



# THE ROLE OF EMPATHY, SOCIAL ANXIETY AND AUTISTIC TRAITS IN THEORY OF MIND: A BEHAVIORAL STUDY OF TACIT COORDINATION

Bachelor's Project Thesis

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**Abstract:** Theory of Mind (ToM) consists of the cognitive skills we utilize in predicting people's behavior by considering their intentional mental states. ToM can be explored in a coordination task between two people in which there is no explicit communication. This implicit understanding is defined as tacit coordination. There are multiple factors which affect the ability to make use of ToM such as Working Memory (WM); degrees of empathy, social anxiety and autism. In this research, behavioral data is collected from an N-back task with no explicit communication to measure accuracy. This data was tested for correlation with each paired session's levels of empathy, social anxiety and autistic traits. No significant correlations were deducted for empathy and social anxiety. Autism showed weak correlation with the tacit coordination performance.

## 1 Introduction

It is a natural sense to many people to recognize other people's minds along with their own. This cognitive experience brings the acknowledgement that everyone has their own thoughts, beliefs, intentions and emotions. Relying on this understanding while predicting people's behavior means that 'Theory of Mind' (ToM) is acquired (Frith and Frith, 2005). It occurs in the way of collecting clues from your knowledge of this other person and trying to provide an explanation or estimation of their actions or strategies. For instance, utilizing ToM is helpful in a chess game where the actions are calculated on the basis of guessing opponent's future moves. In this case, only the benefit of self is observed because chess players make use of ToM only to optimize their individual winning. However, ToM can also be applied to benefit a group of people such as in football where coordination between team members is required for them to score.

Coordination between people can be established either through communicating explicitly or implicitly. 'Tacit coordination' is achieved when there is no explicit communication (de Kwaadsteniet and van Dijk, 2012), and it is a situation in which you would need ToM. An example scenario can be de-

picted as a child roaming the city with their parent and losing each other in the crowd without the presence of any mobile phones. In order to find each other, they would both need to think of the other person's state of mind and the place they would most likely be at. Since no communication can be formed, the correct coordination depends mostly on how well they can project each other's mental states onto their minds. Transitioning from self to social cognition is an ability that requires mental effort (Lin, Keysar and Epley, 2010). Nevertheless, not everyone requires the same amount of execution power to do so. The accuracy of tacit coordination therefore can vary depending on how strong someone's executive functioning manifests.

Executive functioning is defined as a general group of high level cognitive processes which let us achieve tasks and interact with others by optimizing our behavior to unexpected or unknown situations (Gilbert and Burgess, 2008). Instances of these cognitive processes include Working Memory, Cognitive Inhibition, Response Inhibition, Cognitive Flexibility and Attentional Control (Diamond, 2013). Some of these executive functions can be acting more dominantly during an unexpected situation where tacit coordination is required. Let us

take the example provided earlier: at the moment of realization of having lost each other, both the child and the parent might start feeling scared or anxious. The negative feelings generated due to the unknowing (where the other person might be located) might go against the level of focus on the thoughts and intentions of the other person. Therefore, one would require a strong attentional control in this scenario. Further, both would have to synchronize their decision making to be able to steer back to each other in the city. Such manipulation of the stored information in order to achieve the right reasoning and a clear guidance to their decision making is known to be processed by the Working Memory (WM) (Diamond, 2013). This suggests that WM may be crucial for tacit coordination to be accomplished.

Another factor that could influence the tacit coordination is the existence of different characteristics among people. As mentioned earlier, some people require less effort in executing Theory of Mind and some require more. For individuals who have autism, it is studied that their ability to make use of ToM is impaired (Frith and Happé, 1994). An example among such studies is from Baron-Cohen et al. (1986), their experiment included autistic child subjects who were given mixed pictures from comic strips and asked to tell a story in their own words. There were 3 different types of stories to be told and the findings revealed that the majority of children could not tell stories by attributing mental states rather dealt better with mechanical or behavioral story types. It was concluded that autism had links to limitations in mentalizing. Mentalizing in this context refers to the functioning of ToM. So, if tacit coordination relies on ToM, it would follow that autism impairs the performance of tacit coordination as well.

There are also other personality traits which are thought to affect success in tacit coordination. Recall that ToM refers to the ability of building connections to others by means of realizing they are similar to oneself. Similarly, empathizing with people is understanding people's thoughts and feelings by associating self to others (Meltzoff, 2013). Social anxiety can also be taken into account as a personality trait playing a role in tacit coordination. Taking fear and anxiety under control is an essential skill to achieve healthy social interactions (Goldstein and Winner, 2012). Experiencing increased

levels of such negative feelings might inhibit efficient utilisation of ToM. It might appear as a challenge to quantify such characteristics so it is very important to recognize the endorsed methods to do so. Within the field of cognitive psychology, aforementioned qualities do not necessarily have to be clinically assessed; rather it is a common practice to refer to multidimensional self-report questionnaires. These tools reveal an individual's personal trait in question in terms of their capacity to understand the personal intentional mental states they possess such as their desires, feelings, goals (Allen, Fonagy and Bateman, 2008). As an example, in a study from Yun et al. (2012) higher-level social cognition was analyzed to be negatively correlated to the level of social anxiety which was measured with self-report questionnaires.

It has been suggested that Theory of Mind is an essential tool to form and maintain tacit coordination (de Weerd, Verbrugge and Verheij, 2015). This has been connected to how much individuals are capable of associating themselves with the rest by realizing other people's thoughts, intuitions and strategies. Efficient use of social skills like these have been linked to different personality traits and attitudes. Besides, the underlying cognitive factors have been discussed such as the importance of executive functioning. Working Memory thereof was defined as an executive function relating to the efficient utilisation of ToM because employing it requires an effortful cognitive shift from the perception of self to others (Bradford, Jentsch and Gomez, 2015). The aim of this research is to provide a better understanding of coordinated ToM between a pair. This will be done by exploring how much average of the combined personality traits of a pair (autism, empathy, social anxiety) affect a tacit coordination task. To analyze the role of executive functioning, more specifically Working Memory, the trials will contain two different WM load tasks. The research question is therefore: Does the variation in empathy, social anxiety and autistic traits of a pair affect the performance in their tacit coordination? It is expected to observe a declined performance for higher level of autistic traits and social anxiety because these traits are known to impair ToM as well as decreasing Working Memory efficiency. For increased levels of empathy, ToM is expected to be facilitated better which should then result in a better performance. High WM load

should impair the tacit coordination more because it requires more effort in employing ToM. On the other hand, combined with low WM load, increase in the performance should be observed more significantly.

## 2 Methods

### 2.1 Subjects

The subjects of the experiment consisted of 86 people, who were all associated with the University of Groningen, aged from 18 to 35 years old (with mean age of 23.14 and a standard deviation of 4.06). These subjects were arbitrarily matched as same-sex pairs. In all paired sessions, the assigned partners were strangers to each other. This was ensured by asking them whether they were in any way related to the assigned partner (friend, romantic partner, family member etc.), if so the session groups were re-arranged. However, during the experimental setup, co-participants were able to meet and briefly chat with each other.

In terms of physical attributes, all the subjects were right-handed and were reported to have normal vision (including healthy perception of colors) or corrected to normal with glasses or contact lenses. Furthermore, none of the participants had a medical history of neurological damage, psychiatric disorder or general illness; all acquired normal intelligence.

Session number 34 was discarded in the behavioral data-frame therefore it was also removed from the questionnaire scores leaving us with a total of 42 sessions.

### 2.2 Procedure

The experiment took place in Bernoulliborg building at the University of Groningen. It took around 1.5 hours to complete a session: 15 minutes for filling in questionnaires relating to their use of Theory of Mind, 1 hour for computerized behavioral task and the remaining time was reserved for overall setup and a demo run.

Before the start of each session, subjects received a verbal overview about the research followed by an informed consent form to be signed. After these forms, the experiment was initiated with the ques-

tionnaires. Everything that was designed and performed within the experiment was approved by the Research Ethics Committee while abiding by the corresponding laws and institutional guidelines. As a part of the agreement, each participant received 8 Euros per hour, and if they showcased excellence in the computerized behavioral task they received an additional 4 euros.

For each session, a pair of subjects were seated in a room, required to engage in no verbal or physical communication during their coordination task. They were assigned to individual-use computers with identical qualities. It was instructed that the keyboard would be utilized as a response tool to the visual stimuli they would receive through their monitors.

### 2.3 Questionnaires

The personal traits of the subjects relating to social and executive functioning skills are measured through 3 different questionnaires: Autism Spectrum Quotient (AQ) (Baron-Cohen, 2001), Interpersonal Reactivity Index (IRI) (Davis, 1983), Interaction Anxiousness Scale (IAS) (Leary, 1983). These questionnaires reveal the level of autistic traits, empathy skills and social anxiety provided that the subject answer the questionnaires truthfully.

More specifically, AQ measures the characteristics of the subjects relating to autistic spectrum disorders which can vary from having difficulties with social engagements to delayed cognitive skills. On the other hand, IRI is designed to assess empathy through 4 divided scales: perspective taking, fantasy, empathic concern, personal distress. Finally, IAS measures the general tendency to experience anxiety in situations where feedback from other social agents is anticipated by a person.

### 2.4 Design

The trial design of this experiment is a 2 by 2 within-subjects factorial design: low or high WM load task by either color or shape stimuli. Participants had both stimulus types and both WM load conditions. Stimulus and WM load types differed between 2 blocks of 90 trials and a self-paced break was included in between blocks. In fact, the reason for alternating stimuli types between two

blocks was to prevent participants from sticking to the same strategy the whole coordination task.

The sequence of a trial can be seen through image A in Figure 2.1. Participants first perceive 4 unique images on their monitors with altering colors or shapes and are expected to choose the same image as the other participant to score '1' as correct, otherwise '0'. An example of such stimuli can be observed with image B in Figure 2.1 which was adapted from Alberti et al. (2012). The images which the pair receives (at the same time) on their individual monitors were not given in the same order and this fact is known to the participants. Hence, the order was randomized even though they perceived the same stimuli, so that they had to build a strategy around the features of the images rather than their positions on the attention zone. An example strategy is to pick a random image for the first trial, and when the partner's choice is revealed the features of that image should be paid attention to. This knowledge can be used for deciding which images to select that are similar to the partner's choices in the next trials. If the partner does not tune into these actions then the strategy can be changed by searching for patterns in the answers to comprehend the other subject's strategy.

After the appearance of each stimulus, co-participants had to pick their "first-best guess" and "second-best guess" images. In doing so, participant 1 had to press either of the keys "1", "2", "3", "4" and participant 2 had to press either of the keys "z", "x", "c", "v" corresponding to the location of the image of choice. Both participants were instructed to use their right hands. After every trial, monitor showed whether the choices have matched or not as well as the stimulus picked by both of the subjects (shown for 3 seconds). The goal of this part of the design was to aid building Theory of Mind within subjects about each other's strategy.

To be able to explore the effects of questionnaire scores with different dimensions, two conditions of Working Memory loads were included. As explained in the introduction, the reason for doing so depends on the links revealed between empathy, social anxiety, autistic traits and the degree of executive functioning. The participants were loaded on their working memory either lightly or intensely during their engagement with the image selection task. Both WM load tasks were conducted before

the image coordination phase of each trial and the maximum response time was set to be 2.5 seconds after the display of the visual stimulus. For low WM load task, participants attended to a fixation cross for a second where a number appeared. They were instructed to press on a key either '1' or '2' ('z' or 'x' for participant 2) to indicate whether the number appeared was an odd or even number. For high WM load task, a standard N-back task was performed (Kirchner, 1958) wherein the participant had to recall whether the number shown at that moment was the same as shown two trials ago (key press either '1' or '2' for participant 1; 'z' or 'x' for participant 2). Whenever participants gave the correct response green text displayed the word "CORRECT" otherwise red text displayed "INCORRECT". Additionally, if they exceeded the set response time red text displayed "TOO SLOW". As can be seen on the trial sequence in Figure 2.1, feedback was provided to the participants on their mean accuracy on the corresponding WM load task followed by a fixation cross again right before proceeding with the image selection task.

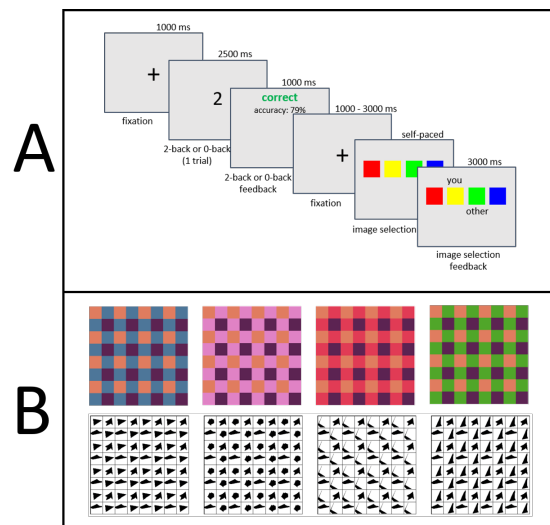


Figure 2.1: Trial sequence (A) and example stimuli (B).

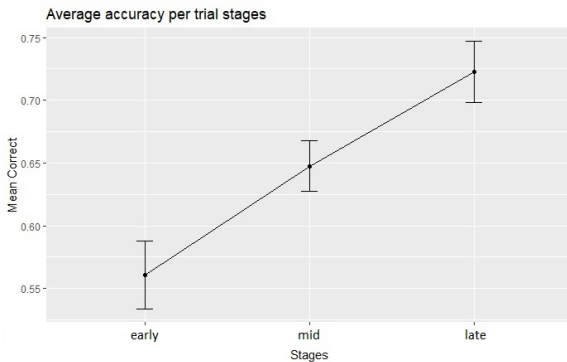
## 2.5 Data Analysis

First of all, it is a common scenario that subjects learn the task over time because they go through multiple trials and can eventually perform better.

The coordinated ToM task guides the participants to tune into each other’s answers hence allows for learning within the experiment. In order to observe this effect better, the trials will be divided into three different stages. It will then be examined whether the subjects’ mean correct values showed any differences for such division. Secondly, to analyze how the change along empathy, social anxiety and autism scales relate to a pair’s ability to match their implicit strategies, a correlation test will be applied.

### 3 Results

We will now take a look at the average proportion of correct responses for all the participants in three specified stages. Figure 3.1 shows that the early stage had the lowest and late stage had the highest mean correct. This means that throughout the experiment participants managed to tune into each other’s mental states. Early stage can be perceived as an adaptation phase where subjects get familiar with the task and their co-participant’s choices. For this reason, early stage data will be disregarded for the analyses.



**Figure 3.1: Mean correct among all participants throughout 3 different stages of the trials.**

Pearson correlation test was conducted to see whether there was a meaningful pattern in the way accuracy differed with continuous change in autism, empathy and social anxiety levels. There were two continuous variables analyzed: mean correct versus average questionnaire score of the corresponding session. Correlation tests resulted in  $R = 0.0078$ ,  $p = 0.96$  for autism;  $R = 0.0029$ ,  $p = 0.99$  for em-

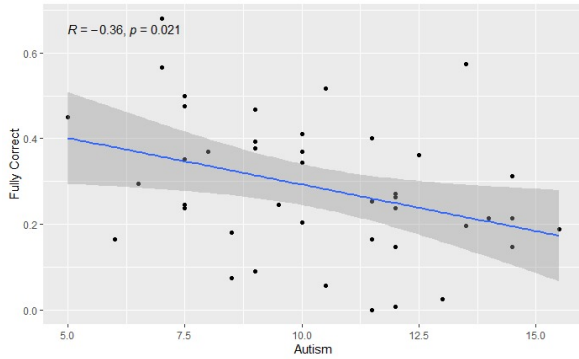
pathy and  $R = -0.058$ ,  $p = 0.72$  for social anxiety. None of the p-values are significant, meaning that the correlations are effectively zero.

It was also analyzed whether the continuous change in these traits correlated with the accuracy under different Working Memory load conditions (high/low). The reason to do so depends on the background which suggests that Working Memory modulates the degree of attributing mental states to other people. If Working Memory is required for utilizing Theory of Mind during the tacit coordination task, then an additional Working Memory task would exhaust the resources. P-values for the correlation test under separated WM load types resulted in quite high values: between 0.5 to 0.94 meaning that they are insignificant.

Due to having no significant results to support correlation between mean correct and the questionnaire scores, a Bayes Factor Analysis was conducted. The goal of Bayes Factor Analysis is to investigate whether the lack of significance was because of either having too much uncertainty in the data or there not being any correlations at all. Bayes factor for the null versus the alternative hypothesis  $BF_{01}$  gives how many times the data is more likely to be observed under the null hypothesis. For autism  $BF_{01} = 5.196$ ; for social anxiety  $BF_{01} = 4.879$ ; for empathy  $BF_{01} = 5.201$ . These Bayes factors were also calculated under the separated WM load conditions: all turned out to have a value between 4 and 5. Therefore, Bayes factor analysis suggests that the data for any of the mentioned conditions are around 5 times more likely to be observed under the null hypothesis. It means that there is moderate evidence to show that a pair’s average of autism, empathy, social anxiety traits are not correlated with their performance.

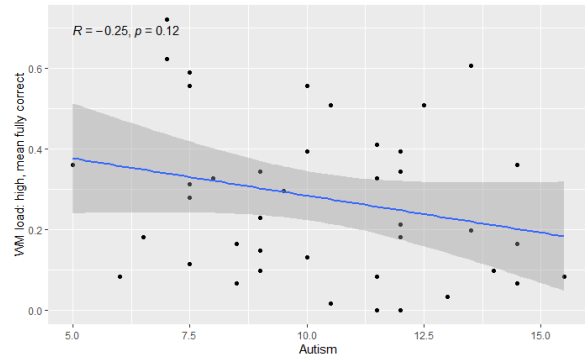
So far, the accuracy has been represented by average proportion of ‘correct’ answers, for the case of co-participants’ first image choices matching only. Furthermore, Pearson correlation test is conducted for a different measure of the performance: ‘fully-correct’ referring to first and second choices matching. If the subjects were able to match both of their guesses, it would signify a robust tacit coordination. Figure 3.2 shows that there is a negative correlation between Autism and average proportion of ‘fully correct’ with  $R = -0.36$ ,  $p = 0.021$ . Figure 3.3 shows that there is a negative correlation between Autism and average proportion of ‘fully correct’ un-

der the low WM load condition with  $R = -0.38$ ,  $p = 0.013$ . Both of these results are found to be significant because they have a p-value around 0.01 and 0.02.

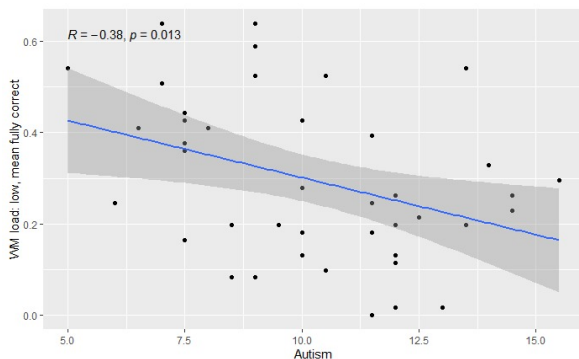


**Figure 3.2:** Mean fully correct per session versus corresponding AQ scores.

and social anxiety. Overall, the negative correlation autism has with the average proportion of 'fully correct' is observed to be a weak one: resulted Pearson coefficient is not very close to -1.



**Figure 3.4:** Mean fully correct per session with high WM load versus corresponding AQ scores.



**Figure 3.3:** Mean fully correct per session with low WM load versus corresponding AQ scores.

Figure 3.4 shows a lack of significance in the correlation of autism with accuracy under high WM load condition with  $R = -0.25$ ,  $p = 0.12$ . This was not the case for low WM load condition. To investigate why, a Bayes Factor Analysis was conducted: it resulted in  $BF_{01} = 1.572$  which refers to the data being 1.572 times more likely to be observed under the null hypothesis. This only provides anecdotal evidence for the null hypothesis being true which suggests the reason for a lack of significance could be depended on having too much uncertainty in the data. On the other hand, Bayes Factor Analysis provided moderate evidence in favor of the null hypothesis for the insignificant results of empathy

## 4 Discussion

In this study, we investigated the relationship between empathy, social anxiety and autism levels of a pair, and the accuracy of this pair's performance in a tacit coordination task. These personality traits were measured with self-report questionnaires. The goal of the tacit coordination task was to match answers with the co-participant's choice without explicit communication, but only through the provided feedback. This feedback was shown to both co-participants about what their first and second guesses were and whether these matched. The accuracy of the performance was measured with correct answers (first choices matched) and fully correct answers (first and second choices matched). Two different Working Memory (WM) load conditions were taken into account to observe the effects of executive functioning on this task as well. To analyze the relationship between these variables, Pearson correlation test was applied. Furthermore, to understand the lack of insignificance in the results, Bayes Factor Analysis was carried out.

### 4.1 Limitations

It is important to identify the factors that might have limited the understanding of the way tacit

coordination is established. The previous studies suggested that empathy aids facilitating the Theory of Mind hence was theorized to improve tacit coordination, no significant evidence was found to support this claim for a pair of people. Social anxiety and autism were known to impair Theory of Mind hence the performance in tacit coordination: in this research only the latter correlation was observed. The reason for not observing all the mentioned effects could be depended on the fact that previous studies mostly included the impacts on an individual. In this research however, focus was on the matched individuals' personality traits and whether averaging these would affect the overall performance. Moreover, the uncertainty in the data could be depended on participants not answering the questionnaires truthfully. Even if they did try to answer truthfully, their level of reflecting on the questions or their subjective perspective could affect the accuracy in their answers. So, this limitation could be improved by referring to clinical assessments rather than self-report questionnaires.

## 4.2 Future Research

Efficient utilisation of Theory of Mind in daily lives is an essential skill to have if one wants to engage in proper social interactions. It would then be important to further explore what other personality traits or levels of social skills have an impact on ToM. Moreover, a possible research can be designed to test the relationship between attention disorders and tacit coordination performance. If such relations can be identified then specified strategies can be designed to help improve people's ability to employ ToM.

## 4.3 Conclusions

No correlations were found for empathy and social anxiety levels of a pair between their tacit coordination accuracy (neither for correct nor for fully correct scores). Moderate evidence was provided by Bayes Factor Analysis to support this claim. Defining the accuracy in terms of first and second choices matching gave out significant results for the average of each pair's Autism Spectrum Quotient scores. It was found that there is a weak negative correlation between the autism levels and the tacit coordination accuracy. This effect was significantly observed

under the low Working Memory load condition yet for high load this was not the case. Bayes Factor Analysis could only provide anecdotal evidence in favor of the null hypothesis (no correlation). Therefore this insignificance could be explained by the uncertainty in the data. This is a point that can be improved in the future research by gathering more data to allow for more balanced data set. The aim of this research was to explore whether the variation in empathy, social anxiety and autistic traits of a pair affect the performance in their tacit coordination. In conclusion, increased autistic traits of a pair is found to decrease the accuracy in a ToM coordinated task where there is no explicit communication.

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