6	1.4	155	91.2	14	8.2	1	0.6
14	394	94.5	17	4.1	6	1.4	167	98.2	1	0.6	2	1.2
19	352	84.4	55	13.2	10	2.4	148	87.1	17	10	5	2.9
22	366	87.8	45	10.8	6	1.4	155	91.2	13	7.6	2	1.2
26	284	68.1	98	23.5	35	8.4	127	47.7	31	18.2	12	7.1

Note. CR = Correct responses; IR = Incorrect responses.

Subsequently, we analysed differences in the 26 ADHD knowledge items by category (university students vs. teachers). As Table 5 shows, in terms of correct responses (in which teachers scored higher than university students) the differences between

university students and teachers were statistically significant in most of the items in Symptoms/Diagnosis and Aetiology, and in half of the items in General Information (differences were only significant in one of the items in Treatment). With respect to gaps, the differences were statistically significant in most of the items in Symptoms/Diagnosis and in half of the items in Aetiology (only one item in General Information and three in Treatment were statistically significant). For incorrect responses, the differences between university students and teachers were statistically significant for two items in Symptoms/Diagnosis and one item in Aetiology. Analysis of the percentages indicated that teachers had more correct responses and fewer gaps and incorrect responses than university students (with the exception of 7 items in which university students had fewer incorrect responses than teachers).

Table 5

Differences Between University Students and Teachers in the ADHD Knowledge Items

Dimensions	Correct Responses			Gaps			Incorrect Responses		
	SE	*z*	*p*	*SE*	*z*	*p*	*SE*	*z*	*p*
Information									
4	.045	-2.020	**.043**	.040	1.740	.081	.037	0.586	.557
7	.045	-1.693	.090	.015	1.678	.093	.019	0.046	.962
11	.045	-1.841	.065	.045	1.570	.115	.020	0.615	.538
17	.045	-3.209	**.001**	.045	3.296	**.000**	.022	-0.150	.880
Total	.022	-4.379	**.000**	.022	4.104	**.000**	.013	0.299	.548
Symptoms									
1	.037	-2.772	**.005**	.020	1.800	.071	.033	1.982	**.047**
3	.039	-2.749	**.005**	.032	3.262	**.001**	.028	0.156	.875
6	.040	-2.073	**.038**	.035	2.004	**.044**	.026	0.515	.605
8	.045	-4.592	**.000**	.042	4.139	**.000**	.027	1.093	.274
12	.034	-2.650	**.008**	.031	2.882	**.003**	.016	.040	.968
15	.043	-1.894	.058	.038	1.709	.087	.029	.560	.575
18	.043	-2.933	**.003**	.040	3.486	**.000**	.025	-0.495	.620
20	.043	0.059	.952	.040	1.833	.066	.024	-3.147	**.001**
21	.042	-1.964	**.049**	.035	2.244	**.024**	.029	0.076	.938
23	.035	-1.536	.124	.032	1.777	.075	.017	-0.158	.873
25	.045	-3.507	**.000**	.043	3.352	**.000**	.027	0.496	.619
Total	.012	-7.906	**.000**	.011	8.486	**.000**	.008	0.624	.532
Aetiology									
2	.044	-2.730	**.006**	.041	2.561	**.010**	.030	0.544	.585
9	.044	-2.682	**.007**	.043	1.107	.267	.039	1.840	.065
16	.044	-4.766	**.000**	.044	2.702	**.006**	.035	2.648	**.008**
24	.044	-3.249	**.001**	.042	-0.045	.963	.036	0.684	.493
Total	.022	-6.634	**.000**	.021	3.153	**.001**	.017	2.904	**.003**
Treatment									
5	.026	-1.926	.054	.024	2.552	**.010**	.011	-1.032	.302
10	.018	-1.561	.118	.015	2.751	**.005**	.010	-1.320	.186
13	.026	-0.463	.643	.025	0.156	.875	.009	0.861	.389
14	.018	-2.003	**.045**	.0156	2.223	**.026**	.010	0.248	.803
19	.032	-0.818	.413	.029	1.068	.285	.014	-0.378	.705
22	.028	-1.185	.235	.027	1.157	.246	.010	0.248	.803
26	.041	-1.583	.113	.037	1.397	.162	.024	0.540	.588
Total	.011	-3.285	**.001**	.010	3.691	**.000**	.005	-0.101	.919

Note. *SE* = Standard Error

Considering the dimensions on a general level and following the procedure presented by Soroa et al. (2016), we calculated the percentage of correct responses,

incorrect responses, and gaps for the four knowledge dimensions. The teachers gave correct responses to 57.2% of the questions about General Information but to 86.72% of the questions about Treatment and 76.47% of the Symptoms/Diagnosis questions. The teachers' overall mean percentage of correct responses was 68.91%. Teachers answered 9.07% of items incorrectly, with most of their incorrect responses in the Aetiology dimension. Lastly, teachers exhibited gaps in their knowledge in a mean of 21.03% of items overall.

The university students had fewer correct responses, correctly answering 47.22% of the items related to General Information, 40.27% in Aetiology, and a higher percentage of items related to Symptoms/Diagnosis and Treatment (overall the mean percentage of correct answers was 60.24%). Overall, the university students answered 10.67% of the questions incorrectly, with the highest percentage of incorrect answers in Aetiology. Lastly, the university students exhibited gaps in their knowledge in 28.33% of items over the four dimensions, with the highest percentage being in the General Information dimension. Differences between university students and teachers were statistically significant in the four dimensions (see Table 5) when assessing correct responses and gaps. However, differences only were significant in the dimension Aetiology for incorrect responses.

The ANOVA reflected that differences in real knowledge were statistically significant in the four dimensions: General Information, $F(1, 585) = 12.334$, $p < .001$, $d = 0.292$; Symptoms/Diagnosis, $F(1, 585) = 17.949$, $p < .001$, $d = 0.351$; Aetiology, $F(1, 585) = 18.725$, $p < .001$, $d = 0.357$; and Treatment, $F(1, 585) = 5.409$, $p = .020$, $d = 0.190$; although the effect sizes were minimal and smalls.

Differences Between University Students and Working Teachers in Attitudes Towards ADHD

Table 6 shows the responses by university students and teachers in the 29 items about attitudes towards ADHD. For Feelings and Beliefs, 73% of the university students and 86.5% of teachers agreed that "behaviours associated with ADHD are irritating in the classroom". However, in general, the university students and the teachers tended to agree with statements about positive Feelings and Beliefs, and disagree with statements about negative Feelings and negative Beliefs.

In relation to Knowledge, Training and Accommodations, more teachers than university students agreed that they were knowledgeable about ADHD-type behaviours (62.9% and 55.6%, respectively). Around 55% of teachers reported that they felt that they could effectively teach students with ADHD (compared to 36% of university students). For Accommodation questions, the majority of university students (75%) and teachers (84%) agreed that they would "refer a student to the school counsellor for a possible ADHD assessment".

In the case of Desire for further training, almost 100% of university students and 98% of teachers would like to know more about ADHD.

Once we had the total score, the sum total of the responses in the questionnaire (negative items were reversed), we analysed the differences between university students and teachers. The results of the ANOVA did not show statistically significant differences ($p = .166$), although the trend of means indicated more positive attitudes reported by the university students than the teachers (see Table 3). However, in terms of the four

components, the differences between university students and teachers were statistically significant for Feelings, $F(1, 585) = 23.004$, $p < .001$, $d = 0.397$; Knowledge, Training and Accommodations, $F(1, 585) = 5.968$, $p = .015$, $d = 0.201$; and Desire for Training, $F(1, 585) = 4.432$, $p = .036$, $d = 0.179$; with minimal and small effect sizes. Differences were nonsignificant for Beliefs ($p = .567$).

Scores reported by university students were higher in the case of Feelings, Beliefs, and Desire for Training, than in the teachers. However, teachers had higher scores than university students in the variable Knowledge, Training and Accommodations.

Table 6

Percentage of Responses Reported by University Students and Teachers in the Scale for Specific Attitudes Towards ADHD

Items	Percentage of Responses by University Students / Teachers					
	1	2	3	4	5	6
Negative feelings towards teaching students with ADHD						
I find behaviours associated with ADHD irritating in the classroom.	2.9/ 0	12.2/ 6.5	12.0/ 7.1	48.7/ 34.7	19.7/ 40.6	4.6/ 11.2
I dislike teaching classes that contain students who display ADHD-type behaviours.	42.9/ 31.2	29.3/ 28.8	7.7/ 14.1	7.2/ 14.1	9.1/ 8.2	3.8/ 3.5
Students who display ADHD-type behaviours cause me to experience stress.	16.1/ 11.8	33.1/ 22.4	21.1/ 15.3	23.5/ 36.5	4.8/ 10.0	1.4/ 4.1
I find students who exhibit ADHD-type behaviours rude.	32.1/ 30	43.4/ 40.6	16.1/ 15.9	7.2/ 11.2	1.2/ 1.2	0/ 1.2
It is challenging for me to teach students who exhibit behaviours associated with ADHD.	2.2/ 0.6	7.9/ 5.9	9.6/ 3.5	37.9/ 25.3	30.2/ 41.2	12.2/ 23.5
Positive feelings towards teaching students with ADHD						
ADHD is a benefit to my teaching skills, as it allows me to differentiate lesson plans.	1.4/ 1.8	4.8/ 1.2	23.5/ 1.8	21.1/ 16.5	33.1/ 49.4	16.1/ 29.4
Students with ADHD-type behaviours bring new perspectives to the topics I am teaching.	0.2/ 1.8	3.8/ 11.8	9.8/ 11.8	35.5/ 35.9	41.5/ 27.1	9.1/ 11.8
It is rewarding to see the accomplishments of students who display ADHD-type behaviours.	0/ 1.2	0.2/ 0	0.5/ 0	4.8/ 4.1	29.7/ 31.8	64.7/ 62.9
Students who exhibit behaviours associated with ADHD are rewarding to work with.	1.2/ 3.5	1.7/ 4.1	8.4/ 12.9	20.4/ 28.8	47.7/ 36.5	20.6/ 14.1
Negative beliefs about ADHD and its associated behaviours						
I believe ADHD is overdiagnosed.	5.5/ 2.9	13.4/ 13.5	14.1/ 8.8	20.1/ 32.9	26.1/ 26.5	20.6/ 15.3
Children who exhibit ADHD-type behaviours need to try harder to focus on their schoolwork.	2.2/ 4.1	5.3/ 7.1	9.4/ 7.1	32.1/ 25.3	40.0/ 38.2	11.0/ 18.2
I believe ADHD is an excuse for poor parenting.	31.7/ 30.6	37.4/ 37.1	13.7/ 11.8	11.8/ 17.1	4.6/ 2.4	1/ 1.2
Children who exhibit behaviours associated with ADHD misbehave because they don't want to follow the set rules.	21.1/ 19.4	37.2/ 41.8	18.2/ 14.7	15.8/ 14.1	6.2/ 8.2	1.4/ 1.8
Students who display behaviours associated with ADHD do not need assistance with their academic work, they need more structure and discipline.	40.5/ 37.1	38.6/ 40.6	10.1/ 9.4	7.7/ 7.6	2.6/ 4.7	0.5/ 0.6
Students who exhibit ADHD-type behaviours but don't have a diagnosis have no excuse for their poor behaviour.	22.5/ 30	43.2/ 32.9	16.8/ 13.5	10.6/ 9.4	5.8/ 11.8	1.2/ 2.4
I believe children who exhibit ADHD-type behaviours are deliberately misbehaving.	64.7/ 60.0	30.5/ 34.1	3.4/ 5.3	0.5/ 0.6	0.7/ 0	0.2/ 0

Items	Percentage of Responses by University Students / Teachers					
	1	2	3	4	5	6
Positive beliefs about ADHD and its associated behaviours						
I believe ADHD is a valid diagnosis.	1.2/ 1.8	2.9/ 4.1	8.6/ 9.4	25.2/ 27.6	45.3/ 41.8	16.8/ 15.3
Children who exhibit behaviours associated with ADHD can perform well in some subjects and not in others.	1/ 0	4.3/ 5.3	8.9/ 7.6	23/ 16.5	51.3/ 56.5	11.5/ 14.1
Accommodations						
I would refer a student who exhibited ADHD-type behaviours in my classroom to the school counsellor for possible ADHD assessment.	0.2/ 2.4	2.2/ 2.4	2.9/ 1.5	20.1/ 10	48.9/ 43.5	25.7/ 40.6
I change my teaching styles and differentiate my lessons for students who exhibit ADHD-type behaviours.	3.1/ 0.6	5.0/ 5.9	8.4/ 7.6	30.2/ 29.4	43.9/ 40.0	9.4/ 16.5
The accommodations suggested to me for working with students who exhibit behaviours associated with ADHD are easy to implement in a general education classroom.	1.4/ 4.1	11.8/ 15.3	27.8/ 24.7	32.6/ 37.6	22.3/ 16.5	4.1/ 1.8
I don't have the lesson time to differentiate curricula and create activities that are engaging for students who exhibit ADHD behaviours	36.2/ 31.8	38.6/ 32.9	15.1/ 11.8	8.2/ 11.8	1.2/ 8.8	0.7/ 2.9
Knowledge and Training						
I have received adequate professional development about managing ADHD-type behaviours.	18.7/ 18.2	30/ 30	19.2/ 14.7	20.6/ 20	9.6/ 14.7	1.9/ 2.4
I can effectively teach students who exhibit behaviours associated with ADHD.	15.8/ 7.6	28.1/ 13.5	20.6/ 24.1	23.7/ 32.5	10.1/ 20	1.7/ 2.4
I feel I am knowledgeable about ADHD-type behaviours.	10.1/ 8.8	19.2/ 12.9	15.1/ 15.3	34.5/ 30.6	18.2/ 27.6	2.9/ 4.7
I feel I am knowledgeable about classroom interventions to manage behaviour that are not conducive to effective learning.	13.7/ 8.2	25.9/ 15.9	18.0/ 18.8	27.3/ 32.9	13.4/ 22.4	1.7/ 1.8
Desire for Training						
I would like to know more about ADHD and its associated behaviours.	0/0	0/ 1.2	0.5/ 0.6	5.0/ 4.7	36.2/ 41.2	58.3/ 52.4
I want to be more effective teaching students who display ADHD-type behaviours.	1.0/ 1.2	1.4/ 0.6	1.4/ 0.6	6.0/ 8.8	36.2/ 40	54.0/ 48.8
I would like to have more information about classroom interventions to assist me with educating students who display ADHD-type behaviours.	0/ 0.6	0/ 1.8	0/ 0	4.6/ 4.1	29.0/ 39.4	66.4/ 54.1

Note. 1 "completely disagree", 2 "disagree", 3 "disagree somewhat", 4 "agree somewhat", 5 "agree", and 6 "completely agree".

Predictors of Attitude Towards ADHD

In the hierarchical linear regression model the independent variables were added in three blocks (see Table 7): in block 1 (Model 1) only the variables sex and age were added; block 2 (Model 2) added the variables Category and Experience; block 3 (Model 3) added the four knowledge variables (General Information, Symptoms/Diagnosis, Aetiology, and Treatment). The results indicated that the three models were statistically significant, Model 1: $F(2, 577) = 19.662$, $p < .001$; Model 2: $F(4, 575) = 10.051$, $p < .001$; Model 3: $F(8, 571) = 14.280$, $p < .001$. As Table 7 shows, age predicted Attitude in the three models with minimal to small effect sizes between .186 and .308 (the older the subject, the worse the attitude towards the disorder). Category and Experience were not significant predictors of attitudes towards ADHD. However, knowledge about General Information, Aetiology, and Treatment of ADHD were statistically significant with small and medium effect sizes (General Information $d = .197$; Aetiology $d = .219$; Treatment $d = .399$) indicating that the greater the knowledge in these dimensions, the better the attitude towards ADHD.

Table 7

Regression Models for the Prediction of the Attitude towards ADHD

Variables	Model 1			Model 2			Model 3		
	β	β stand	*t*	β	β stand	*t*	β	β stand	*t*
Age	-0.134	-0.128	-3.150**	-0.163	-0.155	-2.251**	-0.258	-0.245	-3.691***
Sex	5.881	0.204	5.039***	5.843	0.203	4.994***	5.051	0.175	4.479***
CAT				1.080	0.048	0.939	0.667	0.030	0.608
EXP				-0.006	-0.001	-0.012	0.070	0.010	0.144
INF							0.832	0.104	2.377*
SYM							0.130	0.037	0.808
AETI							0.706	0.108	2.644**
TRT							1.739	0.210	4.748***
R^2	0.064***			0.065***			0.167***		
ΔR^2				0.002			0.101		

Note. The values in the table are non-standardized β coefficients; standardized values are given in parentheses. *t* = student t-test; R^2 = variance explained; ΔR^2 = change in variance explained; CAT = Category; EXP = Experience; INF = Information; SYM = Symptoms; AETI = Aetiology; TRT = Treatment.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Discussion

The aim of this study was to analyse how much university students (doing degrees in infant or primary education, teaching, and psychology) and teachers (infant, primary, and secondary school teachers, along with university teachers in the field of education) know about ADHD and their attitudes towards it. In addition, we aimed to establish how knowledge would predict attitudes in order to determine whether those with better knowledge would in turn have more positive attitudes towards ADHD.

The results showed that the teachers had deeper knowledge of ADHD than the university students. We saw the largest differences between university students and teachers in items referring to Symptoms/Diagnosis and the Aetiology of the disorder (with teachers scoring higher). However, other studies, such as Jarque and Tárraga (2009) have reported that despite finding differences between how much working teachers and first-year teaching students knew, no differences were seen with third-year students.

In terms of the level of knowledge, Jarque et al. (2007) indicated that teachers demonstrated a moderate level of knowledge about ADHD, with the best results in domains related to Symptoms/Diagnosis. It is worth noting that Jarque was considering knowledge in primary and infant teachers, whereas in this study we also included teachers in compulsory and further secondary education as well as university teaching staff. Soroa et al. (2016) reported that Spanish teachers (infant education, primary education, foreign language, music, physics, and special education) demonstrated low to moderate levels of knowledge. According to them, the teachers correctly responded to a little over half of the questionnaire items (62.85% correct responses). The highest scores were reported in the Treatment dimension (83.54%), followed by Symptoms/Diagnosis (72.41%), Aetiology (56.23%), and General Information (39.22%). The results of our study were similar. The teachers correctly responded to just over half of the items and demonstrated better knowledge in relation to Treatment, followed by Symptoms/Diagnosis, General Information, and lastly, Aetiology (we found the same profile in university students). In terms of errors, Soroa et al. (2016) reported that the teachers had higher percentages of errors in the dimensions related to Symptoms/Diagnosis (7.49%) and Aetiology (7%). In

our study the levels of errors related to Aetiology was notable, 15.6% for teachers, and 20.755% for students; in both cases much higher than in previous studies. This might be related to some current trends questioning the existence of the disorder, or its neurobiological origin, especially the thinking that ADHD may be the result of certain family patterns. The teachers may have been responding according to their beliefs and not merely because they did not know the cause or origin of ADHD. In addition, as in the previous study, the dimensions with the greatest levels of gaps in knowledge were General Information (56% unknown in Soroa's study compared to 42.975% for the teachers in our study) and Aetiology (36.77% in the previous study compared to 29.125% in our study). We found the same profile of gaps in knowledge for university students, the pattern was equivalent in the two categories. Although results reported by research analysing university students and teachers in other cultures have reported different profiles (Greenway & Edwards, 2020), in Spain using the same questionnaire as in previous research, we can see that the results are consistent, and indicate professionals and future professionals in education know more in the dimensions of Treatment and Symptoms/Diagnosis,

Studies in other countries have reported compatible results. For example, Greenway and Edwards (2020) carried out a study with teachers at different levels (95 secondary school teacher, 70 primary school teachers, 80 teaching assistants in secondary school, and 77 teaching assistants in primary school) in the United Kingdom. Their results demonstrated a percentage of real knowledge between 62-69% with more questions correctly answered about symptoms, and the lowest levels of knowledge in prevalence/assessment and aetiology

In terms of attitudes, in line with Anderson et al. (2012), we did not find significant differences in the attitude variable between university students and teachers. However, looking at the four attitude components, university students reported better attitudes towards ADHD (with statistically significant differences) in terms of Feelings towards teaching students with ADHD whereas teachers reported better attitudes in relation to Knowledge, Training and Accommodations. We did not find significant differences between university students and teachers in their Beliefs about ADHD or Desire for Training. The analysis of responses indicated generally positive attitudes in both groups, although as Table 4 shows, attitude can be positive and negative at the same time in relation to Feelings. For example, many university students and teachers reported that they agreed with the statement "I find behaviours associated with ADHD irritating in the classroom". However, many participants also disagreed with the idea that "I dislike teaching classes that contain students who display ADHD-type behaviours". Using the SASA scale with 116 school teachers in Sydney, Mulholland et al. (2015) observed that teachers held both positive and negative attitudes simultaneously. In addition, Anderson et al. (2012) and Anderson et al. (2017) reported positive and negative attitudes simultaneously or ultimately ambivalent attitudes. Those authors suggested that ambivalent attitudes can lead to inconsistent decisions and actions regarding students with ADHD. This ambivalence, can also be seen in the present study in Feelings about ADHD, although it seems to be less marked than in previous research given that fewer participants in the present study felt that "students who display ADHD-type behaviours cause me to experience stress" unlike in the study by Greenway and Edwards (2020). Twenty nine percent of the university students and 50% of the teachers in our study agreed that students with ADHD caused them to

experience stress, compared to the 61% found in the study by Greenway and Edwards (2020) and the 69% in the study by Mulholland et al. (2015).

The results of the regression model showed that having broad experience in the sector did not ensure a good attitude towards ADHD. In contrast, Mulholland et al. (2015) showed that teachers' experience was a significant predictor of their Feelings towards ADHD. Those authors hypothesized that as a teacher becomes more experienced, they also become less sympathetic to students with ADHD. On the other hand, age was a significant predictor of Attitude in the present study in a negative direction, indicating as people get older, they demonstrate worse attitudes towards ADHD. Our study also shows that having sufficient knowledge about ADHD, especially about its Treatment, Aetiology and General Information, has a direct influence on having a good attitude towards ADHD. Along similar lines, other studies (e.g., Greenway & Edward, 2020; Ohan et al., 2008) have found significant associations between knowledge of ADHD and attitudes towards it. These results highlight the importance of teacher training about specific disorders such as ADHD, given that knowledge is directly and positively related to attitude, even more so than experience.

Lasisi et al. (2017) carried out a study aimed at evaluating the effect of a teacher training programme in a primary school about ADHD and identifying the attitudes of the teachers towards this type of student. The sample was made up of 84 primary school teachers and the method they used followed the World Health Organisation's Mental Health Gap Action Programme Intervention Guide (MhGAP-IG) (World Health Organisation, 2010). The results indicated that the teachers who received the intervention

had better knowledge (in terms of knowledge about ADHD and intervention methodology) and less negative attitudes.

In summary, it is important to emphasise the need to include specific intervention programmes for students with different types of problems (ADHD, behavioural disorder, autism spectrum disorder) in teacher training programmes, as indicated in the study by Lasisi et al. (2017). Currently, during the training process teachers usually receive information about main characteristics of the neurodevelopmental disorders like ADHD (its conceptualization, main symptoms, types of presentations, prevalence and comorbidity) as well as information about specific intervention programs. However, in the future, the intervention programs should be focused also on Aetiology, given that it is the dimension in which university students and teachers have been shown to know the least. It is also necessary to emphasize that compared to experience, category, subject being studied, knowledge is the best predictor of attitudes toward ADHD.

This research has some practical implications, as it has allowed us to identify the need to increase the level of teacher training as a method of minimizing negative attitudes towards ADHD. As Tsiplakides and Keramida (2010) stated, a teacher's perception influences their students' performance and wellbeing, which is why having trained teachers, with positive attitudes towards the disorder would have beneficial consequences for the most-affected students, not only over their academic achievement, but also in the students affective-motivational variables which in different contexts have shown to be crucial for the student's development (García et al., 2016).

In addition, we can conclude that the level of knowledge displayed by students and professionals in the educational field is moderate about General Information and the Aetiology of the disorder, but high in terms of Treatment and Symptoms/Diagnosis. This is important considering the fact that teachers are often the first to detect ADHD in a student, hence it is essential for them to be able to recognize the characteristic symptoms, and they will presumably be the education professional who will carry out subsequent interventions with students with ADHD.

Limitations

Finally, it is important to note the limitations of this study. One limitation related to the use of the questionnaires is that in the case of the evaluation of attitudes towards ADHD, there may be a social desirability effect which may mean responses not being given as that might be better considered socially. Furthermore, it is also convenient to highlight that although the original version of the widely used Scale for Specific Attitudes Towards ADHD has been showed good psychometric properties, currently it does not exist data about validity values of this scales in its Spanish version. Regarding the knowledge about ADHD we used the Questionnaire for the Evaluation of Teachers' Knowledge of ADHD, considering it has been used in Spanish population previously. However, in the future it would be interesting to include more specific questions related for example with the comorbidities of ADHD with other disorders such as the learning disabilities (González-Castro et al., 2014) or anxiety (Rodríguez et al., 2014).

Another limitation is that the sample was not balanced, there were more university students than teachers. Future research would hopefully have more representative samples

that would allow us to compare the levels of knowledge about ADHD and attitudes towards it not just between university students and teachers. This would also allow to consider the academic year in which the students are, as well as the type of university degree (i.e., comparing the knowledge and attitudes towards ADHD between students from Psychology degree and those from Teaching degree, and in turn, controlling these differences depending on whether they are in first to fourth year of degree). This would allow a more accurate evaluation of whether university students are receiving suitable training about ADHD in their courses so that they can later begin teaching with a positive attitude.

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Artículo 2

Segundo estudio publicado en la revista *Journal of Clinical Medicine*:

Differential Efficacy of Neurofeedback in Children With ADHD Presentations

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Abstract

Purpose: Training in neurofeedback (NF) reduces the symptomatology associated with Attention Deficit with Hyperactivity Disorder (ADHD). However, ADHD differs in terms of the type of presentation, inattentive (ADHD-I), impulsive/hyperactive (ADHD-HI), and combined (ADHD-C). This study attempts to analyze the efficacy of NF in the ADHD presentations. Methods: Participants were 64 students (8 - 12 years old). Cortical activation, executive control and observed symptomatology by parents were assessed. Results and Discussion: Results indicated that ADHD-C and ADHD-HI showed greater improvements than ADHD-I. It was concluded that this kind of training produces an improvement, and that it is necessary to consider further in terms of the protocol used.

Keywords: ADHD, presentations, neurofeedback, cortical activation, intervention.

Differential Efficacy of Neurofeedback in Children With ADHD Presentations

Introduction

Attention Deficit with Hyperactivity Disorder (ADHD) is understood as a persistent pattern of inattentive, restless and impulsive behavior which is more frequent and severe than that typically observed in subjects at a similar stage of development.[1] Its prevalence is estimated to be 5.9–7.1% in childhood and adolescence and 5% in adults.[2] The new classification of the Diagnostic Statistical Manual DSM in its fifth edition (DSM-5) [1] has been included the ADHD as a neurodevelopmental disorder and has replaced the differentiation between subtypes by types of presentation (predominantly hyperactive/impulsive; predominantly inattentive; and combined presentation) (López-Villalobos, 2017).[3]

Given the symptomatic of ADHD and its high prevalence rates,[4,5] it is important for researchers to analyze the efficacy of the different treatments and interventions aimed to improve the inattention, hyperactivity and impulsivity.

Currently, both stimulant medication and behavior therapy are the most often applied treatments for ADHD,[6] although recent large-scale studies and meta-analyses have demonstrated limitations of these treatments.[6-8]

Some authors pointed that stimulant medication is effective in reducing ADHD symptoms in 70–80 % of children suffering from ADHD.[9,10] Thus, about a quarter of adolescents with ADHD do not benefit (enough) from standard treatment with stimulant medication.[9] With the aim to analyze different ADHD treatments, [11] carried out a meta-

analysis of behavioral treatments for ADHD, comparing the efficacy of 7 non-pharmacological interventions (behavior modification, neurofeedback therapy, multimodal psychosocial treatment, school-based programs, working memory training, parent training, and self-monitoring). Their results showed that behavior modification and neurofeedback treatments were most supported by most evidence. In this sense, in recent years various studies have shown the effectiveness of neurofeedback training because it is aimed at increasing levels of cortical activation.[12-14] Neurofeedback (NF) is aimed to teach or improve self-regulation,[6, 15] and it is based on the classical conditioning principles (learn new behaviors through the process of association) applied to the electroencephalogram (EEG).[6] Training in NF emerged as an intervention aimed to stimulate cortical activation,[16, 17] especially in disorders that require increasing intervals of attention, self-regulation and control skills, such as ADHD.[18] Previous studies have demonstrated the increase in activation by NF training, not only thanks to immediate feedback (visual and auditory) provided by the instrument, but also due to the establishment of new neural pathways and connections.[13, 19] For example, González-Castro, Cueli, Rodríguez, García and Álvarez[20] compared the efficacy of NF and pharmacological support in 131 students. Their results indicated that the combined group (NF and pharmacological support) benefited more and that the NF group improved to a greater extent in executive control (measured by a continuous performance task) than the pharmacological support group.

Clinicians commonly utilize 3 basic types of NF training protocols, based on the alterations in ADHD.[12] First, a conventional protocol to reduce inattention and impulsivity, which consists of operant suppression of theta activity and enhancement of beta activity.[21,

[22] Second, a protocol to reduce hypermotoric symptoms and enhance sensorimotor rhythm (SMR), which is sometimes used in addition to the previous theta-beta protocol.[18, 23] Third, based on electrophysiological evidence of altered slow cortical potentials (SCPs) in ADHD, another protocol has emerged, which is aimed at modifying SCPs in order to regulate cortical excitation thresholds.[24] Among the varieties of NF protocols, the most commonly used protocol is theta suppression/beta enhancement, usually enhancing sensorimotor rhythm (SMR) simultaneously.[25, 15] Studies comparing the effects of NF to stimulant medication found that the effects of NF were at least comparable to stimulant medication in measures of inattention and impulsivity,[27, 28] and these effects persisted after medication wash-out only for the group that also received NF.[29] The empirical evidence of NF was analyzed by Monastra and colleagues[18] in a review applying the guidelines of efficacy concurrently established by the Association of Applied Psychophysiology and Biofeedback and the International Society for Neuronal Regulation. On the basis of these principles, they concluded that NF is "probably an efficacious instrument" for treatment of ADHD, as clinically significant improvement is observed in approximately 75% of the cases treated in each of the studies analyzed. According to Arns, De Ridder,Strehl, Breteler, and Coenen[25] the level of clinical efficacy has been determined to be “Efficacious and Specific” and “Probably Efficacious” based on Lofthouse, Arnold, Hersch, Hurt, and deBeus.[30] Also, following American Academy of Pediatrics[31] NF has received “Level 1 Best Support” as an evidence-based treatment for childhood ADHD. This designation means that there have been studies with sufficient sample size indicating that NF is safe and effective in reducing ADHD symptoms in children, but evaluations of NF outside of research trials have been

more limited, meaning it is not yet known how laboratory studies translate to real clinical practice.

At the same time, the efficacious of the NF could be different in function of the ADHD types of presentation, specially, taking into account the differences between the three types of ADHD. With this in mind, it makes sense to analyze the differential effect of a NF intervention on improvement in the different types of presentation. One meta-analysis which incorporated 15 studies,[25] found that NF resulted in large and clinically relevant effect sizes for inattention and impulsivity and a medium effect size for hyperactivity.

Bakhshayesh et al.[21] compared clinical and neuropsychological effects of theta/beta training and showed a large effect size for inattention and small to medium effect sizes for hyperactivity and impulsivity, respectively. In this sense, taking into account that the NF effect looks to be greater in inattention and impulsivity, the benefits can change in the types of presentation of ADHD.

In the meta-analysis carried out by Micouland-Franchi, Geoffroy, Fond, Lopez, Bioulac and Philip[32] they considered the efficacy of NF on overall ADHD symptoms as well as in the inattention and hyperactivity/impulsivity dimensions assessed by parents and teachers, who had no knowledge that children had received NF. They found an improvement on parent assessments for overall ADHD score, inattention score, and hyperactivity/impulsivity score in NF groups compared to control groups. For the teacher assessments, improvements were only found for the inattention score. They took into account symptom instance the specific diagnosis.

Aims

The aim of this study was to analyze the differential efficacy of NF training in the ADHD types of presentation on the executive control, cortical activation and observed symptomatology. To achieve this, we used three groups; subjects with ADHD-I, ADHD-HI, and ADHD-C. All groups received a NF intervention based on the classic beta-theta protocol (reduce theta and enhance beta). The working hypothesis was that, although all three groups will show improved performance in the variables assessed (executive control with TOVA, cortical activation with Q-EEG and observational symptomatology with EDAH), the ADHD-I will improve more, taking into account the previous research in which the inattention get greater results.[21, 32]

Method

Participants

The participants in this study were 64 students with ADHD, 22 girls and 42 boys, between 8 and 12 years old (M = 9.58; SD = 1.11). The subjects in the ADHD groups had been diagnosed with ADHD by their neuropediatrician of reference. They were identified in the Child and Adolescent Psychiatric Service of the Central University Hospital of Asturias, according to the *Diagnostic and Statistical Manual of Mental Disorders-5*.[1] Participants were classified into three groups in function of the ADHD types of presentation: ADHD-I (n = 15, 6 girls and 9 boys); ADHD-HI (n = 11, 6 girls and 5 boys);

and ADHD-C (*n* = 38, 10 girls and 28 boys). They all had an IQ of 80 or above (see Table 1), assessed using the Wechsler Intelligence Scale for Children.[33]

Analyses of the participants in this study showed that the sample was homogeneous, with no statistically significant differences among them in terms of IQ (p = .666) or age (p = .515). Differences in terms of gender were significant so this variable was taken as a covariate in the later analysis $\chi^2(1) = 6.25$, $p < .012$. In addition, 31 participants had pharmacological support (7 ADHD-I, 4 ADHD-HI, and 20 ADHD-C), which was taken as a covariate in the analysis linked to gender.

Table 1. Means and Standard Deviations of IQs and Age of the Groups

Groups		IQ		Age		Gender F/M
	n	*M*	*SD*	*M*	*SD*	
ADHD-I	15	96.67	13.947	9.667	1.128	6/9
ADHD-HI	11	97.45	9.095	9.883	1.456	6/5
ADHD-C	38	99.47	10.118	9.458	1.005	10/28
Total	64	98.47	10.860	9.580	1.113	22/42

Note. IQ: intelligence quotient, M: mean, SD: standard deviation

Instruments

Participants were assessed at three levels (assessment of symptoms -EDAH- assessment of performance -TOVA- and assessment of cortical activation -QEEG-), at two

different times (before treatment initiation and after treatment). The EEG-Spectrum was used for the neurofeedback intervention.

Scale of Assessment of Attention Deficit with Hyperactivity (EDAH). Assessment of ADHD symptoms was performed with the EDAH scale for parents.[34] The scale has 20 items providing information about attention deficit (AD; 5 items), hyperactivity-impulsivity (H; 5 items), and conduct disorder (CD; 10 items). Items are scored on a 4-point Likert-type format, ranging from 0 to 3. The reliability of the instrument, using Cronbach´s Alpha, is high for the whole scale (α = .929) and its components: DA (α = .898), H (α = .849), and CD (α = .899). For the purposes of this study only the subscales AD and H were used. Attention deficit and/or hyperactivity-impulsivity are considered to exist when the score in one of the subscales is over 90%.

Test of variables of attention (TOVA). Performance was assessed with the TOVA.[35] This test presents two alternative stimuli on a computer screen, for an average of 22.5 minutes. The first stimulus is a black square on the upper border, and the subject should press a button when it appears. The second stimulus is a black square on the lower border, and the subject should not perform any action when it appears. The TOVA controls omissions (OM), commissions (COM), response time (RT), and variability (VAR). Obtaining a standard deviation below the mean in omissions and response time indicates attention deficit; if this occurs in commissions, it indicates impulsivity; and, lastly, if it occurs in variability, it is an indication of hyperactivity. Other indicators to be taken into account in the TOVA are the D value (D') and the ADHD score. D' is obtained from the subject's performance across the test, so that the more errors made, the higher this index

attributable to hyperactivity is. The ADHD score is the result of the sum of the response time of the first half, D' of the second half, and the total variability. If the ADHD score is lower than -1.80, it indicates a deficit in executive control.

Quantified electroencephalography EEG (Q-EEG). Cortical activation is recorded with Q-EEG, providing levels of cortical activation through the beta/theta ratio. It measures attention capacity independently of the task to be performed. To that end, an electrode is placed on the corresponding cortical areas (central area of the cortex -Cz-, and left prefrontal area -Fp1-) to record the beta/theta ratio. Two more control electrodes are placed on the left and right earlobes. The Q-EEG is administered to each participant, with open eyes, for a maximum duration of 10 minutes. An EMG system is placed on the right forearm to control the degree of movement. Once the electrodes are placed, participants are asked to remain relaxed, without moving significantly, breathing slowly and evenly, and concentrating exclusively on the computer screen, on which the theta and beta waves emitted by the participant are displayed successively. Once the degree of cortical activation is registered, the results are interpreted. A beta/theta ratio lower than 50% at Cz is indicative of sustained attention deficits, whereas if the ratio is below 50% at Fp1, the deficit is associated with a lack of executive control, linked to hyperactivity.[36]

Neurofeedback (EEG Spectrum). Initial activation, assessed through the beta/theta ratio, was enhanced by means of neurofeedback using the *EEG Spectrum* (www.neurocybernetics.com) designed by Howard Lightstone for Neurocybernetics, Inc. The instrument consists of two pieces of apparatus: one for the person who guides the training and the other for the person being trained. The trainee is connected to the apparatus

through an EEG preamplifier with wires connected by simple electrodes: signal, ground, and reference. The electrode signal is fixed to the prefrontal area (Fp1) with conductor gel, the reference and ground electrodes are placed on the earlobe. Samples of the EEG signal are taken 256 times per second and digitalized. The trainer's software processes the samples of the transformed digital signals and stores, filters, and separates them into various frequency bands, visualizing both the unprocessed signals and the filtered signals on the computer at a rate of 160 samples per second. Brain wave amplitude data at each frequency band are transmitted by the trainer's computer to the subject's computer as a game. The trainer monitors the activity of the brain waves and sets the goals, while the patient experiences the feedback through the game.

Design and Data Analysis

We used a *cuasi-experimental* design with three groups (ADHD-I, ADHD-HI, ADHD-C). All three groups received the neurofeedback intervention.

Firstly, we analyzed the difference between the pre-treatment-post-treatment scores in the three subtypes using the Student t test for related samples. Secondly, these differences in improvement were analyzed via a Multivarite Analysis of Variance (MANOVA) using the gain (the difference between the pre-treatment and post-treatment scores) as a dependent variable and the group (ADHD subtype) as an independent variable.

For effect size interpretation, Cohen´s criterion was used, which states that the effect is small when $\eta p^2 = .01$ ($d = .20$), medium when $\eta p^2 = .059$ ($d = .50$), and large when $\eta p^2 = .138$ ($d = .80$).[37] SPSS v.17 was used to conduct statistical analyses. For greater

clarity, in the results section, we present pre-and post-treatment data of the variables recorded by the instruments separately.

Procedure

This study was conducted in accordance with the Helsinki Declaration of the World Medical Association.[38] After obtaining parents' consent, each child was assigned to a reference group according to the diagnosis (ADHD-I, ADHD-HI and ADHD-C). Then, we administered the pre-treatment assessment with Q-EEG and TOVA. For the Q-EEG assessment, participants were instructed to remain relaxed, without moving, with eyes open, and to keep looking at the computer screen. Next, TOVA was applied after giving participants the following instructions: “During the next few minutes, you will see a sequence of figures on the computer. You should press the key as fast as possible when you see the rectangle with the square near the top border of the screen, but not when the square is near the lower border”. Participants had an initial 3-minute practice session.

NF training was carried out for 15 minutes, 3 days a week, for 3 months (36 sessions). The training began with the EEG Spectrum rocket game. After 3 months, participants were assessed again with the aforementioned instruments (post-treatment assessment) to evaluate the effects of the intervention. Typical NF interventions in ADHD involve 30–40 sessions, each lasting 30–60 min.[21, 39] NF can help children with ADHD symptoms learn which brain waves are associated with focused attention and which are not. In any case, Nooner, Leaberry, Keith and Ogle[40] showed the initial effectiveness of 12 sessions of NF in reducing ADHD symptoms in children according to the behavioral measure

Students with pharmacological support received methylphenidate adjusted by the neuropediatrician according to parameters such as weight and height. The presence of pharmacological support was taken as covariate in the specific analysis.

Results

Firstly, table 2 gives the data including means and standard deviations for each group of variables (cortical activation with Q-EEG -central and left prefrontal-; executive control with TOVA -omissions, commissions, response time, variability, D', and ADHD score-; and observation with EDAH completed by parents).

Table 2. Pre- and Posttreatment Means and Standard Deviations for Cortical Activation, Execution and Observation

	ADHD-I (n = 15)		ADHD-HI (n = 11)		ADHD-C (n = 38)		Total (n = 64)	
	PRE *M*(*SD*)	POST *M*(*SD*)	PRE *M*(*SD*)	POST *M*(*SD*)	PRE *M*(*SD*)	POST *M*(*SD*)	PRE *M*(*SD*)	POST *M*(*SD*)
Cz	.43 (0.05)	.51 (0.02)	.52 (0.02)	.55 (0.03)	.40 (0.06)	.49 (0.06)	.43 (0.07)	.51 (0.05)
Fp1	.51 (0.02)	.56 (0.04)	.43 (0.06)	.54 (0.04)	.39 (0.05)	.50 (0.04)	.42 (0.07)	.52 (0.04)
OM	79.20 (4.17)	88.13 (5.08)	89.64 (5.51)	95.00 (7.29)	75.97 (11.24)	91.05 (6.53)	79.08 (10.40)	91.05 (6.63)
COM	93.66 (4.45)	102.73 (5.86)	91.00 (5.77)	102.27 (9.28)	86.55 (5.36)	96.84 (8.40)	88.98 (6.00)	99.16 (8.41)
VAR	89.47 (6.49)	96.13 (7.22)	74.82 (9.23)	89.00 (5.13)	74.71 (6.64)	88.92 (7.34)	78.19 (9.40)	90.62 (7.54)
TR	79.13 (3.81)	91.00 (3.20)	90.36 (4.27)	92.55 (7.69)	76.76 (8.50)	90.29 (11.15)	79.66 (8.58)	90.84 (9.24)
D’	-1.15 (0.44)	-0.64 (.34)	-1.32 (0.86)	-0.57 (0.70)	-1.78 (0.62)	-0.81 (.54)	-1.55 (0.68)	-0.73 (.53)
ADHD score	-2.92 (0.64)	-1.70 (0.87)	-2.84 (1.32)	-1.54 (1.34)	-4.45 (1.44)	-1.94 (0.86)	-3.82 (1.55)	-1.81 (0.96)
H	82.53 (2.72)	81.27 (5.32)	93.09 (3.14)	82.00 (9.14)	93.89 (2.72)	84.79 (4.93)	91.09 (5.52)	83.48 (6.03)
AD	94.53 (2.64)	85.60 (2.82)	75.18 (10.82)	69.91 (12.76)	92.76 (4.44)	83.76 (6.66)	90.16 (8.93)	81.81 (9.17)
H+AD	81.53 (10.07)	76.73 (11.84)	76.18 (18.30)	70.36 (16.28)	94.00 (3.54)	84.92 (4.34)	88.02 (11.79)	80.50 (10.83)

Note. ADHD-I: inattentive subtype; ADHD-HI: Hyperactive-impulsive subtype; ADHD-C: combined subtype; M: mean, SD: standard deviation

Gain of the three groups

Table 3 shows the gain of the three subtypes in each set of variables. The three types of presentation showed improvement following the intervention. ADHD-I had significant differences pre-treatment-post-treatment in all variables except hyperactivity measured by EDAH. ADHD-HI showed significant improvement in all variables except RT

measured by TOVA. ADHD-C showed significant improvement in all variables with larger effect sizes in the majority.

Furthermore, the differences in the gain between the types of presentation were analyzed with MANCOVA (with gender and pharmacological support as covariate variables, the latter being significant as a covariate $p \leq .001$). The results were statistically significant for all variables except commissions and D prime, measured by TOVA, and AD and H+AD, given by EDAH (see table 3). Post hoc analysis showed that the differences in cortical activation were in Cz between ADHD-HI and ADHD-C ($p = .006$) and in Fp1 between ADHD-HI and ADHD-I ($p = .048$), and between ADHD-I and ADHD-C ($p = .003$).

Table 3. Student t-Test and MANOVA for analyzing the gain and the differences between the subtypes.

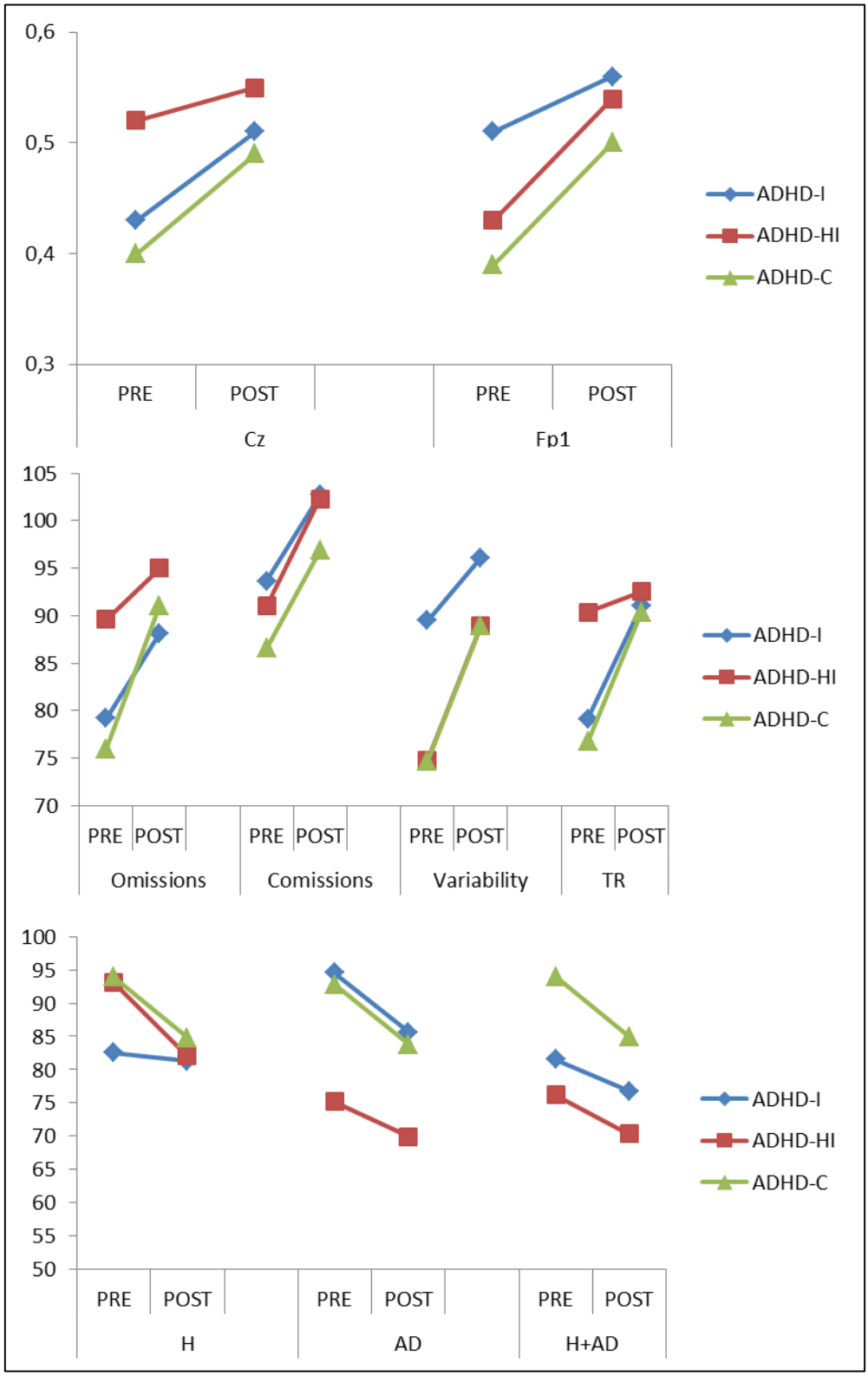
	ADHD-I (n = 15)		ADHD-HI (n = 11)		ADHD-C (n = 38)				
	t(14)	*d*	*t(10)*	*d*	*t(37)*	*d*	*F(2,59)*	*ηp²*	*Post hoc*
Cz	-5.01***	0.66	-2.41*	1.08	-10.38***	2.41	5.39**	0.16	C>HI
Fp1	-6.06***	2.29	-4.54***	2.03	-11.62***	2.7	7.18**	0.19	C&HI>I
OM	-6.08***	2.3	-3.46**	1.55	-7.93***	1.84	5.75**	0.16	C>HI
COM	-6.03***	2.28	-4.02**	1.8	-7.81***	1.81	0.25	0.01	
VAR	-4.79***	1.81	-6.28***	2.81	-11.17***	2.6	6.76**	0.19	C&HI>I
TR	-10.43***	3.94	-1.10	0.49	-7.49***	1.74	5.10**	0.15	C&I>HI
D’	-3.22**	1.22	-5.81***	2.6	-7.78***	1.81	2.59	0.08	
ADHD score	-6.16***	2.33	-2.93*	1.31	-12.01***	2.79	9.47***	0.24	C>HI&I
H	0.87	0.33	4.26**	2.02	11.35***	2.64	12.37***	0.29	HI&C>I
AD	11.68***	4.41	3.03*	1.36	7.96***	1.85	1.30	0.04	
H+AD	1.67	0.63	1.74	0.78	12.56***	2.92	2.14	0.07	

Note. ADHD-I: inattentive subtype; ADHD-HI: Hyperactive-impulsive subtype; ADHD-C: combined subtype; OM: omissions; COM: commissions; VAR: variability; TR: response time; D’: D prima; H: hyperactivity; AD: attention deficit.
***$p \leq .001$; ** $p \leq .01$; *$p \leq .05$

In performance, differences were significant between ADHD-HI and ADHD-C for omissions (p = .019), RT (p = .003) and ADHD score (p = .020). Between ADHD-I and ADHD-C in variability (p = .005) and ADHD score (p = .004). Between ADHD-I and ADHD-HI in variability (p = .041) and RT (p = .039).

Finally, for observation symptomatology, differences were significant in the variable H between ADHD-H and ADHD-I ($p \leq .001$) and between ADHD-C and ADHD-I ($p \leq .001$). Figure 1 provides a visual analysis of these differences.

Figure 1. *Evolution after intervention with neurofeedback of the three types of presentation in cortical activation (Cz and Fp1), execution (omissions, commissions, variability and RT) and observed symptomatology (H: hyperactivity, AD: attention deficit).*



Discussion

The main goal of this work was to analyze the differential effect of NF on the three subtypes or types of presentation. To that end, the design was based on analyzing the benefits of this type of intervention in three areas, cortical activation, performance and observed symptomatology.

Firstly, the results showed that in general, the three subtypes or types of presentation, showed improvements in the three areas following the intervention, although these differences there were not statistically significant in all cases. In cortical activation, the three types showed a positive improvement. The direction of the differences indicated that this improvement was greater in ADHD-C and ADHD-HI than in ADHD-I in Fp1. In Cz, the improvement was better in ADHD-C and ADHC-I than in ADHD-HI. However, if we focus on effect size, it is largest in ADHD-C followed by ADHD-HI for Cz and in ADHD-C followed by ADHD-I for Fp1. Thus, the results suggest that ADHD-C and ADHD-HI benefit most from the intervention. This may be related to the fact that ADHD-I does not have a major deficit in Fp1, a similar case exists for ADHD-HI in Cz.[36] Furthermore, the intervention with NF was carried out in the Fp1 point.

In the executive control, the profile in the six variables was similar. ADHD-C and ADHD-HI demonstrated better progression than ADHD-I when looking at mean scores. ADHD-C demonstrated better progression than ADHD-HI except in two variables, commissions and variability (variables associated with impulsivity and hyperactivity). The effect size reflected that the improvement was greater in ADHD-I for omissions, commissions and RT. In the case of ADHD-HI the effect size was greater for variability

and D', and in ADHD-C it was greater for the ADHD score (obtained from the set of RT, variability and D prime). Given that the Fp1 point is related to inhibition of behavior, hyperactivity and impulsivity, it is logical that the ADHD-C and ADHD-HI groups improved more than ADHD-I. In addition, the variables commissions, variability, D prime, and ADHD score are more associated with impulsivity symptomatology so it was expected that the improvement would be more significant in this area if the benefit was more significant for Fp1.

In the case of observed symptomatology measured with EDAH, parents reported good progression after intervention in the three subtypes. Again, parents of students with ADHD-C observed better improvement. Parents of students with ADHD-I saw better progression in inattentive symptoms and parents of ADHD-HI students reported greater improvement in hyperactive-impulsivity, as expected.

It short, we analyzed differences in the gain (the improvement in scores) in the subtypes or types of presentation. The conclusion is that the types of presentation have such different profiles of activation and performance that the pre- to post-test progression varies significantly.

In general, one conclusion that we can reach is that although ADHD-C represents the combination of symptoms, this group show better improvement after intervention. It could be related to the fact of the initial scores being lower than the other types so there is more room for improvement in this type. Furthermore, the intervention was focused on the Fp1 area, but the improvements in performance were in the variables associated not only with hyperactivity and impulsivity but also the variables associated with inattention. The

improvement produced in cortical activation has an effect on performance and on the observed symptoms.

These results are consistent with previous research in which the NF intervention produces a good progression of ADHD symptoms.[25, 15] Also, as Fuchs and colleagues[27] pointed out, NF has an effect on measurements of inattention and impulsivity. This is more significant when noting that around 40 to 60% cases of ADHD persist into adolescence and adulthood,[6] and given that stimulant medication is effective in reducing ADHD symptoms in only 70–80 % of cases.[9] It highlights the need to include different treatments that allow the reduction of symptoms and help students to face the difficulties the disorder poses.

The meta-analysis of Hodgson et al.[11] showed that interventions with NF were generally more efficacious for girls, and least efficacious for the ADHD-C. It is possible that this depends on the intervention protocol. Thus, a NF intervention situated in the Fp1 area, produces a marked improvement in the hyperactivity and impulsivity over inattention deficit. This would make sense in relation to others studies,[36, 41] in which the authors concluded that the Fp1 area is more affected in ADHD-HI and ADHD-C and the Cz area is more affected in ADHD-I and ADHD-C. Given that the intervention was carried out in the Fp1area in which students with ADHD-HI and ADHD-C have more difficulties, it is understandable that they showed a greater improvement after intervention.

Implications for practice

A prior implication of these results is that the intervention must be adapted to the specific profile of the students. It is necessary in the future to analyze the improvements of ADHD in different points or cortical areas to determine the most effective intervention

protocol for each diagnosis. That would produce better results from of the intervention in a shorter time. Finally, we must consider some limitations of this work, such as selection of the students who were chosen to have this specific NF intervention based on their parents' wishes. Furthermore, as the intervention program was applied for 15 minutes, it would be interesting to study the benefits of intervention with periods of 30 minutes, and maybe the difference between the effects of these two durations. It would allow the intervention to be better adjusted and the establishment of a training protocol. In this regard, according to Duric and colleagues,[17] there is no standard recommended regarding the number, duration or frequency of sessions when these types of protocols are administered so that is the challenge in this area of research.

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Artículo 3

Tercer estudio publicado en la revista *International Journal of Environmental Research and Public Health*

A Case Study in Attention-Deficit/Hyperactivity Disorder: An Innovative Neurofeedback-based Approach

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Abstract

In research about attention-deficit/hyperactivity disorder (ADHD) there is growing interest in evaluating cortical activation and using neurofeedback in interventions. This paper presents a case study using monopolar electroencephalogram recording (brain mapping known as MiniQ) for subsequent use in an intervention with neurofeedback for a 10 year-old girl presenting predominantly inattentive ADHD. A total of 75 training sessions were performed and brain wave activity was assessed before and after the intervention. The results indicated post-treatment benefits in the beta wave (related to a higher level of concentration) and in the theta/beta ratio, but not in the theta wave (related to higher levels of drowsiness and distraction). These instruments may be beneficial in the evaluation and treatment of ADHD.

Keywords: ADHD; attention; neurofeedback; theta/beta protocol; SMR protocol

A Case Study in Attention-Deficit/Hyperactivity Disorder: An Innovative Neurofeedback-based Approach

1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is one of the most common Childhood disorders, affecting between 5.9 and 7.2% of the infant and adolescent population. The fifth edition of the Diagnostic and Statistical Manual of Mental Disorders [1] describes ADHD as a neurodevelopmental disorder characterized by a persistent pattern of inattention, hyperactivity, and impulsivity manifesting in children before the age of 12 years old more frequently and with greater severity than expected in children of equivalent ages. Depending on the predominant symptoms, three types of presentation may be identified: predominantly hyperactive-impulsive, predominantly inattentive, and combined. There are two theories that attempt to explain the neurophysiological nature and characteristics of ADHD. Mirsky posited a deficit in attention as the main focus in ADHD, such that the failure is found in processes of activation [2]. The other theory was proposed by Barkley, who attributed the problems of ADHD to a deficit in behavioral regulation, where processes associated with the frontal cortex fail [3].

The determination of ADHD symptoms, along with the underlying neuropsychology, as outlined by the theories above, have led in recent years to the incorporation of evaluation and intervention techniques that do not solely focus on the behavioral aspects of the disorder. More specifically, techniques such as electroencephalography in ADHD evaluation and neurofeedback in interventions may provide greater benefits in detection and treatment.

The present study analyzes a specific case of ADHD with predominantly inattentive presentation, covering monopolar electroencephalogram recording (brain mapping called MiniQ) and intervention via neurofeedback.

The study was approved by the relevant Ethics Committee of the Principality of Asturias (reference: PMP/ICH/135/95; code: TDAH-Oviedo), and all procedures complied with relevant laws and institutional guidelines.

1.1. Evaluation of ADHD

The current diagnostic criteria for ADHD can be found in the DSM-5 [1] and in the Interna-tional Statistical Classification of Diseases and Related Health Problems, eleventh revi-sion, from the World Health Organization [4]. Various evaluation instruments are used for to identify ADHD, from general assessments via broad scales such as the Wechsler scale, to more specific tests assessing execution (e.g., test of variables of attention, D2 attention test), symptoms (e.g., Conners scale, EDAH scale), and the evaluation of cortical activity (e.g., using quantitative electroencephalograms, qEEG).

One alternative to qEEG is monopolar EEG recording (fundamentally used in clinical practice), called MiniQ (software Biograph Infinity). The MiniQ is an instrument for eval-uating brain waves from 12 cortical locations (international 10/20 system) [5]. This type of evaluation (monopolar EEG, MiniQ) lies somewhere between the traditional baseline (single channel qEEG) and full brain mapping. The frequency ranges evaluated match the classics [6,7]: delta 1-4 Hz, theta 4-8 Hz, alpha 8-12 Hz, sensorimotor rhythm SMR 12-15 Hz, beta 13-21 Hz, beta3 or high beta 20-32 Hz, and gamma 38-42 Hz. Theta waves have been related to low activation, sleep states, and low levels of awareness, beta

and alpha waves have been associated with higher levels of attention and concentration [8]. In addi-tion, the MiniQ, in line with qEEG, provides the relationships or ratios of theta/alpha, the-ta/beta, SMR/theta and peak alpha. Previous research, has established that the ratio be-tween theta and beta waves is a better indicator of brain activity than each wave taken separately (see Rodríguez et al. [9]). Monastra et al. attempted to establish what values of the theta/beta ratio would be compatible with those seen in subjects with ADHD [7]. They indicated critical values (cutoff points) for ADHD in theta/beta absolute power ratio, using 1.5 standard deviations compared to the control groups and based on age, those cutoff points are: 4.36 (6-11 years old), 2.89 (12-15 years old), 2.24 (16-20 years old), and 1.92 (21-30 years old). Higher values than the cutoff points would indicate a profile that is compatible with a subject with ADHD.

The distribution of electrical brain activity must be analyzed considering each site and the expected frequency. A regulated subject is characterized by more rapid activity in the frontal regions (predominantly beta) which decreases towards the posterior (occipital) regions, where slower waves (theta and delta) are expected [10,11]. Slower brainwaves are expected to predominate in the right hemisphere compared to the left, in which faster waves predominate. More specifically, beta waves will predominate in the left hemi-sphere, alpha waves in the right hemisphere, and there will be similar levels of theta waves in both. In addition, during a task (e.g., reading or arithmetic) rapid (beta) waves are expected to increase.

In contrast, the electrical activity in a subject with predominantly inattentive ADHD is characterized by a predominance of theta waves (compared to beta) in the frontal re-

gions, particularly on the left (F3). During tasks (e.g., reading or arithmetic), a subject with predominantly inattentive ADHD will exhibit increased slower (theta) waves, and there will be a slowdown in the frontal regions that hinders attentional quality, as suggested by researchers such as Clarke et al. [10] and more recently, Kerson et al. [12]. Studying the profile of cortical activation allows suitable intervention protocols to be established tailored to each subject.

1.2. ADHD Intervention

Many studies have examined the efficacy of the various treatments and interventions aimed at improving symptoms associated with ADHD (inattention, hyperactivity, and impulsivity) such as medication, behavioral treatments, and neurofeedback (see Caye et al. [13]). Neurofeedback is a type of biofeedback which aims for the subject to be aware of their brain activity and to be able to regulate it via classical conditioning processes [14,15]. In neurofeedback training, a subject's electrical brain activity is recorded via an electroen-cephalograph and the signal is filtered and exported to a computer. Software then trans-forms and quantifies the brainwaves, presenting them in the form of a game with move-ment or sounds which give the subject feedback about their brain activity [16].

The use of neurofeedback in interventions for ADHD began in 1973, although the first study with positive results was published in 1976 [17]. Since then, various studies have reported benefits from using neurofeedback in infants, with improvements in be-havior, attention, and impulsivity control (e.g., [18-22]). A meta-analysis by Arns et al. [14] concluded that treatment of ADHD with neurofeedback could be considered "effective and

specific", with a large effect size for attention deficit and impulsivity, and a moderate effect size for hyperactivity. In a systematic review and meta-analysis, Van Doren et al. [21] found that neurofeedback demonstrated moderate benefits for attention and hyperactivi-ty-impulsivity which were maintained in subsequent follow ups (between 2 and 12 months after the intervention). However, in a recent meta-analysis aimed at comparing the effects of methylphenidate and neurofeedback on the main symptoms of ADHD, Yan et al. [20] found methylphenidate to be better than neurofeedback, although the authors highlighted that the results were inconsistent between evaluators.

Neurofeedback training is normally done two or three times a week and around 40 sessions are needed to see changes in symptomatology [13]. Although it is an expensive treatment that needs consistency and continuity, in the USA, around 10% of children and adolescents with ADHD have received neurofeedback [23]. The benefits of neurofeedback training may depend on the type of protocol used. The three most-commonly used protocols in subjects with ADHD are [14]: (1) theta/beta ratio; (2) sensorimotor rhythm, SMR; (3) slow cortical potential. The most widely used of these three protocols is the theta/beta ra-tio, based on inhibition of theta and increasing beta, which usually improves SMR at the same time [13]. However, it is important to note that there is no recommended standard about the number, time or frequency of sessions, and there is no standard placement of NF screening when this type of protocol is administered [24,25]. In this context, the present study aims to provide a structure in which the neurofeedback intervention is adjusted based on the data provided by the previous assessment in a specific case.

The intervention protocol must be tailored to each individual case based on prior assessment, especially when using results from tests such as the MiniQ. In this context, the objective of the current study is to present the process of analyzing brainwaves in a case with ADHD (predominantly inattentive presentation) via the MiniQ test, the protocol for intervention using neurofeedback, and its efficacy. Although the alteration of brainwaves in specific areas in subjects with ADHD is well documented and the efficacy of neurofeedback has been observed in various studies, the present study aims to provide a specific procedure for assessment and intervention. Researchers and professionals need specific protocols and procedures that allow them to determine what is effective for each individual case.

2. Methodology

2.1. Description of the Case

This was a case study using monopolar electroencephalogram recording (brain mapping known as MiniQ) for subsequent use in an intervention with neurofeedback for a 10 year-old girl presenting predominantly inattentive ADHD.

2.1.1. Patient Identification

The subject was a 10 year-old girl in the fourth year of primary education. Her academic performance was poort, with the worst results in language, social sciences, and science. She found it difficult to go to school and was shy and reserved. She was the younger of two sisters, the older being an outstanding pupil. Her mother characterized her

as a quiet girl who needed a lot of time to do any kind of task. In addition, during the study and academic tasks, she would often gaze into space, as if she were in her own world. Both her father and her mother evidenced concern for her school results, but also for her social relationships, as her self-absorption appeared in all contexts, making it hard for her to have conversations, pay attention to others, or follow the rules in games.

2.1.2. Reason for Consultation

The consultation was for poor academic performance, slowness doing tasks, and wandering attention from when she had started school, although that had increased in the previous year. Initially, the subject did not demonstrate any great willingness to attend the consultations, but over time, she demonstrated a participative attitude with good involvement in doing the tasks she was set.

2.1.3. History of the Problem

The subject's school history was one of failure in the main school subjects. She had not had to repeat a school year, but her form tutors repeatedly raised this possibility with her parents. At the time of the study, there had been no clinical or educational psychology assessments. Previous diagnosis of ADHD was by her neuropediatrician one month before the assessment in the Psychology clinic consultation. From that point, guidelines were given for pharmacological treatment, which had not begun.

2.2. Proposed evaluation and intervention

2.2.1. Evaluation: Brainwave analysis with the MiniQ instrument

An assessment was performed using a MiniQ (Monopolar, from Biograph Infinity). Assessment using the MiniQ is a two-step process (evaluation and interpretation) which is simple, relatively fast, and inexpensive.

The first step is to make the recording from the 12 cortical sites, which can be done with eyes closed or open, and either with or without tasks (reading or arithmetic). This gives information about the values of the different brainwaves at each site. To begin, electrodes are placed on the earlobes and two active electrodes in each of the sites indicated by the program. Before beginning the assessment for each site, the impedance level—the quality of the connection—for each of the electrodes must be checked, both on the ears and on the scalp, to avoid artefacts. When the impedance level is below 4, the recording process can begin. The subject is instructed to remain still and to look at the computer screen where there is an image of a landscape. They must keep their eyes open and keep silent. The program guides the application, which is based on the placement of electrodes in groups of two following the sequence: Cz-Fz, Cz-Pz, F3-F4, C3-C4, P3-P4, O1-O2, and T3-T4. For sites F3-F4, subjects are asked to read a story quietly and to do some simple arithmetic (e.g., 2+3, +5, +4, -1, +6, -3, etc.). Once recordings have been made at all of the sites, the program filters the data to remove artefacts. Finally, the recorded data is interpreted, and the values are analyzed, allowing the state of the subjects' brainwaves to be determined. Applying the test takes approximately 60 minutes.

The second step is to analyze the collected data considering the site and the frequency ranges at each. The sites are labelled based on the four quadrants of the cortex: anterior, posterior, left hemisphere (odd numbers) and right hemisphere (even numbers). The in-

strument gives the results in two formats, an excel spreadsheet and a power point. In addition to the measurements or wave values (delta, theta, alpha, sensorimotor rhythm SMR, beta, beta3, and gamma) at the sites noted above, the spreadsheet also includes the values for the ratios of theta/alpha, theta/beta, SMR/theta, and peak alpha. The power point presentation gives the same information, although over a background image of a brain which allows scores to be seen at the relevant site (see Figure 1). With that information, it is possible to assess cerebral asymmetry, both anterior-posterior and right-left, according to each location.

The values of the theta/beta ratios are interpreted based on Monastra et al. (1999) [7], bearing in mind that in this case, the scores were relative power not absolute. Scores are indicative of ADHD when the values are: over 2.5 for those up to 7 years old, over 2.8 for 7-11 year-olds, over 2.4 in adolescents, and over 1.8 in adults. Traditional ratios for ADHD indicators use absolute power values measured in peak volts (microvolts squared divided by the hertz value). Biograph for theta/beta ratio calculation uses relative power values (microvolts divided by the hertz value).

2.2.2. Intervention: Neurofeedback Protocols

The intervention was carried out using the Biograph Infiniti biofeedback software (Procomp2 from Thought Technology; https://thoughttechnology.com/). Two protocols were used in the intervention process, an SMR protocol and a theta/beta protocol. The protocol and specific sites selected were based on the prior evaluation.

The SMR protocol used site Cz and was designed to work on three frequencies, theta, SMR, and beta3 [26]. The objective of this kind of protocol is to perform SMR (12-

15Hz) training to increase the production of this wave and inhibit the production of theta (4-7 Hz) and beta3 (20-32 Hz) activity. During the training sessions, the subject watches a vid-eogame or a film on the screen. Following the neurofeedback dynamic, the game or the film progresses positively if the level of electrical activity increases and stops when the level of electrical activity falls. Reinforcement occurs when the value of theta and beta3 are below the set value and SMR is above a pre-determined threshold. The reinforcement consists of a sound and points awarded to the subject. The working thresholds are provided by the program automatically, although they can be modified manually by the therapist. The level of reinforcement is set by the therapist. Initially it is set at 80%, and depending on how the subject masters the task, the reinforcement is reduced. The subject is not given explicit instructions about what they have to do, they are told "try to keep the animation on the screen moving".

The theta/beta protocol works at site Fz. The aim of this protocol is to reduce the am-plitude of theta waves and increase beta to work on concentration. The subject has to do tasks which consist of concentrating on a game that appears on the computer screen. The game presents a pink square (which represents the value of theta) and a blue square (representing the value of beta). The subject is told that the game involves trying to make the pink square as small as possible and the blue square as large as possible. The computer automatically generates the ranges over which the waves are worked, although they can be changed manually by the therapist. The desired working theta/beta ratio can also be set manually. The protocol begins with high ratios, close to three, such that the task is simple

and the subject achieves reinforcement on many occasions. The ratio is progressively reduced according to the subject's progress.

The intervention lasted for a year and consisted of 75 neurofeedback sessions. There were two phases to the training. The first phase, "the regulation phase", covered the first 15 sessions, during which the SMR protocol was followed at Cz. The aim of this first phase was to strengthen SMR and inhibit theta and beta3 in the central region. These ses-sions were around 45 minutes each. To avoid tiredness, different presentations of neu-rofeedback were used (videogame or film) during the sessions, with five-minute breaks between each presentation.

The second phase ran from session 16 to session 75. In these sessions the SMR protocol at Cz was applied for 20 minutes followed by a five-minute break before the theta/beta protocol at Fz was applied for another 20 minutes. For the first six months of the intervention, sessions were 45 minutes, twice weekly. During the remaining six months, the sessions were weekly, and remained 45 minutes long.

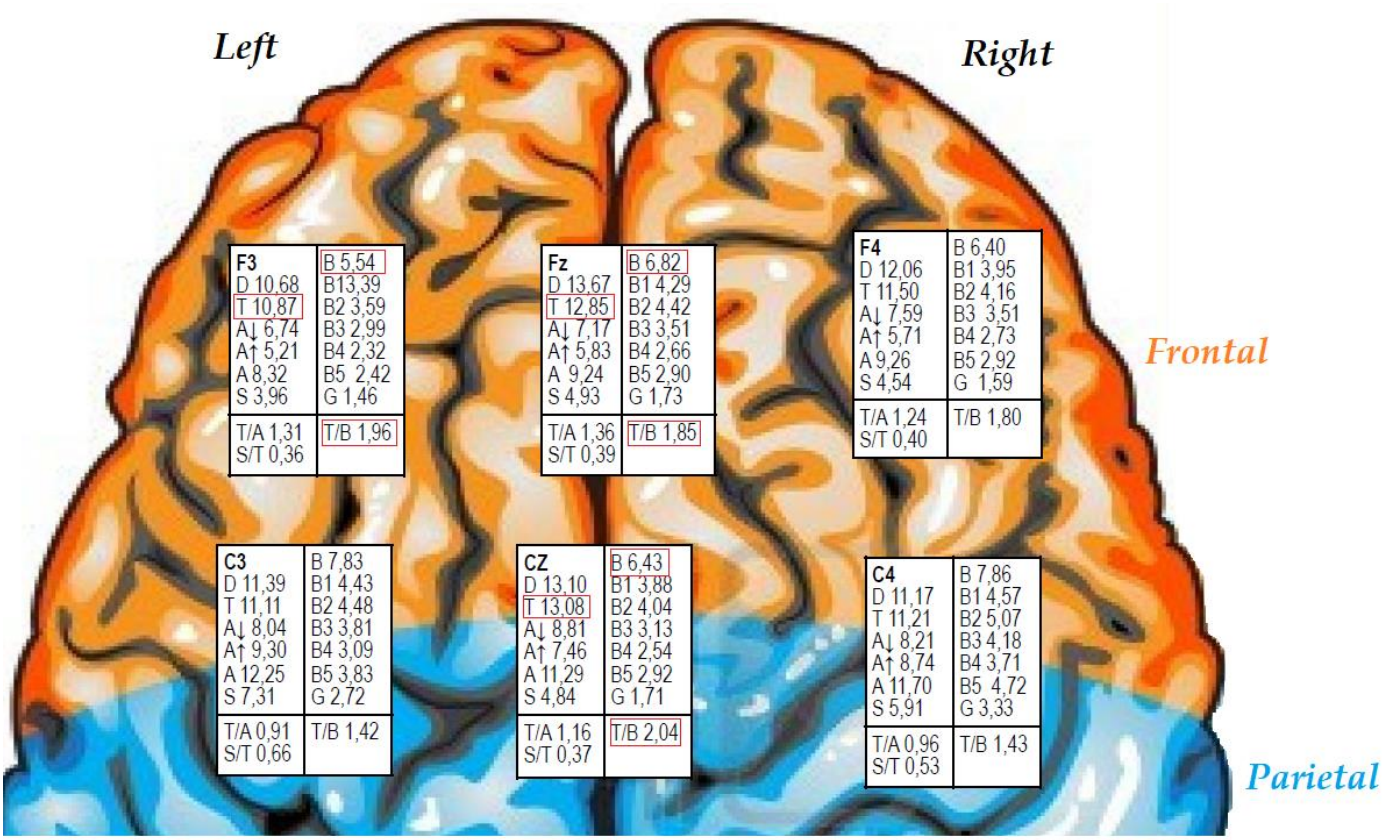
3. Results

3.1. Brainwave Evaluation

Based on the information obtained over the evaluation of the case, and considering the prior diagnosis from her pediatric neurologist, the subject presented ADHD with predominantly inattentive presentation. As Figure 1 shows, her brainwave profile indicated scores for the theta/beta ratio of close to 2.8 in the central (Cz) and frontal regions (Fz). Considering the scores in Cz and Fz, the neurofeedback needed to include these sites.

Furthermore, neurofeedback on frontal-midline theta (Fz) has been shown to be frequently more effective than neurofeedback protocols that do not include Fz [22].

Figure 1. Pre-Treatment Results From the MiniQ Instrument



Note. T = theta; B = beta; T/B = theta/beta ratio. In subjects aged between 7 and 11 years old, values over 2.8 for the theta/beta ratio are compatible with a profile of ADHD.

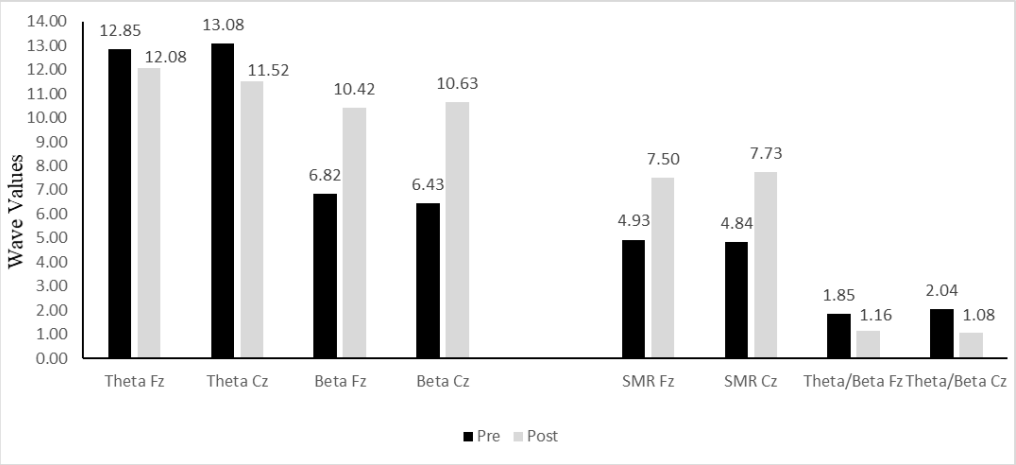
Given the brainwave profile, the aim of the intervention was to reduce theta and increase beta in the frontal zones. That indicated using the SMR and theta/beta protocols [15].

3.2. Progression Fllowing Neurofeedback Intervention

Once the neurofeedback intervention was completed, brainwave activity was assessed again using the MiniQ. Figure 2 illustrates the change in theta, beta, and SMR, along with the theta/beta ratio at sites Cz and Fz. The results show a positive progression following the neurofeedback training.

Theta activity fell following the intervention, both at Fz (by 0.77) and at Cz (by 1.56). To put it another way, there was a reduction in the slow wave at both sites (mainly in the central region compared to the frontal region). This is in line with expected values of theta at the cortical level, as they should be higher in posterior areas and lower in frontal areas.

Figure 2. Pre and Post-Treatment Activity in Sites Cz and Fz



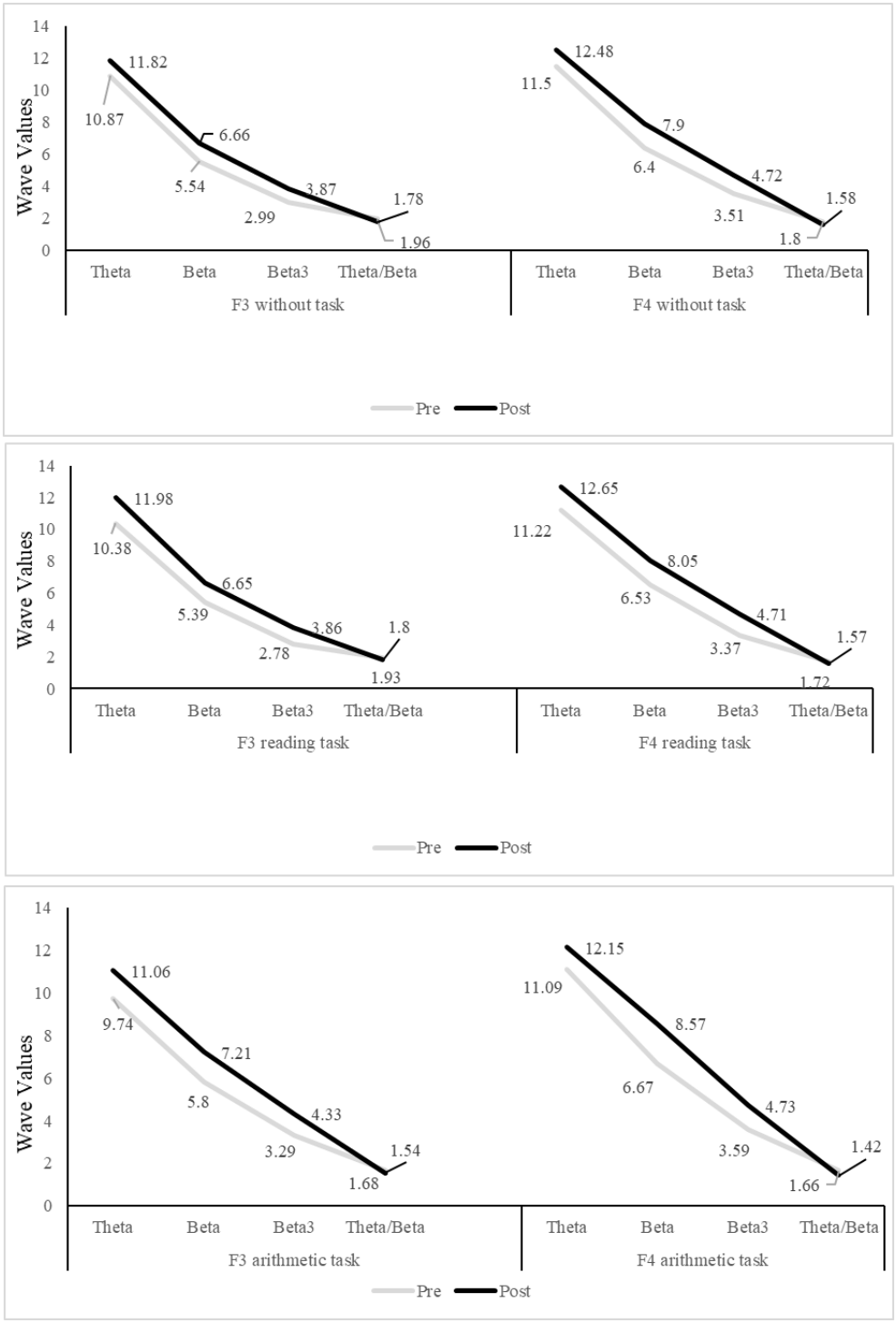
There was also an increase in beta at the two sites, with a 3.60 point increase at Fz and a 4.2 point increase at Cz. In this case, the intervention produced considerable increases in the rapid wave values at both sites, although the value was slightly higher in the central area than in the frontal. Values for beta waves are expected to be higher in frontal areas than central areas, and although that was not the case here, the values were very close. The SMR wave also increased notably, by 2.57 points at Fz and 2.89 points at Cz. In short, the intervention led to a slight reduction in the slow wave, with lower values at post-treatment (less distraction), and increases in fast waves, beta, and SMR, with higher values after the intervention (better ability to concentrate). The theta/beta ratio also de-creased at post-treatment (basically due to the increase in beta), both at Fz (by 0.69) and Cz (by 0.96), from values close to those for ADHD to scores more indicative of a subject with-out ADHD.

In addition, as initially proposed, the assessment with the MiniQ also considered the subject's activation levels during reading and arithmetic tasks. Measurement of these val-

ues was at sites F3 and F4. The subject did three types of task for two minutes each: Paying attention to the screen on which a landscape appeared, reading a story, and doing simple arithmetic (addition and subtraction). As Figure 3 shows, post-treatment scores were different to pre-treatment scores.

In the first task (pay attention to the screen), the values for theta, beta, and beta3 at F3 and F4 all rose. In the second and third tasks (reading and arithmetic), there were variations in all of the waves, both slow and fast. These results indicate that there was no improvement during tasks following the intervention, because although the fast waves (beta and beta3) increased, the slow wave (theta) did not diminish. Following the intervention, the expectation was to have increased levels of beta and beta3 (especially at F3), while reducing levels of theta. However, as Figure 3 shows, the theta/beta ratio fell, with lower values post-treatment.

Figure 3. Pre and Post-Treatment Evolution in F3 and F4 Areas With and Without Tasks



4. Discussion

The aim of this study was to present the process for detecting a case of ADHD (predomi-nantly inattentive presentation) using the MiniQ test, along with the neurofeedback inter-vention protocol and its efficacy. In terms of detection, the MiniQ showed the subjects' brain activity, which together with behavioral symptoms, provided details of their char-acteristic profile and allowed tailored treatment. Various studies in the literature have concluded that children with ADHD exhibit higher levels of theta waves and lower levels of beta waves, particularly in frontal areas [10,11]. In addition, the relationship between the theta and beta waves (the theta/beta ratio) had already been associated with ADHD symptomatology through the research by Monastra et al. [7] and Jarrett et al. [27].

In the current case study, the MiniQ was relatively simple to apply, and it provided large amounts of information related to brainwave values at the 12 different sites. More specifically, the EEG record of the 10 year-old subject showed lower levels of beta activity in the frontal regions and a higher level of theta activity in the frontal and central regions. However, the slow wave (theta) should be higher in posterior regions and fall in the cen-tral area, whereas the fast waves (beta and beta3) should be higher in the anterior regions and lower in the posterior. The subject's theta/beta ratio was high (Cz: 2.05) and close to values seen in subjects with ADHD according to Monastra et al. [7]. and Jarrett et al. [27]. Although the theta/beta ratio was not high enough to clearly or exactly indicate the pres-ence of ADHD with predominantly inattentive presentation, it is important to consider the full set of data provided by the MiniQ. It is also important to note that the diagnosis of ADHD was reported by the neuropediatrician, who usually uses behavioral criteria. At the

same time, we cannot ignore the fact that the use of the theta/beta ratio has also been questioned by other works (e.g., [28]). In any case, the importance of the brainwave analysis lay in helping decide which intervention protocols to follow, along with the frequencies and the sites to use. The chosen neurofeedback protocols were the SMR protocol and the theta/beta protocol. There were 75 intervention sessions, 45 SMR at Cz and 30 theta/beta at Fz. Once the intervention was complete, the changes in theta, beta, beta3 and SMR waves were assessed using the MiniQ.

The intervention produced a variety of results. Firstly, there was a small reduction in theta activity and an increase in SMR which would indicate better levels of attention. In addition, the theta/beta ratio fell to levels which were closer to those in subjects without ADHD. However, this improvement in the theta/beta ratio was due to increased beta ra-ther than by the reduction of theta. Janssen et al. found similar results in 38 children with ADHD by analyzing the learning curve during 29 neurofeedback training sessions [29]. Their results indicated that while theta activity did not change over the course of the sessions, beta activity showed a linear increase during the study. In our study, the subject was able to significantly improve the levels of beta, but was hardly able to reduce theta activity, which is what would allow even greater improvements in attentional ability. Given this progress, the use of a protocol for inhibition of theta waves at Fz may be effective in strengthening the development of attention levels. Although there were no notable chang-es at other sites, such as F3 and F4, it is important to note that the intervention was carried out only at Cz and Fz.

On similar lines, during tasks after the intervention (reading and arithmetic), there was no reduction in theta but there was an increase in beta and beta3, again in line with the results from Janssen et al. [29]. For reading and arithmetic one would expect, at least in subjects without ADHD, that in the frontal regions, values of slow waves would fall and fast waves would rise. However, in this study, there was no increase in beta waves in frontal regions during the tasks. This may indicate that although the neurofeedback intervention protocols in subjects with ADHD produce improvements in baseline activation (increased beta), the same does not happen with activation during the execution of tasks such as reading and arithmetic. In addition, Monastra et al. [7] showed that the activation profile of subjects with ADHD was similar with no task and during a reading task (unlike the control subjects, in whom activation increased during the reading task). Although this fact may be related to the ADHD profile, in our case study, with 75 neurofeedback sessions, we found no differences in the activation of frontal areas during a specific task such as reading or mathematics.

As Enriquez-Geppert et al. [24] and Duric et al. [25] state, it is still necessary to develop specific procedures (which consider electrode placement and the specific theta/beta, SMR or slow cortical potential protocol) for intervention tailored to the different cases that professionals may find in clinical practice, in order to achieve better results. In this regard, it would be interesting to study theta/beta-ratio learning curves during intervention with neurofeedback, with the aim of achieving better results and making this tool as adaptive as possible in the future.

5. Conclusions

T These results point towards the hypothesis that the low baseline cortical activation seen in subjects with ADHD would be found to be the basis of the disorder. While neurofeedback training may produce a positive progression, difficulties would persist, particularly during specific tasks in which subjects with ADHD are unable to achieve an ideal profile of brainwave activity for optimum performance. This is a reflection of the fact that the disorder persists throughout life and hence despite improvements in the cortical activation profile, and the subject learning to strengthen their beta wave activity to concentrate, there will continue to be high levels of theta.

In this context, various studies such as Doppelmayr and Weber [30] and Vernon et al. [31] have reported the benefits of the SMR protocol and others, such as Arns et al. [13], Gevensleben et al. [32] and Leins et al. [33], have done the same with regard to the theta/beta protocol. However, other studies, such as Cortese et al. [34] and Logemann et al. [35], have not found improvements following neurofeedback intervention in children with ADHD. Considering these differences between previous studies, it would be interesting to establish the benefits of one or other of the protocols in interventions in children with ADHD. For example, in adults without ADHD symptoms, Doppelmayr and Weber [30] examined the efficacy of the theta/beta and SMR protocols. They found that the subjects who followed the SMR protocol were able to modulate their brain activity, whereas the theta/beta protocol did not provide benefits in regulation of brain activity.

It is also worth noting that, while previous studies employed similar protocols (SMR, theta/beta), the numbers of sessions and the session durations varied between

studies. These variations may be related to the differences in the results and indicate the need to establish intervention protocols not only about what to work with (brain waves) but also how to do it (e.g., number of sessions, session duration, break schedules, etc.). At the same time, the present study underscores the need to tailor protocols to subjects' profiles, along the same lines as previous studies, for instance Cueli et al. [16], which noted differences in the benefits of interventions based on the type of ADHD presentation. As authors such as Leins et al. [33] have indicated, most neurofeedback intervention programs combine two protocols, and it would be interesting to determine whether the combination is more effec-tive than applying a single protocol.

In the future, it would be advisable to assess subjects' levels of activation every 10 to 15 sessions of neurofeedback training in order to tailor the protocols to their progress and to study the theta/beta ratio learning curve as mentioned above. One limitation it is important to note is that multidomain assessments before, during, and after treatment (and adequate follow-up) should include blinding and sham inertness Another limitation of the present study is the lack of a behavioral assessment that would allow for an in-depth analysis of the subject's progress in line with the protocol from Holtmann et al. [36]. At the same time, in spite of the limitations associated with case studies, such as not being able to produce generalizable results, the present work aims to be of some use to clinical and educational professionals so that they may consider intervention protocols for cases simi-lar to the one described here.

Finally, despite the limitations described above, it would also be useful to consider the possibility of incorporating this type of training in more cases of subjects with ADHD,

because neurofeedback intervention may offer long-term benefits in terms of improving the attentional abilities of subjects with ADHD, especially if one considers that approxi-mately a third of ADHD patients do not respond to, or sufficiently tolerate, pharmacolog-ical treatment [37]. In this regard, it would be interesting to analyze the efficacy of new po-tential tools that combine neurofeedback and virtual reality and incorporate them into clinical practice [38].

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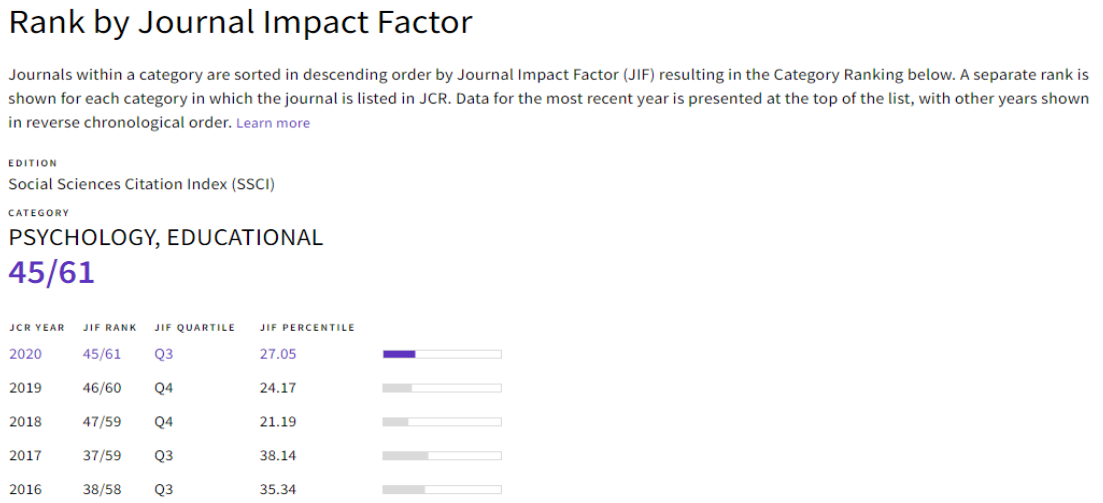
Informe del factor de impacto de las publicaciones

A continuación, se presenta la información referente al Factor de Impacto de las revistas en las que se han publicado los trabajos mencionados. Todas ellas se encuentran incluidas en *JCR Social Science Edition*. Para obtener el Factor de Impacto se consideró la información recogida en la *Web of Sciences*. Concretamente, se empleó el año 2019 como referencia, al ser la última anualidad recogida hasta el momento.

1. Revista Psychology in the Schools: Cuenta con una Factor de Impacto en el año 2020 de 1.774, y se encuentra en el tercer cuartil. Más específicamente, se sitúa en el puesto número 44 de la categoría Psychology Educational de un total de 61 revistas.



Rank by Journal Impact Factor

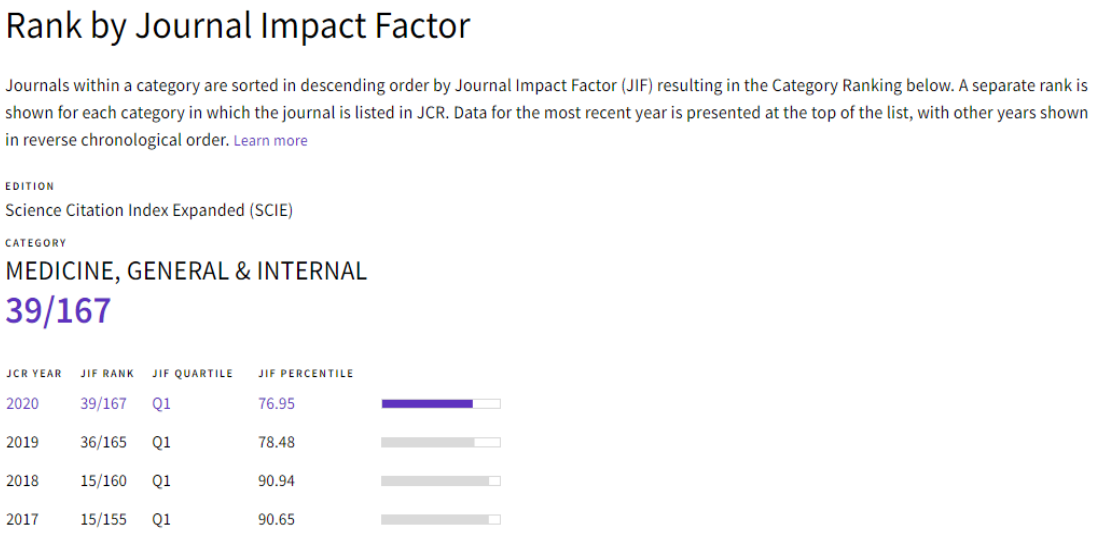
Journals within a category are sorted in descending order by Journal Impact Factor (JIF) resulting in the Category Ranking below. A separate rank is shown for each category in which the journal is listed in JCR. Data for the most recent year is presented at the top of the list, with other years shown in reverse chronological order. Learn more

EDITION
Social Sciences Citation Index (SSCI)

CATEGORY
PSYCHOLOGY, EDUCATIONAL
45/61

JCR YEAR	JIF RANK	JIF QUARTILE	JIF PERCENTILE
2020	45/61	Q3	27.05
2019	46/60	Q4	24.17
2018	47/59	Q4	21.19
2017	37/59	Q3	38.14
2016	38/58	Q3	35.34

2. Revista *Journal of Clinical Medicine*: Esta revista tiene en el año 2019 (año de la publicación recogida en esta Tesis Doctoral) un Factor de Impacto 3.303 situándose en el primer cuartil (posición 36 de un total de 165 revistas en la categoría Medicine, General & Internal).



Rank by Journal Impact Factor

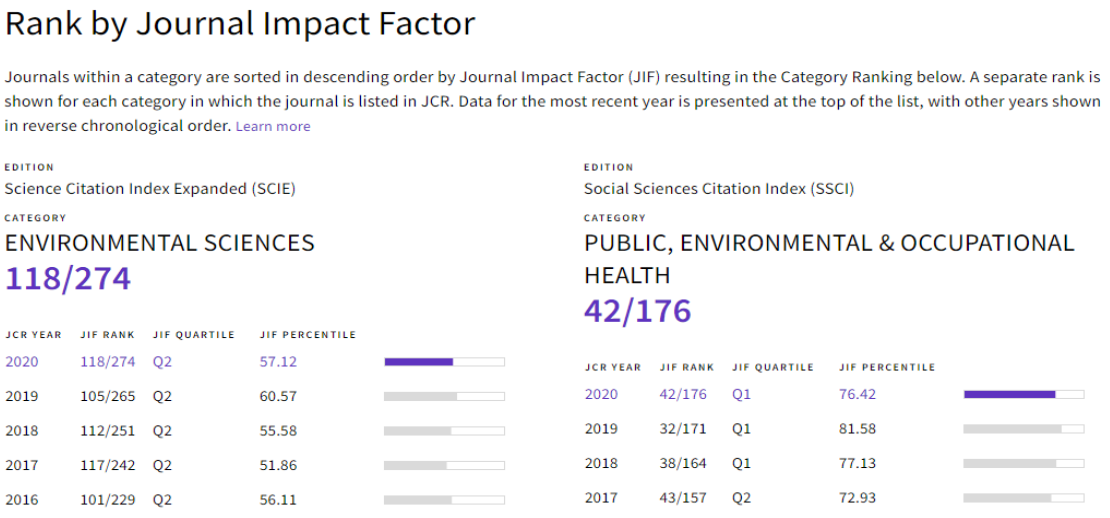
Journals within a category are sorted in descending order by Journal Impact Factor (JIF) resulting in the Category Ranking below. A separate rank is shown for each category in which the journal is listed in JCR. Data for the most recent year is presented at the top of the list, with other years shown in reverse chronological order. Learn more

EDITION
Science Citation Index Expanded (SCIE)

CATEGORY
MEDICINE, GENERAL & INTERNAL
39/167

JCR YEAR	JIF RANK	JIF QUARTILE	JIF PERCENTILE
2020	39/167	Q1	76.95
2019	36/165	Q1	78.48
2018	15/160	Q1	90.94
2017	15/155	Q1	90.65

3. Revista *International Journal of Environmental Research and Public Health*: Esta revista tiene en el año 2020 un Factor de Impacto de 3.390, situándose en el primer cuartil (posición 42 de un total de 176 revistas en la categoría Public, Environmental and Occupational Health).



Rank by Journal Impact Factor

Journals within a category are sorted in descending order by Journal Impact Factor (JIF) resulting in the Category Ranking below. A separate rank is shown for each category in which the journal is listed in JCR. Data for the most recent year is presented at the top of the list, with other years shown in reverse chronological order. Learn more

EDITION
Science Citation Index Expanded (SCIE)

CATEGORY
ENVIRONMENTAL SCIENCES
118/274

JCR YEAR	JIF RANK	JIF QUARTILE	JIF PERCENTILE
2020	118/274	Q2	57.12
2019	105/265	Q2	60.57
2018	112/251	Q2	55.58
2017	117/242	Q2	51.86
2016	101/229	Q2	56.11

EDITION
Social Sciences Citation Index (SSCI)

CATEGORY
PUBLIC, ENVIRONMENTAL & OCCUPATIONAL HEALTH
42/176

JCR YEAR	JIF RANK	JIF QUARTILE	JIF PERCENTILE
2020	42/176	Q1	76.42
2019	32/171	Q1	81.58
2018	38/164	Q1	77.13
2017	43/157	Q2	72.93

Discusión de resultados

Tal y como se planteó inicialmente, en esta tesis doctoral se trataron de alcanzar tres objetivos que se desarrollaron en tres estudios que se podrían encuadrar bien en la línea de detección del TDAH o en la línea de la intervención teniendo en cuenta dos contextos principales: El escolar (para su detección) y el personal (para su intervención). A continuación, se discuten los resultados alcanzados en cada uno de estos tres estudios en función de la pregunta general a la que pretendían responder.

¿Qué es Relevante en el Diagnóstico de TDAH?

El primer objetivo de esta Tesis Doctoral surgía de la pregunta ¿qué es relevante en el diagnóstico de TDAH? Concretamente, dentro de esta cuestión global, se focalizó en profundizar en el conocimiento y actitud hacia el TDAH de estudiantes universitarios (cursando grados de educación infantil, de educación primaria, pedagogía y psicología) y profesores en activo (en educación infantil, primaria, secundaria y profesores universitarios del campo de educación). Aditivamente, este trabajo también buscó establecer cómo el conocimiento sobre el trastorno servía de predictor de las actitudes hacia el TDAH.

Para evaluar el conocimiento sobre el TDAH, se utilizó el Cuestionario de Soroa et al. (2014) que incluye cuatro dimensiones: información general, síntomas, etiología y tratamiento. Este cuestionario permite valorar el conocimiento real (aciertos), los conocimientos erróneos (fallos) y las lagunas (desconocimiento de la respuesta). Para valorar la actitud, se empleó una parte del Cuestionario ASKAT (ADHD-specific knowledge and attitudes of teachers; Mulholland, 2016) que valora cuatro dimensiones de

la actitud: Sentimientos hacia el TDAH; Creencias sobre el TDAH; Conocimiento, entrenamiento y adaptaciones para estudiantes con TDAH; y Deseo de mayor conocimiento sobre el TDAH.

En consonancia con el trabajo de Soroa et al. (2016), en este primer estudio se observó que los participantes presentaban un mayor conocimiento en la dimensión de tratamiento, seguida de síntomas/diagnóstico, información general y etiología. Además, los profesionales en activo obtuvieron un conocimiento superior al de los estudiantes universitarios (principalmente en las dimensiones de síntomas/diagnóstico y etiología). También, se observó que los estudiantes presentaban un mayor número de errores que los profesores, siendo la dimensión de etiología en la que se observaba un mayor número de respuestas erróneas en ambos grupos.

En términos de actitudes, no se observaron diferencias significativas en la actitud de profesionales en activo y estudiantes (en la línea de Anderson et al., 2012). Sin embargo, en lo que respecta a los componentes de la actitud, los estudiantes universitarios alcanzaron puntuaciones más positivas en relación con los sentimientos hacia el TDAH y los profesionales en activo mejores puntuaciones en el componente de Conocimiento, entrenamiento y adaptaciones hacia el TDAH. Además, si bien variables como la experiencia no resultaban predictores significativos de la actitud, sí lo hacía el nivel de conocimiento sobre el TDAH, siendo las dimensiones de información general, etiología y tratamiento, las mejores predictoras de la actitud hacia el TDAH en el modelo analizado. Otros trabajos ya habían observado una asociación entre el conocimiento sobre el TDAH y la actitud hacia el trastorno (p.e., Greenway y Edward, 2020; Ohan et al., 2008). Sin

embargo, resulta relevante concretar, que es sobre todo el conocimiento en relación con el tratamiento del trastorno, el que muestra un poder predictivo mayor de la actitud hacia el TDAH.

Teniendo en cuenta estos resultados, en este estudio se destacó la importancia de incrementar el conocimiento del profesorado sobre el TDAH, dado que en la línea con otros trabajos, ese conocimiento es moderado (Jarque et al., 2007; Soroa et al., 2016) y tiene una influencia importante sobre la actitud que los profesionales presentan hacia el trastorno (Greenway y Edward, 2020)

No podemos olvidar que los profesionales de la educación juegan un papel crucial en la detección inicial del trastorno y en su intervención. Una detección temprana, permitirá poner en marcha las medidas y entrenamientos más ajustados a cada caso en particular.

¿Qué Intervenciones Pueden Resultar Eficaces Para el TDAH?

El segundo y tercer trabajo que se recogen en esta tesis doctoral trataban de responder a la pregunta ¿qué intervenciones pueden resultar eficaces para el TDAH? Para profundizar en esta cuestión se realizaron dos estudios en los que dentro de las diferentes intervenciones dirigidas a mejorar la sintomatología del TDAH, se puso el foco de análisis en la intervención con neurofeedback.

En el segundo de los trabajos, se trató de analizar la eficacia diferencial del neurofeedback en los tres tipos de presentación del TDAH tanto a nivel de activación cortical (valorada con el electroencefalograma cuantificado), como de ejecución (valorada con el Test of Variables of Attention) y sintomatología observada (valorada con la escala

para padres EDAH). Tal y como se pudo ver, los resultados reflejaron que los tres tipos de presentación del TDAH mostraban una evolución favorable tras la intervención a nivel de activación cortical, de ejecución y de sintomatología observada. Además, eran los estudiantes con TDAH presentación combinada quienes obtenían un mayor beneficio en los tres niveles (activación cortical, ejecución y sintomatología observada). Este aspecto, se relacionó en el trabajo con el hecho de que este grupo de estudiantes presentaban una sintomatología más severa en la que se unía la falta de atención y la hiperactividad-impulsividad, de ahí, que partieran de puntuaciones más bajas (de activación cortical, ejecución y sintomatología observada) en el inicio, lo que permitía al mismo tiempo un mayor margen de mejora.

Los resultados fueron compatibles con los de otros trabajos que aportaron un efecto positivo del neurofeedback en personas con TDAH (ver Caye et al., 2019). El metanálisis de Arns et al. (2014) concluyó que el tratamiento con neurofeedback para el TDAH podía considerarse "eficaz y específico", con un tamaño del efecto grande para el déficit de atención y la impulsividad, y un tamaño del efecto medio para la hiperactividad. En nuestro estudio, si bien los resultados fueron más relevantes en el caso de la presentación combinada e hiperactiva-impulsiva, es preciso destacar que la intervención se llevó a cabo en una zona cortical relacionada con el autocontrol y el control inhibitorio, más deficitario en el caso de la hiperactividad-impulsividad.

Cabe subrayar que los resultados alcanzados, pueden estar condicionados por el protocolo de intervención llevado a cabo. Concretamente, se realizaron 36 sesiones de entrenamiento Theta/Beta en el área Fp1. Habitualmente, el entrenamiento se realiza entre 2

y 3 veces por semana y algunos trabajos apuntan que son necesarias unas 40 sesiones para observar cambios en la sintomatología (Arns, 2014; Caye et al., 2019).

En cualquier caso, con este trabajo quedó patente que la intervención debe estar ajustada al perfil del estudiante dado que ello permitirá alcanzar resultados más favorables. En esta línea, surgió el tercero de los estudios, también enfocado a la pregunta ¿qué intervenciones pueden resultar eficaces para el TDAH? Este trabajo trató de analizar el proceso de detección de un caso con TDAH (niña de 10 años con presentación predominante con falta de atención) a través de la prueba MiniQ y el protocolo y eficacia de la intervención llevada a cabo a través del neurofeedback.

Los resultados indicaron que el MiniQ permitía constatar la actividad cortical del sujeto para profundizar en el perfil característico de la persona y ajustar su tratamiento. En la literatura, diferentes trabajos concluyen que los niños con TDAH presentan un mayor nivel de onda Theta y un menor nivel de onda Beta, sobre todo, en zonas frontales (Clarke et al., 2019). Además, la relación entre las ondas Theta y Beta (ratio Theta/Beta) se ha asociado con la sintomatología del TDAH (p.e., Jarrett et al., 2017).

En el estudio de caso se pudo ver que la aplicación del MiniQ, permitía detectar un menor nivel actividad de onda Beta en las regiones frontales y un mayor nivel de actividad de onda Theta en las regiones frontales y centrales. La intervención se ajustó en ese momento al perfil de activación cortical detectado en la niña valorada. Se establecieron como protocolos de intervención con neurofeedback, el protocolo SMR y el protocolo Theta/Beta (Arns et al., 2014; Caye et al., 2019).

Tras la intervención se pudo observar una pequeña reducción de la onda Theta y una mejora de la onda SMR que se reflejaría en un mejor nivel atencional. Además, la ratio Theta/Beta disminuyó sus niveles situándose en valores próximos a los detectados en sujetos sin TDAH. Esta mejora en la ratio Theta/Beta se produjo como consecuencia del aumento de los valores de la onda Beta pero no por la disminución de la onda Theta. No se observó una evolución favorable en otras localizaciones como F3 y F4 (cabe destacar que la intervención se realizó únicamente en Cz y Fz).

En este contexto, diferentes trabajos han observado los beneficios del protocolo SMR (p.e., Doppelmayr y Weber, 2011) y del protocolo Theta/Beta (p.e., Gevensleben et al., 2009). Sin embargo, otros estudios no han detectado mejoras tras la intervención con neurofeedback en niños con TDAH (p.e., Cortese et al., 2016; Logemann et al., 2010). Teniendo en cuenta estas diferencias en los trabajos previos, tanto en el segundo como en el tercer estudio se estableció como línea de interés la necesidad de establecer los beneficios de un protocolo u otro en la intervención con niños con TDAH.

En base a los hallazgos en los tres trabajos descritos, es preciso hacer hincapié en la importancia de tener en cuenta los diferentes contextos que envuelven a los estudiantes con TDAH. El DSM-5 (APA, 2013) establece que para considerar el diagnóstico de TDAH la sintomatología debe aparecer al menos en tres contextos (personal, social, escolar, o familiar). Para analizar la sintomatología en el ámbito escolar, es preciso que el profesorado cuente con la formación adecuada. Sin embargo, los niveles de conocimiento parecen aun moderados en los profesionales de este ámbito educativo. Su conocimiento no solo es relevante de cara a la detección, sino también a su actitud durante el proceso de

intervención. A nivel de intervención, también es preciso tener en cuenta los diferentes contextos del sujeto. Por ejemplo, el profesor en lo que atañe al ámbito escolar, es un referente a la hora de establecer la evolución del estudiante. Al mismo tiempo, la intervención que se lleva a cabo en el ámbito personal debe tener en cuenta las diferentes opciones ante las que nos encontramos en la actualidad siendo el neurofeedback una modalidad de intervención que está reportando efectos positivos como los descritos en los presentes trabajos.

En base al artículo más citado de TDAH en los últimos años (ver Lin et al., 2021), entre el 2003 y el 2011, alrededor de 2 millones de niños y adolescentes en los Estados Unidos fueron diagnosticados con TDAH (Visser et al., 2014). Este dato ha generado una gran preocupación social por la salud mental de niños y adolescentes y señala la necesidad de establecer un diagnóstico certero e incorporar una intervención efectiva. Sin embargo, en la actualidad es alto el porcentaje de personas que duda de la existencia del trastorno (ver Speerforck, 2021), generando este hecho una mayor complicación en la detección e intervención del trastorno con las implicaciones que ello puede trasladar a niños y adolescentes con TDAH. Cada vez más a nivel de investigación se tiene en cuenta no solo la sintomatología conductual del trastorno, sino también la emocional destacando la relevancia de tener en cuenta los niveles de ansiedad, autoconcepto y autoestima de niños y adolescentes con TDAH (p.e., Barkley, 2016; Christiansen et al., 2019; Cueli et al., 2020).

Finalmente, en este contexto en el que destacamos la importancia de analizar el perfil de los estudiantes con TDAH a todos los niveles con evaluaciones exhaustivas que incluyan desde el estudio de los síntomas, de la activación cortical, de su ejecución y de su

perfil emocional, resaltamos la importancia de incluir en el proceso de valoración el estudio de sus puntos fuertes y débiles en consonancia con el concepto de neurodiversidad y la propuesta de Armstrong (2011) que tiene como precursores los principios de atención a la diversidad. Contar con el perfil de capacidades de los estudiantes, nos permite establecer intervenciones ajustadas a sus necesidades. Este es el principio básico de la atención a la diversidad que siguiendo a Álvarez y Soler (2000) se basa en tomar conciencia de las diferencias fundamentales que poseen los alumnos, valorando la diversidad de capacidades desde una perspectiva positiva dirigida a fomentar sus fortalezas y trabajar sus dificultades.

Limitaciones y Líneas Futuras

Los trabajos descritos no están exentos de limitaciones tal y como se describe en cada uno de los estudios. En el primer caso, en el análisis del conocimiento y actitud hacia el TDAH, la metodología de estudio se basó en el empleo de cuestionarios, los cuales, no están exentos de desventajas. Además, no se incluyó ninguna medida de control con el fin de asegurar que las respuestas no se producían de forma azarosa. Por otro lado, la muestra no se encontraba balanceada habiendo un mayor número de estudiantes universitarios que de profesorado. En el futuro, sería interesante contar con una muestra mayor que permitiese analizar el conocimiento del profesorado o de los estudiantes en base a su perfil educativo, con el fin de comparar si en base al tipo de formación previa (infantil, primaria, pedagogía, etc.), hay diferencias en el conocimiento o en la actitud hacia el TDAH.

En relación con el segundo estudio, debemos señalar que si bien se tuvieron en cuenta los tres tipos de presentación de TDAH, el tamaño muestral en cada uno de los grupos era pequeño, sobre todo, en el caso del TDAH tipo presentación predominante

hiperactiva-impulsiva. Además, no se tuvo en cuenta un grupo control de estudiantes sin TDAH que realizasen la intervención, ni un grupo que llevase a cabo un entrenamiento en otras áreas corticales no asociadas al trastorno con el fin de concretar aún más los beneficios de la intervención. En el futuro sería conveniente establecer diferentes protocolos de intervención en cada uno de los tipos de presentación del TDAH con el fin de establecer dentro de cada tipo de presentación de TDAH, el protocolo más beneficioso.

Por último, en lo que respecta al tercer estudio una de las limitaciones principales se halla en la ausencia de otras medidas de valoración como las conductuales o las ejecutivas que permitirían constatar con mayor profundidad la eficacia de la intervención con neurofeedback. El estudio de caso único no nos permite obtener conclusiones generalizables a otros contextos, pero si profundizar en mayor medida en el procedimiento a seguir con la utilización de instrumentos específicos (como el MiniQ o el neurofeedback) y trasladar a otros profesionales de la práctica clínica o educativa, ese procedimiento.

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Conclusiones

- El conocimiento sobre el TDAH de profesionales en activo y estudiantes universitarios fue mayor en la dimensión de tratamiento, seguido de las dimensiones síntomas/diagnóstico, información general y etiología.
- El mayor desconocimiento en relación con el TDAH, se observó en la dimensión de etiología, tanto para los profesionales en activo, como para los estudiantes universitarios.
- Los profesionales en activo presentaban un conocimiento sobre el TDAH superior al mostrado por los estudiantes universitarios.
- No se observaron diferencias en la actitud hacia el TDAH entre estos dos grupos (profesionales en activo y estudiantes universitarios). Sin embargo, los estudiantes universitarios alcanzaron puntuaciones más positivas en relación con los sentimientos hacia el TDAH.
- El conocimiento sobre el TDAH predijo de forma significativa las actitudes hacia el trastorno. Las dimensiones de conocimiento sobre el TDAH que presentaron un mayor poder predictivo de la actitud hacia el TDAH, fueron información general, etiología y tratamiento. Concretamente, la dimensión de tratamiento fue la variable con mayor poder predictivo de la actitud hacia el TDAH.
- La experiencia profesional en el ámbito educativo no tuvo poder predictivo sobre la actitud hacia el TDAH.

- La intervención con neurofeedback usando el protocolo Theta/Beta en Fp1 produjo efectos positivos para los tres tipos de presentación de TDAH, pero sobre todo, para la presentación combinada y la presentación predominante hiperactiva-impulsiva.
- Con respecto a la presentación predominante con falta de atención, el protocolo de intervención con neurofeedback Theta/Beta en Fp1, tuvo efectos positivos en relación al control ejecutivo. Concretamente, sobre el tiempo de respuesta y las omisiones.
- En el estudio de caso evaluado, se observó que el MiniQ permitía detectar un menor nivel actividad de onda Beta en las regiones frontales y un mayor nivel de actividad de onda Theta en las regiones frontales y centrales.
- Después de la intervención con neurofeedback en un caso de TDAH con presentación predominante con falta de atención usando el protocolo SMR en Cz y el protocolo Theta/Beta en Fz, se observó que se reduce ligeramente la onda lenta (Theta) así como un aumento de la onda rápida (Beta) y SMR lo que se traduce en una mayor capacidad de concentración.
- Los valores de la ratio Theta/Beta tanto en Fz como en Cz, tras la intervención con neurofeedback se reducen llegando prácticamente a valores cercanos a los de un sujeto sin TDAH.