Noémi Hahn[1]
Eötvös Loránd University, Budapest

Developmental relationships of understanding complements, naïve theory of mind and word acquisition – ToM said that there was a wug in the box

Keywords: complements, naive theory of mind, word acquisition, autism

Abstract
Our developmental psycholinguistic research focuses on the way language system interacts with other aspects of human cognition, more specifically, with the development of naive theory of mind. In the past ten-fifteen years numerous articles were written about the possible connections between the two abilities with contradictory results and contradictory conclusions. The aim of our 2 studies is to shed light on the possible relationships of understanding complements, naïve theory of mind and word acquisition using new test processes; a nonverbal false belief test and a word-learning complement task. In our first study we found in agreement with our channel-effect hypothesis that connection between complement syntax and false belief test (FBT) is due to the verbality of the tests and not to the causal connection between complement syntax and naïve theory of mind as it was suggested by DeVilliers (2002). In our second study we tested the effect of word learning situations; in contrast with Happé & Loth's (2002) results in our research these situations made both FBT and Complement tasks more difficult for children.

1. Introduction

Relationship between acquisition of language and social cognition, more specifically theory of mind, is well established by several research (e.g. Astington, 1999). However, the questions of the exact mechanisms and the nature of this relationship in acquisition which have significant implications to the approaches of the cognitive developmental psychology in general are still open.
Theory of mind is the ability to attribute mental states to others and to interpret and predict their behaviors by these mental states. The ability to attribute false belief to others has been taken as the litmus test for theory of mind ability. One of the standard false belief tests is the Sally Anne test in which the child watches as Sally places her ball to a basket and leaves the room. In her absence the other puppet called Anne transfers Anne's ball into a box. When Sally returns and wants to play with her ball the child is asked: "Where will Sally look for her ball?" To pass the test the child must realize that Sally doesn't know that Anne transferred her ball into the box and will therefore look for it in the basket where she left it. Children typically do not pass such tasks until the age of four (Baron-Cohen, 1985).
As both language and theory of mind abilities are complex cognitive abilities, connections between them were found in different aspects of them and at different developmental levels. We emphasize two aspects of language, semantics and syntax and their relationships to theory of mind which are relevant in our studies.

[1] All of the studies were designed with and supervised by my tutor Miklós Győri. I would like to thank the members of the Autism Foundation and Research Group, Budapest, Hungary: Barbara Batta, Eszter Sajó, Krisztina Stefanik and Zsuzsa Várnai, and Ágnes Pinter for their help in the investigations. Thank the children who participated and their parents. Preparation of these research was supported by Autism Foundation, Budapest, OTKA, NKFP.

In the case of *semantics* several investigations found connection between the acquisition of mental state words (attend, want, think) and the performance on theory of mind tasks (Moore et al, 1989; Astington et al, 1995). Further studies stated that joint attention behavior which is – according to several authors (e.g. Carpenter et al, 1998) – a precursor of theory of mind has an important role in word acquisition; so the way a child finds out what the reference of a new label is by checking the gaze direction of the person who said the new label (Baldwin & Moses, 1994). The generalizations of these later results suggest that theory of mind is needed to the acquisition of language.

In a recent study by Happé & Loth (2002) the effect of the acquisition of a new label was tested in a FBT so children had to track a false belief in order to learn a novel word. They found that in spite of the increased task complexity significantly more children passed the false belief task when it was combined with a word learning task than when presented in its standard form. Happé and Loth interpreted these results that theory of mind mechanism might be not a unitary mechanism but it might consist of more – at least two – component mechanisms, and their developmental trajectories may be different.

In case of *syntax* and its relation to theory of mind the results are ambiguous, too. Tomasello (2000) suggests based on his empirical findings and observations that the construction of grammar framework needs general cognitive and sociocognitive skills, including the precursors of theory of mind.

DeVilliers found the opposite connection between theory of mind and a particular aspect of syntax: sentential complements. DeVilliers defines complements as a type of embedded sentences where the complement-taker verb can be communication or mental verb. The embedded part of the sentence (subordinate clause) is the complement. According to the *DeVilliers hypothesis* the acquisition of complement syntax is the requirement of passing false belief test so the emergence of the theory of mind ability based on metarepresentations.

Similar connection was found between complement syntax and theory of mind in children with autism (Tager-Flusberg, 2000). Autism, a pervasive neurocognitive developmental disorder with heterogeneous but dominantly genetic origins is an excellent test-field of empirical hypotheses concerning the relationship between linguistic and sociocognitive development. This is so, because while language in the formal sense is often sound in autism, existence of a theory of mind deficit in children with autism has been confirmed in hundreds of studies since it was first found in Baron-Cohen et al. (1985). What makes autism especially relevant for our studies is the “problem of passers”: that although most children with autism fail on theory of mind tasks, there are a few who pass them. A possible resolution of this problem is the assumption that these children use *a verbal compensatory strategy* to pass false belief tasks (see, e.g., Happé, 1995). If this is indeed the case, we expect a very strong predictive effect of complement understanding to theory of mind ability in autism.

In sum, beyond the correlational results which made the existence of developmental connection between language and theory of mind even more evident and empirically underpinned some of the studies were able to determine the direction of this connection but as we could see these results are contradictory.

In the first study we investigated our *“channel-effect” hypothesis*; that the predictive effect of language level concerning theory of mind ability is due to the *verbal* nature of theory of mind tests. In this case the above-mentioned findings are rather methodological byproducts than valid indicators of a real causal connection between the two abilities.

In our second study the method of testing complement understanding was combined with the testing of word acquisition. The main question of this study is whether children can pass the word-learning false belief task earlier than the complement task and by this means the word-learning FBT (WFBT) could predict the performance on FBT the most. (see fig. 1) In this case the original DeVilliers hypothesis would meet another challenge.

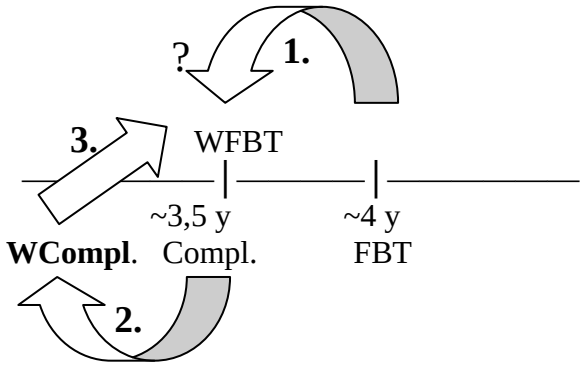

Figure 1 Our hypotheses are shown by the arrows. Arrow 1: the facilitation effect of word-leaning situation in false belief test (WFBT). The question mark indicates the uncertainty when children can pass the WFBT. Arrow 2: the facilitation effect of word-leaning situation in Complement test (WCompl). Arrow 3: the predictive relationship between word-learning complement test (WCompl.) and word-leaning false belief test (WFBT) (the extended DeVilliers hypothesis).

In our second study we tested two further related hypotheses (1) one of them was what we call the *extended de Villiers hypothesis;* we expect that mastery of sentential complements predict false belief understanding not only in the standard, but also in the word learning context. The other aim of the study was to reveal the mechanism of the effect of word learning situations on mental state attribution. In contrast with Happé and Loth's interpretation, (2) in our *facilitation hypothesis* we suggest that the better performance in false belief understanding in word learning contexts is due to a general facilitation effect of such situations and not to the different developmental trajectories of two separate mechanisms of theory of mind.

2. Study 1 [2]

2.1. Method

2.1.1. Participants

Two groups of children participated in our study; typically developing children and children with autism spectrum disorder, all children were native Hungarian speakers.
Twenty *typically developing children* (11 girls) aged 3 to 5.5 years (mean age 4;8 years) participated in our first study. All of them were recruited from local preschools.
Sixteen *children with autism spectrum disorder* (1 girl) aged 7;7 to 11;9 (mean age 10;2) .All children were recruited through the Autism Foundation, Budapest, Hungary. Diagnosis of autism was made on the basis of DSM-IV criteria (APA, 1994). The children's IQ scores were obtained using the Wechsler Intelligence Scale for Children III (WISC-III; Wechsler, 1991), the mean IQ was 79.7 (verbal IQ: 81.33; performance IQ: 62.6). The main criterion of selecting children was the verbal mental age based on the investigation of Happé (1995) according to which children with autism do not tend to pass the false belief tests under the verbal mental age of seven.

2.1.2. Materials and procedure

Language
Language level was assessed by the *Peabody* Picture Vocabulary Test (PPVT; Csányi, 1974) which is a measure of one-word receptive vocabulary and with the Hungarian version of

[2] All investigations with children with autism were the part of Krisztina Stefanik's PhD dissertation (2005).

Trog[3] (Bishop, 1983) which is under standardization and which measures the receptive grammar. In the lack of a complete Hungarian standard we used the raw scores at both tests. Complement tasks: as the age of the two groups of participant was significantly different and therefore their linguistic abilities too we used/applied two tasks which differed in their difficulty to test sentential complements. *Memory for Complements* was used to test typically developing children. An example: The girl said to her sister that she brought some apples, but she really brought some oranges. "What did the girl say?" The correct answer was "that she brought some apples" ("apples" was accepted as correct answer too). We presented 12 sentences and children passed the test if they answered minimum 10 questions correctly. *Complements in wh-questions* were used to test children with autism. An example: A boy was having chocolate in the school at noon. Later he went home and played with his toys. That evening he said to his mum "I ate chocolate this noon!" We asked then two questions: (1)When did the boy say what he ate? The correct answer was "that evening". (2) When did he say he ate? The correct answer was "that noon". 8 stories were presented; criterion for passing was set at 13 or more out of 16 (as two questions were given after every story).

Theory of Mind
Two different type of false belief tests were administered; a verbal and a nonverbal test. In the verbal test three standard false belief tasks were presented; two location-change false belief tasks based on Baron-Cohen, (1985) and an unexpected-contents false belief task based on Perner, Leekam, and Wimmer (1987). Children passed the *verbal FBT* if minimum 2 tasks were passed (and all the control questions were answered correctly). The *nonverbal FBT* was based on Győri et al (in press) it contains two false belief tasks and a true belief task. Children passed the nonverbal FBT if all the three tasks were passed.

2.2. Results

2.2.1. Results on typically developing children

Table 1 shows the partial correlations (age was partialled out) among the two type of FBT and the language tests; the Peabody, Trog and Memory for Complements.

	Peabody	**Trog**	**Memory for Compl.**	**vFBT**	**nvFBT**
Peabody	1,0000				
Trog	,2748	1,0000			
Memory for Compl.	,3427	**,3882(*)**	1,0000		
vFBT	,1172	**,4211(*)**	**,4948(*)**	1,0000	
nvFBT	,0942	-,0886	,0388	**,4585(*)**	1,0000

Table 1 Partial correlations in typically developing children. (* p<0.05, ** p<0.01)

[3] The development of the Hungarian version is in progress by Ágnes Lukács and Miklós Győri (BME KT Department, Budapest)

The correlations in bold are significant as shown. We found significant correlation between Memory for Complements and Trog, Memory for Complements and verbal FBT, the verbal FBT and Trog, and the verbal FBT and nonverbal FBT.
The verbal FBT was passed by 13 (65%) children and the nonverbal was passed by 12 (60%) children, the difference is certainly not significant with McNemar tests.
Finally, stepwise method of discriminant analysis was used to investigate which language measures contribute most strongly to performance on verbal and nonverbal false belief test. The performance on verbal FBT was predicted by Memory for Complements the most (Wilks' Lambda=0.639, F=10.153, p<0.005) but the performance on nonverbal FBT wasn't predicted by any of the language tests.

2.2.2. Results on children with autism

We used partial correlation where the age was partialled out. Table 2 shows the results the correlations in bold are significant so between Trog and Complements in wh-questions, verbal FBT and Trog, and verbal FBT and Complements in wh-questions.

	Trog	**Compl. in wh-questions**	**vFBT**	**nvFBT**
Trog	1,0000			
Compl. in wh-questions	**,4864(*)**	1,0000		
vFBT	**,7250(**)**	**,5425(*)**	1,0000	
nvFBT	-,2288	,1034	,2365	1,0000

Table 2 Partial correlations in children with autism. (* p<0.05, ** p<0.01)

Eleven (68%) children passed the verbal FBT but the nonverbal test was passed only by 7 (43%) children, the difference is not significant (McNemar tests) (Győri, 2004; in press).
We used stepwise method of discriminant analysis to investigate which language measures contribute most strongly to performance on verbal and on nonverbal false belief test. The performance on verbal FBT was predicted by complements in complex wh-questions the most (Wilks' Lambda=0.492, F=13.43, p<0.05) but the performance on nonverbal FBT wasn't predicted by any of the language tests.

2.3. Discussion

In our first study we reproduced the results of DeVilliers on typically developing children and Tager-Flusberg's results on children with autism with the verbal FBT. Our findings underpin that the performance on Complement task predicts the performance on the *verbal* FBT. In contrast the results in *nonverbal* FBT didn't mirror such a connection. These results on both samples strongly suggest that the DeVilliers hypothesis can't be hold in its original form. Rather the data support our channel effect hypothesis; that the effect found between complements and false belief test coming from the verbality of the FBT and not from an essential and causal connection between the two abilities behind the two test processes. It means that DeVilliers' conclusion that the acquisition of a specific aspect of syntax namely sentential complements are prerequisites of theory of mind is not tenable. The even more general conclusions regarding to the developing cognitive architecture became questionable

too. With our new results there is no reason to assume that these two cognitive abilities can't be acquired without each other – in this case theory of mind without language – which was a strong argument for a constructive development theory.
Data on children with autism is consistent with Happé's statement that children with autism pass verbal FBT with verbal compensation. Our results show strong correlation among language measures and verbal FBT, and this connection is stronger than what we found in typically developing children. Further implications on the nonverbal FBT go beyond the focus of this paper for more details about this see Győri et al (in press).

3. Study 2

3.1. Method

3.1.1. Participants

Sixty-five *typically developing children* aged 2.5 to 5.5 years were recruited from local preschools. 14 children were excluded as they failed a memory pretest (see description at Materials). Thus 51 children (26 girls) were included in the final sample (and were divided into four groups: 2.5-3 years: 5 children; 3-4 years: 15 children; 4-5 years: 16 children; 5-5.5 years: 15 children) their mean age was 4;2 years.

3.1.2. Materials and procedure

Memory pretest
A toy tiger was shown to the child and was asked: "What is that?" After the child had named the toy we put the tiger into a box and closed it. Then a toy lion was shown to the child and was asked: "What is that?" Then we took the tiger out of the bow and put the lion inside. The child was then asked: "What is in the box now?" and "What was in the box in the beginning?" Only those children who passed both questions proceeded to the main investigation. In contrast to the original pretest used by Happé and Loth the two toys in our pretest were visually very similar to minimize the possibility that in later tests children fail because they mixed the objects due to the visual similarity. That is reason why we had to exclude much more children from the investigation (14 children) than Happé and Loth (only 5 children).

Language
The same language tests and procedures were administered as in study 1: Peabody Picture Vocabulary Test (PPVT; Csányi, 1974), Trog (Bishop, 1983) and the Memory for Complements task.
Word learning complement task: To avoid such a criticism that the facilitation effect of word learning situation might appear in sentential complements as well so the causal connection between word-learning Complement task and word-learning FBT might still remain we developed a word learning complement test which combined the word learning situation with the standard complement tasks used by DeVilliers. An example: She said to the girl that there is a toy in her hand but it really was a TIMA. What did she say? The correct answer was "that there was a toy in her hand" ("toy" was also accepted). So the child didn't have to repeat the novel word which would have meant extra difficulty for them. But just like in word-learning

FBT we tested if they can decide to which of the two novel objects referred the new label. (The other new object was also in the picture).

Theory of Mind
The verbal FBT was administered the same way as written in study1.
Word learning FBT (Happé & Loth, 2002): Sally places a new object in a box then she leaves. Anne comes in and she has another new object and puts her object into the box (takes Sally's object out of it). Anne leaves too. Sally comes back and labels the object without opening the box „There is a wug in the box" Then we displayed both objects in front of the child and asked: Which one is the wug? (We followed the same methods at labeling the object, at the questions and control questions and at criteria setting as were used by Happé and Loth). We also tested the children with the true belief version of the word-learning test. In that Anne transfers her new object into the box in the presence of Sally so the new label refers to Anne's object what really is in the box.

3.2. Results

Thirty-eight children passed all control questions in Sally Anne FBT. Of these, 27 children, so the 71% passed the Sally Anne FBT too. In the word-learning FBT thirty children passed all the control questions and only 10 children (33%) of them answered the test questions correctly. Finally in the word-learning true belief test (TBT) thirty-eight children passed the control questions and 22 of these (57%) also passed the test questions.
To compare the performance on FBT to the performance on word-learning FBT we selected the children who passed the control questions for both tasks (Table 3). Using McNemar tests we found that significantly more children passed the Sally-Anne FBT than the word-learning FBT (khi square=15.53 df 1, $p<0.001$). Following Happé and Loth's statistical analysis we also focused on the children who could pass only one of these two tests. Of the 10 children who passed the word-learning task only 1 (10%) failed the Sally-Anne task. In contrast, of the 22 children who passed the Sally-Anne test 13 children (59%) failed the word-learning FBT. As expected however the word-learning TBT (38/22) seemed to be easier than the word-learning FBT (30/10) for the children, the difference is not significant.

		Word-learning FBT		
		Pass	Fail	
FBT (Sally-Anne)	Pass	9	13	∑: **22**
	Fail	1	7	∑:8
		∑: **10**	∑:20	

Table 3 Contingency table showing numbers of children passing and failing the Word-learning False Belief test (FBT) and the standard Sally-Anne false belief test. (excluding the children who didn't pass the control questions for both tasks).

As our results are just the opposite as Happé and Loth's results we made further analyses concentrating on the word-learning FBT to determine at what age children can pass it. Children aged 2.5 to 3 years bottom effect in every test so their results won't be shown in the diagram.

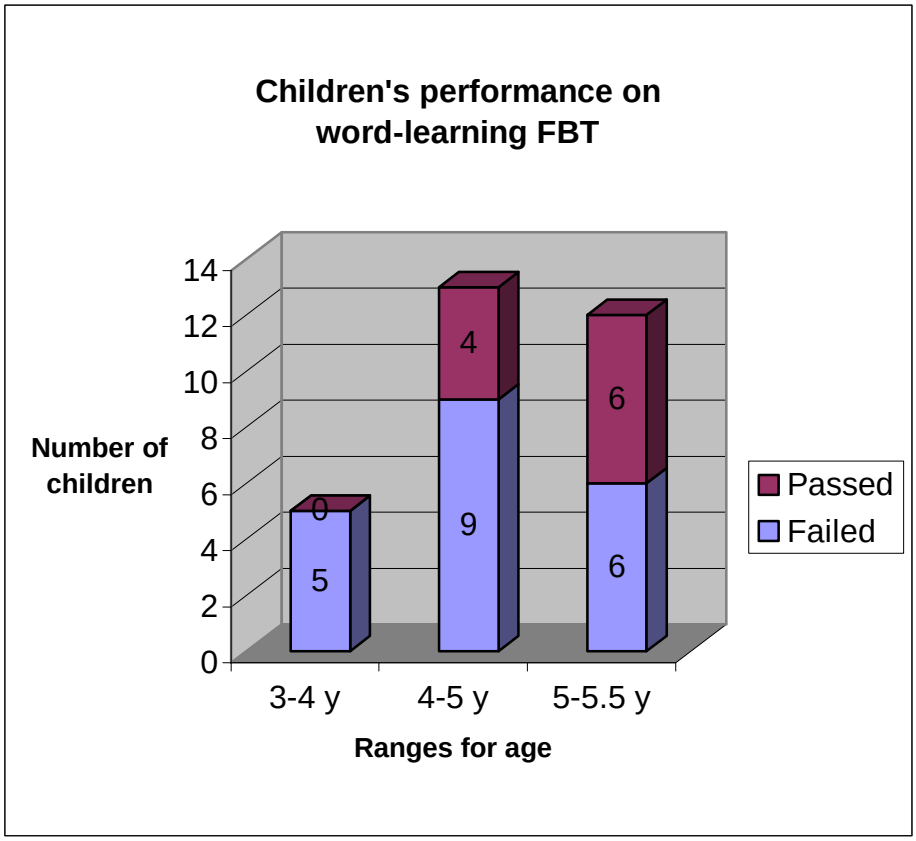

Diagram 1 Children's performance on word-learning FBT (including only those who passed the control questions) in 3 age ranges; 3-4 years, 4-5 years and 5-5.5 years.

In Diagram1 we can see that only the half (12/6) of the oldest children in our sample who aged 5 to 5.5 passed the word learning FBT. Which means it was much more difficult for them than the Sally-Anne FBT, in which our results fit into the results of the literature that children pass the false belief tests from the age of 4.
Fifty-one children passed all control questions in Complement task. Of these, 24 children, so the 47% passed the Sally Anne FBT, too. In the word-learning complement task forty-four children passed all the control questions and 14 children (32%) of them answered the test questions correctly.
To compare the performance on Complement task to the performance on word-learning complement task we selected the children who passed the control questions for both tasks (Table 4). Using khi square tests we found that significantly more children passed the Complement task than the word-learning complement task (khi square=13.56, df 1, $p<0.05$). we used the same method of comparing as in the FBT thus we focused on the children who could pass only one of these two tests. Of the 14 children who passed the word-learning complement task only 1 (10%) failed the standard Complement task. In contrast, of the 23 children who passed the Sally-Anne test 10 children (43%) failed the word-learning FBT.

		Word-learning Complement task		
		Pass	Fail	
Complement task	Pass	13	10	∑: **23**
	Fail	1	20	∑:21
		∑: **14**	∑:30	

Table 4 Contingency table showing numbers of children passing and failing the Word-learning Complement Task and the standard Complement task (excluding the children who didn't pass the control questions for both tasks).

As our further hypothesis built upon the results of Happé and Loth that we couldn't reproduce moreover we found just the opposite results our further analysis lost their reasons. In summary, the word-learning situation made both the FBT and complement task more difficult for children.

3.3. Discussion

In contrast with Happé and Loth's results we found that word-learning situation in a false belief test (and in complement task as well) makes the task more difficult and not easier. What can be the reason of this discrepancy? We would like to emphasize that we followed all the methodology that Happé and Loth used. Sometimes our methodological considerations were even stronger (see Memory pretest). It is also considerable that the effect we found seems to be strong: only the half of 5-5.5 years old children could pass the word-learning FBT while standard FBT was passed from the age of 4 which excludes the possibility that children in our investigations were less gifted than the ones in the Happé and Loth's research. Another tentative possibility is that Hungarian language made the word-learning FBT more difficult. But there is no data indicating that Hungarian children would acquire novel words later or with more difficulty than children speaking other languages. Considering the relatively large number of children and the strict methological considerations there is no reason that could explain such a difference. However, it is paradoxical and against intuition that increased task complexity would result higher performance as it is suggested by Happé and Loth.

4. General discussion

In our two studies we intended to give a deeper understanding of the relationship among sentential complements naïve theory of mind and word acquisition. The aim of our studies in connection with the DeVilliers hypothesis was to investigate the possibility that the causal connection found by DeVilliers between sentential complements and FBT is due the verbal mode of FBT. Our data were consistent with our channel-effect hypothesis since if FBT was presented in a completely nonverbal mode the connection disappeared. There are further

studies which in support with our results found that in languages other than English the connection between sentential complements and FBT suggested by DeVilliers doesn't exist. So their conclusion is that DeVilliers findings are not simply byproducts of the verbality of FBT, but byproduct of the English language (Perner et al, 2005) which is even a stronger statement against the complement hypothesis. We also hypothesized that if we extend the number of tests in the investigation with the word-learning FBT no predictive connection will be found in verbal testing of FBT either. But in our second study we found that word-learning FBT was not easier for children as it was stated by Happé & Loth so the second hypothesis lost its validity.

The importance of findings on children with autism is dual. On the one hand the fact that results on children with autism are consistent with the results on typically developing children in sentential complements is a strong argument for our channel effect hypothesis. We also found that in case of nonverbal testing of FBT the acquisition of complement syntax is not the prerequisite of passing false belief test and hereby the emergence of metarepresentational theory of mind either. On the other hand our data support the verbal compensation theory of Happé as the correlations among verbal FBT and other language tests were stronger than what was found in typically developing children (Győri, in press).

Finally, we investigated the effect of word-learning situation in two tasks; in the FBT and in Complement tasks. In contrast with earlier findings, our results suggest that word-learning situations make FBT more difficult for children. Similar effect was found in Complement tasks. So here again the further hypothesis based on the earlier findings lost their validity. However the reason of such an appreciable difference between the data of the two studies is not clear yet, our studies suggest that we have no reason to assume that theory of mind mechanism (ToMM) would consist of (at least) two subcomponents: one for detecting communication situations and the other for detecting behavioral situations. The idea of a non unitary theory of mind mechanism is not a new thought. In the literature we can find a few researchers who suggest that subcomponents or sub-modules exist inside if ToMM. Tager-Flusberg and Sullivan (2000) for example interpret her results on children with Williams syndrome that theory of mind has two subcomponents: a social-cognitive and a social-perceptual component. Another example is Sperber (2000) who in partial consensus with Happé and Loth, argues for the existence of (sub-)systems of ToMM and one of them would be a (sub-)system for communication. But until now we have no unambiguous empirical evidence against the unitary theory of mind.

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