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READING THE MIND OF OTHERS: DEVELOPMENT OF AUTO-RECURSIVE MINDREADING INVENTORY (ARMI)

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ABSTRACT
Theory of mind (ToM) or mind reading ability is a fundamental characteristic of human kind that is necessary to successfully functioning in social communications and interpersonal interactions. Individuals with mindreading ability also consider others as mindreaders who have a theory of their minds and content of thoughts. Then, if we suppose that in a two sided relationship, both parties have a theory of the other one`s mind, there should be a recursive structure here, and therefore we can conclude that recursive thinking is the fundamental feature of mindreading, and mindreading in turn, is the basis of interpersonal relations. Researchers tried to measure ToM ability through recursive thinking capacity and levels of its complexity, but due to difficulties in assessment of mindreading in adults, there are only a few measures available for this purpose and all are somehow unpleasant. The current study is an attempt to develop a new method for measuring ToM through assessing mindreading ability through increasing levels of complexity of auto-recursive thinking (A recursive thinking that refers back to oneself in every other level) in the framework of dyad relationship between supervisors and subordinates in organizational environment. 200 subordinates and 10 supervisors (every 20 employees were under supervision of one supervisor) answered to Auto-Recursive Mindreading Inventory (ARMI). ARMI Measure consisted of 20 statements about subordinates` traits, in 4 level of complexity. Results showed an appropriate internal consistency of scale sub categories. Also construct validity confirmed by assessing ARMI subscales correlation with IMT scale. Reliability of scale was at 0.75. Results showed that this scale has suitable features and could be used for measuring adult`s individual differences in mindreading ability and recursive thinking complexity.

KEY WORDS: dyad recursive mindreading scale, Mindreading, recursive thinking, Theory of Mind,

INTRODUCTION

In order to function successfully in social communications and interpersonal interactions, it has been suggested that individuals must attend to what others think, feel, and see, and be able to compare and contrast different perspectives, including their own, as they attempt to ascertain the intentions and mental states of others living and working around them (Chandler, 1977; Shatz *et al*., 1983). An individual with a well-developed mentalistic theory of behavior is able to see himself and others in terms of mental states that result in what he may do and so are manifested in behavior (Wellman *et al*., 2001). In fact, this ability helps him interpret intentional action of others as well as predict and explain their behavior (Strange, 1999). In the cognitive psychology literature, such ability is called “theory of mind” (ToM) or mindreading (Chandler *et al*., 1989; Gopnik, 1993; Perner *et al*., 1994), and is defined as people's perception of mental states of others such as beliefs, desires, concepts, intentions and emotions (Premack and Woodruff, 1978). Thus, that is our theory of mind or mindreading ability that makes us enable to navigate our personal and social world by explaining past actions, and anticipating and predicting future behavior (Moore *et al*., 1990).

Many authors have argued that the proximate mechanism which facilitates human`s highly developed sociality is Theory of Mind (Dunbar, 1998, Liddle and Nettle, 2007). Studies also suggested that social competence and prosocial activity even in school age children, has a positive relationship with their level of ToM ability (Strange, 1999, Watson *et al*., 1999). Liddle and Nettle (2007) also examined individual differences in ToM functioning on social competence, and concluded that the ability to deal effectively with the demands of everyday social interaction has a positive relationship with ToM. Stiller and Dunbar (2001) showed that performance on ToM task has a significant positive correlation with individuals social network size.

It is clear from above that in the context of social behavior, mindreading ability can play an important role in our interpersonal relationships, for cooperation, competition and manipulating others (Paal and Bereczkei, 2007). However, studies related to the theory of mind have been often performed for children and the methods for their investigations have usually consisted of the assignments of false belief tasks, like false signs and false photographs, additional information and stories designed for the same reason (Baron-Cohen, 1995; Happe, 1994) Studies showed that acquisition of ToM begins somewhere in third year of a child`s life, and develops through cognitive precursors such as mutual attention, social imitation and pretend play during first years (Baron-Cohen, 1995; Stone *et al*., 1998) and normal children acquire full competence on simple (first-level) ToM tasks when they become 5 years old (Wellman *et al*., 2001).

Despite the mass of studies about ToM in recent decades, it is surprising that there are very little researches on mindreading in normal human adults (Apperly, 2012). Thus, much less do we know about adults ToM abilities and except some notable studies (e.g. Chandler and Helm, 1984; Happe, 1994; Happe *et al*., 1999), We know little about how theory of mind develops beyond the age of approximately 7, when understanding of more complex mental situations emerges (Perner and Winner, 1985; Sullivan *et al*., 1994; Happe *et al*. 1998). Also there is relatively little research evidence about how social cognition develops beyond school years and our knowledge about how child's knowledge concerning the specifically human objects and events in his environment grows (Wallach, 1963). However studies showed that ToM abilities continue to develop and improve through the school years to adulthood (Happe, *et al.* 1998), but we do not know how adults use their ability of mindreading in their interactions with other people, and how individual differences may influence this ability.

It seems that main problem is due to construct assessment issues in these ages. Usual ToM tasks such as false belief are too simple in terms of cognitive complexity so that with the exception of individuals with pervasive disorders such as autism, all healthy individuals over 5 years old, with every degree of intelligence and emotional intelligence, can easily manage them and their performance on simple belief tasks is usually at ceiling (Liddle and Nettle, 2007; Apperly, 2012). In other words, these tests don't have enough validity for adults. Thus, some researchers have shifted from simple belief tasks to more complicated tasks like emotion-recognition tasks (Baron-Cohen, 2000), belief tasks in uncertain or probabilistic conditions (Mitchell *et al*., 1996; Britch and Bloom, 2007), speed and accuracy of task accomplishment (Apperly *et al*, 2008), using mindreading inferences in referential communication (Keysar *et al*., 2003), tasks centered around the detection of white lies and double bluff, humor, irony or non-literal meaning (Happe, 1994), or self-rated, personality-style questionnaires (Apperly, 2012). Also some researchers have developed more cognitively effortful tasks by probing "recursive" ToM understanding.

In computational terms, recursion is a process that calls itself, or that calls a similar process (Corballis, 2003). Recursive thinking refers to the ability to think about one's own or another person's thinking (Mueller and Overton, 2010). Already we know that an individual having a theory of mind can read the minds of others. If we assume further that individuals with a ToM also consider others and themselves to have a ToM, then as Takano and Arita (2010) have suggested, there should be a recursive structure here. Once a child has an understanding of the representational aspects of thinking and believing, more complex abilities like reasoning about another's embedded thoughts or recursive thinking become possible (Eliot *et al*., 1979; Oppenheimer, 1986; Veith, 1980). In fact as Miller *et al* (1970) argued, human can contact other external objects in three ways: motor actions, perceptual actions, and representational actions (like symbolic actions). Among these type of actions, it has argued that representational actions differ from the other kind of actions in a significant way; motor and perceptual actions can not constitute their own domain of application, also can`t bear subsume themselves as their own object so they could not be recursive (Miller *et al*., 1970).

In this framework, among all human acts, it is just a representational action that can take itself as an object, and can possess a recursive structure. For example, perceiving is not recursive, because people cannot perceive their perceptions, but perceptions can be the object of a representational act like thought (Mueller and Overton, 2010). Among the representational acts, the act of thinking is the most important one because of its vast domain of implication. If a recursive structure of a representational act like thinking act get iterated, recursive thinking will result in long and nested series of embedded acts of thought, [e.g., "she is thinking that (he is thinking that (she is thinking...))"]. As the level of iteration goes higher, the complexity of cognitive task needed to perceive the meaning inside, increases exponentially. When people in social interactions engage in a complex recursive structure, it seems like they would need their mindreading ability or their theory of mind about the mind content of the person in front of them to make a precise perception of the relation. One of the first studies that tried to assess recursive thinking was Miller *et al* (1970) study, which consisted of 18 cartoon drawing included thought bubbles (like comic strips) and were designed to measure four levels of thinking. The first two levels - thinking about contiguous people and thinking about actions- did not involve recursive structure of thinking. The third and fourth type of thinking, namely - one and two-loop recursive thinking - thinking about thinking and thinking about thinking about thinking - both involved recursive thought (Milller *et al*., 1970; Lepisto, 1997). As Mueller and Overton (2010) emphasize, one loop recursion is the simplest level of recursive thinking and consists of the thinking about thinking, whereas two-loop recursion, a more complicated form of recursive thinking, involves thinking about thinking about thinking. These cards were shown to participants and then they were asked to interpret the contents. This kind of assessment of recursive thinking was used in some other studies (e.g. Strange, 1999; Muller and Overton, 2010). One criticism that was made about this methodology was its requirement of advanced level of verbal production. Further studies tried to somehow improve methodological futures of Miller *et al* (1970) study and asked children to point to a specific picture among a set of pictures which were presented to them (Oppenheimer, 1985).

Another method that were used in some studies to assess the ability of recursive thinking understanding, took place with the application of short stories. These kind of recursive mindreading scales, which were designed for both normal and abnormal adults, involved reading or hearing multiagent stories, and inferring what one agent believes, thinks or knows about another agent`s belief, desires, intentions or some other subjective mental states (Happe, 1994; Paal and Bereczkei, 2007). Like false belief understanding, these recursive thinking tasks require the additional ability to utilize a mental model of two or more individuals' beliefs about each other. These vignette or story typed measures, all suffered methodological and conceptual problems. One of the most important in these measures was the inference of memory capacity and executive functioning in the assessment of ToM ability and recursive thinking. Some have tried to overcome these problems by correlating participants` scores in questions which assess factual memory and scores in ToM questions, and have argued that just if there is no relation between these two scores, it would be right to assume that we have tested the individual differences of recursive thinking, not other intellectual abilities.

Another problem is that there is not a unique and consistent definition of recursion levels among studies. This inconsistency could be seen as a result of limited number of studies in the domain. In some studies two levels are chosen for maximum level of complexity (e.g. Miller *et al*., 1970; Strange, 1990; Happe, 1994), in some 4 and 5 level (e.g. Liddle and Nettle, 2007), and some of them have had even up to 9 levels. These inconsistencies to some extent are due to modeling beliefs and intentionality sequencesSome other studies defined their first level as solid thinking about non-mental external objects (Miller *et al*, 1970).

In summary, due to these inconsistencies and the need for an efficient method, the goal of this study was developing a new method for measuring adult`s recursive thinking abilities. In this study, we have purposed that in a dyad relationship, both sides have some beliefs or a ToM about the other. One of the best environments that these dyad relationships could be investigated, is dyad relationship between a supervisor and his direct subordinate, because quality of these relationships has important consequences on both sides` work outcomes. The importance of leadership is investigated in many organizational literatures and frameworks such as LMX theory (Truckenbrodt, 2000).

In a dyad relationship, if one side`s theory of the other`s mind is complex enough, it should include the fact that the other side is too provided with a similar system and a recursive situation could rise (Zanlungo, 2007). In order to investigate these recursive ToM models of one side`s about the other, we need to make a criterion for assessing the precision of these thoughts. Furthermore, we need to define the depth and the complexity of these thoughts. In this study, we use a subordinate`s thinking about his supervisor`s beliefs (about that subordinate, about that subordinate`s beliefs and so on), and we will investigate that to what extent these thoughts are consistent with that supervisor`s real beliefs. Thus real beliefs of supervisors, would be our criterion and we compare a subordinate`s thoughts and beliefs (about supervisor`s beliefs) with this criterion. We define levels of thinking in the relationship between supervisor and subordinate, in a manner that higher levels would have more depth of recursion. Applying Miller *et al*. (1970) framework, we define level 0, individual at level 0 has beliefs and desires about a subject but no beliefs and desires about beliefs and desires about a subject (for example: "I believe that I am a responsible employee"). A level 1 individual has beliefs and desires about beliefs and desires about a subject (e.g. "I think my subordinate believes that he is a responsible employee"). In this manner, an individual in level 2 has beliefs and desires about beliefs and desires about beliefs and desires about a subject (e.g. "I know my supervisor thinks that I believe that I am a responsible employee"), and so on. However, we won`t go further than level 4 in this research, because we believe that in a dyad recursive thinking ToM, when both parties just have to model their own and the other side`s desires and beliefs, higher level than level 4, are too sophisticated to percept. It is worth noting that, as intentionality relies on the intentional idioms like "knows that", "expects that", and "wants that" (Takano and Arita, 2009) we have used a variety of intentional idioms in order to make the perception of the underlying concepts easier and minimize linguistic interferences and difficulties. Because in this framework, content of an individual recursive thinking, takes his thoughts as object, we called this kinf of recursive thinking, auto-recursive thinking. Finally, we think that if an individual (in this study subordinate) could better predict the other side of a dyad relationship`s beliefs (Supervisor) in various subjects in a specific level, he would have a better recursive thinking ability than others in that level. At the other hand, if an individual can predict the other side`s belief in higher levels, he would be higher in overall recursive thinking ability.

MATERIALS AND METHODS

Participants

The research conducted within a large industrial Company in Iran. Individuals invited to participate included newly selected employees who had passed their common on the site training and were participating in their on the job training course. Among a list of all possible participants, we randomly chose 200 employees. Because these employees were in their first year of employment, every 20 of these newly selected employees had a specific supervisor, from the beginning of their entrance in the training course, who was in a constant relationship with them about one year and was making some instructions about their job and organization for them. Thus 10 supervisors were chosen that their beliefs about their subordinates were assessed as the criterion variable. All of supervisors were organization`s experts who had between 8 to 12 years of work experience (Mean=10.4, SD=2.64) with age range from 32 years old to 45 (Mean=40.1, SD=2.7). All of subordinates were male, operational engineer, had an academic degree of B.Sc. in mechanical engineering or chemical engineering, and had an age range between 22 to 27 years old (Mean=24.3, SD=1.1). Thus our sample included 10 groups, all with one supervisor and 20 subordinates.

Measures

Auto-Recursive Mindreading Inventory (ARMI): In order to assess levels of recursive thinking, 20 traits was selected from a list of 100 possible organizational characteristics which an employee should have. A set of statements about these traits (in subordinates) were developed at different levels of complexity. For subordinates, at level 0 an example statement about goodness of performance would be like this: "I believe I have a good performance"; level 1: "I think my supervisor knows that I have a good performance"; level 2: "I think my supervisor knows that I believe that I have a good performance"; level 3: "I predict my supervisor feels that I think that he knows that I have a good performance"; and level 4 would be like:" I predict my supervisor feels that I think that he knows that I believe that I have a good performance". Relatively supervisors statements should be: level 0: "I know that my subordinate has a good performance"; level 1: "I know my subordinate believes that he has a good performance"; level 2: "I feel that my subordinate thinks that I know that he has a good performance"; level 3: "I feel that my subordinate thinks that I know that he believes that he has a good performance"; and finally level 4: "I expect that my subordinate predicts that I feel that my subordinate thinks that I know that he has a good performance". Both subordinate and their supervisors have to declare their agreement with these statements on a five point likert type scale (From 1: strongly disagree to 5: strongly agree).

Because matching the subordinates` beliefs were checked with their subordinates` real belief, the level n of recursive thinking in subordinates form, would be matched by level n-1 of same trait statement in supervisors. Hence, subordinates` levels would range from 1 to 4, and subordinates` levels from 0 to 3, and there would be 4 forms with 20 items for each to be calculated. At every level of complexity, a subordinate`s and his supervisor`s answers would be matched, and mismatch score would be calculated. The mismatch score may range from a minimum of 0 (that shows the individual subordinate had predicted exactly what his supervisor`s thought was about his trait -level 1 for subordinate that is checked with supervisor`s level 0- or his thought about his traits -for level2- and so on), to a maximum of 4 (that shows subordinate`s prediction about supervisor`s belief and his supervisor`s real belief were at the opposite extremes of strongly disagree and strongly agree, or vice versa). For every level of recursion, the mismatch score would range from 0 to 80. A total score of recursive mindreading ability simply could be calculated by the sum of levels` scores. An average of error scores in every level could be an appropriate estimation of recursive mindreading ability. All recursive mindreading scores could be transposed to have a score of match instead of mismatch (by applying Y=20-x/4 transposition, where x is the mean error for every level and Y is the score of predicting right or reading the mind of the other side of relationship; in this study, supervisor). However, it is obvious that the lower the mismatch score (or higher the match score) in a specific level of complexity is, the higher the subordinate`s recursive mindreading ability would be in that level. This would be also true for the total score.

Imposed Memory Task (IMT). For validating the scale, we have used IMT scale introduced that is widely used in the investigation of adult theory of mind (Paal and Bereczkei, 2007). In this scale, mindreading ability was tested with the use of a number of brief stories about real life situations, interpersonal relations or conflicts of levels of complexity. Some of the stories involved either intended misleading or deception and some involved unintended ones. Four of these stories involved complex situations in social life and required the participant to understand the perspective and intentions of the actor. The stories were read to the participants by the experiment coordinator. After reading one story to the end, participants were asked to answer some two statement questions (a true and a false one) representing different levels of mindreading and intentionality, in the questionnaire booklet. Questions either concerned ToM elements of stories (the expectations or beliefs of the actors) or were memory questions. Both types of questions were asked at different levels of complexity. For example, based on the story participants had to decide whether A thinks that B believes that C is lying, or A thinks that B does not believe that C is lying (Liddle and Nettle, 2007). Scoring the IMT scale is similar to ARMI scale. There is 5 levels of complexity in ToM ability (16 questions), and 6 levels for memory questions (24 questions). In every level of ToM or memory tasks, the average number of errors could be an appropriate estimation.

Procedure
Participants were presented with ARMI and IMT scale questionnaires. First they had to show their levels of agreement about each statement in every of 4 levels of ARMI scale (by keeping in mind their supervisors thought about the traits for level 1, supervisors thought about his thought about the traits for level 2, and so on). Then stories of IMT scale were read one by one and after reading each story, they were asked answer the questions in the booklet. Obtained data was analyzed with statistical methods to find reliability and validity of ARMI scale of recursive mindreading.

RESULTS
First, means and standard deviation of variables of study were calculated. Then reliability of ARMI scale, and its subscales (four levels of recursion complexity, namely ARMI1, ARMI2, ARMI3 and ARMI 4 which refer to level 1 to 4 of recursive mindreading), were calculated by cronbach`s Alpha coefficient. Also reliability of IMT scale was calculated. These coefficients are shown in table 1.

Table1. Means, Standard Deviations and reliability of variables used in the study

Cronbach`s Alpha	Standard Deviation (SD)	Mean (M)	Number of items	Variable
0.75	15.1	40.5	80	ARMI
0.87	10.3	14.7	20	ARMI1
0.80	13.2	11.9	20	ARMI2
0.65	18.6	6.6	20	ARMI3
0.62	16.4	6.3	20	ARMI4
0.81	1.23	22.18	24	IMT-Memory
0.85	1.45	13.92	16	IMT-ToM

For IMT scores, means, standard deviations and reliability coefficients were calculated for its two sub-categories, memory and Theory of Mind (ToM). Scores for all 200 subordinates on the Imposed Memory Task, as shown in table 1 revealed a mean of 22.18 on the memory 24 questions with the standard deviation about 1.23, and a mean of 13.92 on the Theory of Mind 16 questions with the standard deviation about 1.45. On the other hand, on ARMI scale, mean scores of recursive mindreading, diminished as the level increased. Participants (subordinates) recursive mindreading ability on the level 1 showed a mean of 14.7 of correct predicting score. This mean score for higher levels was 11.9, 6.6 and 6.3 for level 2, 3 and for in turn. The relatively high standard deviations (10.3, 13.2, 18.6 and 16.4 for level 1 through 4), suggested there were great individual differences between participants on recursive mindreading ability.

Figure 1 illustrates proportion of correct answers to study scales. Participants (subordinates) answers to auto-recursive mindreading inventory, shows the mean of correct prediction of supervisors` thought for different levels of complexity (from level 1 to 4) and IMT, memory and ToM subscales for all participants. Answers are presented for different levels of complexity for each item. As the levels of complexity increases, proportion of scores of all scales decreases.

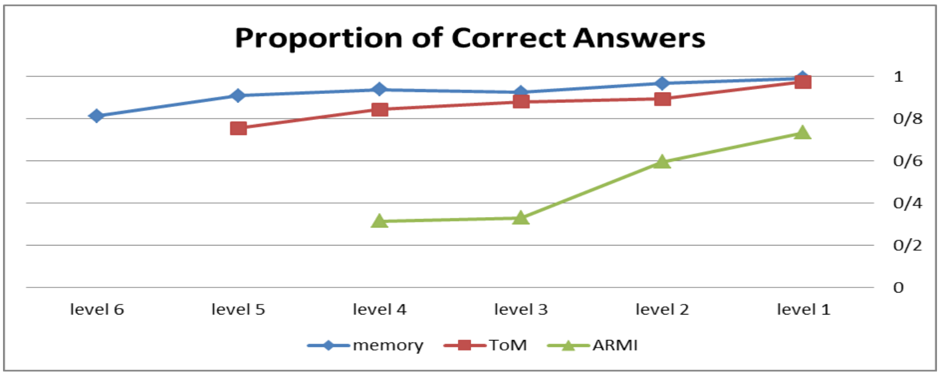

Figure 1. Proportion of correct answers to auto-recursive mindreading inventory and IMT, memory and ToM subscales for all participants. Answers are presented for different levels of complexity for each item.

For validating the ARMI scale, first inter-correlations of ARMI subscales and their correlations with total score of the scale were calculated. Then correlations of ARMI total score and its levels scores of recursive mindreading with IMT scale and its subscales were calculated. Table 2 summarizes these calculations.

Table 2. Correlations between study variables.

10	9	8	7	6	5	4	3	2	1	Variable	
									1	**IMT-TOM1**	1
								1	.662**	**IMT-TOM2**	2
							1	.467**	.575**	**IMT-TOM3**	3
						1	.320**	.664**	.581**	**IMT-TOM4**	4
					1	.550**	.541**	.561**	.653**	**IMT-TOM5**	5
				1	.514**	.438**	.488**	.456**	.467**	**ARMI1**	6
			1	.510**	.431**	.491**	.365**	.528**	.449**	**ARMI2**	7
		1	.622**	.432**	.501**	.250**	.462**	.302**	.376**	**ARMI3**	8
	1	.394**	.471**	.491**	.334**	.226**	.359**	.261**	.341**	**ARMI4**	9
1	.351**	.435**	.580**	.574**	.796**	.834**	.617**	.874**	.845**	**IMT-TOM**	10
.397	.697**	.501**	.838**	.826**	.606**	.536**	.529**	.585**	.595**	**ARMI**	11

**** p<0.05 , * p<0.01**

Findings show an appropriate internal consistency between ARMI subscales. In addition, correlations between levels of recursive mindreading as measured by ARMI subscales, confirms the ARMI scale validity.

DISCUSSION

This study at the first place was an attempt to make a better understanding of the underlying causes of mindreading or Theory of Mind ability in human kind and then developing a new method for measuring the construct. In fact, mindreading plays an important role in everyday social life of people. We can see people try to make a theory of others` mind, in all kind of interactions and communications in the public society, work places, virtual networks and every place that people interact with each other. Reading the mind of others or trying to take their perspectives and seeing and perceiving world as they do, is an important antecedent of high-quality interpersonal communications in organizational contexts (Moates, 2007). Despite the importance of mindreading ability, studies generally focused on children and vastly tried to trace the age that this ability emerge. In addition, these researches just studied the emergence of first-order ToM and more complex structures of recursive mindreading and ToM skills especially in adults has been much less studied.

In this study, mindreading has been considered as a recursive cognitive function. Findings confirm that mindreading ability has a multi-level structure. These findings are consistent with a small number of studies that have tried to implement a multi-level structure for measuring the ability of Theory of Mind and measured higher levels of ToM (Sullivan *et al*., 1994). One reason for little empirical evidence for higher levels of mindreading might be that these higher levels demanding cognitive skills develop after childhood. Children mostly master first and to some extent second level ToM problems embedded within the story tasks (Liddle and nettle, 2006). But evidences from some few surveys that assessed ToM up to the third and fourth levels for children have suggested that children`s mean performance at third level is only slightly better than chance, and at fourth level is at chance ToM (Perner and Wimmer, 1985; Sullivan *et al*.,1994, Liddle and nettle, 2007). Perner and Wimmer (1985) claimed that second-order mindreading ability develop after 6 years old.

Thus, we need to measure mindreading ability after school years in adults to discover the development of higher levels of mindreading. But as mentioned above, mindreading investigations in adults are very rare. Methodological difficulties have been known responsible for the shortage of researches concerning adults` mindreading ability and its underlying causes (Apperly, 2012; Happe, *et. al*., 1998). This research tried a new method for studying adults` mindreading capability with the use of recursion concept.

However, there are a few studies that tried to investigate mindreading ability and its levels in adults (Happe *et al*., 1994). It is not surprising that findings of these researches are in contrast with what we learned about children mindreading ability. For example, suggest that adults perform better than chance at third and fourth level. But even normal adults may not perform levels higher than fourth better than chance. Current research findings confirm these findings. Adult participants performed well in two firs levels and better than chance in third and fourth levels of auto-recursive mindreading tasks, also their performance decreased as the complexity or levels of mindreading increased. It should be noted that in this study, we didn`t go further than level 4, because in our method of conceptualizing mindreading, as levels increase, complexity exponentially grows and in higher levels than 4, it is almost impossible for participants to understand the recursive statements and their semantic meanings. However, we can conclude that individuals that are better in recursive mindreading ability could predict others` thoughts, beliefs and desires. So it seems that mindreading ability continue to develop into adulthood and even in old ages.

As a consequence of the present study, one could conclude that the higher levels of mindreading emerge when people get older. This could be seen like getting wisdom, which increases by the age, through development of recursion levels. These findings are consistent with Happe *et al*. (1998) suggestion, that as age increases, performance reduces in memory tasks, but mindreading ability promotes. They concluded that if reasoning in social contexts increases and other cognitive functions decrease, there should be a separate cognitive system underlying social versus nonsocial reasoning. Our findings to some extents confirm this claim and suggest that this structure or underlying system, is recursive thinking.

Clark and colleagues have long argued that successful communication depends on speakers and listeners working within a ‘‘common ground’’ of mutually known information. This common ground might be the space in which mindreading or making theories about each other`s mind takes place. Some researchers even argued that thinking recursively is the key to social intelligence and relationships (Takano and Arita, 2010). Also our results suggest that having theories about others` minds takes a recursive structure in a dyad relationship, because in a two-sided communication, both sides have a theory of other side`s mind and the way he thinks. However, some of findings of the current study suggest that there is a need for further research in order to show why and how levels of recursive thinking are initiated and developed and how this ability affect a relationship between two individuals. To clarify the underlying causes and effects of recursive thinking and mindreading, further studies should focus on more in depth investigations. Also there is not enough evidence to show what the behavioral consequences and correlates of variation in these more subtle levels of ToM might be (Liddle and Nettle, 2006). We tested a method for assessing higher-order ToM (up to 4th level) performance in adults (subordinates) in an organizational context. In fact subordinates who were higher in recursive mindreading ability, could predict their supervisors` thought about a subject (a trait of them, their thought if a trait, and so on) better and more precise than others. It should be logical that one concludes that subordinates with higher levels of mindreading, have a relationship of more quality with their supervisors. This may help practitioners in organizational contexts to make a better understanding of dynamics of organizational relationships. However these hypotheses should be studied in further investigations.

It is worth noting that there are some studies in other fields of science that have identified the importance of ToM and have tried to make some use of it in their researches (e.g. Takano and Arita, 2010; Zunlongo, 2007). For example in the artificial intelligence and computer sciences researchers by the means of computer simulations, have tried to investigate ToM consequences in the multi agent environments, like social contexts (Takano and Arita, 2010). Moreover, one can observe using of ToM consequences in game theory, social sciences, and computer sciences. Thus, making a better understanding about mindreading or recursive thinking may help the scientists of these fields to make a more precise model of human thinking.

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