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# Autism spectrum disorder and cognitive flexibility: A cognitive neuropsychological study

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*ABSTRACT.* La presente ricerca si propone di valutare la flessibilità cognitiva (CF), cioè la capacità di passare da un compito a un altro quando il nuovo compito non è familiare, tra i bambini con ASD rispetto a quelli con sviluppo tipico (TD). Il campione di ciascun gruppo era composto da 54 bambini di età compresa tra i 6 e i 12 anni. I risultati dello studio hanno indicato che i soggetti con ASD soffrono di problemi nella FC rispetto a quelli con TD, in quanto i bambini con ASD impiegano più tempo (risposta lenta) e commettono più errori (numero totale di errori) e tendono a commettere più errori di perseverazione (risposta ripetuta) rispetto a quelli con TD.

*SUMMARY. Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by persistent difficulties in social communication and social interaction, along with restricted and repetitive patterns of behaviours, activities and/or interests. These symptoms generally appear before early childhood. Cognitive flexibility (CF) is the ability to shift from one task to another, where the new task is unfamiliar and novel. CF was assessed in this study among children with ASD compared to typical development (TD). The sample for both groups consisted of children aged between 6-12 years, with each group comprising 54 children. This study employed three tests to evaluate CF, including the Trail Making Test (TMT), the Playing Cards Test (PCT), and the New Card Sorting Test (NCST). Results indicated that individuals with ASD suffer from impairments in CF compared to TD, as children with ASD take longer (slow response) and make more errors (the total number of errors) and tended to make more perseveration errors (repeat response) compared to TD. Our findings may explain many of the problems that these children suffer from, especially with regard to interaction, social communication, and stereotypical behavior, which deserves further research.*

**Keywords:** *Autism spectrum disorder, Executive functions, Cognitive flexibility, Typical development, Neurodevelopmental disorder*

# INTRODUCTION

Autism spectrum disorder (ASD) is characterized by deficits in social interaction and communication, in addition to stereotypical behaviors and restricted, repetitive interests. These symptoms typically appear in the early years of childhood (APA, 2013; Gerlach, 2003; WHO, 2019). ASD is considered one of the most important disorders studied by researchers, affecting males more than females. It is a neurodevelopmental disorder diagnosed through behavioral symptoms, such as communicative and interactive impairments, as well as restricted and repetitive interests (APA, 2013). Behavioral difficulties reported in autism spectrum disorder, such as resistance to change, inflexible thinking, repetitive language, and problems switching from activity to activity, and body movements, may appear to be indicators of impairment of cognitive flexibility (Smithson et al., 2013).

Cognitive flexibility (CF) is the ability to change behavioral and cognitive patterns to adapt to changes in the environment (Dennis & Vander Wal, 2010). This ability is often required in school environments especially in academic skills (Censabella, 2007). It is related to reading comprehension (Colé, Duncan, & Blaye, 2014), and mathematics skills (Purpura, Schmitt, & Ganley, 2017).

A study using functional magnetic resonance imaging revealed a set of brain regions responsible for CF, confirming that there is no single region responsible for CF, but rather it is distributed across several regions, such as the prefrontal cortex, anterior cingulate cortex, posterior parietal cortex and basal ganglia (Turk-Browne & Chun, 2008). Another study focusing on brain injuries investigating the neural basis of CF competencies found that the essential elements of CF are distributed across a network of brain regions that support specific abilities of human intelligence (Barbey, Colom, & Grafman, 2013). CF is associated with an extensive network of brain regions, primarily within the left hemisphere, including many brain regions such as the prefrontal cortex, left superior temporal lobe, left inferior and superior parietal cortex, and superior parietal cortex (Barbey, Colom & Grafman, 2013).

Among individuals with autism spectrum disorder, difficulty with executive functions (EF) in general, and impairments CF in particular, have been recorded (Garon, Smith, & Bryson, 2017). This makes it difficult for them to break away from repetitive behaviors and transition quickly and effectively from one task to another (Boyd, McBee, Holtzclaw, Baranek, & Bodfish, 2009). Series of experiments studies have investigated CF in individuals with ASD, beginning in the mid-1980s with the first experimental test of EF and CF conducted by Rumsey (1985). Subsequent studies have largely confirmed the impairment of CF in individuals with ASD, while a few others (despite their limited number) have acknowledged the absence of such impairments (Van Eylen et al., 2011). Some studies suggest that individuals with ASD who have deficits in CF struggle with social interaction (e.g., the inability to shift one's visual attention from the eyes to the mouth, a rigidity in applying social norms, inability to change social behavior or conversation subjects to adapt to shifting contextual needs, repetition of words and phrases), as well as limited and repetitive activities and behaviors, such as insistence on the same routine and rituals, and persistence in the same topics, movements, and activities (Geurts, Corbett, & Solomon, 2009).

Geurts and colleagues (2009) highlight that studies addressing CF in individuals with ASD can be characterized by two types of contradictions. The first contradiction is evident in the use of a specific measure; different results can be obtained from studies that utilize the same task. These inconsistencies could result from characteristics in participant like age, intelligence, and associated disorders. The second contradiction is the presence of discrepancies between measures. For example, the results of the *Wisconsin Card Sorting Test* (*WCST*) indicate deficits in CF among individuals with ASD, while studies using other CF tasks generally fail to detect these deficits (Geurts et al., 2009). According to some researchers, deficits in CF are persistent and associated with repetitive and restricted behaviors in ASD, although there are many inconsistent findings (Yerys et al., 2009). Other studies investigating CF in natural environments through the *Behavioral Assessment Inventory* of EF have shown that individuals with ASD experience difficulties and problems related to flexibility in daily life (Gioia, Isquith, Retzlaff, & Espy, 2002). However, contradictory results have been obtained from studies measuring CF in clinical or research settings (Van Eylen et al., 2011).

Researcher Rumsey (1985) conducted the first experimental test of EF in individuals with ASD, applying to the WCST, which measures CF abilities. According to this study, people with ASD exhibit deficits in CF, as detected by the same CF test. The study also confirmed that adults with ASD perform worse on the same test, committing more errors compared to the group of control (Rumsey, 1985). In

another study comparing the performance of children with ASD with average intelligence to a control group at the same intellectual level the researchers found that children with ASD made errors three times more frequently compared to children in the control group (Prior & Hoffman, 1990).

A group of researchers in Taiwan discovered significant difficulties in CF a sample of 26 Taiwanese children with ASD (Shu, Lung, Tien, & Chen, 2001). Children with ASD and those with developmental language disorders did not significantly differ in their attendance errors, suggesting that the tendency for attendance errors may be related to verbal skills (Liss et al., 2001). Another study examined the natural performance of persistence in individuals with ASD who have average intelligence (IQ of 70 or above according to intelligence tests). The same study observed lower rates of persistence in children with ASD through a computerized version of the WCST compared to the classic card version, which may reflect the reduced verbal and social task requirements (Ozonoff, 1995). Although some researchers did not find the same results in all individuals with ASD who possess average intelligence (Minshew & Rattan, 1992), poor performance may be related to the overall intellectual engagement level (general intelligence level), verbal ability, and task requirements (Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009). However, many studies have found difficulties in CF in individuals with ASD, and poor performance may be related to the overall intellectual engagement level (general intelligence level), verbal ability, and task requirements (Robinson et al., 2009)

A study investigated whether this deficiency in CF is related to ASD itself or to the intellectual disability (cognitive impairment) associated with it. The study concluded that although children with ASD were able to switch tasks accurately like the control group, their ability to self-regulate performance by using feedback to prevent superior responses was weak (Robinson et al., 2009). Research has indicated that people with ASD suffer from deficits in CF (Van Eylen et al., 2011). Another study used the WCST to assess CF in children with ASD. The study's findings showed that children with ASD performed worse on the test tasks than did TD children (Reed, Watts, & Truzoli, 2011). In a study on 31 children with ASD (25 males and 6 females) and 31 children from the control group, aged between 8 and 12 years, matched for age, intelligence quotient, and gender, an emotion switch task based on gender was performed. The researchers used a computer screen to display images of male and female faces, either angry or happy (reporting emotions or the gender). The researchers found that overall performance did not differ between the groups, but a subset of the ASD group had slow and inaccurate performance, with slow shifting from emotion to gender experiences. The environmental switching task did not present any challenges for children with ASD. Children with ASD did not show difficulties in the environmental switching task, but they faced difficulty in solving or disentangling the emotional task set, with shifting performance associated with the amount of repetitive behavior (De Vries & Geurts, 2012).

The purpose of the study was to determine CF in kids with ASD and how it related to variables such as age and gender. The study concluded that CF deficits were higher in females compared to males, and for age, the study found that younger children had greater deficits in CF compared to older children (Memari et al., 2013). This tudy aimed to compare children with ASD and typically developing children in inhibition and CF; this study used the WCST to assess CF and the STROOP test to assess inhibition. The study results concluded that CF and inhibition deficits were present in children with ASD compared to TD (Pooragha, Kafi, & Sotodeh, 2013). In a Japanese study investigating the relationship between the need for closure and CF in individuals with ASD, 28 individuals with ASD and 28 individuals from the control group were included, with ages ranging between 20 and 45 years. This study used the Japanese version of the CF Scale (CFS-j). The study concluded that the need for closure was lower in the group with ASD and had difficulty in decision-making flexibility compared to the control group (Fujino et al., 2013).

Based on the above, we conclude that the majority of the studies we have discussed indicate the presence of CF deficits in individuals with ASD. Most researchers have found clear evidence of these deficits in individuals suffering from ASD. However, not all results unanimously agree on this deficit, especially among individuals with a high level of intelligence. In our study, we will attempt to examine this relationship to either confirms or refutes this deficit in children with ASD compared to TD.

Thus, the research problem can be summarized as highlighting and determining the impact of ASD on CF and evaluating this ability by measuring and comparing it with TD of the same age. In other words, we will try to answer the following question: are there statistically significant differences between children with ASD and TD in terms of CF?

Based on this, the present study aims to evaluate the performance of CF in individuals with ASD and compare their performance in this task with a group of children without neurodevelopmental disorders of the same age.

# METHOD

## Participants

The autism spectrum disorder (ASD) group was composed of 54 children (42 boys and 12 girls), aged between 6 and 12 years and who are verbally. All of them were officially diagnosed with autism spectrum disorder (between mild and moderate, according to the scales they passed during diagnosis by specialists) by a group of specialists (child psychiatrist, pediatrician, neurologist etc.) according to DSM-IV-TR and DSM 5 criteria (APA, 2000; APA, 2013). We chose 35 samples from the Oumi Association for Autism Spectrum Disorder: they continue their studies in different schools in the city of M'diq. 10 samples from the Mirror Association for Autistic Children and those who are pursuing their studies in primary school (Omar Al-Khayyam School) in the Moroccan city of Fes, and 9 samples from the Sabah Association for Autistic Children those who are pursuing their studies in primary school attending (Imam Malik School) in the same city (Fes).

The typically developing children (TD) group comprised 54 children (42 boys and 12 girls), aged between 6 and 12 years. They all were selected based on not having any sensory, motor, or cognitive disorder that could affect their cognitive performance. A total of 19 students are studying at Shahid Mohammed Al-Zerqatouni Primary School in the city of Fes, and we selected the remaining 35 samples in different schools in the city of M'diq.

The total number of research samples is 108 (they all continue their studies within educational institutions in primary schools), with 54 samples diagnosed with ASD and 54 samples typically developing by any neurodevelopmental disorder. We will distribute these samples according to gender, although we are not interested in studying the gender variable in this study, just to clarify more about the sample selection. The study was approved by all parents.

Based on Table 1 by comparing the average performance between ASD ($n$ = 54) and children with TD ($n$ = 54) in CF tests, it is clear that children with ASD suffer from deficits in CF. This is evident in the TMT (A) and (B), which rely on time and determine the level of CF. The same tests also reveal that children with ASD performed on average for longer periods of time than those with TD, suggesting CF deficiencies. The PCT also reveals that the average completion time and number of errors committed by children with ASD in both parts of the test were higher compared to TD, indicating deficits in CF. As for the NCST, which shows the level of perseveration, the averages indicate that children with ASD tend to have more perseverative responses compared to neurotypical children, indicating deficits in CF.

## Measures

In this study, we utilized three neuropsychological tests to measure CF in individuals with ASD and typically developing children.

These tests are used to evaluate CF and include the following research tools.

– *New Card Sorting Test*. The New Card Sorting Test (NCST) measures cognitive flexibility ability, that was developed (Roy, Fournet, Roulin, & Le Gall, 2013). The researchers drew inspiration from Wisconsin Card Sorting Test (WCST) (Heaton,1981), Modified Wisconsin Card Sorting Test (MWCST) (Cianchetti, Corona, Foscoliano, Contu, & Sannio Fancello, 2007), and Modified Card Sorting Test (MCST).

  The NCST consists of 48 cards, in addition to four guiding cards, based on three criteria (color, number, shape). This test measures cognitive flexibility in children and adolescents between the ages of 6 and 16 years (Roy, Le Gall, Roulin, & Fournet, 2020). The reliability of this test has been investigated (Guerra, Hazin, Roulin, Le Gall, & Roy, 2021).

  The researcher faces the children (one by one) and places the NCST (one red triangle, two green stars, three yellow plus signs, four blue circles) in front of the children and gives all the instructions. Passing the test begins according to the approved procedures, and so on until the child reaches the last card given to him.

– *Playing Cards Test*. This test falls within the Behavioural Assessment of the Dysexecutive Syndrome in Children (test battery) (BADS; Wilson, Evans, Alderman, Burgess, & Emslie, 1996). PCT is a neuropsychological test that measures CF and consists of 21 cards with two parts (first

**Table 1** – Mean performance, minimum, maximum values, and standard deviations for children with ASD and TD

| | Group ASD ($n$ = 54) | | | | Group ASD ($n$ = 54) | | | |
|---|---|---|---|---|---|---|---|---|
| **Measure** | Minimum | Maximum | *M* | *SD* | Minimum | Maximum | *M* | *SD* |
| TMT (A) | .51 | 7.12 | 2.94 | 1.86 | .18 | 1.23 | .65 | .34 |
| TMT (B) | 1.22 | 8.47 | 4.92 | 2.17 | .52 | 3.17 | 2.08 | .77 |
| PCT completion time | 1.05 | 6.39 | 2.21 | 1.53 | .52 | 2.08 | 1.01 | .37 |
| Errors in part one of PCT | .00 | 7.00 | 1.36 | 2.19 | .00 | 1.00 | .05 | .22 |
| Errors in part two of PCT | .00 | 9.00 | 5.31 | 2.56 | .00 | 8.00 | 1.94 | 1.92 |
| NCST | 3 | 20 | 9.89 | 4.78 | .00 | 18 | 5.42 | 4.68 |

rule and second rule). In the first part, the individual is asked to respond Yes to a red card and No to a black card. The second part contains a different rule that the individual says Yes if the card is the same colors the one before it and No if the card is of a different color (Rozenblatt, 2018; Siu & Zhou, 2014).

– *Trail Making Test*. Trail Making Test (TMT) is neuropsychological test measures a range of abilities, including CF and visuomotor skills (Seron, & Van Der Linder, 2014). It consists of two parts, A and B (Czermainski, Riesgo, Guimarães, Fumagalli de Salles, & Bosa, 2014). In the first part (TMT-A) individuals draw lines to sequentially connect 25 numbers (from 1 to 25), and in the second part (TMT-B) where individuals similarly draw a sequential line, but must alternate between numbers (from 1 to 13) and letters (from A to L) (Bowie & Harvey, 2006; Reitan, 1958).

## Procedure

Approval was obtained from the associations to which children with autism spectrum disorder belong, and tests were passed within the schools in which they continue their studies or within the associations to which they belong (great cooperation from the Learning Support *Assistant*). Informed consent was also obtained from the parents of both ASD children and TD children.

Educational institutions (most notably the academy) have agreed to pass the tests to ordinary children who are continuing their studies in school.

All participants were tested individually in a room either at the school or the association. Before starting the neuropsychological assessment, the experimenter initially engaged the children in a conversation about general topics that interested them to establish rapport.

## Data analysis

We focused on presenting the data that we reached through the tests that we applied on the sample of children with ASD and TD children. First, we used descriptive statistics to calculate the minimum, average, and maximum values and cognitive deviation for the two groups in the variable number of errors, habituation response, and time period.

Independent *t*-tests to investigate statistical significances between the two groups. The duration of time, the number of

errors, and the perseverance response were calculated for the two samples.

It's important to point out that initially we note that high scores on neuropsychological tests do not always indicate high performance. When it comes to the number of errors, time, and perseverance responses, the situation may differ entirely. The higher the number of errors, time, or perseverance responses, the weaker the performance.

## Findings

By analyzing the data we obtained from the tests that included three variables, we reached a conclusion: which are the time, number of errors, and perseveration errors for both autism and typical development.

A *t*-test revealed that the ASD group presented a significantly higher reponse time than the TD group [Path TMT (A): T = −5.26, $p$ = .00; TMT (B): T = −5.36, $p$ = .00; PCT: T = −5.36, $p$ = .00]. Statistically significant differences were found (see Table 2).

In addition, children in the ASD group made significantly more errors than children in the TD group during stage [PCT (1): T = −5.36, $p$ = .01; PCT (2): T = −4.57, $p$ = .00]. Similar to time, Statistically significant differences were found (see Table 2 and Table 3)

The mean number of perseveration errors was higher for the ASD group than for the TD group (NCST: $p$ = .06, T = −2.91), but no significant group differences were found (see Table 3).

## DISCUSSION

The current study aimed to investigate the cognitive flexibility skills of autistic children of children with ASD and typically developing through the variables of time, number of errors, and perseveration errors, in order to evaluate the cognitive flexibility of the two groups, using three tests TMT (Bowie & Harvey, 2006; Reitan, 1958), PCT (Wilson et al., 1996) and NCST (Roy et al., 2020).

When comparing the performance of the ASD and the TD groups, the data revealed that children with ASD take longer (slow response) and make more errors (the total number of errors) and tended to make more perseveration errors (repeat response) compared to TD. This is consistent with our

**Table 2** – The average of children with ASD and TD through the TMT (A) and the TMT (B); the PCT variable related to time

| Sample | Sample size | *M* | *SD* | *t*-test | Significance level |
|---|---|---|---|---|---|
| Children with ASD sample TMT (A) | 54 | 2.94 | 1.86 | −5.26 | .00 |
| Neurotypical children sample TMT (A) | 54 | .65 | .34 | | |
| Children with ASD sample TMT (B) | 54 | 4.92 | 2.17 | −5.36 | .00 |
| Neurotypical children sample TMT (B) | 54 | 2.08 | .77 | | |
| Children with ASD sample PCT | 54 | 2.21 | 1.53 | −3.33 | .003 |
| Neurotypical children sample PCT | 54 | 1.01 | .37 | | |

**Table 3** – The average of children with ASD and TD through the PCT variable related to errors in the first part, the second part and the NCST

| Sample | Sample size | *M* | *SD* | *t*-test | Significance level |
|---|---|---|---|---|---|
| Children with ASD sample PCT first part | 54 | 1.36 | 2.19 | −2.60 | .01 |
| Neurotypical children sample PCT first part | 54 | .05 | .22 | | |
| Children with ASD sample PCT second part | 54 | 5.31 | 2.56 | −4.57 | .00 |
| Neurotypical children sample PCT second part | 54 | 1.94 | 1.92 | | |
| Children with ASD sample NCST | 54 | 9.89 | 4.78 | −2.91 | .06 |
| Neurotypical children sample NCST | 54 | 5.42 | 4.68 | | |

predictions and indicates cognitive flexibility impairments in children with ASD. Both groups understood the tasks instructions (in the three tests) and were equally able to learn rules from feedback.

ASD children were significantly slower than typically developing children, pointing to reduced cognitive flexibility skills for the autistic group (Andreou, Konstantopoulos, & Peristeri, 2022). Using the Trail Making Test (A) and a group of other tests, it was found that processing speed in autism spectrum disorder is characterized by a large and significant processing speed deficit (Haigh, Walsh, Mazefsky, Minshew, & Eack, 2018), suggesting that cognitive flexibility is a deficit in ASD.

Our study's results are consistent with Rumsey study (1985), which confirms that individuals with ASD make many more errors compared to the control group members when applying the WCST. This is what our study revealed through the PCT, where it was found that children with ASD make many errors in performing CF tasks compared to neurotypical children, confirming the existence of deficiencies at the level of CF. Our study also aligns with Prior and Hoffman's study (1990), which confirms that children with ASD commit errors three times more compared to the control group.

Similarly, the study by Van Eylen and colleagues (2011) is consistent with the results of this study, as indicates that individuals with ASD tend to make perseverative errors compared to children in the control group. This is what we found in our study through the NCST, showing that the number of perseverative errors committed by children with ASD is higher compared to TD. Individuals who had more parent-reported language deficits, education and lower level of intelligence, and more engagement in solitary instead of social daily activities or showed lower daily sleep time were more likely to demonstrate perseverative (Memari et al., 2013). In addition, the results are consistent of this research also agree with studies by Shu and colleagues (2001), Reed and colleagues (2011), Pooragha and colleagues (2013), which confirm the impaired performance of children with ASD in WCST compared to TD children. However, a range of studies have achieved different results. Our findings differ in all individuals with ASD who possess an average IQ (above 70) (Minshew & Rattan, 1992; Ozonoff, 1995).

This variation between studies may be due to a number

of factors. This difference may be due to a group of studies regard is that individuals with ASD are characterized by a large heterogeneity both in the ASD phenotype (Wing, 1997), and in neurocognitive characteristics (Van Eylen et al., 2011). In addition to age, a meta-analytic study showed a decrease in the number of perseverations (including both errors and answers) as age increases (Landry & Al-Taie, 2016).

Thus, it appears that the results of this research confirm the presence of clear deficiencies in CF among children with ASD compared to TD. These results also align with most previous studies on CF in individuals with ASD, which confirm the existence of deficiencies in CF. In summary, most studies addressing CF in children with ASD confirm the presence of deficiencies in CF, which is reflected in several areas, such as:

- social interaction, which is evident in the inflexibility in applying social rules, changing social behavior, and the inability to shift attention to a space outside of oneself;
- social communication, which appears through the inability to flexibly combine language elements, perseveration on a single specific meaning of words, weak flexibility in interpreting words in an alternative way, and inflexible use of language and perseveration on one type of activity;
- restricted and repetitive activities and behaviors, which are most common in individuals with ASD, manifesting through insistence on the same routine and rituals, perseveration on the same subject, movements, and activities. In addition, the impaired observational learning in daily classroom activities among children with ASD is related to deficiencies in CF. These children have difficulty transitioning from one learning task to another compared to neurotypical children, all of which result from impairments in EF in general and CF in particular.

This is confirmed by most studies addressing CF in individuals with ASD, which clearly reveal the presence of deficiencies in CF compared to neurotypical individuals. This makes this group suffer from difficulties in various fields (reading, writing, adaptive behavior, reasoning, calculation, etc.).

## CONCLUSION

In summary, the present study investigated cognitive flexibility in children with autism spectrum disorder compared to typical development by using three tests (TMT, PCT, NCST). We focused on measuring three variables: time (slow response), number of errors (the total number of errors), and perseveration errors (repeat response).

As predicted, individuals with ASD made more perseveration errors and they took a long time to complete the tasks and make more errors.

Findings indicate that individuals with ASD do have cognitive flexibility impairments. However, further research is needed to fully establish this claim.

**Ethical considerations:** Comply with ethical guidelines. The study was approved by the Regional Academy of Education and Training of the Fes-Meknes region, Fes Regional Directorate. Approval of the Shahid Muhammad al-Zarqtouni primary school in Fes. Approval from the Mirror Association for Autistic Children, and Oumi Association for Autism Spectrum Disorder, and Sabah Association for Autistic Children. The study was approved by all parents.

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