Decision making in adults with autism: The role of ecological executive dysfunctions

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Abstract: Autism spectrum disorder (ASD) is characterized by presenting problems such as executive dysfunction and behavioral problems. Within the executive functions (EF) a warm area and a cold area can be differentiated; the latter is the most studied, although recent research points to a primary deficit in warm EFs or decision-making in ASD. In the present study, the symptomatology analyzed that accompanies ASD influencing «hot» EFs, or decision-making capacity. The sample consisted of 31 adults with intellectual disability and ASD, with an average mental age of 4.74. Hierarchical multiple regression analyses showed that the executive dysfunction, more specifically the mechanisms of inhibition (impulsive system), was a significant predictor of decision making by adults with ASD.

Keywords: Autism spectrum disorder; decision making; executive function; intellectual disability; adults

Toma de decisiones en adultos con autismo:
Papel de la disfunción ejecutiva desde una perspectiva ecológica

Resumen: El trastorno del espectro del autismo (TEA) se caracteriza por presentar problemas como disfunción ejecutiva y problemas de conducta. Dentro de las funciones ejecutivas (FE) se puede diferenciar el área cálida y el área fría; esta última es la más estudiada, aunque investigaciones recientes apuntan a un déficit primario en las FE cálidas o toma de decisiones en el TEA. En el presente estudio, se analiza la sintomatología que acompaña al TEA que influye en las FE cálidas, o capacidad de toma de decisiones. La población está formada por 31 adultos con discapacidad intelectual y TEA, con una edad mental media de 4.74. Los análisis de regresión múltiple mostraron que la disfunción ejecutiva, más específicamente los mecanismos de inhibición (sistema impulsivo), fue un predictor significativo de la toma de decisiones de los adultos con TEA.

Palabras clave: Trastorno del espectro del autismo; toma de decisiones; funciones ejecutivas; discapacidad intelectual; adultos

Introduction

The core symptoms of people with autism spectrum disorder (ASD) are deficits in social interaction, communication, flexibility and imagination (DSM-5; APA, 2013), along with health and behavioral problems that affect such important areas as learning or socio-emotional development (Blain, Peterman, & Park, 2017; Dominick, Davis, Lainhart, Tager-Flusberg, & Folstein, 2007; Hurtig et al., 2009; Pearson et al., 2006).

The social functioning of people with ASD is influenced by executive dysfunctions (Lai et al., 2017; Lawson et al., 2015; Rosenthal et al., 2013; Wallace et al., 2016). Recent research has found anomalies in

people with autism in the frontal lobe, and in particular, in the ventromedial circuit (Carper & Courchesne, 2000; Shafritz, Bregman, Ikuta, & Szeszko, 2015), which points to the existence of a dysfunction in the orbitofrontal cortex (Carlisi et al., 2017; Fujino et al., 2017). Zelazo and Müller (2002) argue that people with ASD primarily suffer from a deficit in the so-called «hot» executive functions, which are mainly linked to ventromedial prefrontal circuits. These hot executive functions are related to affectivity, motivation, and decision making. In individuals with ASD, dysfunctions in the so-called «cold» executive functions, which are associated with dorsolateral prefrontal circuits, are considered less dominant (Zelazo & Müller, 2002).

There is a significant influence of executive functions, both hot and cool, on the ability to make decisions (De Martino, Kumaran, Seymour, & Dolan, 2006; De Martino, Camerer, & Adolphs, 2010; Kahneman & Frederick, 2007; Robic et al., 2015; Schiebener & Brand, 2015a, 2015b; Schiebener & Brand, 2017; Zimmerman, Ownsworth, O´Donovan, Roberts & Gullo, 2016). In this context, Bechara (2005) uses the terms impulsive system and reflexive system, but the main idea is comparable: When subjects have to make decisions under uncertainty or risk, individuals are guided by an interaction between the impulsive/affective/hot and the reflexive/neutral/cold prefrontal system and associated basal ganglia structures.

Recent research reports on the relationship between atypical decision-making processes and social and behavioral deficits in people with ASD (De Martino, Harrison, Knafo, Bird, & Dolan, 2008; Mosner et al., 2017; Shah, Catmur, & Bird, 2016; South, Dana, White, & Crowley, 2011). Johnson, Yechiam, Murphy, Queller, and Stout (2006) and Vella et al. (2018) observed an adequate performance in intellectually able adults with ASD in decision making using the Iowa Gambling Task (Bechara, Damasio, Damasio, & Lee, 1999), but their decisions were slower (Vella et al., 2018) and guided to a lesser extent by motivation compared with the control group, showing an unusual procedure characterized by frequent shifts between decks, regardless of whether they are advantageous or disadvantageous (Johnson et al., 2006). Shah et al. (2016) also noticed a lesser influence of the emotions in decision making in people with ASD, measured using the financial decision-making task (De Martino et al., 2006), while alexithymia correlates significantly with decision making in the neurotypic population, in people with ASD this relationship does not exist. Other studies have found atypical responses during decision making using different tasks and questionnaires; Effort Expenditure for Rewards Task

(EEfRT) (Damiano, Aloi, Treadway, Bodfish & Dichter, 2012), economic task (Fujino et al., 2017), General Decision Making Style inventory (GDMS) (Luke, Clare, Ring, Redley, & Watson, 2012), Iowa Gambling Task (Mussey, Travers, Klinger, & Klinger, 2015) and Simplified Binary tasks (Yechiam, Arshavsky, Shamay-Tsoory, Yaniv, & Aharon, 2010). On the other hand, a slower learning curve was detected over the course of performing the Iowa Gambling Task (Mussey et al., 2015), while South et al. (2014) observed an adequate performance in those with autism between 8 and 16 years in this task.

There are some variables that are related to the capacity to make decisions in people with ASD, such as repetitive behaviors (Damiano et al., 2012; Minassian, Paulus, Lincoln, & Perry, 2007), theory of mind (Kouklari, Thompson, Monks, & Tsermentseli, 2017), executive dysfunction, and behavioral rigidity (Mussey et al., 2015). In recent years, the influence that different variables such as cognitive processes, personal attributes such as age, past experiences or environmental variables, have exerted on decision making (Fujino et al., 2019; Mueller, Schiebener, Stöckigt, & Brand, 2017; Schiebener & Brand, 2015a, 2017).

In the present study, we try to find out to what extent the symptoms and the problems that often accompany ASD influence decision-making capacity. Therefore, it is expected that the decision making of this group is influenced by: (i) the presence of self-destructive, stereotypic and aggressive behaviors, (ii) executive dysfunction, and (iii) the degree of social maturity measured in everyday life skills.

Method

Participants

The sample consisted of 31 adults with ASD and intellectual disability (ID) (Table 1). The participants were selected at a non-profit institution dedicated to the care of adults with autism in the Community of Madrid (Spain). All have been diagnosed by specialists in the evaluation of ASD, according to the diagnostic criteria of the American Psychiatric Association (DSM-IV; APA, 1994).

The only criterion for exclusion was that no participant was being treated with medications that could impair the performance of cognitive tasks (psychotropic or corticosteroid treatments). The selection of the sample was made with all the persons who fulfilled this criterion, except for a single participant in the study

Table 1. Demographic characteristics of participants.

	ASD with ID (n = 31)	
	M	*SD*
Chronological age	35.76	3.33
Nonverbal mental age	4.74	2.30
Intelligence Quotient (IQ)	36.46	17.69
VABS		
Socialization	39.03	25.32
Communication	51.03	29.11
Daily life skills	70.70	29.11

Note: ASD = Autism Spectrum Disorders; ID = Intellectual Disability; VABS = Vineland Adaptive Behavior Scales.

who is undergoing treatment with steroids because of allergies.

Informed consent was provided by the participants or their guardians and the ethics commission of the Nuevo Horizonte Association reviewed and approved this study.

Instruments

Self-destructive, stereotypic and aggressive behaviors were assessed using the Behavior Problem Inventory (BPI; Rojahn, Matson, Lott, Esbensen, & Smalls, 2001), executive dysfunction with the Dysexecutive Questionnaire (DEX; Burgess, Alderman, Wilson, Evans, & Emslie, 1996), and the degree of social maturity using the Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla, & Cicchetti, 1984). Finally, the Hungry Donkey Task (HDT; Crone & van der Molen, 2004), was used to evaluate the capacity to make decisions.

Behavior Problem Inventory (Rojahn et al., 2001). The Behavior Problem Inventory was composed of 49 items and was used to evaluate the self-injurious (14 items), stereotypic (24 items) and aggressive (11 items) behaviors. Each item is evaluated on a frequency scale with a range between 0 (never) and 4 (at all times), and on another scale of gravity between 0 (not a problem) and 3 (big problem). Only the behaviors occurring at least once in the last two months are scored. Cronbach's alpha obtained with our population showed an acceptable internal consistency (.77) (González et al., 2009). Validation in the Spanish population shows adequate psychometric characteristics, with a Cronbach's alpha of .85 (Vázquez-Morejón, Vázquez-Morejón, & Bellido Zanin, 2018). In the present study Cronbach´s alpha coefficient was .81.

Dysexecutive Questionnaire (Burgess et al., 1996). The executive alterations that appear in daily life were valued through the Dysexecutive Questionnaire. It is part of a broader battery that evaluates the dysexecutive syndrome, the Behavioral Assessment of the Dysexecutive Syndrome (BADS; Wilson, Alderman, Burgess, Emslie, & Evans, 1996). This questionnaire consists of 20 items that evaluate problems in abstract thinking, impulsivity, fable, planning problems, euphoria, temporal sequencing problems, lack of insight, apathy, disinhibition, difficulties in impulse control, superficial affective responses, aggression, lack of interest, perseverance, restlessness, lack of ability to inhibit responses, dissociation between knowledge and response, distraction, poor decision-making ability, and lack of interest in social rules. Each is scored on a 5-point scale arranged in a Likert format ranging from 0 (never) to 4 (very often), the maximum score is 80. The more points, the more likely you are to have executive dysfunction. The original factor analysis revealed the existence of five factors: inhibition, executive memory, intentionality, and two emotional factors called positive affect and negative affect (Burgess, Alderman, Evans, Emslie, & Wilson, 1998). Cronbach's alpha obtained with our population demonstrated an acceptable internal consistency of the test (.78). In adapting the questionnaire to the Spanish population (DEXSp), Cronbach's alpha of .87 was obtained (Pedrero-Pérez et al., 2011). In the present study Cronbach's alpha was .75.

Vineland Adaptive Behavior Scale (Sparrow et al., 1984). The Vineland Adaptive Behavior Scales scale values four areas of behavior: communication, everyday life skills, socialization, and motor skills. In this study, the scores are used in the subdomain of the skills of daily life. The skills of daily life section contains 3 subdomains: the subdomain «personal», with 19 items (such as meals, refreshments, hygiene assistance, toilet capacity, etc), the subdomain «household», with 13 items (such as cleaning the house, placing items, preparing food, using tools, etc.), and finally, the subdomain «community», with 15 items (home and street safety, orientation, etc.). The internal consistency of the questionnaire was measured through Cronbach's alpha, which turned out to be exceptional (.98) (Sparrow, Carter, & Cicchetti, 1993). Cronbach's alpha obtained in this study was .99.

Hungry Donkey Task (Crone & van der Molen, 2004). To assess the dependent variable, the Hungry Donkey Task was used, which is a computerized decision-making task that is based on the fundamental ideas of the Iowa Gambling Task (Bechara, Damasio, Damasio, & Anderson, 1994). The HDT consists of 200 slides where a donkey has to choose between 4 doors that make him win or lose «apples». As in the Iowa Gambling Task, gates A and B represent large short-term apple yields,

but unpredictable losses are also very high. On the other hand, gates C and D bring small gains in the short term, together with losses which are also small, so in the long run this choice is more advantageous. The main objective is for the donkey to collect as many apples as possible. The HDT is supposed to evaluate «hot» executive functions (Crone & Van derMolen, 2004), through decision making. The logical progress in the test is to give a greater selection of doors A and B in the first slides until one begins to notice the punishments associated with them. When this happens, learning occurs, making the most selected doors in the last slides doors C and D. As demonstrated by the Iowa Gambling Task, patients with ventromedial damage (Bechara et al., 1994) and other pathologies, such as psychopathy and substance abuse (Hulka et al., 2015; Lopes et al., 2017), do not achieve this learning and so do not follow this progress. These anomalous responses may be due to insensitivity to future consequences.

Leiter International Performance Scale (Leiter, 1948). The nonverbal mental age and Intellectual Quotient (IQ) of the participants was calculated using the Leiter application (Leiter, 1948). This test measures cognitive functioning through tests that do not require the use of language, either by the examiner or the person performing it. This test consists of 54 subtests, divided into three blocks. It shows satisfactory internal consistency with a reliability of .91 (Shah & Holmes, 1985; Sharp, 1958), and is very suitable for people with ID (Tsatsanis et al., 2003). In the present study Cronbach´s alpha coefficient was .80.

Procedure

Once the subjects were selected, and after having obtained informed consent from all legal guardians, the evaluation process was initiated. All tests were applied by a single examiner, individually and in quiet rooms.

For the application of these tests, the evaluators took into account the particular characteristics of the people with ASD. One of these characteristics is the difficulty in maintaining attention (Kamphaus, 2005), which can often be confused with a deficit in other skills. This population also tends to have little intrinsic motivation, so verbal reinforcement and other sources of extrinsic motivation are appropriate. Anxiety is another factor to consider, especially if the subjects do not understand what they are being asked to do (Lezak, Howieson, & Loring, 2004). Further of great importance in this population is the psychological state of the participant, who must be observed and reflected upon by the people who know him, before beginning the evaluation.

At the same time, certain recommendations have been followed, such as taking the necessary breaks, providing adequate feedback, and being especially attentive to signs of fatigue, since the participants do not usually communicate and have a special sensitivity to the surrounding environmental elements to maintain their attention (fragrances, temperature, light, sounds and visual stimuli) (Tylenda, Beckett, & Barrett, 2007).

Statistical analysis

Prior to analysis, data were examined. The residuals were normally distributed, and the assumption of homoscedasticity was met. None of the cases were identified as multivariate outliers, leaving all cases for the final analysis. Pearson product-moment correlation coefficients were calculated to evaluate the relationship between decision making, behavioral problems, executive dysfunction, and everyday life skills. Subsequently, with the objective of analyzing how a set of independent variables (self-destructive, stereotypic and aggressive behaviors, executive dysfunction and social maturity) contribute to and explain the changes that occur in the dependent variable (decision-making capacity) the multiple linear regression analysis was used. In the regression analysis, assumptions of collinearity were assessed through the evaluation of variance inflation factor (VIF) and tolerance statistics. Conservative cut-offs of VIF > 4 and tolerance < .20 were used, as described in Dormann et al., (2013) and Lavery, Acharya, Sivo and Xu (2017). Changes in multiple correlations squared (R^2 change) are reported to demonstrate the amount of variance explained by each variable. All statistical analyses were computed using SPSS Statistical Software Package, version 25 for Mac.

Results

The results in the Hungry Donkey Task can be seen in Table 2, which shows the net mean scores obtained during the development of the test; number of advantageous choices [A+B] minus number of disadvantageous choices [C+D]. It can be observed that there is no learning process since the scores are always below 0 and there is no improvement during the course of the task.

A correlation analysis was performed with the purpose of confirming and analyzing the relationship between the variables included in the study

The results of the correlation analysis (Table 3) show the existence of significant correlations between decision making and all independent variables: behavior

Table 2. Mean net scores and standard deviations obtained during the development of Hungry Donkey Task.

	ASD with ID ($n = 31$)	
	M	SD
Trials 1-20	−2.07	8.54
Trials 21-40	−1.84	8.66
Trials 41-60	−2.53	8.92
Trials 61-80	−1.84	8.87
Trials 81-100	−2.20	8.97
Trials 101-120	−2.30	9.22
Trials 121-140	−2.23	9.32
Trials 141-160	−2.69	9.24
Trials 161-180	−2.07	9.25
Trials 181-200	−2.46	9.26

Note: ASD = Autism Spectrum Disorders; ID = Intellectual Disability

Table 3. Pearson's Bivariate Correlation Analysis between decision making, behavioral problems, executive dysfunction, and everyday life skills.

	HDT	BPI	DEX	VABS
Decision Making (HDT)	–			
Behavioral Problems (BPI)	−0.36*	–		
Executive Dysfunction (DEX)	−0.58**	0.47**	–	
Everyday Life Skills (VABS)	0.40*	−0.32	−0.65**	–

Note: HDT = Hungry Donkey Task; BPI = Behavior Problem Inventory; DEX = Dysexecutive Questionaire; VABS = Vineland Adaptive Behavior Scales; *$p < .05$, **$p < .01$, ***$p < .001$.

problems ($r = -.36$, $p < .05$), executive dysfunction ($r = .58$; $p < .01$) and daily life skills ($r = .40$, $p < .05$).

Subsequently, a multiple regression analysis was performed, in which the capacity to make decisions was taken as the dependent variable. As independent variables, the self-destructive, stereotypic and aggressive behaviors, executive dysfunction and the degree of social maturity were measured through the skills of daily living. The results of the analysis can be seen in Table 4.

The results show that executive dysfunction, behavior problems, and skills of daily life, accounts for 31% of the dependent variable (R^2 corrected). The value of the partial regression coefficient typed β of the variable DEX (Dysexecutive Questionnaire) indicates that this contributes significantly to improve the fit of the model (β = -.65; $t = -2.87$; $p < .01$). On the other hand, daily life skills (β = -.18; $t = -.84$; $p > .05$) and behavioral problems (β = -.11; $t = -.68$; $p > .05$) were not statistically significant.

Discussion

The logical progress in the HDT is to give a greater selection of doors A and B in the first slides until one begins to see the punishment associated with them. Thus, learning occurs, making the most selected doors on the last slides to be C and D and, consequently, «win more apples» and have fewer losses. Specifically, in population without ventromedial damage, the selection of advantageous doors begins to be produced from the approximately 40 trials (Bechara, Damasio, & Damasio, 2000; Crone & van der Molen, 2004).

In the ASD population of the present study, this learning does not occur, so the losses remain the same throughout the task. The current findings support the view that individuals with ASD suffer from reductions in ventromedial prefrontal functioning (Damiano et al., 2012; De Martino et al., 2008; Fujino et al., 2017; Johnson et al., 2006; Luke et al., 2012; Mosner et al., 2017; Mussey et al., 2015; Shah et al., 2016; South et al., 2011; Yechiam et al., 2010).

Table 4. Hierarchical multiple regression analysis of the decision making predictors (Hungry Donkey Task)

Predictors	R^2	R^2 adjusted	β	B	F	tolerance	VIF
Model 1	.33	.31			$F_{(1,29)} = 14.72$**		
Executive Dysfunction (DEX)			−.65**	−6.09		.50	2
Behavioral Problems (BPI)			−.11	−.26		.77	1.2
Everyday Life Skills (VABS)			−.18	.23		.57	1.7

Note: BPI = Behavior Problem Inventory; DEX = Dysexecutive Questionaire; VABS = Vineland Adaptive Behavior Scales; VIF = variance inflation factor; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Despite the fact that the literature supports the existence of a close relationship between atypical decision-making processes and the social and behavioral deficits presented by people with ASD (Mosner et al., 2017; Shah et al., 2016; South et al., 2011), the results obtained do not allow us to confirm that the social and behavioral area is a good predictor of performance success in the tasks related to decision making.

Unlike in previous research (Damiano et al., 2012; Minassian et al., 2007; Mussey et al., 2015), the regression analysis showed that the self-destructive, stereotypic and aggressive behaviors assessed by the Behavior Problem Inventory (Rojahn et al., 2001) and the degree of social maturity using the Vineland Adaptive Behavior Scales (Sparrow et al., 1984), do not have predictive value for the variance in decision making, although statistically significant correlations between these variables were obtained. Some previous research that can explain these results are those that observe the influence of other personal variables in decision-making, such as age, past experiences, environmental variables (Fujino et al., 2019; Mueller et al., 2017; Schiebener & Brand, 2015a, 2017), and anxiety which can restrict the ability to think abstractly and disturb the normal patterns of autonomic arousal present in decision-making (Vella et al., 2018). In addition, the individuals with ASD have an increased tendency towards deliberation, attributable to impairment within intuitive reasoning systems (Brosnan, Lewton & Ashwin, 2016; Ashwin & Brosnan, 2019; De Martino et al., 2008). According to the Dual Process Theory (Evans & Frankish, 2009), the independent variables included in the regression analysis are linked to intuition processes and this could explain why they do not predict the processes of deliberate reasoning in the decision making tasks.

In contrast, the results confirm the hypothesis that executive dysfunction does significantly predict the ability to make decisions in people with ASD. These results are in line with previous research that observes an influence of executive dysfunction and social-emotional functioning on the ability to make decisions (De Martino et al., 2006; De Martino et al., 2010; Kahneman & Frederick, 2007; Robic et al., 2015; Schiebener & Brand, 2015a, 2015b; Schiebener & Brand, 2017; Zimmerman et al., 2016).

Through the results achieved in this research, a causal relationship between executive dysfunction, more specifically the mechanisms of inhibition (impulsive system), and decision making can be observed.

These results may have practical implications when structuring interventions. If we know the variables that influence decision-making, we can empower this ability through them.

Limitations and Future Research Direction

In this research, a number of limitations have emerged which are detailed below.

Some of the people evaluated had no verbal language. Certain tasks of the tests used in the study were not adapted to this characteristic, and attempts were made to adapt using sign language or pictograms. This problem suggests that some result obtained below the actual development of the person, due to a poor adaptation of the existing assessment instruments to the functional diversities that occurs in ASDs.

The number of participants may restrict the power to detect causal relationships between variables. This limitation, although it must be taken into account, is attenuated if we take into account that other studies have presented a sample size equal or even lower. On the other hand, the lack of a control group limits the possible interpretations of the research.

The results of the present investigation demonstrate the influence of some of the characteristic symptoms of ASDs in the decision making of these people. But more research is needed to investigate this relationship throughout the life cycle of people with ASD and to contemplate the heterogeneity of the disorder, taking as a sample people with different profiles, with and without intellectual disability.

Conflict of interest

The authors have no conflicts of interest to declare.

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