Spanish version of the Adult Executive Functioning Inventory (ADEXI): Psychometric properties in adults with Autism Spectrum Disorders and Intellectual Disability

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Abstract. The aim of the present study was to investigate the psychometric properties of the Spanish version of the Adult Executive Functioning Inventory (ADEXI) in adults with Autism Spectrum Disorders (ASD) and Intellectual Disability (ID). A total of 121 adults with ASD and ID were recruited and informant ratings on the ADEXI were collected to investigate the factor structure, as well as reliability and validity. The results showed that we could replicate the two-factor structure (i.e., working memory and inhibition) that had been found in a previous study of adults with Attention Deficit Hyperactivity Disorder (ADHD). The two ADEXI subscales were shown to have high internal consistency and significant associations were found between the ADEXI and the Dysexecutive Questionnaire (DEX), another executive function rating instrument. Conclusively, the ADEXI appear to be a valid instrument for assessing executive function deficits in adults with ASD and ID.

Keywords: Executive deficits; Autism Spectrum Disorders; Intellectual Disability; assessment; psychometric properties.

Versión en español del Inventario de Funcionamiento Ejecutivo para Adultos (ADEXI): propiedades psicométricas en adultos con trastornos del espectro del autismo y discapacidad intelectual

Resumen: El objetivo del presente estudio fue investigar las propiedades psicométricas de la versión española del Inventario de Funcionamiento Ejecutivo para Adultos (ADEXI) en personas adultas con Trastornos del Espectro del Autismo (TEA) y Discapacidad Intelectual (DI). Se reclutó un total de 121 personas con TEA y DI y se recopilaron los resultados obtenidos en el ADEXI para investigar la estructura factorial, la fiabilidad y validez. Los resultados obtenidos replican los hallazgos en cuanto a estructura de dos factores (es decir, memoria de trabajo e inhibición) de un estudio previo con una población de adultos con Trastorno por Déficit de Atención e Hiperactividad (TDAH). Se demostró que las dos subescalas del ADEXI tienen una alta consistencia interna y se encontraron asociaciones significativas entre el ADEXI y el Cuestionario Disejecutivo (DEX), otro instrumento de evaluación de las funciones ejecutivas. En conclusión, el ADEXI parece ser un instrumento válido para evaluar la disfunción ejecutiva en adultos con TEA y DI.

Palabras clave: Disfunción ejecutiva; trastornos del espectro del autismo; discapacidad intelectual; evaluación, propiedades psicométricas.

Introduction

Autism Spectrum Disorders (ASD) are characterized by persistent deficits in communication and social interactions and by showing a repertoire of restricted and repetitive behaviors, interests or activities (American

Psychiatric Association [APA], 2013). One of the variables that causes heterogeneity in ASD is cognitive ability. The first epidemiological studies indicated that 70% of people with ASD had Intellectual Disability (ID) (Fombonne, 2005). Currently, it is estimated that 30% of children with ASD have ID (Baio et al., 2018)

Previous research has shown that executive function (EF) deficits are closely linked to this disorder (see review by Demetriou et al., 2018). EFs are defined as «a set of general-purpose control mechanisms, often linked to the prefrontal cortex of the brain, that regulate the dynamics of human cognition and action.» (Miyake & Friedman, 2012, p. 2). Some of the capacities that make up this construct are inhibition, working memory, and set shifting (Miyake et al., 2000).

The first empirical research on executive functioning in the population with ASD was carried out by Rumsey (1985), who administered the Wisconsin Card Classification Task (Grant & Berg, 1948) to adults with high functioning autism, observing an incorrect classification strategy in this population. Since then, a large number of studies investigating various EF deficits have been carried out in individuals with ASD, demonstrating a broad executive dysfunction that is relatively stable across development (Demetriou et al., 2018). More specifically, previous research has shown that ASD in adults is linked to deficits in both inhibition (Geurts, Van den Bergh, & Ruzzano, 2014) and working memory (Holdnack, Goldstein, & Drozdick, 2011). In addition, a review of studies of cognitive flexibility showed that ratings, but not tests, could discriminate between individuals with ASD and controls (Leung & Zakzanis, 2014). Previous research has also shown that EF deficits in individuals with ASD are related to important daily life outcomes such as social, emotional and behavioral functioning (Vogan et al., 2018), as well as verbal skills (Bishop & Norbury, 2005).

Conclusively, executive dysfunction should be considered an important aspect in ASD (Russell, 1997). However, there is still unclear how to best measure this construct. Currently, there are a number of neuropsychological batteries available, but a recent meta-analysis (Demetriou et al., 2018) concluded that only a very limited number of measures used to investigate EF deficits in individuals with ASD achieved the criterion of clinical sensitivity. Generally, ratings have been found to be better at discriminating between clinical groups and controls and they have also been found to be more strongly related to daily life functioning. It has therefore been argued that EF tests have lower ecological validity compared to EF ratings (Barkley & Fischer, 2011). A number of questionnaires to measure EF deficits in

adults have been developed of which the most commonly used and well-known questionnaires are the following: Behavior Rating Inventory of Executive Functions- Adult Version (BRIEF-A; Roth, Isquith, & Giois, 2005), the Barkley's Deficits in Executive Function Scale (BDEFS; Barkley, 2011), and the Dysexecutive Questionnaire (DEX; Burgess, Alderman, Wilson, Evans, & Emslie, 1996).

A limitation of the questionnaires mentioned above is that they do not target executive dysfunction specifically. Instead, some of them include items that are almost identical as the symptom criteria for Attention Deficit Hyperactivity Disorder (ADHD; APA, 2013) such as difficulties in sitting still or having a short attention span. Items related to ASD are also sometimes included such as getting nervous when there are unexpected changes in one's daily routine. Thus, if finding significant group differences between individuals with ASD and controls when using these instruments, it is difficult to know with regard to what aspects that the groups really differ.

In order to address these limitations, the Adult Executive Functioning Inventory (ADEXI; Holst & Thorell, 2018) was created. The ADEXI is a brief (i.e., 14 items) instrument that specifically targets two major executive functions - working memory and inhibition. It is available both as a self-rating and a rating for significant others. The ADEXI is originally a Swedish instrument and the original version of the instrument has shown high reliability and high construct validity (Holst & Thorell, 2018). Previous research has also shown that the ADEXI can discriminate well between individuals with ADHD and controls in both younger adults (Holst & Thorell, 2018) and adults age 60-75 years (Thorell, et al., 2017).

Both the ADEXI and the childhood version of this instrument referred to as the Childhood Executive Function Inventory (CHEXI; Thorell & Nyberg, 2008) are freely available in many different languages. The interest of using these instruments in both research and clinical practice has been high in Spain, Portugal, and South/Central America, which has resulted in translations of the CHEXI and/or the ADEXI to Spanish, Portuguese, Catalan, Galician, and Spanish-Latino (see «www.chexi.se» for free downloads of these instruments). However, the reliability and the validity for the other language versions of the ADEXI has not yet been investigated. In addition, the ADEXI has not yet been used in clinical samples besides adults with ADHD and the psychometric properties of the version for significant others have not been examined. The aim of the present study was therefore to investigate the psychometric properties of the Spanish version of the informant rating of the ADEXI in adults with ASD.

Method

Participants

The study included 121 adults with Autism Spectrum Disorder (ASD) and Intellectual Disability (ID). The sample was a convenience sample recruited from healthcare centres, two from the Community of Madrid and one from the Community of Galicia. The number of males was 81 (66.9%), and the number of females was 40 (33.1%). The age ranged between 18 and 62 years, with a mean age of 35.46 years (SD = 9.46). Participants had IDs associated with ASD: 15.7% (n = 19) of the sample had a mild ID; 31.4% (n = 38) had a moderate ID; 23.9% (n = 29) were severe, 20.6% (n = 25) had profound ID, and the remaining 8.2% (n = 10) had unspecified ID. With regard to comorbid condition, 41.3% of participants had epilepsy, 40.5% had some type of comorbid psychiatric disorder such as anxiety or depression and 18.2% had a comorbid medical condition such as gastrointestinal diseases or allergies. All participants had informed consent provided by their legal guardians.

Procedure

The translation and adaption of the items included in the ADEXI were carried out by two individuals with expertise in the area of executive functioning in populations with ASD and ID, as well as fluent in both English and Spanish. The authors of the original version of ADEXI approved the translation. The questionnaires were completed by the participants' therapists, who were not included as researchers in the project. The project was approved by the ethics committee at the Department of Personality, Evaluation and Clinical Psychology of Complutense University of Madrid.

Instruments

Adult Executive Functioning Inventory (ADEXI; Holst & Thorell, 2018). The Spanish version was retrieved from www.chexi.se. The ADEXI is a questionnaire that measures executive functioning in adults, specifically deficits in working memory and inhibition. The instrument is made up of 14 items that are rated on Likert scale from 1 (definitely not true) to 5 (definitely true). The questionnaire is divided into two subscales: working memory and inhibition. The working memory subscale includes 9 items (e.g., «I have difficulty remembering lengthy instructions») and the inhibition subscale includes 5 items (e.g., «I sometimes have difficulty stopping an activity that I like»). Previous

research of the self-report version has shown adequate test-retest reliability (.70) as well as very good internal consistency (.90) for the working memory subscale but somewhat lower internal consistency (.70) for the inhibition subscale (Holst & Thorell, 2018). High convergent validity for the self-report version of the instrument has been demonstrated in relation to Barkley Deficits in Executive Functioning Scale (BDEFS) with correlations ranging from .48 to .72 (Holst & Thorell, 2018). The items for the other-report version of the English ADEXI are presented in Table 1 and the other-report version of the Spanish ADEXI is presented in Appendix A.

Dysexecutive Questionnaire of the Behavioural Assessment of the Dysexecutive Syndrome (DEX; Burguess et al., 1996; Spanish version by Pedrero et al., 2009). The DEX is an instrument for the measurement of executive dysfunctions in daily life that is part of the Behavioural Assessment of the Dysexecutive Syndrome (BADS; Wilson, Alderman, Burgess, Emslie, & Evans, 1996). In the present study, we used the DEX-R version, which is an informant report completed by a person close to the evaluated subject. The DEX consists of 20 items rated on a Likert scale from 0 (never) to 4 (very frequently). Some examples of items included in the DEX are «Has difficulty thinking ahead or planning for the future» or «Finds it difficult to stop doing something even if s/he knows s/he shouldn't». The DEX has been shown to have good psychometric properties (Burgess et al.,1996). Previous research (Pedrero et al., 2009) has shown that the Spanish version of this instrument has high internal consistency (a = .91) and the internal consistency was high also in the present study (a = .87). This scale has been widely used in different populations, including people with ASD (García-Villamisar, Dattilo, & Muela, 2016; García-Villamisar & Rojahn, 2013; Hagberg, Billstedt, Nydén, & Gillberg, 2015).

Statistical analyses

All analyses were performed using SPSS Statistics Base 25 (IBM Corp., 2018). First, the Kolmogorov-Smirnov test was used and results showed that all included variables followed a normal distribution. Second, an item discrimination analysis was performed. Thirdly, a confirmatory factor analysis (CFA) was performed using AMOS v.22 statistical program for SPSS. This analysis was based on the original two-factor model established in previous research (Holst & Thorell, 2018). The Maximum Similarity method was used to estimate the parameters. According to

Table 1. Results of the confirmatory factor analysis

Item	WM	INH
1. Has difficulty remembering lengthy instructions	.89	
8. When asked to fetch something, he/she sometimes forgets what he/she supposed to fetch	.86	
5. When someone asks him/her to do several things, he/she sometimes remembers only the first or last	.84	
2. Sometimes has difficulty remembering what he/she is doing in the middle of an activity	.80	
12. Has difficulties with tasks or activities that involve several steps	.78	
11. Sometimes has difficulty understanding verbal instructions unless he/she is also shown how to do something	.78	
7. Has difficulty coming up with a different way of solving a problem when he/she gets stuck	.65	
9. Has difficulty planning for an activity (e.g., remembering to bring everything necessary when going on a trip/ to work/to school)	.61	
13. Has difficulty thinking ahead or learning from experience	.55	
10. Sometimes has difficulty stopping an activity that he/she likes (e.g., watch TV or sit in front of the computer in the evening even though it is time to go to bed)		.86
4. Sometimes has difficulty stopping him-/herself from doing something that he/she likes even though someone says that it is not allowed		.82
14. Appears to be more lively/wilder compared to other people his/her age		.71
6. Sometimes has difficulty refraining from smiling or laughing in situations where it is inappropriate		.71
3. Has a tendency to do things without first thinking about what could happen		.68
Explained variance (%)	46.21	17.10

Note. WM = working memory; INH = inhibition

recommendations (e.g., Hair, Black, Babib, & Anderson, 2010), a number of different of model fit indices were presented. For the Comparative Adjustment Index (CFI) and the Tucker-Lewis adjustment index (TLI), values of ≥ 0.90 are considered indicative of a good adjustment (Hu & Bentler, 1998). The root mean square error of approximation (RMSEA), for which values between .05 and .08 assume a suitable fit (Browne & Cudeck, 1993), was also included to evaluate the fit of the model. Finally, for the chi-square (χ^2) value divided by the degrees of freedom (CMIN/DF), values close to 2 means a suitable fit (Brooke, Russell, & Price, 1988). Third, convergent validity was examined by calculating Pearson correlation coefficients between the two ADEXI subscales and the DEX. Fourth, reliability was calculated using Cronbach's alpha, a measure of internal consistency. According to guidelines (Nunnaly, 1978), a < .50 is considered as unacceptable, .50 to .59 as poor, .60 to .69 as questionable, 70 to .79 as acceptable, .80 to .89 as good and ≥ .90 as excellent. Estimates of reliability were obtained for the full scale as well as for each factor. Finally, the reliability of the Spanish ADEXI was further investigated using Guttman's split half coefficient Cronbach alpha and omega score.

Results

Item analysis

Table 2 shows the results of a discrimination study of the items that make up the test. According to what is presented in it, all the items have very good scores indicating high capacity for discrimination. Item 14 had the lowest score, still being an adequate score to continue being part of the measurement instrument.

Confirmatory factorial analysis

The Kaiser-Meyer-Olkin test showed good sampling adequacy test (.87) and Bartlett's test of sphericity was significant, χ^2 (91) = 961.47, $p < 0.001$. Together, this indicates that the data was suitable for a factor analysis. The internal structure of ADEXI was evaluated through a confirmatory factor analysis (CFA), testing the original two-factor solution found in previous research (Holst & Thorell, 2018). As shown in Table 2, the indices showed a good fit (CMIN/DF = 2.54; CFI = 0.87; TLI = 0.87; RMSEA = 0.11). For getting an even better model fit, some errors were allowed to correlate with one another.

Table 2. Items discrimination indexes

Item	Discrimination index
Item 1	.64
Item 2	.72
Item 3	.67
Item 4	.42
Item 5	.71
Item 6	.48
Item 7	.50
Item 8	.70
Item 9	.63
Item 10	.49
Item 11	.57
Item 12	.68
Item 13	.55
Item 14	.32

The standardized solution of the final model and correlations are presented in Figure 1 and Table 3. Results showed that the original two-factor solution, with nine items comprising the working memory subscale and five items comprising the inhibition, could be confirmed. The mean value for the adults with ASD included in the present study was 4.28 (SD = .88) for the working memory subscale and 3.85 (SD = 1.07) for the inhibition subscale.

Convergent validity

The convergent validity of ADEXI was demonstrated through its correlation of that and its subscales with the DEX scale. The results showed positive and significant correlations between the DEX and both the ADEXI working memory subscale (r = .69, p < .001) and the ADEXI inhibition subscale (r = .39, p < .001).

Reliability analyses

The internal consistency was within the range of what is normally considered as good for the subscale working memory (α = .88). The internal consistency was somewhat lower, but still acceptable for the inhibition subscale (α = .72). Omega scores were also adequate, .92 for the working memory scale and .87 for the inhibition scale. Guttman's split-half coefficient was .90, which indicated good reliability.

Discussion

The aim of the present study was to investigate the psychometric properties of the Spanish other-report version of the ADEXI, a new questionnaire that specifically targets deficits in working memory and in inhibition. In addition to introducing the Spanish version, the present study adds new valuable information by investigating the psychometric properties in adults with ADS and by including the other-report version of the ADEXI rather than the self-report version investigated in previous studies.

The results of the CFA showed that the ADEXI should be considered as a valid instrument for the evaluation of executive functioning in our study population, with two clear factors emerging. However, some minor changes were made to the original model (Holst & Thorell, 2018) as five errors were allowed to correlate, improving the fit of the model while maintaining the original factorial structure. The errors in items 1 and 11 seem to be associated, since the response to the first is conditioned on many occasions by the answer to item 11. Similarly, the response tendency in items 11 and 12 is similar. These 3 items are related to working memory linked to verbal instructions. In the same way, the answers given to items 8 and 12 are related to the same capacity, since they involve remembering the steps that make up a task. The answers to questions 9 and 13, which refer to planning capacity, could also be conditioned as in previous cases. Finally, items 7 and 10 allude to the exaltation of the state of mind and the difficulties of emotional and

Table 3. Model fit of models 1 and 2 estimated in the CFA

	χ^2	DF	CMIN	CFI	TLI	RMSEA
Model 1	193.25	76	2.54	0.87	0.87	0.11
Model 2	127.62	71	1.79	0.94	0.92	0.08

Note: DF = degrees of freedom; CMIN = χ^2/DF; CFI = comparative fit index; TLI = Tucker-Lewis Index: RMSEA = root mean square error of approximation.
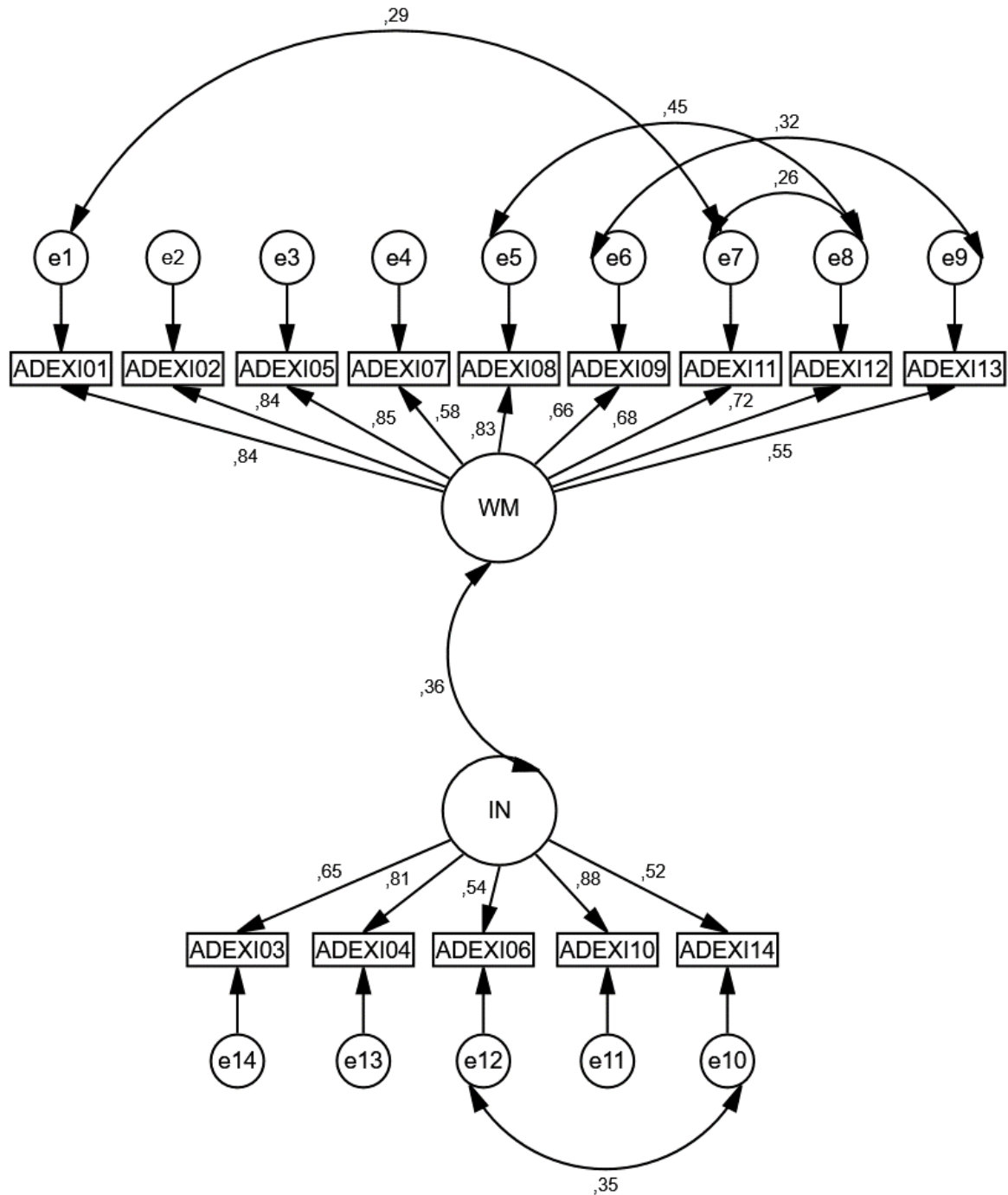
Figure 1. Confirmatory factorial analysis (CFA). The standardized solution of the final model and correlations derived from the CFA showing two factors: working memory (WM) and inhibition (IN)

behavioral control of the people evaluated. The indicated residual errors seem to conceptually share a certain level of variability, obtaining similar responses in them.

At a more general level, these results indicate that inhibition and working memory are two main constructs that are distinguishable within the domain of executive functioning in adults with ASD, and this is consistent with previous research on adult ADHD (Holst & Thorell, 2018; Thorell et al., 2017). This indicates that the ADEXI could be a valuable tool for use with adults with ASD as previous studies have identified inhibition and working memory as being related to ASD (Demetriou

et al., 2018), and it has also been demonstrated that EF deficits in ASD have negative impact on several aspects of daily life functioning (Vogan et al., 2018).

With regard to convergent validity, the results of the present study showed that the two ADEXI subscales were significantly correlated with the DEX, with a high correlation being found for the working memory subscale (.69), but a substantially lower correlation for the inhibition subscale (.39). It is difficult to know what conclusions to draw based on this finding, especially as the DEX does not have separate subscales for inhibition and working memory. However, maybe these results can be explained by the fact that the DEX (Burgess et al., 1996) includes items with a somewhat stronger emphasis on memory and planning and only a few items related to inhibition such as acting without thinking and inability to stop an action.

Regarding internal consistency, the results of the present study showed satisfactory reliability for other-reports in an ASD population for the global scale (α = .89) was well as the two subscales of inhibition (α = .72) and working memory (α = .88). These data are very similar to those obtained by Holst and Thorell (2018), where the internal consistency for self-reports in a clinical population of individuals of ADHD was .89 for the working memory subscale and .73 for the inhibition subscale. The possible reason for why the internal consistency has consistently been shown to be lower for inhibition compared to working memory, could be that the inhibition subscale only includes five items and both cognitive inhibitory control (e.g. »I have a tendency to do things without first thinking about what could happen») and more emotionally-based inhibitory control (e.g., «I sometimes have difficulty refraining from smiling or laughing in situations where it is inappropriate») is included.

The sample used in this study does not quite reach the size normally recommended for confirmatory factor analysis. However, the population for which this instrument has been adapted is of limited access due to its clinical characteristics. Previous research has revealed significant EF difficulties as well as severe negative social and behavioral consequences in the daily functioning in adults with ASD. For this reason, it is necessary to have ecologically valid instruments for this population, and we therefore believe that the results of the present study add valuable new information, regardless of the somewhat limited sample size.

It would be of value to conduct further studies using the ADEXI in adults with ASD and preferably include both non-clinical controls and adults with other psychiatric disorders. The mean values for the informant ratings of adults with ASD included in the present study where similar to those obtained for self-ratings in an adult sample of patients with ADHD with regard to inhibition but much higher (about 1 SD) for working memory (Holst & Thorell, 2018). However, this may be a result of the fact that the present study included patients with ASD and comorbid ID. This means that our sample is likely to have larger EF deficits compared to adults diagnosed with ASD recruited from the general population and this is an issue for future research to examine.

The main conclusion from the present study is that the informant rating of the ADEXI is a reliable and valid measure for the assessment of difficulties in working memory and inhibition in adults with ASD and Intellectual Disability. However, as previous research has shown that EF ratings and EF tests capture at least party different construct (Toplak, West, & Stanovich, 2013), we recommend that the ADEXI should best be used as a screening instrument or as complement rather than as a replacement to EF test.

Conflict of interest

The authors have no conflicts of interest to declare.

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Appendix A. Spanish ADEXI (other report version).

Inventario de Funcionamiento Ejecutivo para Adultos (ADEXI)
Versión hetero-informe

A continuación, va a encontrar una serie de afirmaciones. Lea, por favor, cada una de ellas detenidamente e indique luego hasta qué punto le describe a la persona. Indique su respuesta rodeando con un círculo uno de los números (de 1 a 5) que aparecen a continuación de cada afirmación. La gente que le conoce puede pensar de diferente manera acerca de usted; queremos saber lo que piensa de usted mismo. Intenta responder lo más honestamente posible.

Absolutamente incierto 1	No es cierto 2	Parcialmente cierto 3	Cierto 4	Muy cierto 5				
1. Tiene dificultades para recordar instrucciones largas				1	2	3	4	5
2. A veces tiene dificultades para recordar lo que está haciendo en medio de una actividad				1	2	3	4	5
3. Tiene tendencia a hacer cosas sin primero pensar en las consecuencias				1	2	3	4	5
4. A veces tiene dificultades para dejar de hacer algo, aunque alguien le diga que no está permitido				1	2	3	4	5
5. Cuando alguien le pide que haga varias cosas, a veces recuerda solo la primera o la última				1	2	3	4	5
6. A veces tiene dificultades para evitar sonreír o reírse en situaciones donde es inapropiado				1	2	3	4	5
7. Tiene dificultad para encontrar una forma diferente de resolver un problema cuando se bloquea				1	2	3	4	5
8. Cuando alguien le pide que busque algo, a veces se olvida de lo que esta buscando				1	2	3	4	5
9. Tiene dificultades para planificar una actividad (por ejemplo, recordar llevar todo lo necesario cuando va de viaje /a trabajar/ a la escuela)				1	2	3	4	5
10. A veces tiene dificultades para acabar una actividad que le gusta (por ejemplo, ver la televisión o sentarse frente al ordenador por la tarde, a pesar de que es hora de irse a la cama)				1	2	3	4	5
11. A veces tiene dificultades para entender instrucciones verbales a menos que también le muestren cómo hacerlo				1	2	3	4	5
12. Tiene dificultades con tareas o actividades que implican varios pasos				1	2	3	4	5
13. Tiene dificultades para pensar en el futuro o aprender de la experiencia				1	2	3	4	5
14. Parece actuar de manera más «alocada» en comparación con otras personas de su edad				1	2	3	4	5