

## Comparing Response Inhibition and Flexibility for Two Components of Executive Functioning in Children with Autism Spectrum Disorder and Normal Children

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### Abstract

**Objective:** The aim of this study was investigating and comparing two components of executive functioning in children with high function autism with normal children.

**Methods:** this study was correlation descriptive (causal-comparative). There were two groups, one consisted of 15 participants of children with high function autism disorder (Intelligence quotient [IQ]>80) and the other consisted of 15 normal children, all age and education matched. They were compared with two neuro-cognitive tests, Color Word Stroop and Wisconsin Card Sorting, and one IQ test called Ravens Progressive Matrices test.

**Findings:** Analysis of data showed significant difference in both executive functionings, response inhibition (Stroop) and flexibility (Wisconsin Card Sorting) between normal children and children with autism disorder, but there was no significant relation between age and IQ and executive functioning in children with autism.

**Conclusion:** The results showed that children with autism disorder have deficits in executive functions regardless of their IQ level and it can be attributed to the symptoms of autism spectrum disorders.

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**Key Words:** Executive Function; Autism; Autism Spectrum Disorder; Flexibility

### Introduction

Autism spectrum disorder (ASD) is a developmental disorder characterized by impaired social interaction and communication as well as repetitive behaviors and restricted interests. It is a lifelong disorder and affects at least 0.6% of the population with males being affected three times more often than females<sup>[1,2]</sup>. Although cognition component is not one of the main criteria for diagnosis of autism but it has comorbidity with other disorders like mental

retardation, and there are evidences that individuals with autism disorder show patterns of weakness and strength in cognition abilities<sup>[3]</sup>. Results of neurobiological studies in autistic individuals indicated abnormal neurobiological processing in the frontal lobes which is related to deficits of executive functioning (EF)<sup>[4]</sup>. There is wide consensus among neuropsychologists that intact executive functions are central to optimal daily functioning; yet the precise definition of the construct remains elusive. Executive function is traditionally used as an umbrella term for

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functions such as planning, working memory, impulse control, inhibition and shifting set as well as the initiation and monitoring of action. These functions share the need to disengage from the immediate environment to guide actions. Executive functions are typically impaired in patients with acquired damage to the frontal lobes as well as in a range of neuro- developmental disorders that are likely to involve congenital deficits in the frontal lobes<sup>[4-6]</sup>.

'Inhibition' means a quick stop in the responses to the environment and it plays a main role in self-regulation. Results of the studies showed that children with autism have lower functions in the task of inhibition rather than normal children<sup>[7,8]</sup>.

Poor mental flexibility is illustrated by preservative, stereotyped behavior and difficulties in the regulation and modulation of motor acts. This indicates problems in the ability to shift to a different thought or action according to changes in a situation. One task in which poor mental flexibility has been shown in autism is the Wisconsin Card Sorting Task. On this and similar tasks, individuals with autism experience a difficulty in mental flexibility in relation to normally developing individuals and those with other neuro-developmental disorders<sup>[2,6]</sup>. In a research executive functioning of children with autism disorder was studied. Robinson et al examined 54 individuals with autism disorder and Intelligence quotient (IQ) higher than 70 compared with a homogeneous IQ and age control group in the task of planning, flexibility, response inhibition, production and self-monitoring functioning. The results showed significant impairments in response inhibition (Stroop) and planning components (Tower of London) in children with autism disorder<sup>[9]</sup>. In another study Blair et al examined 15 autistic patients with Stroop and Wisconsin Card Sorting tests. Results of Wisconsin Card Sorting test showed that the obtained score of only two individuals with autism disorder was below 50% and only one of them could not do the test in the time that they were given. Neither was there any significant difference between individuals' functions in color word Stroop test<sup>[10]</sup>. Some researches examined 18 children with autism disorder and 17 normal children and found that there was no significant difference between them in the case of executive functioning, but all studies showed that all

children with ASD had difficulties in beginning of activities, co-attention and behaviors which are related to social connections<sup>[11]</sup>.

In a review of the available evidence Osorio et al concluded that inhibition seems to be an important factor in intelligence in non-clinical samples<sup>[12]</sup>. Recent researches found an association between inhibitory control and intelligence in 9-, 12-, and 18-year-olds<sup>[13]</sup>. However, other researchers reported correlations between Wisconsin Card Sorting Test, a measure of flexibility, and adult IQ on the Wechsler adult intelligence scale (WAIS). Similar results were found in a sample of children aged 3-6 years, whose performance on a dimensional- change card sort task (with high demands in terms of flexibility) was strongly correlated with measures of intelligence<sup>[12,13]</sup>.

Contrasts in results that were obtained from examining executive functioning in children with ASD especially participants with cognitive deficits brings this hypothesis to mind that IQ plays a role in executive dysfunctions, so children with high function autism were examined in this study. To summarize, the purpose of the present work was twofold. First, we compared performance on tasks assessing inhibiting and flexibility between two groups: (a) a group of individuals with ASD aged 7-15 years and (b) a group of typically developing individuals matched by chronological age and education. Second, we aimed to explore the pattern of associations between the two types of EF and explore the pattern of associations among the two types of EF (inhibiting and flexibility) and intelligence and age in the two groups.

## Subjects and Methods

### Study design and subjects:

This research is correlation descriptive. Thirty samples (15 children with high function autism and 15 normal children) were non randomly selected from subjects who referred to Shafa Hospital in Rasht (North Iran) and children counseling clinics in 2012. The number of samples was limited because of small number of children with high function ASD, lack of information in educational system, parents' attempts to hide their

children's problems, finding children with autism between ages 7 to 15 who were able to read and write, IQ at least 90 for control group and 80 for children with high function autism and without any psychological diseases and impairments.

**Instruments:**

*Raven Progressive Matrices test:* This test is a nonverbal intelligence test which was prepared by an English psychologist J.C. Raven in 1938, and was revised in 1956. Reliability and factorial validity of Raven Progressive Matrices test was evaluated in 6529 samples of 8 to 15 year old Kuwaiti children. Test-retest ranged from 0.69 to 0.85 and Kronbach Alpha 0.88 to 0.93. Barahani examined and standardized Raven Progressive Matrices test in 3010 school children and teenagers aged 9 to 18 years in Tehran and result showed validity in the study<sup>[14]</sup>.

*Color Word Stroop test:* This is one of the most famous and applicable tests used for selective or intensive attention and response inhibition. The study consists of three steps. In the third step, the number of correct answers minus wrong answers (which was considered as the interference task) is computed<sup>[15]</sup>. Ghadiri and colleagues reported 0.97 retest validity coefficient for reaction time in third step and 0.79 for errors at the same step<sup>[16]</sup>.

*Wisconsin Card Sorting test:* Wisconsin Card Sorting test was provided and codified by Grant and Berg in 1984<sup>[17]</sup>. It examines complex variation, flexibility, problem solving, concept formation and the ability to dominate on tendency toward repetition and perseveration which is due to brain executive actions. It gives us some information about obtained categories, total error, perseveration error and other errors<sup>[18]</sup>. Naderi reported test-retest reliability was 0.85 among population of Iran<sup>[19]</sup>.

**Data analysis:**

SPSS, ver 17 software was used for data analysis. Descriptive statistical index was used for examining the mean and standard deviation of demographic variables and research components. Then, Independent t-test and post hoc Bonferroni were used for determining the significance of variables difference statistically in two groups and Spearman Correlation test for examining the relationship between components.

**Findings**

In this study it was not possible to homogenize sexes because of limitations in finding samples. One child with autism and two normal children were female and other participants were male. Mean and standard deviation of demographic variables, age and IQ score are shown in Table 1. Mean IQ and age in children with high function autism is less than that in normal children, but it is not statistically significant (sig=0.316, t=-1.02).

As shown in Table 2, t-test and post hoc Bonferroni (with controlling  $\alpha$ ) there is significant difference between children with high function autism and normal children in the case of inhibition.

Results shown in Table 3 indicate that there is a significant difference in the case of obtained categories, perseveration error and total error between two groups, so children with autism function are weaker than normal children in these cases (Table 2). Post hoc Bonferroni comparisons showed the same results.

Spearman Correlation test was used to examine the relationship between age variables, IQ and

**Table 1:** mean, standard deviation and demographic variable in subjects

| Variables                  | children with Autism disorder(n=15) |                    | normal children (n=15) |                    |
|----------------------------|-------------------------------------|--------------------|------------------------|--------------------|
|                            | Mean                                | standard deviation | mean                   | standard deviation |
| Age                        | 9.33                                | 1.79               | 10.13                  | 2.44               |
| Intelligence quotient (IQ) | 92.73                               | 7.01               | 101.06                 | 9.10               |
| Response inhibition        | 13.60                               | 6.71               | 22.66                  | 9.56               |
| Obtained categories        | 2.40                                | 1.18               | 5.33                   | 1.49               |
| Perseveration error        | 27.66                               | 14.49              | 13.80                  | 5.90               |
| Other errors               | 20.40                               | 15.46              | 20.40                  | 14.13              |
| Total error                | 48.06                               | 10.98              | 32.80                  | 16.44              |

**Table 2:** Results of independent t-test in Color word Stroop and Wisconsin card sorting test of the two groups

| Variable            | Mean differences | Standard errors | df | T     | P. value |
|---------------------|------------------|-----------------|----|-------|----------|
| Response inhibition | 9.06             | 3.01            | 28 | 3     | 0.006    |
| Obtained categories | -2.93            | 0.49            | 28 | -5.95 | <0.001   |
| Perseveration error | 13.86            | 4.04            | 28 | 3.43  | 0.002    |
| Other errors        | 0                | 5.40            | 28 | 0     | 1        |
| Total error         | 15.26            | 5.10            | 28 | 2.99  | 0.006    |

executive components, separately in both groups and the results are presented in Table 3 and 4.

Results in Table 3 show that there is no significant relation between age, IQ score and EF in the group of children with high function autism, but there is a positive and significant correlation between most components of EF.

Results in Table 4 show a positive and significant correlation between age, response inhibition and other errors, IQ score with other errors and total error of Wisconsin Card Sorting test in normal children, so, as can be seen, there is a relation between components of EF in normal children as in children with autism.

## Discussion

EF is a cognition area that is consisted of multidimensional set of abilities which are necessary for complicated behaviors and obtaining a specific goal<sup>[2,6]</sup>. Recent evidences show that deficiency in EF plays a fundamental role in explaining cognition deficits in individuals with autism disorder<sup>[2,18]</sup>. Results of our research show that there is significant difference between two groups of children with high function autism disorder and normal children in terms of

functioning in Stroop test, and the function of children with high function autism disorder is weaker than that of normal children. This result is consistent with previous researches<sup>[7-9]</sup>, although it differs from the results of some of other researches<sup>[10,11]</sup>. Inhibition deficit is one of the primary cognition deficits which is the basis of stereotype and repetitive behaviors in children with autism disorder<sup>[8,20,21]</sup>.

Hill in his review study showed that children with autism have difficulties in planning, inhibition and self controlling. Although in some cases contrast results are obtained, but Hill attributed these contrasts to differences in methods, like choosing the type of the test, and lack of coordination in ability levels of participants<sup>[6]</sup>. Researchers do not have compatible ideas whether executive functions are the primary or a secondary cause of autism. According to these materials, we can assume that deficit in response inhibition component is one of the problems of EF which can be observed in children suffering from autism in spite of their IQ level and can be attributed to ASD symptoms.

In this research, Wisconsin Card Sorting test was used for examining mental flexibility (perseveration). This test examines four components: obtained categories, total error, perseveration error and other errors. The results of this research show significant difference in EF

**Table 3:** Correlation matrix between age, IQ and executive functioning components in the control group

| Parameter                     | 1     | 2    | 3    | 4    | 5    | 6      | 7 |
|-------------------------------|-------|------|------|------|------|--------|---|
| 1- Age                        | 1     |      |      |      |      |        |   |
| 2- Intelligence quotient (IQ) | 0.1   | 1    |      |      |      |        |   |
| 3- Response inhibition        | 0.01  | 0.09 | 1    |      |      |        |   |
| 4- Obtained categories        | 0.7   | 0.2  | 0.5  | 1    |      |        |   |
| 5- Perseveration error        | 0.6   | 0.5  | 0.2  | 0.07 | 1    |        |   |
| 6- Other error                | 0.001 | 0.01 | 0.01 | 0.04 | 0.6  | 1      |   |
| 7- Total error                | 0.05  | 0.02 | 0.01 | 0.24 | 0.09 | <0.001 | 1 |

IQ: Intelligence quotient

**Table 4:** Correlation matrix between age, IQ and EF components in the control group

| Parameter             | 1       | 2     | 3     | 4     | 5    | 6       | 7 |
|-----------------------|---------|-------|-------|-------|------|---------|---|
| 1-age                 | 1       |       |       |       |      |         |   |
| 2-IQ                  | 0.12    | 1     |       |       |      |         |   |
| 3-Response inhibition | 0.01*   | 0.09  | 1     |       |      |         |   |
| 4-Obtained categories | 0.66    | 0.16  | 0.5   | 1     |      |         |   |
| 5-Perseveration error | 0.56    | 0.52  | 0.23  | 0.07  | 1    |         |   |
| 6-Other error         | 0.001** | 0.01* | 0.01* | 0.04* | 0.6  | 1       |   |
| 7-Total error         | 0.05    | 0.02* | 0.01* | 0.24  | 0.09 | 0.000** | 1 |

\* $P < 0.05$     \*\* $P < 0.01$ ; IQ: Intelligence quotient; EF: Executive Functioning

of obtained categories, perseveration error and total error between the two groups. T-test and post hoc Bonferroni data analysis showed that children with high function autism had weaker function in the obtained categories than normal children. Perseveration error and total error in this group was more than normal children. These results are consistent with the results of previous studies<sup>[2,6,10]</sup>, but it is in contrast with the research of Liss et al, who reported that there was no significant difference in perseveration error in Wisconsin Card Sorting test between children with autism and normal ones who became homogeneous in terms of IQ and verbal ability<sup>[11,22]</sup>. We can state that difficulty in attention shift, tendency toward perseveration and lack of impulse control are common symptoms of individuals with autism and who have problems in EF<sup>[6]</sup>. Tendency toward repetitive and limited behaviors are among the other characteristics of individuals with autism. They often react on every change in the environment or the common process of life. In fact, it seems that people with autism often have more tendency toward perseveration and difficulty in change which is effective on their weak function in the flexibility test<sup>[23]</sup>.

Examining the relationship between components of age and IQ and components of EF in children with high function autism showed that there is no relationship between these components, while it was not so in normal children's functioning. Response inhibition improves with increase of age and tendency toward perseveration and errors reduces with increase of age. Although measures of EF are moderately correlated in typical development, they are not redundant, which suggests that they may have different associations with intelligence.

Indeed, over the course of the past two decades, research with normative samples has shown that inhibiting and flexibility display distinct patterns of association with general cognitive ability. Regarding intelligence and inhibiting, Anderson and Spellman state that inhibition is a necessary mechanism in human cognition that relies on both excitatory and inhibitory processes and contributes to the stability of the neural networks<sup>[12,13]</sup>. Some relationship has been also observed between examined EF components which are indicative of overlap between executive functions which would complicate the executive function assessment and lead to inconsistent results in researches.

### Conclusion

Finally, it can be stated that cognition abilities and executive functions might be predictive and participating in compatible behaviors, therefore, EF has an important role in information processing, daily life skills and effective self-preservation and individuals would encounter problems in interaction with others and doing common activities, when these functions damaged. Moreover, with increase of the number of children with ASD in recent decade<sup>[24]</sup> and considering that this disorder often inhibits these children's entrance to society and participating in common daily activities and presence in normal schools, therapists need to focus on cognition debates, specially EF, along with emphasis, on sensory processes, so that to be able to emphasis on systematic strategies for instructing these children and their quality of function in learning process.

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**Conflict of Interest:** None

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