

## Verbal Fluency is Related to Theory of Mind: Comparison in Control Children and with Autism Spectrum Disorder

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### Authors' contributions

This work was carried out in collaboration between all authors. Authors HS and LMF designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SA managed the literature searches. All authors read and approved the final manuscript.

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### ABSTRACT

Autism is a pervasive neurodevelopment disorder, primarily encompassing difficulties in the social, language, and communicative domains. Although neurocognitive impairments in theory of mind (ToM) and in executive functions have both been hypothesized to play a causal role in autism, there has been little research investigating the association of these two aspects with regard to autistic symptomatology. The relation between executive function and theory of mind may involve specific processes of verbal ability and/or working memory capacity contributing to ToM. To differentiate these alternatives, we administered task batteries measuring working memory and ToM, as well as measures of verbal fluency, to 15 children with autism spectrum disorder. The results indicated that children with ASD performed significantly worse than normal children on ToM tasks ( $Z=4.7$ ,  $p<0.001$ ). Furthermore, the results indicated that theory of mind abilities in ASD individuals are strongly correlated with language ability ( $r=0.52$ ,  $p<0.05$ ). However, it was found that autistic children's difficulty in attributing a ToM is not due to memory failure.

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## 1. INTRODUCTION

The DSM-5 (American Psychiatric Association [APA], [1] considers Autism Spectrum Disorder (ASD) to be a neurodevelopmental disorder characterized by deficits in social communication and social interaction across multiple contexts, and restricted, repetitive patterns of behavior, interests or activities. One of the theoretical outlines suggested to explain the disorder is the theory of executive dysfunction [2]. Executive functions (EF) control, regulate and manage lower-order cognitive processes [3,4]. These higher-order executive functions include processes such as planning and sequencing, working memory, attention, reasoning, inhibition of inappropriate and selection of appropriate behaviors. Deficits in executive function will impact on the functioning of lower-order cognitive processes such as language, perception, explicit memory, learning and action. Intact executive function is needed in order to succeed at non-routine problem-solving tasks that require flexible thinking and the generation of novel solution strategies [5].

Throughout the first few years of life, the development of language and theory of mind are interwoven in complex ways. Infants engage in joint attention and demonstrate appreciation of others' intentions within the context of communicative acts. Toddlers begin to use mental state terms in increasingly more mentalistic ways and engage in pretend play [5]. Young children begin to understand that different people have different access to information and different desires. They listen to and participate in conversations in which people predict and explain behavior in terms of desires, beliefs, and feelings.

Research has shown evidence for impaired verbal fluency functioning in children with autism [6]. However, verbal fluency functioning in children with autism spectrum disorder (ASD) is still unclear. Besides, not much is known about the cognitive processes underlying verbal fluency performance in these individuals.

In the present study, the scaled ToM tasks [7] were adapted to Persian language and employed in the assessment of ToM development in high functioning children with autism spectrum disorder [8]. An additional issue of interest was

the relationship of general cognitive ability and particularly language ability as well as working memory to the variables under consideration. For instance, it is well-documented that theory of mind abilities in individuals with autism is strongly correlated with language ability [9,10] Thus, an important consideration in the current study was whether associations between theory of mind ability could be established independently with language skills.

Additionally, working memory (WM), which refers to the capacity to hold information in mind while performing another mental operation or activity, has been found to be impaired in autism [11], although not consistently [12,13]. Working memory is considered fundamental to performance on the ToM tasks because the task requires storage and utilization of information from each story. Therefore, working memory of all participants was also measured prior to the application of ToM tasks and the associations between these two parameters were also investigated.

Subsequently, the main aim of this study was to assess high functioning autism spectrum children's understanding of desires, emotions, beliefs, and knowledge as well as to illustrate if there were correlations between ToM ability of these children and other executive functions such as verbal fluency and working memory.

## 2. METHODS

To assess all components of theory of mind, verbal fluency, and working memory 15 boys with high functional autism spectrum disorder, aged 6 to 13, were selected from possible 85 autistic children.

### 2.1 Participants

All subjects with ASD were selected from Tabriz Autism Association. They were diagnosed with ASD following a detailed psychiatric assessment, developmental history, and a review of the data provided by their teachers and parents. Only 15 participants fulfilled the DSM-IV criteria for ASD [1]. Written informed consents were obtained from at least one parent of all participants, and the research protocol was approved by the ethics committee of Tabriz University of Medical sciences.

For control group, 15 volunteers recruited from local school (15 boys) in the same age range. They were also examined to rule out any neurological, psychiatric, or learning problems. Furthermore, none of these children was on medication and this information was gathered from one of their parents.

## 2.2 Measures

All measures were administered by experienced psychiatrist and cognitive neuroscientist in visits scheduled. The full Wechsler Intelligence Scale for Children-Revised (WISC-R) [14] was used to obtain IQ scores of all subjects. Only ASD children who had the total IQ score above 70 were selected. The participants were group-wise matched on the basis of gender, chronological age, education, and full-scale IQ. WISC-R was adapted and standardized for Iranian children by Shahim [15]. After full diagnostic assessments, IQ and language testing were completed. Then separate batteries of theory of mind tasks were administered in counterbalanced order. Within each battery, individual tasks were administered in randomized order. Children's responses were scored during the assessment.

## 2.3 ToM Tasks

Scaled ToM tasks [7] were employed to assess children's ToM ability. These tasks were categorized into four scales. The original ToM

scale of Wellman and Liu was translated and adapted to Persian. Reliability (Cronbach's alpha) for the ToM tasks was 0.86 [8]. These standard tasks were then administered to assess children's understanding of desire, knowledge, emotion, and belief. Table 1 summarizes scaling of theory of mind tasks, which are designed to measure various aspects of mind development in children [8].

## 2.4 Verbal Fluency Test

The final Persian version of Verbal Fluency Test is adapted from word fluency (FAS) [16] and COWA (controlled oral word association test) [17] and consists of two categories. These categories are semantic, such as animals and supermarket items, and phonemic, such as words that begin with letter M, D, and B. Reliability (Cronbach's alpha) for the Verbal Fluency Test was 0.79.

In this task, participants were asked to name as many animals, and in the second task supermarket items, as possible within 1 min. In the phonemic fluency task, they were asked to name as many words as possible starting with the letter M, in the second task with the letter B, and in the third task with letter D within 1min. Subjects were instructed not to use people's names or repetitions of the same word with different endings. When a certain word was repeated within a task, this response was eliminated from the total score.

**Table 1. Scaling of theory-of-mind tasks (Wellman & Liu, 2004)**

Scale of ToM	Task	Description
Desire	Diverse Desires	Child judges that two persons (the child vs. someone else) have different desires about the same objects.
	Diverse Beliefs	Child judges that two persons (the child vs. someone else) have different beliefs about the same object, when the child does not know which belief is true or false.
Knowledge	Knowledge Access	Child sees what is in a box and judges (yes – no) the knowledge of another person who does not see what is in a box.
Beliefs	Contents False Belief	Child judges another person's false belief about what is in a distinctive container when child knows what it is in the container.
	Explicit False Belief	Child judges how someone will search, given that person's mistaken belief.
Emotion	Belief Emotion	Child judges how a person will feel, given a belief that is mistaken.
	Real-Apparent Emotion	Child judges how a person will feel, given a belief that is mistaken.

### 2.5 Working Memory

To measure working memory, Digit Span from subsets of WISC-R was used. In Digit Span, each subject was asked to repeat 3 - 9 digits forward and 2 - 9 digits backwards. This test was adapted and standardized for Iranian children by Shahim [15].

### 2.6 Statistical Procedures

To compare control measures (Age, IQ) between ASD and control subjects, independent sample t-test was utilized and to equate the level of education in both ASD and control group, Chi-Square test was applied. Furthermore, to evaluate the theory of mind ability of ASD and control subjects, Chi-Square test was also employed. To compare the total scores of ToM amongst both groups, Mann-Whitney U was applied. Moreover, One Way ANOVA was computed to determine significant differences between ASD and control groups on Verbal Fluency and Working Memory measures. Finally, to study the relation between ToM ability and other components such as Verbal Fluency and Working Memory, Pearson Correlation was employed.

### 3. RESULTS

Demographic information for the samples is provided in Table 2. The sample included 15 boys with ASD. In addition, 15 control boys were selected to match children in ASD group for age, sex, IQ, and education. Two-tailed independent t

test results showed that there weren't any significant differences between the ASD and control groups in terms of age ( $t = 0.3, df = 28, P > 0.05$ ), and IQ ( $t = 0.121, df = 28, P > 0.05$ ).

To compare the level of education in both ASD and control groups, Chi-Square test was applied (shown in Table 3). No significant variation in the level of education ( $\chi^2=1.27, p>0.05$ ) between both groups was observed.

To evaluate the results obtained from scaled ToM tasks amongst ASD and control subjects, Chi-Square test was used. The results are illustrated in Table 4.

To determine whether the performance on Verbal Fluency test was associated with autism spectrum disorder, group differences were compared on two measurements using group independent F-tests. According to variance test (One-Way ANOVA), in ASD group, the Semantic Fluency ( $F= 6.05, p<0.05$ ), Phonemic Fluency ( $F= 12.63, p<0.01$ ), and Total Scores ( $F= 5.75, p<0.05$ ) were significantly lower than control group (see Table 5).

The results of working memory tasks were also analyzed using One-Way ANOVA procedure and the outcome (Table 6) revealed no significant variation between both groups on Digit Span test ( $p>0.05$ ). Although ASD group performed poorly on calling series of numbers backwards in digit span task, the overall results did not point out a substantial difference between both groups.

**Table 2. Demographic data for the autism and control groups**

	N	Autism group		Control group		t	P value
		M	SD	M	SD		
Age	15	103.85	26.38	104.92	26.58	0.3	0.76
IQ	15	83.92	9.03	84.23	9.20	0.121	0.90

\*\* significant at the 0.01 level ( $p<0.01$ ); \* significant at the 0.05 level ( $p<0.05$ )

**Table 3. Comparison of education level in ASD and control groups**

	Autism group		Control group		Chi-square tests	
	Count	%	Count	%	Value	P value
0	4	26.67	4	26.67	1.27	0.866
1	3	20.00	3	20.00		
2	7	46.67	6	40.00		
3			1	6.67		
5	1	6.67	1	6.67		
Total	15	100	15	100		

0: preschool, 1: first grade, 2: second grade, 3: third grade, 5: fifth grade (elementary school grades in Islamic republic of Iran)

**Table 4. Evaluation of the results of scaled ToM tasks amongst ASD and control groups**

		Group	Negative		Positive		Chi-square tests	
			Count	%	Count	%	Value	p value
Desire	Diverse desires	Autism	7	46.67	8	53.33	6.14	0.01*
		Control	1	6.67	14	93.33		
	Diverse beliefs	Autism	14	93.33	1	6.67	19.29	0.00**
		Control	2	13.33	13	86.67		
Knowledge	Knowledge access	Autism	15	100			30	0.00**
		Control			15	100		
Beliefs	Contents false belief	Autism	14	93.33	1	6.67	22.53	0.00**
		Control	1	6.67	14	93.33		
	Explicit false belief	Autism	13	86.67	2	13.33	21.99	0.00**
		Control			14	100		
Emotion	Belief emotion	Autism	14	93.33	1	6.67	26.25	0.00**
		Control			15	100		
	Real-apparent emotion	Autism	15	100			10.9	0.001**
		Control	7	46.67	8	53.33		

\*\* significant at the 0.01 level ( $p < 0.01$ ); \* significant at the 0.05 level ( $p < 0.05$ )

**Table 5. The results of verbal fluency test of ASD and matched control groups**

	N	Autism group		Control group		F	P value
		M	SD	M	SD		
Semantic fluency	15	2.62	2.47	5.92	4.17	6.05	.021*
Phonemic fluency	15	8.23	5.63	15.62	4.94	12.63	.002*
Total scores	15	12.08	7.26	20.15	9.78	5.75	.025*

\*\* Significant at the 0.05 level ( $p < 0.01$ ); \* Significant at the 0.05 level ( $p < 0.05$ )

**Table 6. Results of digit span for ASD and control groups**

	N	Autism group		Control group		F	P value
		M	SD	M	SD		
Digit span	15	6.42	1.98	6.82	2.71	0.17	0.69

Not significant ( $p > 0.05$ )

An additional issue of interest was the relationship of language ability and working memory to the variables of ToM measurements. According to the results, shown in Table 7, in ASD group no relation between memory and verbal fluency ( $r=0.08$ ,  $p > 0.05$ ) was found. In addition, there was no relation between working memory and ToM ability ( $r=0.1$ ,  $p > 0.05$ ) of ASD subjects. However, there was a significant correlation between the results of ToM tasks and verbal fluency results ( $r=0.52$ ,  $p < 0.05$ ) of ASD subjects. Likewise, in control group, no correlation between working memory and verbal fluency ( $r=0.52$ ,  $p > 0.05$ ) was found. Moreover, there was no relation between working memory and ToM ability ( $r=0.1$ ,  $p > 0.05$ ) measures. However, there was a significant correlation between working memory and ToM ability ( $r=0.57$ ,  $p < 0.05$ ) of control subjects.

#### 4. DISCUSSION

Autism is a developmental disorder that frequently manifests itself in disturbances of different aspects such as social inadequacies, behavioral stereotypy, and communication delays [1,18]. With respect to social understanding, specifically, there is now an agreement that children with autism show deficits on tasks that assess Theory of Mind [19]. Theory of Mind can be summed up as a person's inability to understand and identify the thoughts, feelings and intentions of others. As a result, people with ASD may not realize if another person's behaviors are intentional or unintentional. This challenge often leads others to believe that the individual with ASD does not show empathy or understand them, which can create great difficulty in social situations.

This study investigated the steps of understandings evident in ASD childrens' developing theory of mind. Wellman and Liu [7] have designed a set of tasks of increasing difficulty to measure ToM ability, but this has not been thoroughly used to assess autistic children or to compare autistic and normal children. In this study, Wellman's ToM Scale tasks were utilized to assess ToM capability of ASD and normal children.

According to the results, some of the ASD children were able to pass the diverse desire and explicit false belief tasks. For the first desire task, more than half of the ASD children managed to give the right responses and only some of them were successful in explicit false belief test. For some of the later tasks especially on knowledge access and real-apparent emotion, none of them could pass the tests [8]. It is alluring to state that Peterson, Wellman, and Liu [7] had similar findings even though, the ToM ability among autistic children in Peterson et al's [4] sample was higher than this study. However,

their autistic participants was larger (N=36) and older (mean and SD for age in months are 112 and 23 respectively).

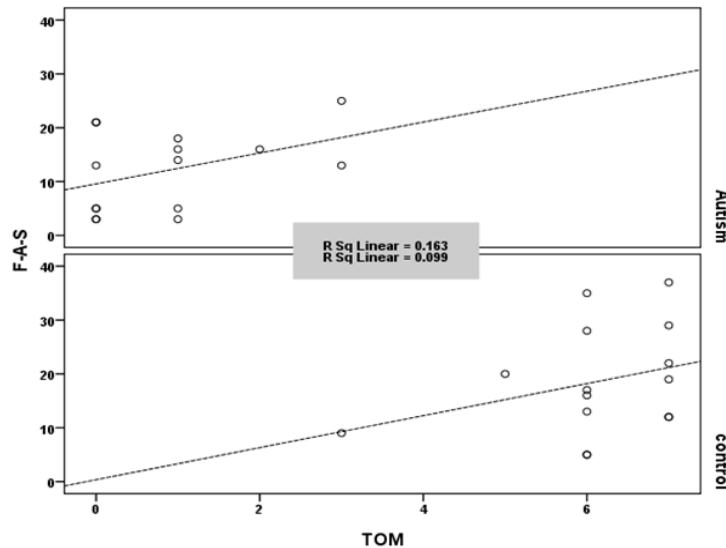
However, the overall results suggest that ASD children's ToM ability is not entirely deficient and maybe it can develop gradually and slowly. However, they had an overall poor performance on ToM tasks suggesting that they have a deficit in their theory of mind ability. The present study has succeeded in confirming the conclusion drawn on the basis of the experiments by Baron-Cohen et al. [20] and Leslie and Frith [21]. It approves the claim that able autistic children are thoroughly impaired in their theory of mind. In fact, the present results high lights the poor performance and understanding of Tom tasks in autistic children.

However, it seems that general impairment in verbal ability might be responsible for the failure of these children on ToM tasks. Nevertheless, autistic children's difficulty in attributing a ToM task is not due to memory failure.

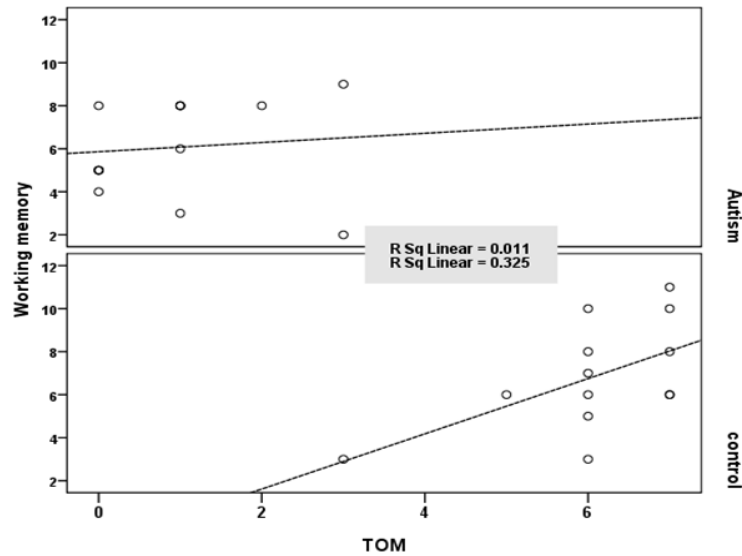
**Table 7. Correlations among verbal fluency, working memory, and ToM measurements**

	Digit span		ToM		Verbal fluency	
	Autism	Control	Autism	Control	Autism	Control
Verbal fluency	0.08	0.26	0.52*	0.4		
ToM	0.1	0.57*			0.52*	0.4
Digit Span			0.1	0.57*	0.08	0.26

\* significant at the 0.05 level ( $p < 0.05$ )



**Chart 1. Correlations among verbal fluency and ToM measurements**



**Chart 2. Correlations among working memory and ToM measurements**

The acquisition of a representational understanding of mind, which takes place at around 4 years of age in normally developing children [22], marks a qualitatively different stage in theory of mind development. The capacity to understand that a person could hold a false belief depends on a more complex cognitive representational system than is needed to support the implicit understanding that people are mental beings [22,23]. At this stage, language, specifically knowledge of the structure of complement constructions, may play a key role in this aspect of theory of mind development for all children [24].

Furthermore, the data presented in this study suggest that there is a correlation between language ability and representation of other minds in ASD children. Unlike other children, for children with autism, it is linguistic knowledge about verbs of communication that provides the crucial link to ToM tasks such as false belief. Nevertheless, there is still much to be learned about the developmental pathways taken by children with autism and in their acquisition of language and a theory of mind.

Interestingly, some researchers [23] have suggested that performance on ToM tasks might relate only to those social skills that require understanding mental states, termed Interactive social skills, but not to more routinized social skills, termed Active social skills. However, results of previous research indicate that some

individuals who pass ToM tasks exhibit Interactive social skills as poor as those who fail ToM tasks.

In working memory tasks, there have been mixed results possibly attributable to the difficulty in dissociating working memory from other executive functions. One study however, found that performance was inversely related to task difficulty, suggesting working memory deficits are a result of the demands in organizing and integrating information. On the other hand, working memory includes components of cognition that are essential to representing and understanding the immediate environment by keeping active incoming information for further processing. It is useful for problem solving and developing, relating and acting on current goals [25,26,13]. Working memory can also be examined in terms of its capacity, or the number of elements that can be held online simultaneously.

Regarding future research, as Peterson et al. [27] already indicated that there may be other social variables affecting ToM ability development. And, this study showed that the verbal ability can be a potential candidate. Any variables of interest can be fitted in some statistical models for further analysis. Another area for further research is to conduct detailed item analysis (e.g. Guttman, Rasch, IRT, etc) to investigate the developmental patterns in terms of item difficulties. In addition, more samples on

autistic children with different stages of development are needed. This study of autistic children in Iran has provided additional and different samples from a different culture and educational system, but perhaps repeats the claim that autistic children do have ToM abilities, which develop at a different pace and in different ways.

## 5. CONCLUSION

ToM abilities develop from a young age. Typically developing children show a progression from understanding simple mental states such as desire to understanding complex social situations. ToM deficits in ASD lead to impaired communication, socialization and imagination in these individuals.

Children with autism spectrum disorder are known to have difficulty with theory of mind, and for them this should be a particular area of emphasis. However, the development of language and theory of mind are closely intertwined from infancy on, and children with language disorders may be at risk for problems with theory of mind, especially when pragmatic deficits are present [28,29]. Conversely, an immature theory of mind may limit a child's language and communicative development, even one that does not have an autism spectrum disorder.

## CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the authors.

## ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the authors.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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