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A Correlational Study Between Executive Functions and Conditional Discriminations in Children with Autism

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ABSTRACT – Neuropsychology is a science that allows tracing the profile of cognitive impairments and preserved skills to design appropriate treatments and educational practices aiming at a better quality of life for the individual. This is basic correlational research, which objective was to verify if the results found in the executive functions in children with autism spectrum disorder (ASD) are predictive of or have some correlation with the performance in conditional discrimination through choice tasks according to the identity matching-to-sample (MTS) model. Correlations revealed significant associations between neuropsychological tests and MTS tasks. Future research may further explore MTS tasks for the assessment and intervention of individuals with ASD.

KEYWORDS: Autism Spectrum Disorder, executive functions, MTS

Um Estudo Correlacional Entre Funções Executivas e Discriminações Condicionais em Crianças com Autismo

RESUMO – A Neuropsicologia é uma ciência que permite traçar o perfil dos comprometimentos cognitivos e habilidades preservadas a fim de delinear tratamentos e práticas educativas adequadas, almejando melhor qualidade de vida do indivíduo. Trata-se de uma pesquisa básica correlacional, cujo objetivo foi verificar se os resultados encontrados nas funções executivas em crianças com Transtorno do Espectro do Autismo (TEA) são preditivas de ou tem alguma correlação com o desempenho em discriminação condicional por meio de tarefas de escolha de acordo com o modelo MTS de identidade. As correlações revelaram associações significativas entre os testes neuropsicológicos e as tarefas de MTS. Pesquisas futuras poderão explorar melhor as tarefas de MTS para avaliação e intervenção de indivíduos com TEA.

PALAVRAS-CHAVE: Transtorno do Espectro do Autismo, funções executivas, MTS

Autism Spectrum Disorder (ASD) refers to a Neurodevelopmental Disorder diagnosed in the presence of persistent deficits in social communication in multiple contexts accompanied by restricted interests and repetitive behaviors that can impair daily functioning. This disorder is called ASD due to the variety of severity of manifestations, developmental level, and chronological age (American Psychiatric Association [APA], 2014). Individuals with ASD may prefer repetitive tasks, routine, and invariance, as well as having problems in recognizing, representing, and expressing thoughts and emotions, which may be related to executive dysfunction (Girodo et al., 2008).

The etiology of ASD has been related to multifactorial conditions that arise when the individual is exposed to three types of events: a critical period in brain development, underlying vulnerability, and external stressors. Strong evidence has been detected through neuroimaging techniques indicating that neurostructural, functional, and connectivity alterations are associated with ASD, mainly related to alterations in the frontal lobe. The main alterations were found in the fiber bundles of the frontal lobe (uncinate fasciculus) and the communication of the frontal lobes (corpus callosum). They may be related to deficits in executive functions, social cognition, language, and repetitive behavior (Schwartzman, 2011).

Czermainski (2012) and Van den Bergh al. (2014) suggest that executive functions correspond to the cognitive area with greater impairment in people with ASD, however, there

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is no consensus in studies on which aspects of executive functions these individuals show greater impairments. Van den Bergh et al. (2014) identified deficits in the following areas of executive functions: 20% in planning and 51% in cognitive flexibility. No correlation was found between the degree of severity of ASD and daily executive functions. This can be explained by the fact that these results represent samples of some deficits in executive functions in a population with ASD with a normal to high level of intelligence. There was no relationship between autism severity and executive function domains. In the study by Jenifer et al. (2017), there was a significant association between executive functions and social communication, and restricted and repetitive behaviors in adolescents with ASD.

Czermainski (2012) compared performance on tasks involving executive functions and working memory in two groups of children and adolescents: a group diagnosed with ASD ($n = 11$) and a control group with typical development ($n = 19$). The results showed significantly lower scores in the ASD group on all executive functions and working memory tasks.

The results of Johnston et al. (2019) showed that adults with ASD had low scores in planning, generativity, and flexibility, leading to functional impairment in the behavioral, cognitive, and emotional domains. The authors highlighted executive functions as a relevant condition to be considered in ASD. Brígido et al. (2022) found a correlation between restricted and repetitive patterns of behavior, interests, activities, and executive functions.

Executive functions are the most complex mental processes of cognition. In phylogenetic terms, they reach their apex in the human species, and, considering their ontogenetic development, they reach maturity later compared to other cognitive functions. Its development begins in the first year of life, reaching intense development between six and eight years of age, and continues until late adolescence and early adulthood (Malloy-Diniz et al., 2008).

Executive functions refer to a system that manages cognitive-behavioral resources for the purpose of planning and regulating behavior (Corso et al., 2013). There is no single definition for executive functions. According to the structure suggested by Diamond (2013), executive functions are composed of three main skills: (i) working memory, (ii) inhibition or inhibitory control (including behavioral inhibition, selective attention, and cognitive inhibition), and (iii) cognitive flexibility. From these three main skills, other skills that are considered complex emerge, such as planning, reasoning, and problem-solving.

Working or working memory refers to the ability to manipulate information and it is the ability to hold information for a limited time while solving some problem, performing some activity, or updating some information. It allows the individual to integrate current information with others stored in long-term memory, remember sequences or orders of events, and project future actions (Diamond, 2013).

Inhibition or inhibitory control is the ability to control inappropriate behaviors, attentional processes, and thoughts. Controlling inappropriate behavior is known as response inhibition or self-control. Control of attentional processes refers to controlling the inhibition of attention to distractors or thoughts and is called interference control. As it inhibits attention to irrelevant stimuli, it includes the concept of selective attention (Diamond, 2013).

Cognitive flexibility involves inhibition and working memory and concerns the ability to consider different alternatives in the face of a problem situation. It makes it possible to deal with new situations without being tied to rigid or pre-established patterns of behavior. It is the ability to change attentional focus, priorities, or perspectives to adapt to the demands of the environment (Diamond, 2013; Seabra et al., 2014).

In short, there is a lot of evidence that individuals diagnosed with ASD have deficits in executive functions (Czermainski, 2012; Van den Bergh et al., 2014), which can, according to Naglieri et al. (2012), be conceptualized as efficiency in acquisition knowledge and how they solve problems in ten areas, namely attention, emotion, regulation, flexibility, inhibitory control, initiation, planning, organization, self-monitoring and working memory. Some of these skills such as visual working memory, selective attention, and cognitive flexibility are of interest to this study and will be defined in functional terms according to the Behavior Analysis view. Behavior Analysis has as its object of study the interactions of the organism with its environment (Martin & Pear, 2017).

In the Analysis of Human Behavior, Rico et al. (2012) define selective attention as "an operant behavior that puts the organism in contact with a discriminative stimulus, thus enabling the behavior to occur in a discriminated way" (p. 45). Wixted (1998) defines memory as an operant behavior that "reflects the previous presentation of a stimulus (remembering) or the loss of a type of stimulus control (forgetting)" (p. 57). Along the same lines, Arantes et al. (2012, pp. 61-62) state that memory, like attention, "involves understanding the control relations between stimulus and environment that are selected through reinforcement", but that working memory involves "some relations between stimuli and responses that are selected at times before the emission of the present response", due to the individual's history of reinforcement.

The process by which we learn to emit a specific response in the presence of some stimuli and not in the presence of others is called stimulus discrimination (Martin & Pear, 2017). The procedure for teaching stimulus discrimination involves reinforcement of a response in the presence of a specific stimulus and extinction (not presenting the reinforcer) of that response in the presence of a different stimulus. Many essential tasks require discrimination skills such as reading, naming objects, following directions, following activity routines, greeting people, and self-care skills. These discrimination skills can also be seen in some tests that assess executive functions such as the Wisconsin Card Test and the Cancellation Test. Many individuals with ASD, especially those who also have an intellectual disability, have difficulty learning such discriminations (Martin & Pear, 2017).

A specific type of discrimination is called conditional discrimination. Michael (2004) defined conditional discrimination as a type of multiple control in which the nature or extent of operant control of a stimulus depends on other stimuli, conditional stimuli (a given stimulus alters the evocative effect of a second stimulus on the same antecedent event and they collectively evoke a single response). For example, when presenting a ball to the child and the instruction to pair this object with a corresponding picture presented simultaneously with other pictures, the child is only successful when the ball (conditional stimulus) alters the evocative effect of one of the pictures (discriminative stimulus). Specifically, the ball establishes the picture of the ball as a discriminative stimulus that evokes the selection response, which is then reinforced. According to Debert et al. (2006), the establishment of directly taught conditional relations and the emergence of novel ones has been the basis of studies on complex behavior, such as language.

Conditional discrimination can be installed through the matching-to-sample (MTS) procedure. In a typical MTS trial, a sample (or conditional) stimulus is presented first. Following an observation response to the sample (e.g., touching or pointing to the sample stimulus), two or more comparison stimuli are presented at distinct locations. For each sample stimulus, one comparison stimulus is arbitrarily designated as positive or discriminative for reinforcement (S+), while the other comparison stimuli presented simultaneously are negative (S-). However, these same S- stimuli are arbitrarily assigned positive with other sample stimuli in other trials. Following the participant's response to one of the comparison stimuli in a trial, programmed consequences are provided (Cummings & Saunders, 2019).

Special arrangements can be implemented in MTS procedures to test, for example, attention and memory. In this case, there are two types of trials called simultaneous MTS and delayed MTS (Cummings & Saunders, 2019). In simultaneous MTS, the sample stimulus remains present until the individual emits the selection response to one of the comparison stimuli. In delayed MTS, after the observation response, the sample stimulus is withdrawn, and the comparison stimuli are presented immediately with a delay of 0 s (short-term memory) or after a certain time interval (working memory). In the case of delayed MTS, it can be said that the individual must respond discriminately to the relations between a sample and comparison stimuli (selective attention) and respond under the control of the sample stimulus that is no longer present (working memory). In addition, verify if the previously reinforced responses and the relations selected by reinforcement are maintained throughout the trials (memory) or, if the unreinforced responses are no longer repeated (cognitive flexibility).

Vanotti et al. (2014) conducted a study to determine whether multiple sclerosis patients had difficulties in MTS tasks and in forming equivalent stimulus classes. The authors also assessed the potential relations between difficulties in these tasks and cognitive deficits. Twelve patients with multiple sclerosis with a mean age of 41 years and an undiagnosed control group with a mean age of 34 years participated. Patients were exposed to neuropsychological assessments to test attention, executive function, verbal memory, and language. Assessments include, for example, the Trail Making A and B (Spreen & Strauss, 1991) and the Wisconsin Card Sorting Test (Heaton et al., 1993/2005). The authors found a significant correlation between performance on MTS tasks and the indices found in neuropsychological assessments of executive functions and memory.

In this way, MTS procedures can represent an experimental model to verify individuals' performance in skills such as visual working memory, selective attention, and cognitive flexibility that are part of executive and cognitive functions. Therefore, the objective of this study was to verify if the results found in Wisconsin, Corsi's Cubes, Trail Test for Preschoolers, and Cancellation Test, in children with ASD, are predictive of or have some correlation with the performance of these children in conditional discrimination tasks.

METHOD

Participants

The research participants were 13 children with ASD, aged between 4 and 12 years, regularly enrolled in a Special Institution for students with ASD or a Regular School of Education. After approval by the Ethics Committee for Research on Human Beings and before the start of data collection, those responsible for the participants signed the Informed Consent Form.

Setting

The application was carried out individually in a room of the institution or school where the participant was enrolled, with the consent of the board of directors. The rooms, without much noise, had at least one table and two chairs and were used at times when no other activity was in progress.

Instruments

The following neuropsychological tests were used to assess executive functions: Wisconsin, Corsi's Cubes, Trail Test for Preschoolers, and the Attention Test for Cancellation. Although there is standardization for the application of these instruments, they will be described in detail according to some specific conditions for the target population of this study.

Wisconsin aims to assess cognitive flexibility. In this test, four sample cards are available in a fixed sequence. The participant receives a matching card, which must be associated with one of the sample cards, according to one of the following criteria, which he chooses: shape, color, or number. With each trial, a new pairing card is presented. It's possible that the participant is not able to associate with any of these categories. No prompts are given. After the association, the researcher informed whether the association was correct, with verbal praise or not, and a new card was presented.

The test started with the color category, after the participant successfully managed 10 uninterrupted cards in this category, he moved to the form category, then the number. The other analysis criterion required for assessment is that the participant gets to manage 128 cards. There is no time limit for completing the task. Once a response receives praise, the participant must continue to respond under the control of the same characteristic (e.g., color) until a given response does not receive the praise; at that moment, the participant must start to respond, in the next trial, under the control of another characteristic (for example, number or shape); and so on, until the last pairing card is presented.

The Corsi's Cubes test assesses, in the direct order, immediate short-term memory and, in the reverse order, the visual working memory through the sequencing and manipulation of visual or visual-spatial information (Abreu & Mattos, 2010). This test consists of a wooden rectangle with nine blue blocks. Facing the applicator, these blocks are numbered from 1 to 9. Facing the participant, these blocks are similar without identification. The applicator obtains a fixed sequence of random digits. The researcher started the test by instructing the participant that she (the researcher) was going to touch a block and that he (the participant) should do the same. Then, she would give an example with a digit, hitting a single block, and ask the child to do the same. If the participant did the same, the researcher continued with a two-digit example, hitting two blocks in a row. The explanation was provided twice if necessary for one digit and two digits. If, even so, the participant did not understand, the task proceeded to the next test. If he had understood, he would begin with the fixed sequence elaborated by the test. There was no time limit for completing the task. The test is interrupted when the participant obtains zero points in the two trials of the same item. The same rule is stipulated for the forward and reverse order. The only difference is that the numbers in the table followed by the applicator are inverted by the applicator during application.

In general, to facilitate the understanding of what should be done, the test was explained in the following steps: (i) the researcher gave the command with her voice and exemplified with her hand "I'm going to hit this one (hitting only one block). Now it's your turn. Do the same". Then, the applicator took the participant's hand to perform together and repeated "The same"; (ii) the command was repeated and the participant was expected to do it without help; (iii) if the participant was unable to do it, she would take his hand again to complete the activity, according to his rhythm and attention; (iv) as soon as the participant responded correctly, the applicator hit a block followed by another giving the same verbal command; (v) if the participant did not get it right, she repeated the application with another example of two blocks holding the child's hand; (vi) then, she repeated the entire process asking the participant to do it without help; (vii) if the participant got it right, the application stipulated by the test began.

The Trail Tests A and B for Preschoolers is an instrument used to assess cognitive flexibility and does not require the participant to know about numerical and alphabetical orders, as the stimuli are presented in the form of pictures of puppies and bones that must be linked in size order (Trevisan & Pereira, 2012). Task fulfillment requires visual perception and attention skills, visual-motor speed and screening, sustained attention, and processing speed. In Trail A, it is explained to the participant about the size order of the dogs with the demonstration of an illustrative picture, and an example is provided. In Trail B, it is explained to the participant about the order of the dogs with their respective bones through an illustrative picture, and an example is also offered so that they can be carried out together, researcher and participant. Then, with the response sheet (pictures without the dashed line), the participant is asked to do it alone.

Instructions and applications were customized according to the understanding and needs of each participant; thus, with some, it was not possible to use the timer during the application, which is why it was decided not to use the time to perform the task with all participants. The explanation started with the presentation of a picture with the different sizes of dogs and the applicator said: "Look at the puppies, they have different sizes, there are little ones that grow until they get big". In general, the child gave feedback on the presentation by responding uniquely. For example, one of them said: "little dog ate, grew up" pointing to the bigger dog. And he repeated this with the other dogs until he reached the biggest one. Based on the feedback offered by the participant that he understood the size order, the researcher continued to explain the test, asking him to connect the pictures by drawing a line with a pencil.

The B Trails explanation was more complex. It was first explained that every dog had a bone the size it would be able to eat; therefore, the participant was asked to point the dog at its respective bone with a finger. This was done twice to confirm if the participant could understand that each dog had its respective bone. Then, the sheet instructing the child to connect the smaller puppy to its little bone, and then connect the larger dog, and so on was presented. Finally, he was asked to complete the task with a pencil.

The Attention Test for Cancellation involves selective attention, the ability to maintain and sustain selective attention, and the ability to switch attentional focus by replacing the target stimulus of attention with another. Initially, the preparation sheet was presented and, in general, the researcher presented the sample picture(s) and asked, "Where is another one like this?" If the participant did not show another similar one, the applicator took the participant's hand and pointed to the same pictures. Then, the question was repeated for the participant to respond on his own. If the participant got it right, he received the pencil and the following instruction was given "Now mark the similar one". If the participant responded positively to the training, the test application sheet was offered, and the following instruction was given "Where is another one like this? Mark the similar one". It was expected that the participant circled or crossed out the images contained along the response sheet according to a picture presented at the top or left.

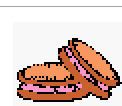
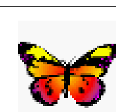
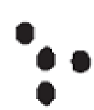
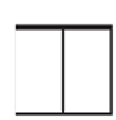
Then another sheet was offered, and the participant was asked to do it alone. Finally, the test was presented and consisted of three parts. In the first part, the target picture was indicated at the top of the sheet and the participant had to search for only one geometric picture among the pictures. The second part had a greater degree of difficulty, and the target stimulus was composed of two pictures. The participant had to search among the pictures for the pair of pictures indicated at the top of the sheet. In the third part, each line was initiated by a different target stimulus indicated on the left part of the sheet. A maximum time of 60 seconds was offered for each part of the test.

A portable microcomputer and the MestreLibras computer software (Elias & Goyos, 2010) were also used to present the MTS trials. This software presents stimuli, records responses, and response latencies on each trial, and provides differential consequences for correct and incorrect responses. Research participants did not need to know how to handle the mouse, since the researcher controls the program, and the participant can respond by touching the touch screen with the hand or fingers.

Each MTS trial started with the presentation of a sample stimulus centered on the upper half of the computer monitor. As soon as the participant emitted an observation response to the sample, the program removed the sample stimulus and presented three comparison stimuli in the lower half of the screen, after a certain interval. The selection of one of the comparison stimuli was identified by touching the stimulus with the hand or fingers. The selection of the comparison identical to the sample (identity MTS) produced an animation shown on the computer screen; other selections produced a black screen on the monitor. Simultaneous identity MTS trials with a delay of 2 and 6 seconds were presented. The stimuli used in the MTS trials are shown in Table 1.

In the simultaneous MTS, in which the relations A1A1, A2A2, and A3A3 were tested in one block and B1B1, B2B2, and B3B3 in another block, the comparison stimuli were presented immediately after the participant touched the sample stimulus. In the 2-second delay MTS, in which the C1C1, C2C2, and C3C3 relations were tested, the comparison stimuli were presented 2 seconds after the participant touched the sample. In the 6-second delay MTS, in which the D1D1, D2D2, and D3D3 relations were tested, the comparison stimuli were presented 6 seconds after the participant touched the sample. In a trial block, each sample was presented the same number of times, randomly distributed, for each position of the correct comparison. Correct comparison stimuli were not presented in the same position for more than two consecutive trials, and no sample stimulus was repeated for more than two consecutive trials. Each MTS block consisted of nine trials, and each relation was presented three times.

Table 1
Experimental Stimuli Used in MTS Tasks, Divided Into Four Sets

Sets	**1**	**2**	**3**
A			
B			
C			
D			

Procedures

Data collection started with the application, in sequence, of the Corsi's Cubes tests, Trail Test for Preschoolers, Attention Test for Cancellation, and Wisconsin. Each assessment took place in one or two meetings of a maximum of one hour each. From each assessment, an individual report was prepared with the results of each test.

Next, the participant was exposed to simultaneous and delayed computerized MTS tasks. The sequence was: (i) simultaneous identity MTS with stimuli A1, A2, and A3; (ii) simultaneous identity MTS with stimuli B1, B2, and B3; (iii) 2-second delay identity MTS with stimuli C1, C2, and C3; and (iv) 6-second delay identity MTS with stimuli D1, D2, and D3. Regardless of the number of correct responses, the participant went through all the tasks unless he refused to do them.

After applying the tests and MTS tasks, the Spearman Correlation Coefficient was used to calculate the correlations between the tests and the tasks through the Statistical Package for the Social Science (SPSS).

RESULTS

Table 2 presents the results obtained by the participants in the neuropsychological tests.

The Spearman correlation coefficient between age and the classification obtained in the neuropsychological tests was very low, with coefficients ranging from $\rho = 0.197$ to $\rho = 0.318$, with some younger participants obtaining a higher classification than older participants, with great variability over the ages.

The data obtained in the Corsi's Cubes test allowed us to observe that 61.6% of the participants understood what was to be done and reached the seventh phase; 15.4% understood what was to be done with a block but were not successful in the sixth phase; 23% could not understand what was to be done even with just one block, as they were not successful in the second phase. All participants were classified as underperforming. No participant was able to perform the reverse order and participants A and B did not respond to the test (no correct responses).

In the Trail Test, two participants (A and B) did not understand the explanation. The other 11 participants (77%) demonstrated that they understood the explanation, but participants D, E, and I did not score on Trails A, and participants F and I did not score on Trails B. It was possible to observe that participants' performance ranged from very low to very high in cognitive flexibility capacity. Considering the total result, A, B, D, and I showed very low performance; F and L showed low performance; C, J, K, and M were medium; E and H achieved high performance and G achieved very high performance.

In the Attention Test for Cancellation, only A and B did not understand the instructions. Although some participants obtained ratings that ranged from very low to high depending on the part of the test (for example, participant M performed high in the first part, low in the second part, and very low in the third part), the final result indicated that participants F, I, J, K and L had very low total performance, C, E, G, H, and M had low total performance and D had a medium total performance.

Regarding language, the results presented in the tests indicated that the participants who did not respond to the tests were non-vocal children. Of those who responded to the tests, only one was not vocal.

Table 2
Participants Results in Neuropsychological Tests

Participant	Age	Institution	Wisconsin	Corsi cubes		Trails test		Attention
			Perseverative Responses	Direct Order	Inverse Order	Part A	Part B	
A	4y 8m	Regular	0	0	0	0	0	0
B	5y	Regular	0	0	0	0	0	0
C	5y 9m	Regular	6	3	0	3	5	20
D	6y	Special	13	3	0	0	3	37
E	8y 5m	Special	110	6	0	0	12	16
F	8y 6m	Special	4	0	0	4	0	10
G	8y 6m	Regular	67	1	0	8	18	27
H	9y 10m	Regular	63	4	0	2	14	40
I	10y	Special	0	0	0	0	0	5
J	10y 7m	Special	1	2	0	3	2	10
K	10y 8m	Special	70	0	0	5	3	12
L	11y	Regular	60	0	0	3	2	21
M	12y 11m	Regular	36	6	0	8	8	60

The scores of the MTS tasks were assessed and correlated into three types: if the participant responds under the control of a stimulus that is no longer present (working memory), if the participant responds under the control of a correct stimulus (selective attention) and if there was a change in unreinforced responses (cognitive flexibility). Figure 1 presents the results obtained by each participant in the different tasks.

In general, the participants obtained better results in the simultaneous MTS tasks, with six and seven of the 13 participants achieving 100% correct answers for the trials with stimuli from Set A and Set B, respectively. In the 2s-delay MTS tasks, only three participants obtained 100% of the correct responses and no participant obtained 100% of the correct responses in the 6s-delay MTS.

Table 3 presents the correlation coefficients between the MTS tasks and the neuropsychological tests.

The correlation coefficient between the results in the Corsi's Cubes Test and the MTS tasks with delay was ρ = 0.380 for the 2s-delay and ρ = 0.457 for the 6s-delay, indicating a moderate correlation. Still, within this correlation, of the seven participants who obtained a score greater than zero in the Corsi's Cubes Test, four obtained results between 89% and 100% of correct responses in the 2s-delay MTS tasks, and one participant obtained 89% of correct responses in the 6s-delay MTS task. On the other hand, of the six participants who did not score in the Corsi's Cubes Test, two obtained 0% of correct responses in the 2s-delay MTS, and four participants obtained between 0% and 44% in the 6s-delay MTS.

The correlation coefficients between the Wisconsin score for perseverative responses and the results obtained in the MTS tasks ranged from ρ = 0.615 (high) for set D (6s delay) to ρ = 0.860 (very high) for set C (2s delay). For the other sets, ρ = 0.714 were found for set A and ρ = 0.711 for set B, both classified as high correlation. Therefore, it can be inferred that there is a significant correlation between the Wisconsin Test score for perseverative responses and the ability to respond to the identity MTS with and without delay. The six participants who scored at least 36 points in the perseverative responses achieved almost error-free performance (one or no errors) on the simultaneous and 2s-delay MTS. Of these six participants, four made only two errors and one made three errors in the 6s-delay MTS; the other participant made five errors. On the other hand, participants who scored between 0 and 6 in the perseverative responses had fewer correct responses in the MTS tasks. An exception was Participant D, who scored 13 points in the perseverative responses and correctly responded to all trials in the simultaneous MTS and made only two errors in the 2s-delay MTS and one error in the 6s-delay MTS.

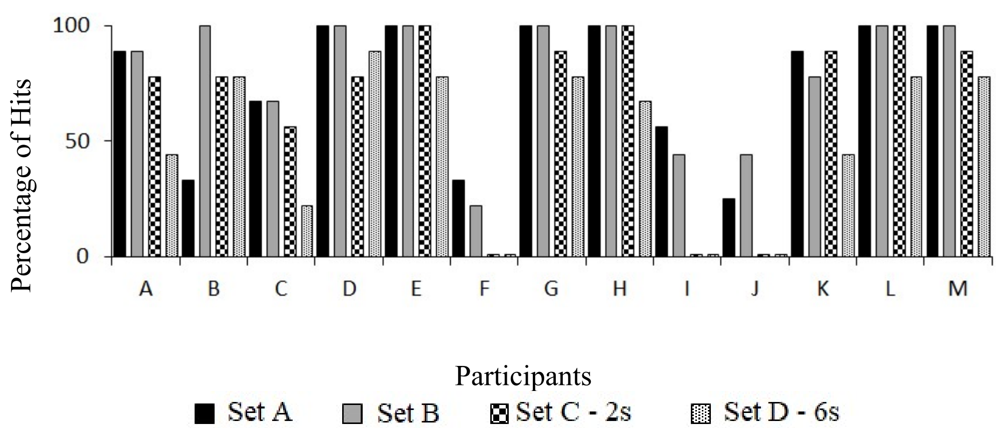


Figure 1. Participants Results in the Identity MTS Tasks
Note. Participants are listed in ascending order of age.

Table 3
Correlation Coefficients Between MTS Tasks and Neuropsychological Tests

	Corsi	Wisconsin	Trails A	Trails B	Cancellation
MTS Set A	ρ = 0.484 (Moderate)	ρ = 0.714 (High)	ρ = 0.114 (None)	ρ = 0.710 (High)	ρ = 0.780 (High)
MTS Set B	ρ = 0.539 (Moderate)	ρ = 0.711 (High)	ρ = -0.090 (None)	ρ = 0.541 (Moderate)	ρ = 0.553 (Moderate)
MTS Set C	ρ = 0.380 (Moderate)	ρ = 0.860 (Very high)	ρ = 0.111 (none)	ρ = 0.637 (High)	ρ = 0.563 (Moderate)
MTS Set D	ρ = 0.457 (Moderate)	ρ = 0.615 (High)	ρ = -0.088 (none)	ρ = 0.443 (Moderate)	ρ = 0.527 (Moderate)

The correlation coefficients between the Trails Test and the MTS were different for Trails A, in which the participant had to link only one type of image based on size, from smallest to largest, and for Trails B, in which the participant should link two types of pictures, also based on size. For Trails A, the correlation coefficient ranged from $\rho = -0.088$ concerning the 6s-delay MTS to $\rho = 0.114$ concerning the simultaneous MTS with familiar stimuli, indicating that there was no significant correlation. However, for Trails B, the correlation coefficient ranged from $\rho = 0.443$ (moderate correlation) concerning the 6s-delay MTS to $\rho = 0.710$ (high correlation) concerning the simultaneous MTS with familiar stimuli, with $\rho = 0.541$ (moderate correlation) concerning the simultaneous MTS with abstract stimuli and $\rho = 0.637$ (high correlation) concerning the 2s-delay MTS, indicating that there was a significant correlation between these two tasks.

Finally, the performance on the Attention Test for Cancellation had a significant correlation to the MTS tasks. The data shows that participants who scored better on the attention test were those who scored better on MTS tasks. The correlation between attention and MTS ranged from $\rho = 0.527$ (6s-delay MTS) to $\rho = 0.780$ (simultaneous MTS with familiar stimuli), indicating a moderate to high correlation.

DISCUSSION

The fluctuation in the results of each participant in both the neuropsychological tests and the MTS tasks may be a function of the great variability in the characteristics and the level of needed support found in the individuals within the spectrum, and the maturation issues of these individuals may depend on more factors beyond the age group. It should be noted that the three youngest children were not vocal. According to the DSM-5, delayed speech corresponds to one of the diagnosis characteristics, usually observed at the school entrance, as it is often not noticed in the family environment (APA, 2014).

The results found in Wisconsin indicate that of the eleven participants who responded to the test, only four were able to meet one of the criteria required for analysis (going through all the cards). It is not yet possible to determine why individuals with ASD fail this test. However, most studies that report deficits in cognitive flexibility in individuals with ASD include the Wisconsin test as a neuropsychological measurement instrument (Geurts et al., 2009; Ozonoff & Jensen, 1999; Prior & Hoffmann, 1990). It is also not possible to state that the failure to complete the test is due to impairments associated with cognitive flexibility, as it refers to an instrument with application, correction, and analysis standards developed to examine the cognitive flexibility of typical people (Geurts et al., 2009). In general, it is an extensive test, tiring and difficult to apply, being more difficult to apply with people with ASD. However, it is noteworthy that given the scarcity of instruments aimed at the public with ASD, it was possible to apply to Wisconsin. However, there is great relevance of more assessments with this population for the construction of normative references with greater empirical validity.

In general, the results of this test indicated that all participants had high rates of perseverative responses that indicate a difficulty in cognitive flexibility and, therefore, impairment in executive functions. These data corroborate those found by Czermainski (2012), Johnston et al. (2019), and Van den Bergh et al. (2014) in which individuals with ASD showed deficits in executive functions. Perseverative responses are persistent responses to an incorrect stimulus feature, presenting difficulty in flexibility in changing the category (Heaton et al., 1993/2005). Individuals with ASD tend to have highly perseverative scores in their responses compared to the control group (Geurts et al., 2009). This difficulty in flexibility may have made it difficult to perform better on the attention test.

The results in the MTS tasks indicate that the nature of the stimulus, familiar or abstract, did not influence participants' performance in the simultaneous MTS tasks and allow us to infer that the lower performances in the delayed MTS tasks were a function of the delay itself and not of the nature of the stimuli (all abstract). The lower performances in the delayed MTS corroborate the results found in Corsi's Cubes Test which measures short-term memory and working memory, in which most participants scored between very low and medium. The correlation data between the Corsi's Cubes and the MTS tasks allow us to initially infer that the participants who obtained at least four points in the Corsi's Cubes Test were more likely to respond correctly in the delayed MTS tasks.

Correlation data between Wisconsin and MTS tasks suggest that participants continue to respond always in the same identity relations. The very high correlation in the 2s-delay MTS may have benefited from previous training in selecting one stimulus in the presence of another in the simultaneous MTS. The slightly lower correlation for set D, despite having shown a high correlation, may be related to attentional skill, since the delay was 6 seconds.

Participants who showed cognitive flexibility according to the results in the Trails Test B achieved better performance in the MTS tasks. Therefore, the data suggest that cognitive flexibility skill may be a necessary skill in performing identity MTS tasks.

These data with children with ASD replicate those found by Vanotti et al. (2014) with patients with multiple sclerosis in which there was a significant correlation between performance on MTS tasks and the indices found in neuropsychological assessments of executive functions and memory for the Trail B Test and Wisconsin. Despite being very different conditions, as Vanotti et al. (2014) report the difficulty of patients with multiple sclerosis in MTS tasks, Green (2001) states that people with autism may also have great difficulties in learning these tasks.

Finally, there was a correlation between attentional capacity and responding correctly in MTS tasks. When the target stimulus is a known picture there is a very high correlation. As well as in Set B, which may have had such a correlation due to previous training with known pictures. In training with a delay of 2 seconds and 6 seconds, there is a high correlation. Based on these data, it can be inferred that attention is a skill, probably, necessary for higher performance in MTS tasks.

Executive functions theory has been used in the study of restricted and repetitive behaviors of people with autism. Lopez et al. (2005) found a strong correlation between cognitive inflexibility and restricted and repetitive behaviors. This finding provides preliminary evidence that the tendency of perseverative outcomes is related to stereotyped behavior. The data from this study replicate the data found by Lopez et al. (2005) with younger individuals with ASD and corroborate the findings of Brígido et al. (2022) that show the correlation between restricted and repetitive patterns of behavior, interests, and activities, and executive functions.

The results of all applied tests confirm the different responses may be attributable to the variability of the spectrum pointed out by Verté et al. (2006) who used the Wisconsin Card Test to investigate whether executive functions can be differentiated between groups of children with Asperger's Syndrome, with High Functioning Autism, with Pervasive Developmental Disorder Not Otherwise Specified, and with typical development. They concluded that it is a disorder with great variability in characteristics and the level of support needed within a spectrum, but they indicated that from a general view of executive functions, it is possible to analyze more clearly whether specific disorders are associated with different executive function strength and weakness points. There is a need for clear criteria to make a more rigorous distinction between subgroups within the autistic spectrum. Furthermore, they added the need for validated tests for this population to reliably measure differences between these ASD classifications (Verté et al., 2006).

It is essential to highlight that all the tests used are not standardized for individuals with ASD. However, it should be noted that the tests were possible to apply. There is a need to consider the breadth of characteristics presented by the spectrum when applied to individuals with ASD for future studies aimed at standardization. Typical individuals, when instructed to perform the test, usually follow the given instruction, acting in a standard way. However, with individuals with ASD, this does not always happen, and there is a need to provide modified instructions as was done in the application of each test. For example, one of the children did not understand during the explanation in the Trail Test that the dog was changing in size. But when the researcher asked what was different about the dogs, he replied "The tail grew". Based on the size of the tail, the orientation for the test was given. Therefore, flexibility in the application instructions was essential, which demonstrates that the tests are feasible for application with this audience. It is relevant to highlight those non-vocal children performed worse in neuropsychological tests. Low performance on neuropsychological tests may have been a function of the size or format of the instruction, which is more evident for non-vocal participants.

The neuropsychological literature aimed at the public of ASD individuals shows that the reliability and validity of neuropsychological tests are far from ideal. To date, there is no standardization for the population with autism and there is a need for more exploratory studies in the area (Prior & Hoffmann, 1990).

Neuropsychological tests still do not provide a standard for the assessment of individuals with ASD. There is a need for new exploratory studies in the area that consider the variability of the spectrum in the validation and standardization of results, language, attentional capacity, and motivation. However, the great variability in the results, also influenced by the heterogeneous sample characteristics of the spectrum itself, commonly found in this population, can be considered an indication that these tests are sensitive to measure certain repertoires of children with ASD.

The data from the present study allow us to infer, in principle, that some initial skills, such as presenting cognitive flexibility and paying attention, represent relevant prerequisites for children with ASD to perform well in conditional identity discrimination tasks, which are often used as a prerequisite to responding arbitrary conditional discriminations and daily activities of these children, especially those assisted by the TEACCH method (Treatment and Education of Autistic and related Communication-handicapped Children).

Future research may explore whether training with multiple exemplars of identity MTS tasks would improve performance on neuropsychological tests. In this case, it is worth mentioning that part of the tests applied are similar to the identity MTS, as is the case of Wisconsin, in which the correct response is based on some physical similarity (such as the color or shapes on the cards), and the Attention Test for Cancellation, where the correct responses are also based on physical similarities (to mark images identical to the image presented as a sample).

In this way, computerized MTS tasks could benefit individuals with ASD in developing skills such as working memory, selective attention, and cognitive flexibility. Thus, in the century in which neurosciences gain strength and advance significantly, empirical expansion on the effectiveness of new alternatives that can contribute to special education becomes increasingly necessary, represented in the present work with the link of Neuropsychology and Behavior Analysis.

In general, for individuals with impairments in attentional capacity and executive functions, it is suggested to help them in the organization of materials, routine, and time management. It is also suggested to break the information into steps, avoid long instructions, and say one thing at a time so as not to overload the child's working memory.

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