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Neural correlates of social interactions and the effects of autistic traits on them

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Zusammenfassung

Soziale Interaktion spielt eine zentrale Rolle in unserer Gesellschaft. Daraus entspringt ein wachsendes Interesse in die neuronalen Korrelate. Gleichzeitig kann realistische soziale Interaktion nicht direkt in einem experimentellen Setting im MRT reproduziert werden. Ein weiteres Problem ist, dass die möglichen Arten der Interaktion so vielfältig sind, und es somit fast unmöglich erscheint eine umfassende Übersicht zu erstellen. Dies zeigt sich besonders in der mangelnden Vergleichbarkeit verschiedener Studien. Die vorliegende Studie nutzt die bildliche Vorstellungskraft in der Form von autobiografischen Erinnerungen. Diese erlauben den Teilnehmern mentale Repräsentationen von sozialen Events innerhalb des MRT-Scanners zu generieren. Sie demonstriert damit die neuronalen Korrelate sozialer Interaktion basierend auf ihrer emotionalen Beschaffenheit sowie der Perspektive die der Teilnehmer in der Erinnerung einnimmt. Zum studieren des Effekts der Perspektive wurde in aktive und passive Interaktionen geteilt. Der Effekt von Emotionen konnte durch die Unterteilung in positive, negativ und neutrale Erinnerungen studiert werden. Insgesamt ergaben sich hierdurch sechs verschiedene Bedingungen mit autobiographischen Erinnerungen sozialer Interaktion. Zusätzlich ergab sich eine Kontrollbedingung mit einer Erinnerung ohne sozialen Inhalt. Wichtige Ergebnisse waren eine Korrelation der Insula mit sozialer Interaktion. Die Insula stellt ein wichtiges Zentrum für die Verarbeitung von Emotionen und Erinnerungen dar. Besonders wichtig war die Region für die passive Interaktion. Negative Emotionen zeigten sich durch eine Aktivierung im Nucleus caudatus, jedoch nur solange die Teilnehmer selbst die Interaktion initiierten. Die nicht-sozialen Erinnerungen wurden von Gebieten die für die Selbstverarbeitung relevant sind repräsentiert. Die gleichen Daten wurden anschließend dafür verwendet den Einfluss von Defiziten in der Aktion zu erforschen, in diesem Fall den Einfluss von autistischen Merkmalen. Es gibt nur wenige Studien die diese Merkmale mithilfe eines fMRTs untersuchen und dies ist die erste Studie die speziell die sozialen Defizite betrachtet. Eine hohe Punktzahl im Autismus-Spektrum-Quotient-Test war positiv korreliert mit Regionen die zuvor mit sozialen Defiziten bei Patienten mit Autismus in Verbindung gebracht wurden. Die Ergebnisse sind daher im Einklang mit früheren Forschungsarbeiten die in der normalen Bevölkerung Merkmale fanden, die zwar denen von Autismus ähneln, jedoch milder ausgeprägt sind. Sie unterstützen die Theorie des kontinuierlichen Autismus-Spektrums, welches von ausgeprägtem Autismus über milde Symptomatik bis in die generelle Bevölkerung reicht und zeigen, dass dieses kontinuierliche Spektrum auch in den neuronalen Korrelaten anzutreffen ist.

Abstract

Social interaction plays a central role in our society. There is therefore growing interest in its neural correlates. At the same time, realistic social interaction cannot be reproduced directly in the experimental setting in an MRI. Another problem is that the types of possible interactions are so vast that it is difficult to get a comprehensive overview. This also often impedes easy comparison of different results in literature. This study uses mental imagery in the form of autobiographic memories, which allowed participants to generate mental representations of social events while inside an MRI-scanner. It attempts to demonstrate differences of neural correlates of types of social interactions based on their emotional valence and whether the participants were taking an active or a passive role during the interaction. The effect of involvement was studied by differentiating between active and passive interaction, the effect of emotions by taking into account the emotional valence (positive, negative and neutral). In total, six different conditions of autobiographical memories of social interaction were used, as well as one control condition comprising of a memory with no social content. Important findings were a correlation of social interaction with the insula, an important centre for the processing of emotions and memory. It was an especially important region for passive interaction. Negative emotions were represented by an activation in the caudate nucleus, as long as it was the participants that initiated the interaction. Non-social memories were represented by areas involved in self-referential processing. The same data was then used to study potential deficits in social interaction, namely autistic traits. There are few imaging studies examining autistic traits on fMRI and this is the first study specifically looking into the social deficits. A high number of autistic traits as found using the Autism Spectrum Questionnaire was correlated with responses in areas that had previously been associated with social deficits in autism. The results are therefore in accordance with previous research that found traits similar to those in Autism but milder in the general population. They are in accordance with the theory of a continuous autistic spectrum reaching from frank autism over milder disease to the average population on fMRI.

1. Introduction

This first chapter depicts the theoretical background relevant for the later described study. First a general overview of social interaction including neural correlates is given followed by chapters on affect control theory, autobiographical memories and lastly the current state of research concerning autistic traits.

1.1 Social interaction

Social interaction, as a part of social science, is the way two or more people interact with one another. It is both active participation and how we react to those around us. Almost all activity is influenced by social content and successful interaction is both closely linked to health (Bloomberg et al., 1994) and psychological well-being (Rook, 1984). Consequently, there is a long history of research connected to how and why we interact with others the way we do. Functional social interaction is a skill that is mostly learned in infancy and early childhood. If there are complications during the development of these skills, people can suffer from the long-term consequences well into their later life (Thompson, 2014; Simonian et al., 1991). A childhood filled with violence and a lack of resources can lead to problems forming healthy relationships and controlling one's emotions appropriately. During social interaction, we can use both verbal and non-verbal cues to transmit our emotions, intentions and goals.

1.1.1 Verbal communication

Basic communication is a skill acquired through observing and practicing social interaction. Group behaviour depends on a mutual understanding of signals, both produced and perceived. Though making sounds and observing the reaction of their caregiver, infants start language development long before they become capable of forming actual words, making interaction a crucial part of language acquisition (Goldstein & Schwade, 2010). For this process to happen appropriately, the caregiver must be sensitive to the infant's immature productions, and the infant must be capable to adapt their articulation by responding to the caregiver's active, real-time feedback. The older an infant, the more its babbling resembles the language their mother is speaking in pitch and rhythm as well as in syllable structure (Goldstein & Schwade, 2010). Mothers responding to their infants leads to reward and reinforcement, causing the infant to expand their repertoire of syllables (Goldstein & Schwade, 2010). Verbal communication can be divided into two different types, monologue and dialogue. Logically it should be easier for us to speak in monologues, as during dialogue we constantly have to pay attention to what our counterpart is saying, formulate an appropriate response as well as find the right moment to start speaking. In practice, most people find it much easier to carry on a conversation with someone than to just speak spontaneously, hold a speech or talk to themselves for a prolonged period of time. To explain this process, Garrod and Pickering (2004) proposed an unconscious process of interactive alignment, where production and comprehension of two conversational partners become tightly aligned. This causes their representations containing space, time causality and current relevant individuals overlap. Unaware, the interlocutors use each other's words, sounds, grammatical forms and meanings. In agreement with this, Stephens et al. (2010) found a speaker's brain activity is mirrored in its listener with a temporal delay of several seconds. The better the listener understood what the speaker was saying, the better was the neural coupling. Joint response could only be achieved when there was actual information being transmitted between the speaker and the listener. If the speaker told the story in a foreign language for example, no significant coupling could be found. Interestingly, the same degree of neural coupling can be achieved while communicating with hand gestures (Schippers et al., 2010) or solely with facial expressions (Anders et al., 2011).

1.1.2 Implicit processes - mentalising, mirror neurons & social knowledge

While interacting with others, we have to be able to constantly grasp their intentions. It helps us to maintain conversations and understand the implied meaning of what someone is trying to communicate. To do this, we don't always have to communicate verbally with someone. When a stranger bumps into us on a busy street, we can usually tell instinctively that it was accidental unless there are obvious signs pointing out the opposite. When we see someone reaching for a full cup of coffee we can guess that the most probable next action is for them to move the cup to their lips and drink. In order to understand others, we rely on two different systems. The first, the mirror neurons network, helps us understand observed motor behaviour. Motor neurons are a group of neurons originally discovered by Rizzolatti and colleagues in macaque monkeys. They were found to fire both when the monkey was performing an action and when it was observing an experimenter performing the action (Pellegrino et al., 1992). When we observe an action, we compare it to a representation in our own memory (Rizzolatti & Sinigaglia, 2016). The activation is therefore different depending on whether we are observing an action that is part of our own motor repertoire or not. When we observe somebody reaching for a piece of fruit and then moving it towards their mouth we recognise the intention of eating it, as it is a pattern we have performed ourselves multiple times. Moving patterns we are not familiar with on the other hand are much more difficult to grasp.

The second network, a mentalising network, also called Theory of Mind (ToM) is responsible for 'reading' another's mental state and its correct interpretation (Van Overwalle & Baetens, 2009). We usually have an idea of what other people want even if they don't explicitly describe it. Much of this information is gathered automatically. It is important for us to infer other's mental state as it allows us to accurately interpret their intentions and actions, their goals, desires and beliefs. We can obtain this information from others using verbal or even nonverbal cues. Through the reading of others' facial expression, from hearing the way they stress their words as well as their intonation, we can perceive their emotional state (Adolphs, 2002). These cues are also culturally influenced. A person who grew up in a warmer climate might stand much closer to a stranger whereas someone from a colder place would not feel comfortable in the same proximity (Sorokowska et al., 2017). The ability to understand different body postures, facial expressions and the way others interact with their environment helps us to appropriately react to the people around us. Implicit mentalising, which is a way of mentalising that works automatically and subconsciously, can be found in infants as well as in the wider animal kingdom, e.g. in chimpanzees who follow each other's gaze (Povinelli 2001). Explicit mentalising, on the other hand, has so far only been observed in humans. It is described as a meta-cognitive process or the ability to reflect on one's own actions (Frith & Frith, 2012). Inferring the mental states of others is not the only process that helps us interpret a social situation. Additionally, our past experience and our social knowledge, can help us understand others. Our social knowledge shapes the way we see the world. Past experiences are spontaneously recalled when we encounter corresponding stimuli in the present. The evoked information can then directly influence how we feel about and understand present stimuli. This can then directly influence our behaviour in this new situation. All of these processes occur multiple times daily, most commonly without peoples' awareness (Smith & Zárate, 1992). When someone encounters a person that one assumes to be belonging to a certain social group, one automatically makes inferences and judgements about that person by activating knowledge they have about that group, including information about other members belonging to that group and the stereotypes connected with it (Smith & Zárate, 1992). Many people assume that the elderly are slower than younger people because it's an experience they have made in the past with other people of advanced age. If they now meet a new person belonging to that group (elderly) they assume them to be slow even without confirmation. Even more, studies found that the way we act is commonly influenced by social knowledge that was incidentally activated beforehand by completely unrelated recent events (Ferguson & Bargh, 2004). As an example, people primed with an elderly stereotype are likely to walk more slowly down a hallway than people that were not primed beforehand. Therefore, social knowledge, activated by the environment, can influence behaviour passively even for a time after being activated in an unrelated event (Bargh et. al.1996). Dijksterhuis and van Knippenberg (1998) found that even more complex behaviour could be primed. In this manner, participants primed with intelligence, by imagining someone perceived as intelligent, were afterwards much more successful when taking a test comprising questions of general knowledge compared to non-primed individuals.

1.1.3 Emotions and their regulation

Emotions play a central role during our daily interaction with others. Nonverbal presentation of emotions is a quick way to give our interlocutor an idea as to what we are feeling and will rapidly allow him to react (Dimberg & Thunberg, 1998). Before we express an actual emotion, the brain has to complete a set number of steps: firstly the perception of a stimulus in our surroundings with potential emotional content followed by a reaction with an appropriate affective state and lastly the regulation of said state (Phillips et al., 2003). These states can then be interpreted by others. While angry and disgusted facial expressions were found to be perceived as very dominant, those expressing sadness and fear were rated as possessing low dominance (Knutson, 1996). Embarrassment has been shown to show submission and appease others (Keltner, 1995). Emotions interrupt our current cognitive processes to allow us to react to new situations and urgent needs quickly and appropriately (Simon, 1967). On the other hand, decisions that are made when we are angry often lack objectivity and rationality. (Lerner & Tiedens, 2006). Disturbances in the expression of different emotions are present in a series of mental disorders. An overabundance of sadness and the inability to experience pleasure can cause depression, while excessive anxiety and fear can cause social phobia (Keltner & Kring, 1998). Adolescents who tend to externalise problems are prone to maladaptive behaviours towards their environment such as aggressive or antisocial conduct. They are less likely to suppress anger in front of authority figures. They also less commonly show embarrassment, which is an emotion commonly causing an inhibition during social interaction that can also inhibit antisocial behaviour. Increased anger and lack of embarrassment together can display a general deficit in emotional regulation causing an increase in delinquent behaviour (Keltner et al., 1995).
In turn, people are more likely to interact with those expressing positive emotions as well as rate potential interactions as positive and rewarding (Harker & Keltner, 2001). While emotions do form

an important component of interaction, sometimes it is essential to be able to regulate one's own emotions in order to appropriately operate in a social setting (Eisenberg et al., 2000). People who have problems regulating their own emotions face greater problems in their friendship, such as more conflicts with friends (Lopes et al., 2011). At the same time a higher ability to regulate emotions did not in turn improve peoples' skills in the positive dimension of friendship, including warmth, companionship and intimacy. The authors suggest that these positive aspects may be more influenced by personality traits such as extraversion and emotional expressiveness. High levels of emotional regulation correlate positively with lower levels of conflict and tension during any type of social interaction. Those able to regulate well also have less negative social events (e.g. getting along poorly with peers).

1.1.4 Mood

Unlike emotions, which are sharp, intense feelings we have about a specific situation, our mood is more of a constant background perception. Moods are usually less intense and can't be traced back to a single event that set it off. At the same time, they can still influence our decision making in the present and have pronounced effects on our cognition and behaviour (Bless & Fiedler, 2006). It has been found that making a decision while in a good mood causes us to mostly rely on prior knowledge, whereas when we are in a bad mood we tend to pay more attention to new situation-specific details (Bless & Burger, 2017). A possible explanation is that positive affective states are often present during benign situations, whereas negative affective states are present in a problematic situation that might go wrong. During benign situations, it's safe to draw back on old, familiar knowledge. It is not needed to rely on specific details. During problematic situations on the other hand, it's safer to look at all details and new information carefully and to consider all options (Bless & Burger, 2017). In accordance with this, happy people tend to rely more on trait information they have about a person than on their distinct behaviour (Isbell, 2004). In principle, it can be said that the general knowledge, including one's principles and values, employed by happy people is more abstract than the attention to detail of those with negative affect. Happy people tend to consider these abstract, idealistic values over more pragmatic considerations. For example, when finding a reason as to why one should not buy clothing in discount shops, happy people are more likely to say it's because "working conditions are poor" rather than "…because quality is poor.", which would signify a more pragmatic approach (Burger & Bless, 2016). Sad people, who tend to focus more on details of their environment than on their prior knowledge, are not only better at attention and memory encoding, but also display better judgment, less gullibility and stereotyping as well as increased fairness (Forgas, 2013). Other studies found episodic and working memory to be increased during positive affect (Ashby et al., 1999). In a setting of social interaction happy people tend to be more impolite when communicating with others (Forgas, 1999) and have a tendency to show more spontaneous and unconventional behaviour (Bless & Fiedler, 2006). They also have been found to be more creative and better at flexible problem solving (Greene & Noice, 1988). Sad people tend to follow social norms and universally accepted behaviour (Bless & Fiedler, 2006).

1.1.5 Brain regions implicated in social interaction

Mirror neurons and Theory of Mind

When looking at brain regions necessary for successful social interactions, those needed to infer other's mental states can be considered first. As aforementioned, we can differentiate between two distinct networks (Van Overwalle & Baetens, 2009). The first one is the mirror neurons network, which is has been shown to be responsible for handling objective behaviour observable by the subject. In order to perform an action, for example lift a cup to drink from it, a number of processes have to be activated in the brain. Firstly, the plan of action is being calculated by the premotor cortex. Secondly the motor cortex gives the signal to activate specific muscle groups responsible for the execution of the action. An observer can only see the cup being lifted by another but the same plan activates in their premotor cortex as in the brain of the one performing the action even though there is no active movement. Their motor cortex on the other hand is not activated in the same way since the fulfilment of the action itself is only realised by the performer. It is only the plan of action which is activated in both brains (motor imagery). The neurons that are activated in the premotor cortex are essentially mirroring the brain they are observing. Comprehending and analysing another's goal behind their action and planning an action ourselves activate the same brain regions (Sinigaglia & Rizzolatti, 2011). Since then, other regions have been found to contain motor neurons, e.g. pyramidal tract neurons and the anterior intraparietal sulcus (Rizzolatti & Sinigaglia, 2016; Van Overwalle & Baetens, 2009). Rizzolatti & Sinigaglia (2016) suggest a possible role of mirror neurons not only for motor observation, but also for the interpretation of other types of observed behaviour. Thus, they propose human interpretation of e.g. observed emotions to be possibly aided by mirror neurons present in the anterior insula. Mirror neurons don't only help us to understand what specific motor action somebody is performing, but also subsequently what the performers' intention behind it is. Ortigue et al. (2010) propose a brain lateralization, where the left hemisphere is responsible for motor action recognition that is then followed by right hemisphere activation to help understand the reasoning behind someone's action. Similarly, to the findings during observed motor action, a speakers' and a listeners' brain activity mirror one another during social interaction. Significant brain areas are not only those connected to speech processing, such as Broca's and Wernicke's but also those that are connected to the mirror neurons network (Stephens et al., 2010). Mentalising on the other hand, necessary to infer others mental state, activates the posterior superior temporal sulcus (STS)/temporo-parietal junction, the temporal poles and the medial prefrontal cortex (mPFC) (Calarge et al., 2003; Berthoz et al., 2002; Calder et al., 2002). Further studies found additional structures such as precuneus, orbitofrontal cortex and anterior and posterior cingulate, among others (Kedia et al., 2013; Sanfey, 2007). The role of the STS may be the primary interpretation of nonverbal stimuli, such as gaze direction and body movements (Allison et al., 2000) whereas the temporal poles contribute to the semantic and episodic contexts (Gallagher & Frith, 2003). Contrary to these findings Michel et al. (2013) found that damage to the left temporal pole does not affect mentalising abilities. A different study on the other hand found ToM impairments during right anterior temporal lobe damage (Irish et al., 2014). After primary interpretation and memory context retrieval the mPFC processes the given stimuli (Walter et al., 2004). Interestingly, one of the parts of the mPFC, the anterior paracingulate cortex, was specifically found to be activated when trying to understand someone who was involved in social interaction. It was, on the other hand, not activated when there was only a private intention without social content and slightly activated when there was only a potential for a future social interaction (Walter et al., 2004). This speaks in favour of a unique role of this region in inferring interaction with others. In addition to its role in inferring interaction, the mPFC has been consistently activated during experiments in which the participants were asked to make statements concerning their own character traits (D'Argembeau et al., 2007). This points to an involvement of the region in self-processing. It activates both during self-referential thinking and when judging others character traits (D'Argembeau et al., 2005; 2007). The regions involved are slightly different, with self-referential judgement activating a more ventral region of the mPFC. It is also activated during competition (Decety et al. (2004). A meta-analysis by Phan et al. (2002) found the mPFC to be the region most likely activated during the induction of different types of emotions. As the activation was not linked to a specific type of emotion, the authors believe the area to play a role in overall emotional processing.

In contrast, it is rarely activated, and often even deactivated, when the stimuli require the recruitment of the semantic memory or the executive functioning (Mitchell, 2009). In opposition to this, Baetens et al. (2013) found the dorsomedial part of the prefrontal cortex (dmPFC) reactive both during social and non-social stimuli, as long as the stimuli were on a high construal level. This was archived by asking participants to form concepts and ideas about pictures instead of simply describing them. Parts of the mentalising network are also activated during social decision making (Sanfey, 2007) and when making social comparisons, e.g. when comparing our intelligence to others (Kedia et al., 2013). These comparisons constantly take place during social interactions. A common supplementary finding during research concerning social interaction is activation of regions associated with an emotional response, such as the amygdala and the insula (Sanfey, 2007).

Emotions and the brain

During social interaction, when we observe another's emotion, this automatically triggers a representation of the emotional state in ourselves. Seeing angry or happy faces can bring about a physical reaction within milliseconds (Dimberg & Thunberg, 1998), thus allowing us to share other's emotional states. The stronger the emotion is displayed, the more affected the observer feels (Wild et al. 2001). When a group of people watch movies containing emotional events, their brains appear to react in the same way (Nummenmaa et al., 2012). Brain activities become synchronised in the limbic area, thought to be responsible for emotional processing. Activation occurs at the same time in different individuals, giving them a similar view of the world, reflected in their brain activations. Seeing the world around us in a similar way is an important factor facilitating mentalising and hereby predicting others motives and reactions accurately. This in turn helps us adapt our own behaviour, encouraging smoother exchanges with others (Nummenmaa et al., 2012). Before we even begin to form our own emotional response, we can observe other peoples' emotions. Observation of emotional states, e.g. seeing a picture of a disgusted facial expression, causes a response in both the amygdala and the insula as well as the adjacent frontal operculum (Phillips et al., 2003; Taylor et al., 2000; Reiman et al., 1997; Jabbi et al., 2007). The next step is the induction of an emotional state, tested e.g. by the exposure to unpleasant odourants, which activates the same regions (Phillips et al., 2003; Jabbi et al., 2007). After we encounter an emotionally relevant stimulus and our first instinctual emotional reaction, these feelings are a subject to evaluation and regulation. When down-regulating emotions, regions implicated in cognitive processes are activated, such as the frontal gyri and the anterior cingulate cortex (ACC) (Frank et al., 2014). Other regions, such as the amygdala, are down-regulated during this process (Frank et al., 2014). The amygdala, classically associated with fear response and conditioning (Büchel & Dolan, 2000; LeDoux, 2007), also contributes to other types of emotion processing, both positive and negative (Sergerie et al., 2008; Fossati, 2012). The strength of activation has been linked to the amount of arousal the emotion elicits, explaining how negative emotions, that often cause stronger arousal, regularly lead to stronger activation of the amygdala (Costafreda et al. 2008). In addition, the region has been shown to process information concerning social interactions, such as reading emotions on other's faces. These informations are important for appropriate social behaviour (Adolphs, 2010). Deliberate emotional upregulation has been found to enhance the activity in the amygdala (Zotev et al., 2011). Other regions have also been described during emotional processing, such as the mPFC, the thalamus and hypothalamus as well as the midbrain during both pleasant and unpleasant emotions (Lane et al., 1997). Additionally, lateralisation was found such as the right amygdaloid complex (comprising of inferior frontal gyrus, fusiform gyrus and temporal gyri) being more activated than the left during both positive and negative social interaction (Semrud-Clikeman et al., 2011). But not all social interaction is experienced in the same way. Different kinds of emotions are able to activate distinctly different brain regions. There seems to be lateralisation with structures on the left side of the brain responding to pleasant stimuli and those on the right sight reacting to unpleasant stimuli, e.g. while pleasant words strongly activate the right dorsolateral prefrontal cortex (DLPFC) (Herrington et al., 2005), processing of negative stimuli causes stronger left sided DLPFC response (Beraha et al., 2012). Additionally, there is left lateralisation of the mPFC during positive stimuli (Beraha et al., 2012). Other differences are e.g. that regions in the temporal lobe are more activated during processing of positive stimuli, whereas negative stimuli tended to activate ventromedial regions (Semrud-Clikeman et al., 2011). Others found that unpleasant emotions specifically activate the occipito-temporal cortex and the amygdala (possibly due to higher arousal, see above) (Lane et al., 1997), showing that, while there are many overlaps when it comes to the processing of different types of emotions, there are also many differences.

The default mode network

The default mode network comprises of a group of structures, such as the dmPFC cortex and the medial parietal cortex (precuneus) that are constantly active at rest. As soon as any mental activity requiring concentration (e.g. cognitive testing) commences these areas become deactivated (Buckner et al., 2008). Iacoboni et al. (2004) on the other hand found that these areas become even more activated than at rest when participants watched videos of people engaged in social interactions. They argue that these constant activations during a resting state represent a constant automatic analysis of social relationships in the background, that only gets deactivated when other tasks require attention. When we engage in an action relevant to social interaction, these areas become active.

1.2 Affect control theory

According to David Heise, every social action we perform is influenced by the social role of both interacting partners. In affect control theory, these roles can all be defined as the result of ratings on three different scales of affective meaning: Evaluation, Potency, Activity. The evaluation scale rates how good or bad a certain role is. Hence, the mother is usually perceived as good, whereas the gangster is perceived as bad. Potency refers to the power one person has over another, e.g. the doctor is usually perceived to be more powerful than his patient. Lastly, activity refers to how animated and likely to be an active member during an interaction someone is. For example, the social role of a doctor is perceived to be less active than the one of a child. When all three scales are taken together, we can calculate a so-called EPA (Evaluation, Potency & Activity) score unique to different roles in society. These affective meanings we have about a certain role are usually the same within one society. They are referred to as fundamental sentiments. E.g. there is a fundamental sentiment that fathers and mothers are good. These shared sentiments are a result of individuals' own experiences with different people belonging to a certain identity as well as being influenced by others reporting about their encounters. This constant exchange is the reason beliefs about a certain role are so similar within society. When comparing the cultural sentiments across countries, small differences become evident. For example, in most countries fathers are seen as more powerful than mothers, with the exception of China, where it seems to be the other way around. Every event has the possibility to change a person's pre-event impression of a role. How much an event changes one's impressions can be evaluated with the help of three terms: stability, morality and consistency. Stability refers to us always keeping some of our pre-event evaluation. If someone we think of as a bad person performs a good act, we will not entirely discard everything we know of them from beforehand and think of them as entirely good due to the good deed we observed. The morality effect can strongly influence our opinion of another on the evaluation scale. If someone performs an action we see as morally very wrong, such as killing another person, this event has great influence on our opinion of another. The third important variable depends on the person being acted upon. We evaluate an act differently depending on whether we think it is consistent with what the other person deserves. Thus, a bad act seems much more horrible, if it is done to someone we perceive as being good, as we believe they deserve to be treated as well as is consistent with their character.

The perceived likelihood of an event is calculated by how much the actor's behaviour deviates from their EPA score, from the fundamental sentiment we have about that person. Actor is a term used in affect control theory to describe those involved in social interaction. If an actor strongly deviates from their expected behaviour, it can cause psychological stress in the observer, as to them this is seen as a foreign event due to the perceived unlikeliness. The idea of a mother killing her child, an act that completely deviates from our understanding of what it means to be a mother, seems almost unbelievable in the eyes of most people. These identities can additionally be supplemented with an adjective describing the actor's state of being (modifiers). A positive identity can in this case be perceived as good to an even greater degree, for example 'the gentle mother' is perceived as kinder than just 'the mother'. On the other hand, having either a negative identity or a negative state of being can consistently lower other's opinion of a person. According to affect control theory, we think that one's emotions should match their identity. For example, we think a bad person should experience anger and a good person should experience friendliness. This helps us confirm the identities we have of ourselves. But during interaction with others it is impossible to perfectly confirm one person's own identities with their emotions, as our interlocutor is trying to confirm its own identity at the same time. This changes our emotions depending on the identity of the person with whom we are conversing. When an unexpected event brings out an uncharacteristic emotion, the actor will then try to overcompensate with an emotion more fitting their own identity in order to retain their sense of self. In affect control theory, one's own fundamental affective meaning is what ultimately influences our behaviour. This leads individuals to try and experience events that confirm the identity they have of themselves, which allows Heise to accurately calculate people's most likely behaviours (Heise, 1987; Schneider & Heise, 1995). This also explains how people with low self-esteem seem to associate with the criticism and opinions that put them down. Being criticised confirms their own low opinion they have of themselves. When one person continuously deviates from the identity he has been assigned by another, the second person might change his idea of the first's identity as to fit their new behaviour. For example, a doctor that is rude to his patients does not fit the classical opinion that doctors are good, so he might be assigned a new identity, such as 'quack', which would still fit the position, but also explain the doctor's new behaviour. Alternatively, an observer could interpret the hostility as a certain mood of the doctor. This implies that his behaviour is temporary and the doctor is still as good as a doctor should be. An observer could also try to find fault in the patient, asking what kind of character they may have that merits being insulted by a doctor. Alternatively, one could assign the doctor a negative modifier such as 'the spiteful doctor' which would then again explain their behaviour. The decision whether or not to change someone's identity is also dependent on the emotions they display. When someone commits a crime but seems to be upset and embarrassed afterwards, his behaviour is commonly explained as temporary and he is expected to behave normally from the event onwards. If they display emotions of happiness or glee on the other hand, the event seems much more like something that is likely to recur and the person's identity might be re-evaluated. In summary, affect control theory is a way to accurately calculate and predict peoples' behaviour in social interactions depending on people's identity, their modifiers and their emotions (Heise, 2002 for a review).

Affect control theory in Germany

By having people rate different words on a scale of evaluation, potency and activity Heise was able to grasp their affective meaning and create a lexicon where all the words he studied and their meaning in terms of social interaction are connected. Each word has a scale depending on these three variables. For example, the mother has a positive rating for all three scales and their values are very similar to those of "caring for". Similar values increase the likelihood of the two words occurring together. Since their values are similar, the thought of a mother caring for someone seems like a very natural occurrence. The values for 'screaming' are significantly different from 'mother'. A mother screaming feels therefore less likely to happen. By comparing the ratings of different words, we can compare how compatible and how likely they are to occur together. Since affective meanings can differ across different cultures, Heise's lexicon cannot be used to reliably predict the interactions of people outside the US, which was the cultural group he studied. To be able to apply affect control theory to a different group, namely the German population, Schröder (2009) had German volunteers rate words that were relevant to social interaction. He created an affective Lexicon comprising 1,587 words, 678 of them nouns, 576 verbs and 336 adjectives, including 485 words evaluated in an earlier study by Schneider (1989). Subsequent testing confirmed that these ratings were able to successfully predict realistic social interaction, meaning the predicted likelihood taken from the word's EPA ratings were similar to the way participants actually reacted and felt during a leadership experiment. In the experiment they had to choose appropriate actions in order to lead a fictional company (Schröder & Scholl, 2009).

1.3 Autobiographical memory

Autobiographical memories (AM) are the memories that are connected to our own past. They can be either episodic or semantic. Those that are episodic in nature describe specific events, of which we can remember the time and place, such as one's graduation day or one's birthday five years ago. In a way when we remember episodic events, we mentally travel into our own past to re-experience them (Tulving, 2002). Autobiographic memories of semantic nature on the other hand describe facts in our past such as the address of one's childhood home (Haslam et al., 2011). Most of the time there is a great overlap when retrieving or encoding these memories. As such, any autobiographical memories we have contain both semantic and episodic parts (Burianova & Grady, 2007). When trying to remember the name of one's primary school teacher, it's very natural to also activate memories of specific interactions. In research papers the term autobiographical memory is usually referring to episodic autobiographical memories (EAM) and not semantic autobiographical memories (SAM). They are often compared to semantic as well as episodic memories which do not contain an autobiographic component. In this case semantic memory refers to our general knowledge about the world, such as the name of the current president. In the experimental setting, episodic memory, also often times called lab memories, refers to memories that are formed in a lab just before being recalled in an imaging session. Oftentimes, during these types of experiments, the participants are asked to remember a set of words they were given beforehand (Gilboa, 2004). Both episodic (lab memories) and autobiographical (episodic) memories consider past events, but episodic autobiographical memories are much richer in terms of personal significance, there are more emotions involved and they describe events that occurred months or years ago, unlike lab memories which are often encoded the same day (Burianova & Grady, 2007). Semantic memories generally contain factual knowledge, but here as well one can differentiate between autobiographical semantic memories describing personal knowledge and general semantic memories which constitute the general knowledge about the world. Of course, in everyday life all these types of memories rarely occur isolated, but instead, are usually embedded in a given context by other past or simultaneously occurring memories (Burianova & Grady, 2007).

1.3.1 The self-memory system

Conway (1992) divides autobiographical memories into three different levels of specificity: lifetime periods, general events and event-specific knowledge (ESK). Lifetime periods have the broadest range, e.g. a person can remember their time at university, or when they lived in Berlin. They usually have a definite start and a finish point and describe a broader period. General events can either refer to single events, such as a summer vacation in Kathmandou or repeated events such as dinners by the seaside. Event-specific knowledge as the shortest unit describes one specific memory. Generally, one can say that these systems work in a hierarchical order and are embedded in one another. For example a person may remember a specific event like dropping a glass of wine during a general event such as a vacation in the mountains. Different lifetime periods can overlap, depending on their content. We can experience the lifetime periods of working job A at the same time as living with B in city C. In this way, we can differentiate between lifetime periods of e.g. relationships or work or location. Each of these will then again have their own general events and ESK associated with them. All three together form our autobiographical knowledge base. In 2000 Conway & Pleydell-Pearce introduced the concept of the working self. The working self encompasses a person's goals and self-image. It works as a control centre, monitoring our access to the autobiographical knowledge base for both encoding and retrieval. In return, the autobiographical knowledge base influences and limits our goals and therefore our working self. Our goals don't come out of nowhere, they need to be represented and supported by our autobiographical knowledge. When someone's autobiographical memory 'tells' them they're suffering from a severe chronic respiratory disease, climbing Mount Everest cannot be a realistic goal. Together, the working self and the autobiographical knowledge base form the Self-Memory System (SMS). Unrealistic goals in opposition to our autobiographical memory can cause conflict within the SMS. Our sense of self is represented and shaped by our memories. While episodic autobiographical memories can be seen as a fairly concrete representation, semantic episodic knowledge is much more abstract but still less so than the concept of our own personal identity (conceptual self). The conceptual self, including personal traits, values and believes, can also be seen as a distinct part of semantic knowledge (Martinelli et al., 2012). This has been confirmed by different studies on amnestic patients (Klein, 2010). Tulving (2002) described the case of a patient named K.C. with episodic autobiographic amnesia that, despite not remembering his own actions in the past, made correct guesses concerning his own character traits. On the other hand, poor retrieval of semantic self-knowledge has been associated with low personal identity strength (Haslam et al., 2011). Addis & Tippet (2004) demonstrated poor self-identity in patients with Alzheimer disease that also scored low on autobiographical episodic and semantic tests.

1.3.2 Brain areas implicated in autobiographical memory

Brain imaging studies have discovered many different brain regions of interest that are have been associated with processing of the different types of memory encoding and retrieval. Semantic, episodic autobiographical and lab episodic memories have been found to share a common core of active brain regions (specified below) that respond irrespective of the type of memory recalled. Other regions have been found to be specifically activated during one or two types of memory or only during a specific subset of conditions. When looking for a common framework underlying all types of memory recall, Burianova & Grady (2007) revealed the activations in lingual gyrus, the thalamus and the caudate. They explained these findings by a suggested role in working memory, which was necessary for a retrieval of all memory types. In addition, they found activation of the left hippocampus during all conditions. A number of patients have been described who had lost (due to different reasons) their episodic memory but were still able to reliably describe their own character traits, which were stored as semantic knowledge. This generally speaks in favour of the theory that different parts of brain regions are responsible for the encoding and retrieval of different types of memory (Klein, 2010). A meta-analysis by Martinelli et al. (2012) tried to summarise different neural representations concerning episodic autobiographical memory, semantic autobiographical memory and the conceptual self. They found both a functional dissociation of regions, suggesting some autonomy of involved brain structures, as well as a posterior-anterior trend of activation with concrete memories activating posterior regions of the brain and more abstract ones activating more anterior brain structures. In this manner, EAM activated parietal-temporal regions including the previously mentioned hippocampus, whereas CS tasks activated the medial prefrontal region of the brain. Others found left hippocampus as well as left amygdala and right inferior frontal gyrus activation to be more specific to EAM than to SAM (Martinelli et al., 2012; Greenberg et al., 2005). The hippocampus is thought to be mainly responsible for episodic memories, and it has been shown in multiple studies that patients with hippocampal damage are unable to remember past events and are incapable of forming new episodic memories (Baxendale, 1998; Parkin, 1996). Famous patient H.M, who underwent a bilateral temporal lobe resection to treat his severe form of epilepsy, suffered from retrograde amnesia for all events up to three years before his operation as well as anterograde amnesia for all events after his operation (Scoville & Milner, 1957). At the same time he retained the ability to retrieve lexical knowledge, or knowledge of words, showing his lexical memory, which is often thought be part of the semantic memory, had stayed intact (Kensinger et al., 2001). The activation of the hippocampus observed during semantic memory retrieval is suggested by Burianova & Grady (2007) to be due to the automatic contextual co-occurence of some episodic memories, as semantic memories are rarely evoked without context but are usually deeply interconnected. A study by Manns et al. (2003) on the other hand found that patients with hippocampal damage acquired less new factual knowledge compared to controls and also remembered less semantic knowledge acquired within the last 10 years. This speaks in favour of a hippocampal involvement in semantic memory retrieval and could be explained by a role of this brain structure in both recent semantic and recent autobiographical memories storage (Manns et al., 2003; Scoville & Milner, 1957). In a meta-analysis by Svoboda et al. (2006) participants underwent fMRI during memory retrieval of personal episodic memories occurring at least a few weeks before in a a specific time and place. Results were then compared to either a resting state or with the condition of the semantic memory retrieval. This demonstrated that AM tasks result in the activation of regions in the left hemisphere. Areas most commonly activated across different studies were medial and ventrolateral prefrontal cortices, medial and lateral temporal cortices, the temporal-parietal junction as well as the retro-splenial/posterior cingulate cortex and the cerebellum. The mPFC is often implicated in self-referential processes and seems to be consistently activated during memory tasks (Martinelli et al., 2012). However, different memory tasks were found to activate different parts of the region depending on the type of memory studied: for autobiographical memories - the ventromedial prefrontal cortex and for episodic memories - the DLPFC (Burianova & Grady, 2007; Gilboa, 2004, Martinelli et al., 2012).

The effect of social interaction and emotions on autobiographical memories

Emotional content enhances the encoding of our memories (LaBar & Cabeza, 2006). Sommer et al. (2008) claims that we are much more likely to remember an event if it means something to us. A person is much more likely to remember their own birthday party compared to someone else's, not because the event is significantly different, but because they feel differently about it. When looking at brain structures responsible for this enhancing effect of emotions one can identify two systems. The first system involves the medial temporal lobe that is influenced by arousal and mostly associated with negative emotions possibly due to enhanced sensorial processing. The second system comprised of a different set of brain regions including the prefrontal cortex is influenced by valence and is mostly associated with positive emotions likely due to increased cognitive effort (see Dolcos et al., 2017 for review). Autobiographical memories have a much higher emotional content when compared to lab memories, as they relate to personal experiences. The ACC and the insula show increased activation during autobiographic memories than during episodic or semantic retrieval (Burianova & Grady, 2007). Emotional memories activate structures similar to those classically associated with AM (Svoboda et al., 2006). While AM studies often show a left lateralisation of structures' activation, those with higher emotional content were found to cause bilateral activation of the brain. On top, these studies were found to activate the amygdala and the insular cortex, generally thought to be responsible for emotional processing (Sanfey, 2007; Phillips et al. 2003). Bado et al. (2014) found greater activation of mPFC and precuneus (parts of the default mode network) during emotional autobiographical memory retrieval when compared to resting state. Other parts of the default mode network, such as ventral striatum, and ACC, were found to be more active during the resting condition. Traditionally, mPFC, precuneus and other parts of the brains default mode system are active during rest and deactivate during tasks that require a cognitive effort (Buckner et al., 2008). But during resting state, when we just let our mind wander, we often also contemplate own memories. This can explain the finding of the overlap between brain regions activated both during resting state and in autobiographical memory recall (Bado et al. (2014). Emotions are also present during social interaction. The mPFC is more activated when emotional memories are social, but an enhancement of memory during the encoding of socially emotional memories only happens as long as cognitive resources are available (Sakaki et al., 2012). Similarly, the retrieval of social memories activates the right mPFC, possibly due to social script activation (Mano et al., 2011). Social scripts refer to stored past knowledge on how to act in a particular social situation. During our lives, we encounter similar situations many times (more than once), e.g. when meeting a neighbour in the street we know we are supposed to greet him/her, likely the exact same way every time the encounter occurs.

1.4 Autistic traits

According to ICD-10, autism is defined as a disorder beginning in childhood, marked by the presence of impaired social interaction and communication, as well as a markedly restricted repertoire of activity and interest. Research suggests a genetic background to this disorder. It has been found to be over 200 times more common in siblings of autistic patients compared to the general population (Ritvo et al. 1989). Autism has long been seen as a distinct disorder, where individuals either exhibit traits sufficient for clinical diagnosis or are considered healthy (Volkmar et al., 1986). Later, a more dynamic view on autism has been realised, with the idea of different severities of autism existing on a continuous spectrum (Volkmar & McPartland, 2014). While DSM-IV still uses Autism

disorder as a rigid term to describe a specific disease, in DSM-V the term has been modified to autism spectrum disorder (ASD) in order to specify the continuity of functional deficit.
Further research on non-autistic relatives has shown that they often express qualitatively similar findings that are milder and therefore do not meet the criteria for ASD. Relatives have been shown to display characteristics ranging from those with strong traits belonging to the spectrum of pervasive developmental disorders to single difficulties of social behaviour or communication (Bailey et al. 1998). Leo Kanner was the first person to describe the symptomatology of autism in 1943. He noticed that parents of the children with autism he examined were mostly very intelligent, had university education, but were also rarely warmhearted and more interested in science than the people surrounding them (Kanner, 1943). In accordance with Kanners findings, Piven et al. (1997) observed that non-autistic relatives of families with at least two children with autism commonly had sub-threshold but qualitatively similar social and communication deficits. Furthermore, research speaks in favour of these traits going even beyond family members. Nowadays we speak about the broader autism phenotype (BAP) where the whole population is a part of a continuous spectrum ranging from few to many autistic traits and ending with frank clinical autism and severe disability at a higher end of the continuum (Folstein & Rutter, 1977; Piven et al., 1997). Screenings for abnormal language, personality and social behaviour found the highest incidence of these traits in multi incidence autism families. The incidence was lower in single incidence families and even lower than that in the control group (Losh et al.,2008). Overall, there is a higher incidence of BAP in parents of children with autism Rubenstein & Chawla (2018). These familial clusters point towards a strong genetic background in autism spectrum disorders that has also been confirmed using twin studies (Ronald & Hoekstra, 2011).

1.4.1 Methods of measuring autistic traits

To examine the distribution of this broader autism phenotype in the general population, the Social Responsiveness Scale (SRS) has been used to demonstrate that autistic traits are moderately to highly heritable. As such they are very common in siblings and other family members of autistic people (Constantino et al. 2006). Additionally, the traits can very often be found in the general population (Constantino & Todd 2003) in those without any affected relatives. When both parents obtain high scores in the SRS, the mean score of their children is also significantly elevated (Constantino & Todd 2005). Considering no evidence of bimodality and instead an uninterrupted continuous distribution of these traits in nature, cutoffs differentiating between autism as a discrete disorder and unaffected individuals were found to no longer be as easily applicable as previously suggested. Thus, Baron-Cohen et al. (2001) created a self-administered questionnaire, the Autism-Spectrum Quotient (AQ), to screen for autism traits in neurotypical adults. Neurotypical describes individuals not diagnosed with autism or other developmental disorders, someone with normal cognitive abilities. Participants filled out a multiple choice questionnaire with 50 statements covering five different domains associated with the autism spectrum: social skill, attention switching, attention to detail, communication, imagination. The original study found men scoring higher than women and scientists scoring higher than both social sciences and humanities students. Similar results have been obtained in later studies. For example, students that had two parents following a scientific career had a higher than average rating on the AQ (Austin, 2005). In the same study, high scores on the AQ were found to be positively correlated with Neuroticism and negatively correlated with Extraversion. This was measured by using personality mini markers (a model for the big five personality traits), an abbreviated questionnaire introduced by Saucier (1994). Parents of children affected by autism have increased scores in two domains of the questionnaire, namely social skills and communication. Attention to detail, attention switching and imagination on the other hand had similar scores as the control group (Bishop et al., 2004). The AQ questionnaire has since been translated into several languages (Hoekstra et al., 2008; Wakabayashi et al., 2006) as well as been modified for different population groups, such as children and adolescents (Baron-Cohen et al., 2006). Ingersoll et al. (2011) compared the AQ to other questionnaires that can be used to measure autistic traits and found the AQ to be inferior in terms of internal consistency. It is at the same time the most commonly used tool measuring autism traits in the general population and therefore useful when aiming to compare the results of different studies. One study by Hoekstra et al. (2008) using factor analysis suggests that four of the five subdomains of the AQ are highly correlated. In this study, social skill, communication, attention switching and imagination constituted the factor ‘Social Interaction’, while fifth domain – ‘attention to detail’, was considered as an independent factor. Males had a higher score compared to females in the social interaction domain, whereas there was no significant sex difference found in ‘the attention to detail’ factor. In the end, the AQ remains a useful tool to measure autistic traits in neurotypical adults.

1.4.2 Different components of the broader autism phenotype

Language & Social behaviour

Language deficiencies are one of the key characteristics of autism. When examining relatives of autistic probands, researchers found that they often struggle with appropriate language use during social interaction, or so-called pragmatic language use. Ruser et al. (2007) found that 15% of parents of children with autism have serious communication problems, the same number they also found in parents of children with specific language impairment (SLI). SLI refers to delayed or disordered language development for no apparent reason and despite normal intelligence. At the same time, unlike parents of those suffering from SLI, parents of autistic children don't seem to suffer from structural language impairments, or the inability to comprehend and construct sentences with proper grammar. The deficits are only apparent during social communication (Whitehouse et al., 2007). Additionally, siblings of children with ASD often have delayed language development (Chuthapisith et al., 2007). Studies comparing social interactions in people with different levels of autistic traits have generally shown social behaviour to be inversely proportional with the number of autistic traits. Siblings of children with autism are both less likely to initiate joint attention (Cassel et al., 2007) and to respond to it appropriately (Presmanes et al., 2007). Joint attention is usually achieved when one person alerts the second to an object, followed by both people focusing their attention on it. Parents of autistic children score higher in tests of alexithemia, the inability to identify and describe one's own emotions, showing that it could possibly be a part of the BAP (Szatmari et al., 2008). In one study by Yang & Baillargeon (2013) had asked the participants to read different scenarios and then rated the appropriateness of a characters' social-acting. Those with a high AQ score gave a significantly lower rating compared to those with low AQ score. Similarly, in another study Jameel et al. (2014) asked a group of adults to read series of stories regarding a character in need. Participants were then asked to first produce a spontaneous response and afterwards pick one of three responses, representing high, medium and low pro-social actions. Those with high AQ were shown to produce both a less pro-social initial spontaneous response as well as to be more likely to select a less pro-social option. Groups with high AQ were just as likely to estimate characters' expectations for help but were more likely to apply rule-based rationales in their reasoning as to why there was an expectation to behave pro-socially. The low AQ group on the other hand was more likely to apply person-based rationales. E.g. the high AQ group would commonly reason that the old women would expect them to offer their seat to her because it is the rule to stand up for the elderly, whereas the low AQ group would base the expectations on the old woman needing the seat more than them. These findings suggest that social judgement in those with high autistic traits may heavily rely on social knowledge, instead of empathy which in turn could be an insufficient motivator to drive pro-social behaviour. (Jameel et al., 2015). People with autistic traits have additionally been found to be more uncomfortable than average during interaction with others. When comparing the number of autistic traits measured by AQ with results on the Inventory of Interpersonal Situations, a self-report questionnaire consisting of 35 interpersonal situations on with people indicate both how often they perform an action and how much discomfort they experience during the action, De Groot & Van Strien (2017) found participants with more autistic traits to display both less social behaviour and more discomfort. There was a particularly high correlation with the social skills and attention switching items of the AQ. Students who present with a more prominent autism phenotype, such as higher rigidity and attention to detail, report shorter friendships and significantly more loneliness (Jobe & White, 2007). Gökçen et al. (2014) compared the number of autism traits with trait emotional intelligence and empathy. Autism trait was found to be inversely correlated with emotional intelligence as well as the Well-being, Emotionality and Sociability.

Nonverbal interaction & inferring mental states

Numerous studies suggest that AQ is associated with cognitive factors that are essential in social communication. In humans, the eyes play a central role in nonverbal information exchange during social interaction. They are both used to perceive others around us and to convey our emotions to the world. Those with low Autism spectrum quotient are more likely to reciprocate direct eye contact instead of looking at actors with adverted gaze, whereas those with high AQ are equally likely to look at direct and adverted gazes (Chen & Yoon, 2011). Eye contact is an important part of social interaction and emotion recognition. Those with a high number of traits show significantly poorer performance on the revised Reading the Mind in the Eyes Test, a non-verbal cognitive test that examines one's ability to infer mental states of others, than those will less traits, pointing towards deficits of social cognition and emotion recognition (Gökçen et al., 2014). Additionally, people with a high Autism spectrum quotient have difficulties recognising facial expression. They were both less accurate in recognising negative emotion as well as less sensitive, requiring a stronger stimulus to correctly identify the emotion (Poljac et al., 2013). Similar impairments in emotion processing are present in children diagnosed with Autism Spectrum Disorder (Gross, 2004).

Executive functioning & stereotyped behaviour

Hughes et al. (1997) found executive function to be impaired in parents of children with autism in three tests measuring attentional flexibility, planning and working memory. Visuo-spatial skills on the other hand have been shown to be increased in people with more autistic traits. Students with high score on the AQ to score higher on both the Embedded Figures Test, a test where simple figures have to be found hidden within more complex figures, and the Block Design subscale of the Wechsler Intelligence Scale, where Participants needed to put together differently coloured blocks according to a displayed pattern. This was irrespective of the students' intelligence (Grinter et al., 2009; Stewart et al., 2009). Melling & Swinson (2016) found a strong correlation between school-age children with high AQ score and uneven intellectual development. Another typical feature of autism is repetitive, stereotyped behaviour, which can similarly, but in milder forms, also be observed in non-autistic relatives (Piven et al., 1997). A poorer shifting ability as well as more perseverative errors were detected using a set-shifting task based on the Wisconsin Card Sorting Test as well as using the emotional rule-shift test, where Participants are asked to sort cards displaying either strong or weak as well as positive or negative emotions (Göçen et al., 2004).

2. Aim of the study

2.1 Social interaction

The aim of the current study is firstly to examine the neural correlates of social interactions using episodic memory retrieval (controlled introspection). Social Interaction has been previously examined in fMRI studies that have described some important regions correlated to participants' exposure to social interactions. Usually, in these studies, participants watch clips of people interacting with one another. Participants then have to interpret the situations seen. They for example are asked to interpret facial expressions or infer mental states (Frith & Frith, 2012). Most of these studies focus on interactions from a third person perspective instead of a direct, face to face interaction. Therefore, in the current study, by re-experiencing memories of previous interactions, the participants obtained a first-person perspective where they themselves where a part of the interaction. Additionally, the impact of the emotional content, (whether the interactions were experienced as positive, negative or neutral), as well as the perspective taken (whether the participant initiated the action or it was started by their interlocutor) was examined. The human ability to establish and maintain good social relationships involves using one's own social scripts by retrieving information about social interaction from episodic memory (Mano et al., 2011). At the same time, emotions are important in shaping behavioural patterns by attributing personal significances and social meanings to objects and events.

The following questions were examined:

1. Do the personal experiences of social interactions in episodic memory retrieval setting activate the brain regions classically associated with social interaction, such as precuneus and medial prefrontal cortex?
2. How do emotions in social interactions affect the neural responses?
3. Does the perspective in the interaction matter? Does active involvement during interactions produce additional activations in comparison to passive involvement?

2.2 The influence of autistic traits

People with autism have deficiencies when it comes to social interactions. Additionally, it has been shown that people without the diagnosis of autism in the general population can have similar, but milder defects. These defects are referred to as autistic traits. At present, there are very few studies regarding the neural correlates of autistic traits. Previous studies have found differences in brain structure such as decreased gyrification in the left temporal and precuneus regions (Blanken et al., 2015). The current study examines whether any differences specific to social interaction can be found. For this differences of brain activations depending on participants' rating in the Autism Questionnaire have been studied. To obtain data specific for social interaction, the same data as in 2.1 was used.

The following questions were examined:

1. Is there a difference in neural patterns of the social interactions processing in the individuals scored with high and low autistic traits?
2. How are the different parts of the AQ such as communication and social skills associated with the neural patterns of the activations?

3. Methods

This third part describes the methods used in the present study. Fist, the sample is described, followed by a description of the investigation process, the experimental paradigm and statistical analysis.

3.1 The sample

The sample consisted of 18 healthy, right handed adults (50% female) between the ages of 28 and 35. 2 participants were excluded from the analysis due to medical reasons.

3.1.1 Enrolment of the sample

The volunteers were enrolled via an Internet survey. They were screened with the help of the demographical data questionnaire, the handedness inventory and the SCID screening for inclusion and exclusion criteria. The Edinburg Handedness inventory (Oldfield, 1971) was used to determine whether the volunteers were left- or right-handed. To test whether the subjects had sufficient imagination abilities, the Questionnaire upon Mental Imagery (Sheehan, 1967) was used (mean score 69, standard deviation 17,06).

3.1.2 Inclusion and exclusion criteria

Exclusion criteria were neurological and psychiatric disease, brain injury, substance abuse and usual MRI contraindications, such as metal implants, a pace-maker or a diagnosis of epilepsy. Inclusion criteria were right handedness, an age between 20 and 40, and an IQ>85.

3.1.3 Ethics

The present study, part of a larger study on the neural correlates of social interaction in healthy adults and patients with schizophrenia has been approved by the ethics commission of the Ludwig-Maximilians-University Munich.

3.2 Investigation process & methods of investigation

This subchapter describes the questionnaires used in the study as well as details of the fMRI image acquisition.

3.2.1 Questionnaires

Edinburgh Handedness Inventory, EHI (Oldfield, 1971)

The EHI contains 10 Items to determine handedness of the participants, by testing whether they were more likely to perform different activities with either their right hand, their left hand or both. Only right handed participants were admitted to the study.

Structural Clinical Interview for DSM Disorders (SCID)

The SCID is a screening tool used by psychiatrists to evaluate whether there are any underlying psychiatric disorders. Those with positive findings were excluded from the study.

Mental Imagery questionnaire (Sheehan, 1967)

The mental imagery questionnaire measures the participants' ability to imagine. It is an abbreviated version of Brett's original 150 items questionnaire from 1909 testing the imaging capacity across 7 different modalities: visual, auditory, cutaneous, kinaesthetic, gustatory, olfactory, and organic. In the shortened version of the questionnaire five items are used in order to rate each modality, the whole questionnaire is 35 items long. For each item, a number of 1 to 7 points could be awarded depending on the imaging capacity, making the minimum amount of points 35 and the maximum 245. The lower the number the better the mental imagery. Participants' scores ranged from 40 to 94.

Autism Spectrum Quotient (AQ) (Baron-Cohen, 2001)

The AQ is a questionnaire containing 50 statements that participants can rate on four points scale from definitely agree to definitely disagree. The statements can be divided into 5 different domains: social skill, attention switching, attention to detail, communication and imagination. Each domain is investigated by 10 questions.

3.2.2 Mode of operation of fMRI

Functional MRI (functional magnetic resonance imaging) is a non-invasive method used to study brain functions. It can be differentiated from normal MRI that is mostly used in a clinical setting in order to obtain structural images of the brain with high spatial resolution. The principal mode of operation of fMRI is dependent on the magnetic properties of both oxygenated and deoxygenated haemoglobin. Since their properties are different they affect the magnetic field in different ways. Deoxyhaemoglobin is paramagnetic and suppresses the MR signal. The more active a group of neurons the higher their demand for oxygen. The body reacts by dilating arterioles and increasing blood flow in active areas, hereby decreasing the deoxyhaemoglobin level relative to oxyhemoglobin and increasing the so called BOLD-signal (blood oxygen dependent signal). While not being able to measure neural activity directly, we can still indirectly conclude which regions are the most active dependent on their metabolic demands and oxygen consumption, as these have been found to be closely related to the local field potential. The changes of the MR signal over time can be described as the haemodynamic response function. Initially, increased metabolic demands cause an increase in oxygen consumption that causes an increase in deoxygenated haemoglobin and therefore an early decrease in BOLD signal called the initial dip. Immediately afterwards the body reacts by dilating the vessels, causing an increase of oxyhaemoglobin that is visible as a peak in the BOLD signal about 4-6 seconds after the initial activation. After the peak the BOLD signal deceases below base-line level due to both lowered blood flow and higher blood volume.

3.2.3 The investigation process and acquisition parameter of the MRT-investigation

The functional data was acquired by T2* weighted echoplanar imaging (EPI) using a 3-Tesla MRI by Philips Achieva 3.0 TX (Philips Medical Systems, Best; Netherlands). 38 transversal slides with a size of 4 mm were acquired. The interslice gap was 0 mm. The time of repetition (TR) was 2,500 ms, the time of echo (TE) was 30ms. Flip angle (FA) was at 90°, Field of View (FoV) was 230 mm x 230 mm. The resulting voxel size was 3 mm x 3 mm x 3 mm. The anatomical reference constituted of 220 T1 weighted images with a voxel size of 1 mm x 1 mm x 1 mm with a FoV of 240 mm x 188 mm x 220 mm. Functional MRI data were recorded during 2 sessions.

3.3 Experimental Paradigm

In this experimental setting, participants were first shown a list of social interaction verbs that had either a positive (eg anlächeln), negative (eg danken) or neutral (eg wecken) significance (Schröder, 2009). The verbs were taken from a bigger pool of words already investigated for valence and arousal in the German population (Heise et al., 2003, Schröder, 2009). In total, participants could choose 4 verbs from a list of 40 in each of the three groups, a total of 12 verbs. Participants were now asked to recollect autobiographical memories related to the verbs they had chosen. They had to recall two memories per verb, one of the memories being about an active interaction, and the second one about a passive one, e.g. one memory about 'hugging somebody' and one about 'being hugged by somebody'. Participants were asked to describe their memories as detailed as possible as well as rate their detailed character, valence and arousal. These characteristics were evaluated on a scale from 1 to 4: where 1 indicated no details, low arousal and low valence, and 4 - very detailed, high arousal and high valence. Other factors that were evaluated were eg. which senses prevailed in the memory, the amount of people present and the age of the participant at the time of the memory (a form for the memory collection is attached in the appendix). Subsequently, the two verbs from each category that were the most detailed as well as had high valence and arousal were chosen to later be presented during the scanning. For the control conditions, words that are not related to social interaction but are self-related were selected (to dress, to brush teeth, to comb etc.). During the scanning participants were able to see the cue verbs and instructions due to mirror attached to the head-coil on a LCD screen. The verb itself was presented for 5 seconds followed by a black screen being shown for 19 seconds for a total of 24. In this time span the participants were asked to imagine the associated memory as vividly and detailed as possible. Active and passive memories were acquired in two different sessions. During the recollection participants were asked to keep their eyes closed. For this reason, a sound marked the end of the recollection period. Each period was followed by two questions, firstly: 'Is the memory detailed?' and secondly 'How strong are the emotions?' Participants could rate these questions each on a scale of 1 to 4, 1 referring to no details for the first and weak emotional reaction for the second questions whereas 4 stood for many details and strong emotional reaction respectively. A fixation asterisk was visible on the screen for 6 seconds afterwards dividing the block from the next verb (see figure 3.1).

3.4 Statistical analysis

This subchapter describes how both the behavioural data and the fMRI data were evaluated.

3.4.1 Analysis of the AQ

The autism spectrum quotient has a total of 50 items that are divided into 5 different domains with 10 questions each. In the analysis, either 0 or 1 points were awarded for every statement, meaning a minimum of 0 and a maximum of 50 points could be reached in total, whereas a minimum of 0 and a maximum of 10 could be reached on each sub-score. Three scores, that were thought to be of particular interest when considering social interaction, were chosen to be used as covariates in the following fMRI analysis. The three scores were the total number of points and the points in the domains of social skill and communication.

3.4.2 Evaluation of the fMRI data

Preprocessing

In order to analyse the fMRI data, the images were preprocessed in order to make them comparable and correct for temporal and spatial differences. The first step, realignment, was done in order to correct spatial differences caused by head movement during the scanning process in X, Y and Z axis direction. Secondly, the scans were corrected for temporal differences. As the fMRI is not capable of scanning the entire brain at the same time and instead measures activity at different levels with a temporal delay the different slices of the brain represent voxel activity at different times. As the slices are used to form a whole 3-D brain image this temporal difference needs to be accounted for. The time it takes for the scanner to scan the entire brain once is referred to as repetition time (RT). The functional images underwent a slice-timing step. Subsequently, the functional images are compared to T1 weighted anatomical images of the participants. This step, called coregistration, was done in order to later be able to decide which anatomical areas are the ones showing a haemodynamic response. The shapes and sizes of brains differ significantly between different people. In order to still make them comparable, they needed to be standardised. During the step of normalisation, they were conformed to fit the size and shape of a standard brain provided by the Montreal Neurological Institute. This step allows comparison within the study, but also across different studies using the same system. Smoothing was the last step used during preprocessing and it is used to improve small remaining differences between the brains being compared. It was done by comparing every voxel to its' neighbours in order to reduce noise and artefacts.

1st level analysis

Data were analysed within the framework of the general linear model (GLM). For each subject, a full factorial model was set up. The seven conditions were modelled by boxcar functions with "on" periods of 24 s, corresponding to the stimuli length, which were then convolved with the canonical haemodynamic response function. Additional regressors included the realignment parameters obtained from preprocessing. On a single-subject level, individual contrast images were calculated for the seven conditions, averaging across the two sessions.

2nd level analysis

During second level analysis the data was evaluated on a group level. For this both contrasts and covariates had to be defined. On a group level, a random-effects one-way within-subjects GLM was set up with two levels. AQ scores were added as a covariate.

Definition of contrasts

During the definition of contrasts we first applied a hierarchical model for the data analysis. We applied a multifactorial design where in model, we defined the factors as follows: valence (positive, negative and neutral) and engagement (active, passive). This allowed us to address: (1) main effect of engagement, (2) the main effect of valence; (3) interaction valence X engagement. Further, a series of post-hoc tests was applied between conditions, between conditions and control as well as between the conditions and baseline. As a final step, we assessed the effect of covariates on the brain activations, specifically the effects of the total score on the AQ as well as the effects on the social skills and communication subscores as obtained from the AQ. The tests were considered significant on a cluster level $p<0.001$ with FWE $p<0.05$. Only significant results are described in the following chapter.

Definition of covariates

Apart from brain activations during social interaction, the present study also examined the effect of autistic traits on the brain during social interaction. In order to study this effect, the results of the Autism Spectrum Quotient have been used in order to separate the participants into two groups, those with a high score, and therefore a high number of autistic traits, and those with a low score and therefore a low number. The groups mean score was used to divide the two groups. In addition, two sub scores of the questionnaire were thought to be of a particular interest in social interaction, social skills and communication. These scores were evaluated individually, the participants were separated into two groups again and compared to one another, so in total three covariates were examined, exploring the effects of communication, social skills and total autism scores. The results were viewed with $p<0.005$. Again, results were considered significant if $p(FWE)<0.05$. The following chapter describes only significant results.

4. Results

The following chapter shows the results of the experiment, starting with the effect of social interaction and the main effect, followed by comparisons between conditions. Last, the results of the covariates are described. Only significant results are shown.

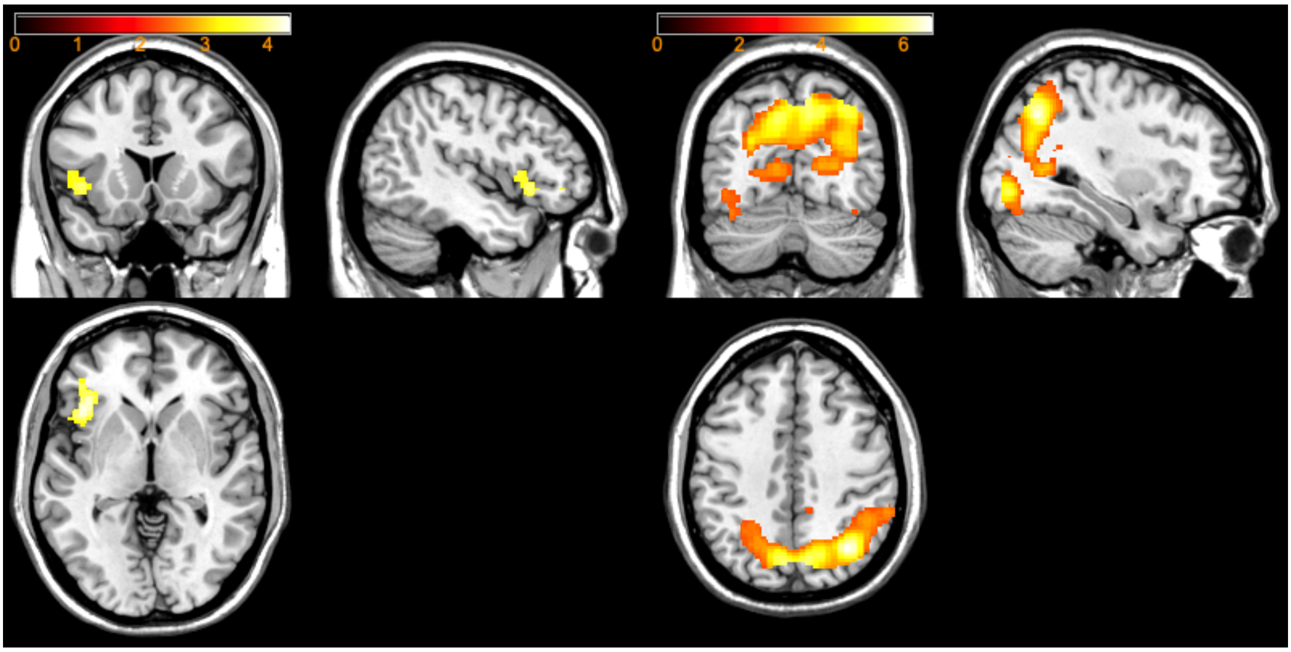
4.1 The effect of social interaction

When comparing the social condition with the non-social (control) condition one cluster was seen on the left side in the anterior insula reaching rostrally into areas of the frontal lobe. When the non-social condition was compared to the social condition two clusters were significant, one in the occipital lobe reaching into the fusiform gyrus on the left and the angular and parietal inferior gyrus on the right and a second in the right posterior cingulum (see table 4.1, figures 4.1 and 4.2).

Table 4.1

Social vs non-social	H	MNI coordinates X	Y	Z	T	Voxel
Insula, inferior frontal gyrus pars triangularis and orbitalis	L	-42	22	-4	4.27	341
Non-social vs social	H	MNI coordinates X	Y	Z	T	Voxel
Inferior occipital gyrus, middle occipital gyrus, superior occipital gyrus, calcarine sulcus, cuneus, precuneus, fusiform gyrus, lingual gyrus	R + L	36	-64	40	6.59	9027
Angular gyrus, inferior parietal lobule	R					
Posterior cingulum	R	4	-40	20	4.18	343

H = hemisphere, R = right, L = left, Voxel = amount of voxels in the corresponding cluster



4.1 Social vs non-social 4.2 Non-social vs social

4.2 Effects of engagement

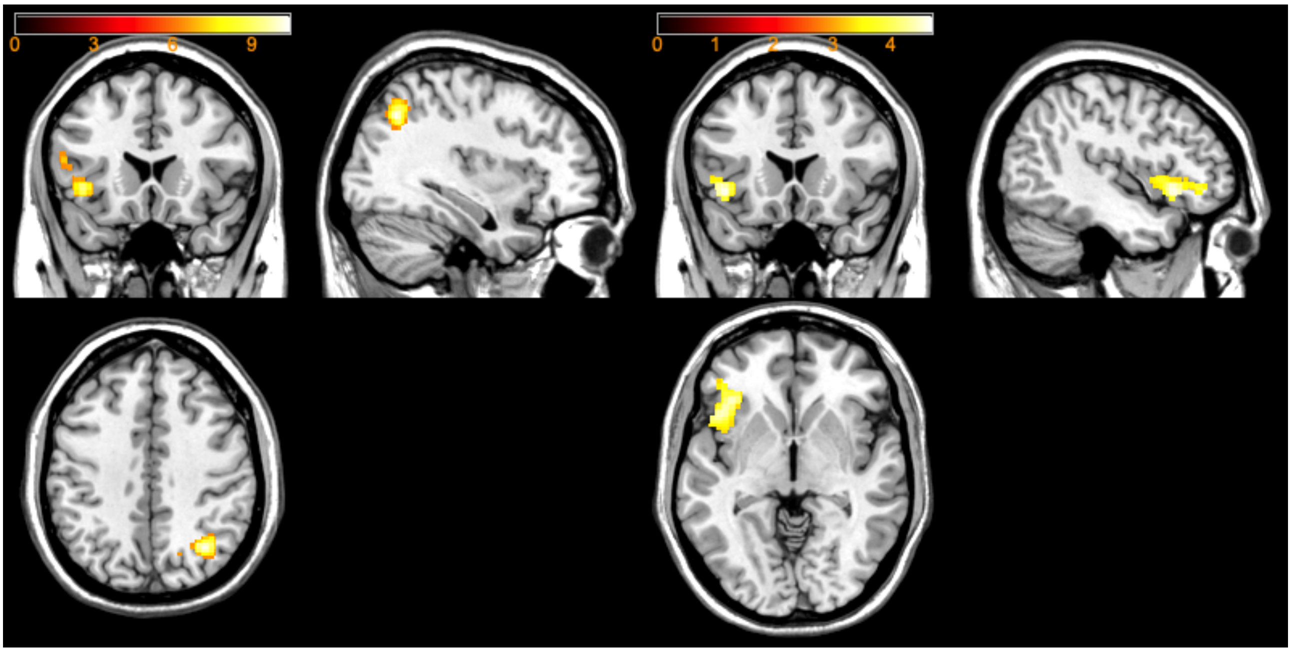
The conditions are defined as the point of view the participant takes during their imagined social interaction. Compared are active memories where the participant is the one initiating the interaction (active engagement) and passive memories where someone else is initiating an action and the participants are reacting to it (passive engagement). Both these conditions are compared to a control condition consisting of a non-social memory (control) with no engagement. The main effect of engagement was found in two clusters. One of them was situated posteriorly in the right angular gyrus. The second cluster was found in the left hemisphere and included the anterior insular cortex as well as adjacent frontal regions (see table 4.2, figure 4.3). Direct and reverse comparison of active vs passive and passive vs active involvement revealed no significant clusters, neither did the comparison active vs control. A significant cluster activation was found when comparing passive and control conditions in the left insular cortex, and parts of the frontal cortex (figure 4.4). Similar results were seen in the control vs passive and control vs active conditions. Both found a cluster comprising of precuneus, occipital cortex and right angular gyrus (figure 4.5-4.6).

Table 4.2

Main effect of engagement	H	MNI coordinates X	Y	Z	F	Voxel
Angular gyrus	R	30	-64	44	10.26	355
Insular cortex, frontal orbital cortex, frontal operculum	L	-42	22	-4	9.25	349
Passive vs control	H	MNI coordinates X	Y	Z	T	Voxel
Insular cortex, frontal orbital cortex, frontal operculum	L	-42	22	-6	4.63	491
Control vs active	H	MNI coordinates X	Y	Z	T	Voxel
Inferior ccipital gyrus, middle occipital gyrus	L	-28	-86	-4	5.05	578
Superior occipital gyrus, middle occipital gyrus, cuneus, precuneus	R + L	34	-64	40	4.89	1085
Angular gyrus	R					
Inferior occipital gyrus, middle occipital gyrus	R	20	-86	2	4.77	481
		MNI coordinates				

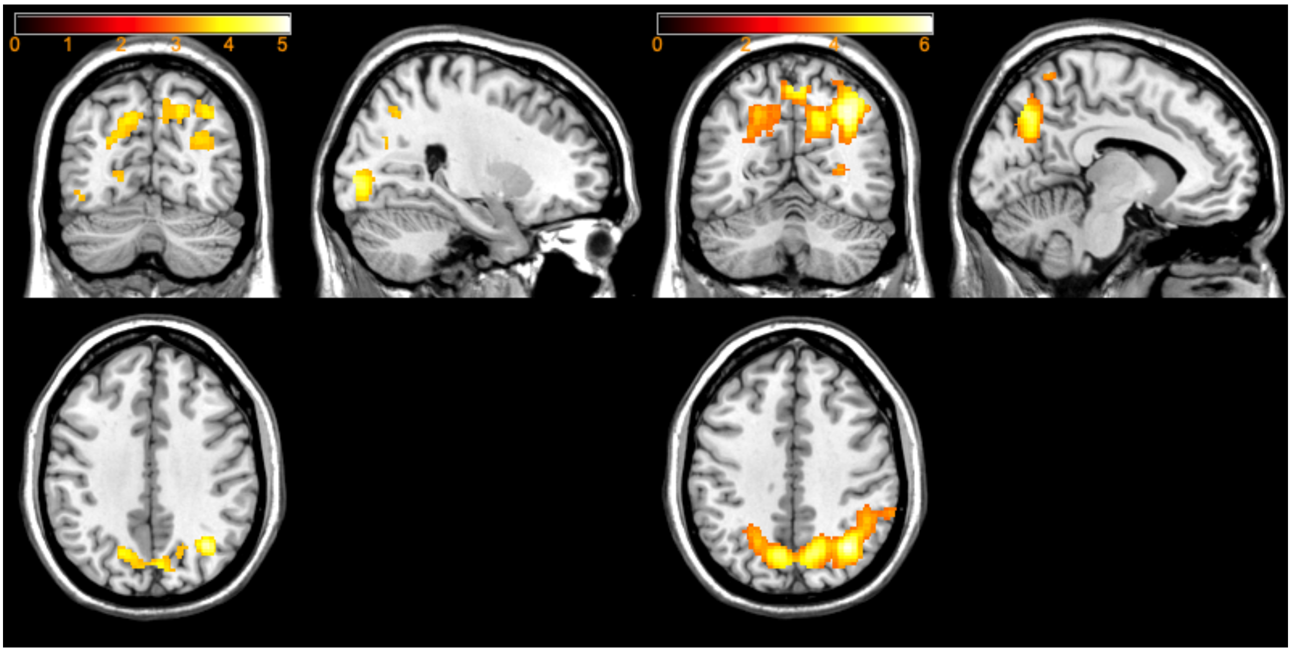
Control vs passive	H	X	Y	Z	T	Voxel
Precuneus, cuneus, middle occipital gyrus, superior occipital gyrus	R + L	30	-64	44	6.07	4712
Angular gyrus, superior parietal gyrus	R					
Inferior occipital gyrus	R	24	-82	-2	3.96	388

H = hemisphere, R = right, L = left, Voxel = amount of voxels in the corresponding cluster



4.3: Main effect of engagement

4.4: Passive vs. control



4.5: Control vs active

4.6: Control vs passive

4.3 Effects of valence

Here, the effects of positive, negative and neutral emotions on the interaction are shown. No effect of valence was found, the condition was therefore excluded from further analysis.

4.4 Valence x Engagement

During the Valence x Engagement interaction one large cluster was found in the posterior part of the brain comprising of the precuneus and the adjacent lateral occipital cortex as well as supramarginal and angular gyrus. Additional clusters were found in the putamen and cerebellum. Post-hoc tests revealed two significant clusters. One was found in the active negative vs passive negative conditi-on in the precuneus. The second one was found in the active negative vs active neutral comparison in the caudate nucleus (see table 4.3, figure 4.7-4.9).

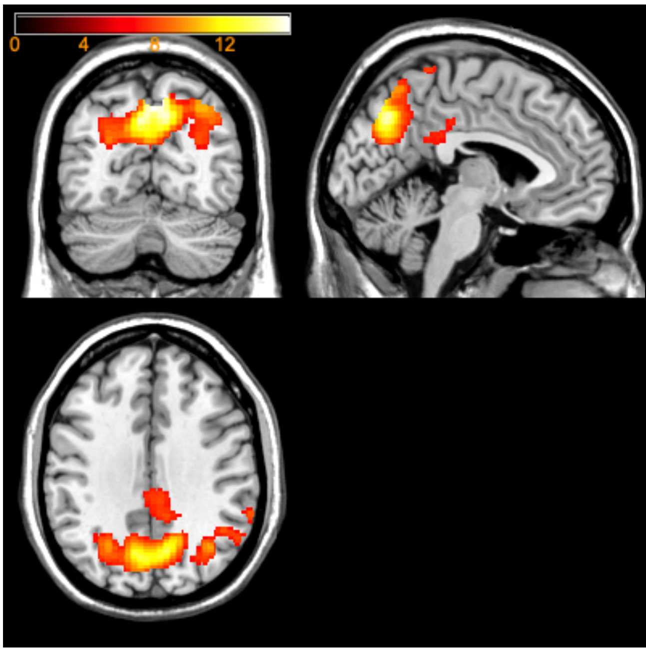
Table 4.3

Valence x Engagement	H	MNI coordinates X	Y	Z	F	Voxel
Precuneus, lateral occipital cortex, cingulate gyrus	L & R	8	-70	48	15.43	5678
Angular gyrus	R					
Occipital fusiform gyrus	L	-26	-82	-6	8.89	504
Occipital fusiform gyrus	R	18	-86	-8	8.46	369

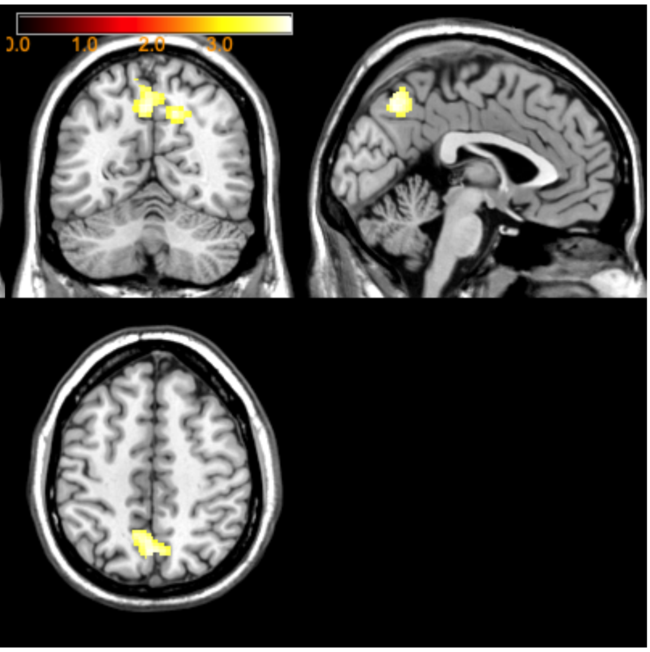
Active negative vs passive negative	H	MNI coordinates X	Y	Z	T	Voxel
Precuneus	L + R	-4	-64	48	3.99	498

Active negative vs active neutral	H	MNI coordinates X	Y	Z	T	Voxel
Caudate nucleus	R + L	6	32	4	4.64	441

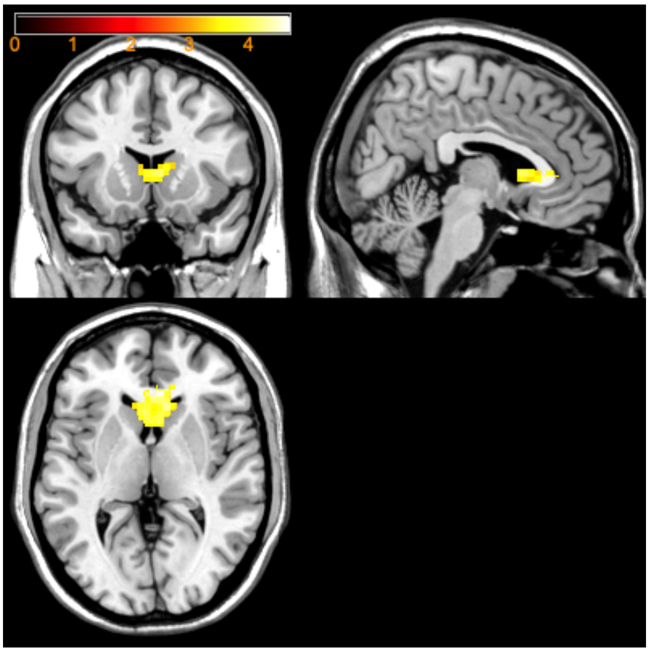
H = hemisphere, R = right, L = left, Voxel = amount of voxels in the corresponding cluster



4.7: Valence x Engagement



4.8 Active negative vs passive negative



4.9 Active negative vs active neutral

4.5 The effect of covariates on the neural processing of social interaction.

The following chapter examines the previous data under the aspect of different covariates, derived from analysis of the autism spectrum questionnaire.

Originally, three covariates were tested. Firstly, the total score of participants' autism spectrum quotient was taken. The other two covariates comprised of the sub scales communication and social skills.

4.5.1 Results of the autism spectrum questionnaire

Of the 18 subjects filling out the autism spectrum questionnaire, only 17 could be evaluated, as the last subject had not given a sufficient number of answers and had to be excluded. The total score of the subjects reached from 7 to 23, the average was 14.2 (see table 4.4). The other two subtypes that were evaluated further were social skill and communication. They reached a score of 1-3 (avg. 1.7) and 0-5 (avg. 1.78), respectively.

Table 4.4

Results of the autism spectrum questionnaire

Subject number	Total score	Social skill	Communication	Attention switching	Imagination	Attention to detail
1	15	1	0	7	1	6
2	15	1	4	4	0	6
3	11	1	3	3	0	4
4	9	1	0	3	1	4
5	11	1	1	3	1	5
6	15	2	2	5	2	4
7	13	1	2	5	0	5
8	13	2	3	2	2	4
9	17	1	0	7	4	5
10	15	1	0	3	1	10
11	22	3	1	8	2	8
12	23	3	3	7	3	7
13	10	2	0	2	2	4
14	14	3	5	4	2	0
15	7	1	1	2	0	3
17	13	3	4	3	2	1
18	19	2	1	7	6	3
Mean	14.2	1.7	1.78			

4.5.2 Results of analysis of the fMRI data including the covariates

Three scores from the autism spectrum questionnaire, total autism score, communication and social skills, were taken in order to study their effect on social interaction as covariates. Out of them, only the autism and communication covariates were found to have significant clusters with p(FWE)<0.05. The results are described in table 4.5. The effect of autism was found in the activations of the precuneus bilaterally and of the right middle frontal gyrus (see figure 4.10), whereas when only the sub-score communication was used, the effect was significant for activity in the left frontal pole (see figure 4.11).

Table 4.5

Effects of covariates

Autism+		MNI coordinates				
	H	X	Y	Z	T	Voxel
Precuneus, angular gyrus, supramarginal gyrus	L	-16	-64	34	6,65	1211
Precuneus	R	42	6	44	5,75	962
Middle frontal gyrus	R	20	-62	34	6,41	1319
Thalamus	L+R	-16	-18	12	6,99	526
Communication		MNI coordinates				
	H	X	Y	Z	T	Voxel
Frontal Pole	L	-24	42	42	5,31	538

H = hemisphere, R = right, L = left, Voxel = amount of voxels in the corresponding cluster

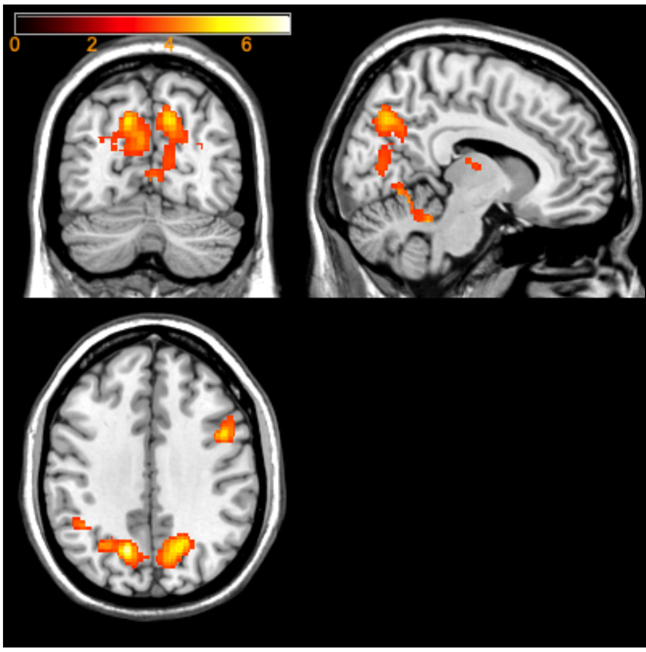


Figure 4.10 Autism

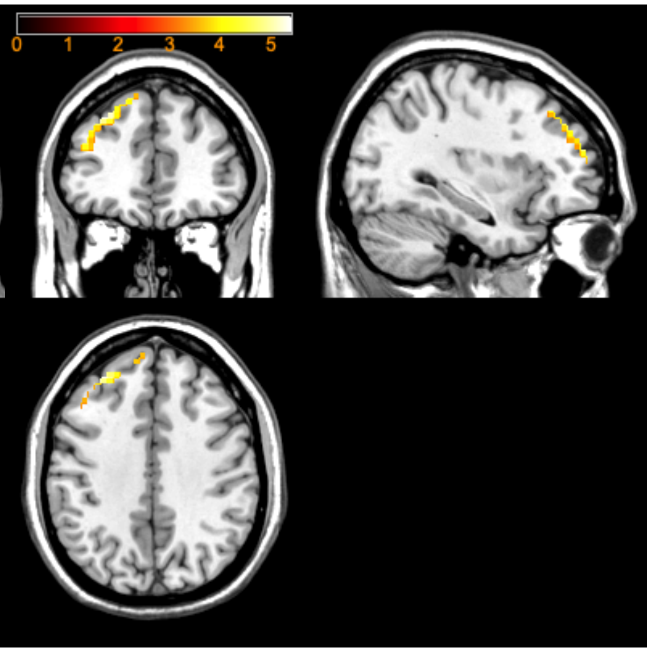


Figure 4.11 Communication

5. Discussion

The present study examines the neural correlates of social interaction as derived from autobiographical memory experiences and compares how the brain responses differ when various types of social interactions are processed. It also explores the effects of behavioural traits on the processing of the social interaction via controlled introspection, by visualising (imagining) the particular type of interaction.

5.1 Social Interaction

Before discussing how the neural correlates of social interaction differ depending on the type, the differences between social and non-social interaction should be examined. When comparing all social conditions together to the control condition we find a correlation in the left anterior insula reaching rostrally into the frontal lobe. Comparing these two conditions focuses on the differences between social and non-social memories, showing the key regions important during social interaction irrespective of its type. The insula has previously been shown to be of great importance during memory retrieval. This is especially true for autobiographic memories, rather than for episodic or semantic retrieval (Burianova & Gady, 2007). The region has been shown to play a role especially during social emotions (Lamm & Singer, 2010). Whereas episodic and semantic memories usually contain simple information, autobiographic memories are associated with strong emotions. Both the social and non-social memories can be classified as autobiographical memories. Nonetheless the social memories were associated with a stronger emotional valence. The insula has been shown to be of particular interest when it comes to the study of emotions. Apart from its role in memory, it has been associated with all the different stages during the process of recognition and processing of emotions, e.g. first during the observation of emotional states in others (Phillips et al., 2003; Taylor et al., 2000; Jabbi et al., 2007) and then as well when it comes to reading and recognising the emotion on the face of another person (Dal Monte et al., 2013; Boucher et al., 2015). The insula then aids in processing of the information (Uddin et al., 2017), and triggers an emotional response (Sanfey, 2007) as well as a feeling of empathy, where one relates to another's emotional state (Fan et al., 2011). The interpretation of observed emotions is possibly also aided by mirror neurons in the anterior insula (Rizzolatti & Sinigaglia, 2016). Damage to the insula leads to the inability for form an adequate emotional response (Knutson et al., 2014).

Activation during the memory paradigm shows the importance of the region during social interaction. The social memories were inherently more emotional than the non-social ones. We did not expect an emotional response to the non-social memories. No correlation was found during the comparison of different emotions, speaking in favour of the region being a general point of emotion processing, instead of it being responsible for the interpretation of only specific emotions. Alternatively, it is possible that there were slight differences of insula activation for the different contrasts that were too subtle to be elicited by the memory paradigm and which did therefore not reach the significant threshold. Perhaps repeating the same experiment with a greater number of participants could show additional results. Nonetheless these results are in agreement with current literature stressing the importance of the insula in the formation of an adequate emotional response during social interaction (Knutson et al., 2014). To this matter, the insula is involved in most of the processing from the observation of an emotion to the response, none of which were present during the non-social condition. The results stress the central role that emotions and their interpretation play during social interaction. During the study, we found a left lateralisation. Previously, during various emotional tasks both bilateral and isolated left sided insula activation have been described (Fan et al., 2011). The left insula seems to be especially involved with the cognitive and conscious aspect of social interaction. It was found for example to be involved during the process of social judgement of emotional faces (Quarto et al., 2016) or when evaluating other's emotional states. Maintaining the feelings of others in working memory has similarly been associated with the left insula. (Smith et al., 2017). While left lateralisation has also been found during positive stimuli (Duerden et al., 2013; Leibenluft et al., 2004), what we see in the results is likely a representation of cognitive effort involved in evaluating the emotions and keeping them in working memory. Autobiographical memories and emotions aren't the only points of interest in this region. The cluster itself was found in the anterior portion of the insula. And especially this part has been implicated as a core region in cognitive control tasks and working memory (Rottschy et al., 2012). Together with the dorsal anterior cingulate cortex and the amygdala, the insula constitutes a 'salience network' where the most relevant of a multitude of external and internal stimuli is determined and attention to those stimuli is regulated (Uddin et al., 2017). It could be argued that perhaps the social tasks required more effort of working memory than the control tasks, considering the memories were generally more complex. Surely it requires more mental effort to imagine an interaction than to imagine performing a simple task. The emotions added an additional mental load. During the different scenarios feelings of the participants themselves and those of their interlocutors had to be kept in working memory as clearly as possible. The scenes remembered during the control task on the other hand weren't nearly as complex neither did they require any social or emotional interpretation. In the end the contrast can be seen as a representation of both the presence of emotions as well as the higher cognitive effort involved in the mental representation of social memories. When the social memories were split into passive and active, and individually compared to the non-social condition, the previously described insular activation did only reach the significant threshold during the passive vs non-social condition. During active vs non-social p was >0.005. This implies that the region plays a more important role during passive interaction, although no significant clusters were found in the passive vs active condition itself, meaning that the difference might be minor. It seems logical that the recognition and interpretation of the interlocutor's emotions, a key feature of the insula, would be more relevant in the passive interaction, where the imagined partner is the main agent driving the interaction and not the participant themselves. During the active interaction on the other hand it is one's own emotions that are at the centre of events. The level of emotion as well as the conscious effort of retaining the emotions in working memory should be similar. Despite not reaching the significant threshold, the cluster seen in the active vs control condition still shows a trend towards activation of the insula in this region. Although not as important as during the passive condition, emotion recognition and interpretation was still relevant for the active condition. Perhaps if the study were to be repeated with a higher number of participants a significant cluster in this region could be found.

The non-social condition on the other hand correlated with an activation of the posterior part of the brain, comprising the occipital cortex as well as the precuneus and surrounding structures bilaterally. Additionally, there were activations of the right angular gyrus and the posterior cingulum on the right side. The precuneus is a region heavily implicated in social interaction and associated with social cognition (Cavanna & Trimble, 2006) and emotional autobiographical memory retrieval (Bado et al., 2014). It is additionally considered a part of the default network of the brain, being active during rest but not during active processing of information (Buckner et al., 2008). Interestingly, an exception to this is its involvement in social interactions, where the brain response seems to be even stronger than during rest (Iacoboni et al., 2004). Due to its important role during social interaction and emotional memory retrieval, we would expect a correlation of this region with the social condition, but the opposite was the case. It must therefore be another function of this region which is responsible for the activation seen. Many studies have demonstrated the role of precuneus during episodic memory retrieval (Cabeza et al., 2003; Lundstrom et al., 2003; Addis et al, 2004). The signal was found to be increased when more relevant information was retrieved (Lundstrom et al., 2005). The region has also been found to be strongly correlated to general rather than specific autobiographical memories. General memories describe events that have occurred multiple times during one's own life and specific events are those that have only occurred once (Addis et al., 2004). Another role that has been attributed to the precuneus is self-referential processes. Kircher et al. (2000, 2002) have found precuneal responses during the judgement of both self-relevant traits compared to traits not describing the participant. It is also involved when applying a first-person perspective as opposed to a third-person view. (Vogeley et al., 2001; Vogeley & Fink, 2003). During the non-social task participants were imagining a situation where they were by themselves, performing a task. They were therefore much more focused on themselves, instead of on another person or an interaction. Another difference between the social and non-social conditions are that described actions have been performed by the participants multiple times, such brushing ones' teeth, or having a shower whereas the social memories described a specific memory that only happened once. These general memories, describing repeating actions in contrast to specific ones that describe one event have been correlated to precuneal activation (Addis et al., 2004). Similarly to the precuneus, the angular gyrus (AG) is associated with Theory of Mind and also social cognition as well as the default mode network. Other functions are semantic processing, number processing and memory retrieval (Seghier, 2013). During the non-social contrast, an isolated right-sided angular gyrus response was seen. As the AGs role in semantic processing is mostly linked to the left gyrus (Seghier, 2013) and its role in episodic memory retrieval is associated with bilateral activation, other functions are probably more relevant here. During mentalising, or Theory of mind, a role has been attributed to both the angular gyrus and the precuneus (Mar, 2011). On the other hand, neural correlates of Theory of Mind usually include the medial prefrontal cortex, which was not detected in our study. Its role in the default network is thought to be in integrating information into working memory (Vatansever et al., 2017). A function that has been attributed more to the right angular gyrus is switching and maintaining of attention (Seghier, 2013). Consequently, lesions in the area cause Neglect Syndrome, a condition in which, usually after damage to one hemisphere, there is a deficit of awareness and attention usually to one side of space (Singh-Curry & Husain, 2009). Together with the left precuneus, it is thought to be relevant during concrete concepts. Concrete concepts are visible and physical entities, such as a desk or a T-shirt, as opposed to abstract concepts such as an idea or tradition. The found neural signatures have been explained by the possibility of mental imagery during concrete concepts, but not during abstract ones (Wang et al. 2010). It's possible that the concepts used for the non-social conditions were more concrete than those for the social actions, e.g. brushing one's teeth is more concrete than getting angry at someone. This could have facilitated the mental effort necessary. The region of the right temporoparietal junction, including both angular and supramarginal gyrus has been associated with a sense of the self and agency (being the cause of one's own actions) as well as a sense of residing in one's own body (Igelström et al., 2017; Decety & Lamm, 2007). It's possible that imagining themselves alone instead of with an interlocutor allowed participants to focus more on themselves instead of on someone else. This might have given them a heightened sense of their self and the actions they were performing, both actions associated with the precuneus and the temporoparietal junction. The precuneus is associated with self-consciousness and mental representations of ourselves as well as the feeling of being the one in control of an action (Vogeley & Fink, 2003; Cavanna & Trimble). When splitting the social condition into an active and a passive condition and comparing them separately with the control condition, both conditions elicited the activations similar to those just described. No neural activation were seen when comparing the active and passive conditions directly. At first there seems to be no significant difference between different types of engagement here. This shows how both conditions apparently were similarly abstract in their layout. At the same time, while essentially comprising of the same regions, the number of voxels of the control vs passive contrast was much larger than during comparison with active memories. This could be due to the sense of agency being greater when initiating an action, than while remaining passive. Therefore, a greater difference and consequently cluster size, can be seen during the comparison of non-social and passive, where the difference in sense of agency was the greatest. Significant results were seen when only comparing the negative active and negative passive conditions. The negative active condition elicited a BOLD response in the precuneus, confirming a greater sense of self and agency during active interaction. It is noteworthy that while there were some differences when comparing the non-social condition with different types of engagement, it only reached the significant threshold during negative valence. It's possible that the sense of the self was stronger during the negative memories or simply that the difference between active and passive was greatest during the negative memories. i.e. the difference in the sense of agency when getting angry at someone and someone getting angry at the participant might be bigger than during positive memories such as hugging someone and being hugged by someone. It seems like the main difference between the passive and the active condition is that during the passive condition mostly recognition and interpretation of another action was demanded from the participants whereas during the active condition the sense of the self and agency played a bigger role. One other role of the precuneus is in guiding movement in space. It was found to not only to be activated in response to real movement (Astafiev et al., 2003) but also when subjects only imagined performing a movement (Ogioso et al., 2000). During the present study participants had to actively imagine movement in space during the recall, e.g. moving to hug somebody or to follow someone. On the other hand not all verbs have to necessarily contain a movement. It is less likely when people recalled memories containing verbs such as „to correct“ or „to remind“. Nonetheless it is another possible explanation as to why in this contrast passive memories have shown less activation of the precuneus than active ones. The participants are likely less active when observing someone else act in contrast to when they performed the activity themselves.

When examining the effects of valence, none of the clusters reached the threshold of significance. This seems surprising as in literature different emotional reactions have been associated with activations in different brain regions. A possible reason could be that due to the memory paradigm emotions weren't felt as strongly as when directly experiencing them. It's also likely that the system used for the recognition and interpretation of emotions was activated in all three conditions (positive, negative, neutral), and did therefore not stand out during direct comparison.

Further analysis revealed a correlation of the caudate nucleus with the active negative condition when it was contrasted with the active neutral one. The caudate nucleus is a part of the reward system. This could therefore be showing that the participants experienced a certain degree of satisfaction when they were the initiators of negative interaction. Anger has been shown to be associated with reward (Aarts et al., 2010). The reward system is similarly activated during schadenfreude, a feeling of pleasure or satisfaction when something bad happens to someone else (Takahashi et al., 2009). But not all the negative emotions reactions shown by the participants in our study involved anger, and other negative emotions such as sadness do not have that connection to the reward system. Other studies found the caudate nucleus responds better to negative emotions in general (Carretié et al., 2009), Badgaiyan, 2010). Its stimulation induces pessimism and negative valuation (Amemori et al., 2018). Overactivity of the caudate nucleus has been found in people with major depressive disorder (Lisiecka et al., 2020). Since other negative emotions, apart from anger, are not associated with the reward system, the finding is more likely linked with the negative emotions themselves. The response in the caudate nucleus only being elicited during active interaction points towards the emotion being stronger when one is at the origin of it instead of simply observing.

5.2 The effect of covariates

The following section discusses the results found using the covariates autistic traits and communication as derived from the autism quotient questionnaire (Baron-Cohen, 2001). When comparing individuals with high and low scores on autistic traits, brain responses were found in the precuneus bilaterally as well as in the right middle frontal gyrus. As not much literature exists describing brain activations in people with autistic traits, those found in people with autism, essentially on the extreme end of the autism spectrum, shall be considered first, to be later compared to those found in normal people with a high number of autistic traits. In individuals with frank autism, altered connectivity in the precuneus as well as the middle frontal gyrus and multiple other regions has been described. According to the authors, this altered connectivity of the precuneus could explain some of the key features that have been found in autism. For example, the precuneus is responsible for spatial representations of the self and the environment, forming a sense of self and agency. Alterations in this brain area can then cause an impairment on the theory of mind, a typical finding in autism (Cheng et al., 2015). Cherkassky et al., 2006 similarly found comparable brain activation of patients with autism spectrum disorder during resting state, but found regions to be much more loosely connected compared to controls, whereas Lynch et al., 2013, while finding hypo-connectivity of the precuneus, did not find it to be responsible for social deficits. Activation of the precuneus in patients with autism spectrum disorder have been also found during a joint attention task where the region was found to be more generally activated when young people with autism were compared to controls. This can be due to a reduced specialisation of the region or a higher demand on it (Oberwelland et al., 2017). Similarly to the precuneus, the middle frontal gyrus, another region that is thought to play a role in the theory of mind, has been previously described as being associated with social cognition in autistic patients when compared to controls (Patriquin et al., 2016). Additionally, gray matter volume of both middle frontal gyrus and precuneus seems to be negatively correlated with symptom severity in autism (Eilam-Stock et al., 2016). But some of these findings are not only a feature of autism. It has been shown that mentalising disabilities can be part of the autism spectrum and be present even in healthy individuals with a high number of autistic traits (Best et al, 2008). It is likely that, similarly to the behaviour observed along the autistic spectrum, that follows a continuous decline from frankly pathological behaviour to what we consider normal, brain activations will, while showing the biggest differences in activation on the extreme end of the spectrum, still show similar but milder activations in normal people with a high number of autistic traits. For example, the number of autistic traits has been found to correlate positively with precuneus activation during a task where social reward was anticipated. The correlation was found to be stronger in women than in men (Barman et al., 2015). Correspondingly, in the current study an activation of the precuneus was observed during imagined social interaction in those with a high number of autistic traits. Communication is one of the subparts of the autism quotient questionnaire, screening for the communicative deficiencies commonly present in autism. In our study, activation of left frontal pole was found to correspond to a deficit of communicative skills, measured by low rating in the communication subpart of the questionnaire. In a way, this sub scale is more specific for social deficits than the total number of autistic traits, which also contain scores not directly associated with social interaction such as attention to detail or imagination. The left frontal pole is one of the regions that is found to possess reduced cortical thickness in people with autism spectrum disorders (Zielinski et al., 2014). Additionally, the thickness seems to be predictive of ADOS (Autism Diagnostic Observation Schedule) scores. Generally, in this study, regions in the left hemisphere were found to be more relevant, possibly due to right handedness of participants (Sato et al., 2013). During the viewing of happy expressions, those with autism spectrum disorders had higher degrees of brain responses in the frontal poles than controls (Rahko et al., 2012). Greater response of the left frontal pole was also described during face anticipation (Dichter et al., 2012), both showing that the activation of this region is associated with autism spectrum disorder during tasks with a social content. These findings speak in favour of changes of the frontal pole in people on the extreme of the autism spectrum. They can be used to interpret its activation in normal people with a high number of traits.

The alterations in the frontal pole are likely to be one of the causes for alternated communication skills in autistic patients. It is now shown that the area is activating during both the exposure of autistic individuals to social stimuli as well as during exposure of healthy people with a high number of autistic traits. We assume that autism works in a continuous spectrum from few to many autistic traits. But this is a theory based on the clinical features. The results show additional proof in favour of a continuous development of not only symptom intensity on the autistic spectrum but also increasing differences on a neuronal level, were we can already see changes in the precuneus and frontal poles in healthy individuals with autistic traits.

5.3 Conclusion

The following subchapter answers questions asked in chapter 2 using the findings stated above. First, the results concerning social interaction are examined, followed by the results concerning the autistic traits.

5.3.1 Conclusions with respect to social interaction

The first question was whether the social conditions resulted in the activations of the brain regions that have previously found to be relevant in social interaction and autobiographic memory recall, such as precuneus and medial prefrontal cortex. This was partially the case. Left anterior insula response was found during the social conditions when compared to the non-social control, likely linked to the role of the region in social cognition as well as to the emotion recognition.
Medial prefrontal cortex response was not found in any condition, whereas precuneus response was found in the active negative vs passive negative condition where it presumably played a role in self-referential processes during the active engagement. These differences could be attributed to the memory paradigm activating different structures than in other studies where social interaction is merely observed. Positive and negative emotions themselves didn't seem to play a big role in the eliciting brain responses during social interaction. The perspective seemed to play a role for the regions responsible for cognition and interpretation of observed emotions being important during the passive condition while the sense of self and agency played a bigger role during the active condition.

5.3.2 Conclusions for autistic traits

The first question concerning autistic traits was whether their presence was associated with the neural patterns of social interaction. Individuals with a high number of traits had an augmented brain response in the precuneus and middle frontal gyrus when compared to those with a low traits features. These regions have been associated with Theory of mind, social cognition and a sense of self. Impairment of these functions has been described in autism, and on a smaller scale in people with a high number of autistic traits as well. This study has now shown corresponding differences in fMRI. The second question referred to the effect of high scores in specific subparts of the autism questionnaire. There was only one significant difference in social interaction processing in the sub score of communication, i.e. in people with deficits in their communication skills. It correlated with brain response in the left frontal pole. The region has been previously described as alternated in people with autism. The results show that these alterations are also present in people with autistic traits and that this alteration is possibly responsible for altered communication skills during social interaction.

5.4 Strengths and Limitations

This study shows a novel way to study and compare many different types of social interaction simultaneously. The present results only show brain responses in healthy adults. The next step would now be to repeat the study with a similar paradigm based on memory, this time with people suffering from diseases that include a social deficit, such as schizophrenia. Then, by direct comparison to the data found in healthy people, more can be learned about the neural correlates of these deficits affecting the different parts of social interaction. Another option would be to repeat the study with a larger number of participants. There is the possibility that some sub-threshold contrasts could be made visible that way. One surprising feature of the study is the absence of some regions often previously implicated in studies concerning social interaction such as e.g. the prefrontal cortex. In the study, a paradigm based on autobiographic memory was used. As established research in the field of social interactions usually uses different methods, the results can differ from what was expected. Participants did not have to create any content but instead used already established information. This could explain why the regions responsible for executive control that were found to be involved in social interaction in previous research are not detected in the present study. People have slight differences in brain size and position of different regions. These differences are neutralised during preprocessing but at the same time these corrections can hide small clusters if they're not perfectly aligned. During imaging there is no such thing as a completely neutral scan with no activations. We are always thinking about something and so some brain areas are always active. Some areas that correlated to both the social and control conditions might have been missed here. The AQ is a screening tool originally designed to identify people with autism spectrum disorder in the general population. It has only later been used as a screening for autistic traits. For this task it seems to be inferior to other, more modern, measuring tools such as the Broad Autism Phenotype Questionnaire

(BAPQ) when it comes to e.g. internal consistency of its subparts. At the same time, the AQ is still a valid tool and has been used to measure autistic traits in the majority of studies available. The use of the well-adapted questionnaire allows to draw a common line with the previous findings or to support existing theories providing neurobiological correlates.

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Abbreviations

fMRI - functional magnetic resonance imaging

ToM - Theory of Mind

STS -Superior temporal sulcus

mPFC - medial prefrontal cortex

dmPFC - dorsomedial prefrontal cortex

EPA - Evaluation, Potency & Activity

AM - Autobiographical memories

EAM - Episodic autobiographical memories

SAM - Semantic autobiographical memories

ESK - Event-specific knowledge

SMS - Self-Memory system

DLPFC - dorsolateral prefrontal cortex

ACC - Anterior cingulate cortex

ICD-10 - International classification of diseases 10

DSM-V - Diagnostic and Statistical Manual of Mental disorders 5

DSM-IV - Diagnostic and Statistical Manual of Mental disorders 4

ASD - Autism spectrum disorder

BAP - Broader autism phenotype

SRS - Social Responsiveness Scale

AQ - Autism spectrum quotient

SLI - Specific language impairment

TEIQue - Trait Emotional Intelligence Questionnaire

EHI - Edinburgh Handedness Inventory

BOLD-signal - blood oxygen dependent signal

EQ - Emotional Intelligence

RT - Repetition time

FWE - Familywise Error

AG - Angular gyrus

ADOS - Autism Diagnostic Observation Schedule

Figures

Tables

Appendix

Appendix A: Instructions

Probandennummer: _____________ Datum: ____________________

Instruktion 1: Verben mit sozialem Kontext

Sie erhalten drei Listen mit Verben, welche verschiedene emotionale Bedeutungen haben können. Die beschriebene Handlung kann jeweils von jemandem ausgehen (aktiv) oder jemandem widerfahren (passiv).

Bitte überlegen Sie sich, mit welchen dieser Verben Sie eine möglichst intensive und emotionale Erinnerung verbinden. Wählen Sie 4 Verben pro Liste aus mit denen Sie jeweils eine aktive und eine passive Erinnerungen verbinden:

Beispiel: *helfen*

1. Ich habe einer Freundin geholfen, eine Krise zu überstehen. (aktiv)
2. Mein Freund hat mir beim Umzug geholfen. (passiv)

Jede Erinnerung soll *Sie und hauptsächlich eine andere Person* einschließen. Alle Erinnerungen sollten möglichst bedeutende Ereignisse aus Ihrem Leben sein.

Wortlisten (3 Seiten)

Instruktion 2: Verben mit sozialem Kontext

Sie haben jetzt vier Verben aus jeder der drei Listen ausgewählt. Zu jedem Verb sollen Sie nun Ihre beiden Erinnerungen (aktiv & passiv) aufschreiben, insgesamt 24 Erinnerungen.

Pro Erinnerung steht Ihnen ein Antwortbogen zur Verfügung. Tragen Sie bitte jeweils zuerst das ausgewählte Verb ein und beschreiben Sie dann Ihre persönliche Erinnerung, die Sie mit diesem Verb verbinden.

Bitte versuchen Sie, sich so lebhaft wie möglich und an so viele Details wie möglich zu erinnern. Beschreiben Sie diese Erinnerung dann auf dem Antwortbogen präzise und knapp mit maximal 4 Sätzen (Diese Beschreibung soll dazu dienen, dass Sie sich im MR-Scanner an die jeweilige Erinnerung/Geschichte erinnern können, wenn Sie das entsprechende Verb sehen).

Nach der Beschreibung jeder Erinnerung, beantworten Sie bitte noch die Fragen unten auf dem Antwortbogen

Fragebogen (12 Doppelseiten)

Vielen Dank für Ihre Teilnahme!

Hinweis: Die Unterlagen werden vertraulich behandelt und gemäß den Vorgaben der Ethikkommission der Medizinischen Fakultät verwendet. Das heißt, dass aus dem Fragebogen keine Rückschlüsse auf Ihre Person gezogen werden können.

Appendix B: Verbs Women

abweisen	erniedrigen
anbetteln	erpressen
anklagen	frustrieren
anschwärzen	fürchten
jd. aufgeben	hinhalten
ausbeuten	manipulieren
ausfragen	missfallen
aushorchen	reinlegen
ausschließen	schädigen
beängstigen	täuschen
begaffen	übersehen
behindern	unterdrücken
belasten	verabscheuen
belügen	verachten
benachteiligen	verdächtigen
beschwindeln	verlassen
bestechen	verpfeifen
betrügen	verunglimpfen
blockieren	verurteilen
bloßstellen	volljammern
demütigen	
einschleimen	
entlassen	
entmutigen	

abraten	konsultieren
anfassen	korrigieren
anlocken	preisen
anmachen	reizen
ansprechen	umgarnen
aufziehen	vergöttern
beaufsichtigen	verpflichten
bedienen	verweigern
beeinflussen	wecken
befragen	weinen
befrieden	zuflüstern
beipliftigen	zurückhalten
belehren	
bemuttern	
berichtigen	
beurteilen	
bewerten	
erinnern	
ernüchtern	
erziehen	
folgen	
gegenüberstehen	
heimsuchen	
instruieren	

Appendix C: Verbs Men

abweisen	schädigen
anbetteln	stehlen
anglotzen	täuschen
anlügen	übersehen
jd. aufgeben	unterdrücken
ausbeuten	verachten
begaffen	vergessen
behindern	verlassen
belasten	verleumden
benachteiligen	verunglimpfen
beschummeln	verurteilen
bestechen	volljammern
betrügen	
beunruhigen	
demütigen	
einschließen	
entlassen	
erniedrigen	
frustrieren	
fürchten	
ignorieren	
missbrauchen	
missfallen	
schaden	

abraten	gegenüberstehen
anlocken	irritieren
anmachen	korrigieren
ansprechen	kritisieren
aufziehen	nacheifern
beäugen	nachmachen
beeinflussen	nähern
befragen	nehmen
behandeln	preisen
belehren	reizen
bemuttern	suchen
berichten	trotzen
berichtigen	umgarnen
beurteilen	verlangen
binden	verweigern
bitten	verzärteln
dienen	vorziehen
dominieren	wecken
einschätzen	zurückhalten
ernüchtern	zusingen
einziehen	
folgen	

anbieten	helfen
anerkennen	herumknutschen
anlächeln	inspirieren
aufmuntern	interessieren
aufrichten	kennen
beachten	kommunizieren
befriedigen	kooperieren
beschützen	kümmern
besuchen	küssen
bezaubern	lernen
danken	loben
ehren	mögen
einigen	schätzen
einladen	schenken
entlasten	sympathisieren
entzücken	teilen
erfreuen	tolerieren
erzählen	treffen
flirten	übereinstimmen
geben	umarmen
gefallen	unterstützen
glauben	versorgen
grüßen	zuwenden
heilen	

Appendix D: Neutral Verbs

sich anziehen	aufräumen
Zähne putzen	duschen

Appendix E: Memory Questionnaires

Questionnaire for active memories

Erinnerungsepisode, bei der die Handlung, die das Verb ausdrückt, Ihnen selbst widerfahren ist.

Verb: ________________

Beschreibung:

____

____

____

____

____

____

____

	kaum Details			viele Details
Wie detailliert ist die Erinnerung?	☐	☐	☐	☐
	negativ			Positiv
Wie haben Sie sich in der Situation gefühlt?	☐	☐	☐	☐

Erinnerungsepisode, bei der die Handlung, die das Verb ausdrückt, Ihnen selbst widerfahren ist. Verb: ________________					
		ruhig			Aufgeregt
Wie stark ist Ihre emotionale Reaktion?		☐	☐	☐	☐
	sehen	hören	riechen	schmecken	Tasten
Mit welchen Sinnen haben Sie die Erinnerung wahrgenommen?	☐	☐	☐	☐	☐
Wie viele Personen kommen in der Erinnerung vor?	Anzahl: ______	Wie alt waren Sie, als die erinnerte Situation stattfand?			Alter: ______
Haben Sie die Erinnerung wahrgenommen als:		Subjekt durch Ihre eigenen Augen		Beobachter von außen	
		☐		☐	

Questionnaire for passive memories

Erinnerungsepisode, bei der die Handlung, die das Verb ausdrückt, jemand anders widerfahren ist.

Verb: ________________

Beschreibung:

____

____

____

____

____

____

____

		kaum Details			viele Details
Wie detailliert ist die Erinnerung?		☐	☐	☐	☐
		negativ			positiv
Wie haben Sie sich in der Situation gefühlt?		☐	☐	☐	☐
		ruhig			aufgeregt
Wie stark ist Ihre emotionale Reaktion?		☐	☐	☐	☐
	sehen	hören	riechen	schmecken	tasten
Mit welchen Sinnen haben Sie die Erinnerung wahrgenommen?	☐	☐	☐	☐	☐
Wie viele Personen kommen in der Erinnerung vor?	Anzahl: ______	Wie alt waren Sie, als die erinnerte Situation stattfand?			Alter: ______

Erinnerungsepisode, bei der die Handlung, die das Verb ausdrückt, jemand anders widerfahren ist. Verb: ________________		
Haben Sie die Erinnerung wahrgenommen als:	Subjekt durch Ihre eigenen Augen ☐	Beobachter von außen ☐

Appendix F: Asperger Questionnaire

ASPERGER FRAGEBOGEN AQ

Entwickelt von S. Baron-Cohen, Cambridge, UK; deutsche Übersetzung: C.M. Freitag, Homburg

Originalveröffentlichung: Journal of Autism and Developmental Disorders, 2001 und im Buch: The Essential Difference, 2003.

Sämtliche Informationen werden vertraulich behandelt und unterliegen dem Datenschutz.

Name: ________________________________ Geschlecht: 0 männlich 0 weiblich

Geburtsdatum: ____.____.________ Das heutige Datum: ____.____.________

Zum Ausfüllen des Fragebogens:

Der Fragebogen besteht aus einer Liste von Sätzen. Bitte, lesen Sie jeden Satz sehr aufmerksam durch und überlegen Sie, ob und wie stark Sie dem Satz zustimmen können. Umfahren Sie dann die entsprechende Antwort mit einem Kreis.

Bitte, lassen Sie keinen Satz aus.

E1: Ich nehme gerne Risiken auf mich.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
E2: Ich spiele gerne Brettspiele.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
E3: Ich finde es leicht, ein Instrument spielen zu lernen	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

E4: Andere Kulturen faszinieren mich.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

Fragebogen:

1. Ich mache lieber Sachen mit anderen als alleine.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
2. Ich bevorzuge, Dinge immer wieder auf dieselbe Art und Weise zu machen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
3. Wenn ich mir etwas vorzustellen versuche, fällt es mir sehr leicht, ein Bild im Kopf entstehen zu lassen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
4. Ich verliere mich in Aufgaben oft so, dass ich alle anderen Dinge rundherum vergesse.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
5. Ich höre oft leise Geräusche, die andere nicht hören.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
6. Nummernschilder, Zeichen oder Symbole erwecken meine Assoziationen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
7. Das, was ich sage oder tue, wird gelegentlich als unkonventionell oder indiskret wahrgenommen, obwohl es nicht so beabsichtigt war.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
8. Bei Geschichten stelle ich mir leicht vor, wie die Charaktere darin aussehen könnten.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
9. Uhrzeiten und Datumsangaben faszinieren mich.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

10. In einer Diskussion kann ich gleichzeitig verschiedenen Beiträgen folgen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
11. In sozialen Situationen fühle ich mich wohl.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
12. Ich nehme intensiv und öfters Details wahr als andere, weil ich Dinge von anderen Perspektiven aus wahrnehme.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
13. Ich gehe lieber in eine Bibliothek als zu einer Party.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
14. Es ist mir leicht zu fantasieren, und Geschichten zu erfinden.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
15. Ich interessiere mich mehr für meine Mitmenschen als für Gegenstände, Räume oder Landschaften.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
16. Meine Neigungen entwickele ich aktiv, konstruktiv und zielorientiert, und bin glücklich, wenn dies möglich ist.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
17. Ich genieße es, zu tratschen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
18. Wenn ich etwas vortrage, können mich andere kaum unterbrechen und es ist für das Publikum schwierig, mir zu folgen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

19. Zahlen, Tabellen und Grafiken faszinieren mich.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

20. Bei der Literatur, bei Hörspielen oder im Theater ist es für mich schwierig, die Absichten der Charaktere zu erraten	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

21. Ich bevorzuge Sachbücher anstelle von Romane.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

Beispiele:

22. Mir fällt es schwer, neue Freunde kennen zu lernen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

23. Mir fallen ständig Muster an Gegenständen auf.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

24. Ich würde eher ins Theater als in ein Museum gehen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

25. Es macht mir nichts aus, wenn sich mein Tagesablauf verändert.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

26. Ich stelle oft fest, dass ich nicht weiß, wie ich ein Gespräch aufrechterhalten kann.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

27. Es fällt mir leicht, Zwischentöne zu verstehen, wenn sich jemand mit mir unterhält.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

28. Normalerweise konzentriere ich mehr auf das Gesamtbild als auf Details.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

29. Ich kann mir Telefonnummern schlecht merken.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

30. Kleine Veränderungen einer bestimmten Situation oder an Personen fallen mir kaum auf.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

31. Wenn ich mit jemandem rede, merke ich, wenn es ihm/ihr langweilig wird.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

32. Mir fällt es leicht, mehrere Sachen gleichzeitig zu machen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

33. Wenn ich mit jemandem spreche, weiß ich nicht genau, wann ich an der Reihe bin.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

34. Ich bin gerne spontan.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

35. Ich verstehe Pointen bei einem Witz oft als allerletzte/r.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

36. Mir fällt es leicht herauszufinden, was jemand denkt, wenn ich nur auf ihr/sein Gesicht schaue.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

37. Wenn ich unterbrochen worden bin, kann ich schnell mit meiner vorherigen Tätigkeit weitermachen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

38. Mir macht es Spaß, mich mit Leuten zu unterhalten.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

39. Oft wird mir erzählt, dass ich ständig über dieselben Dinge spreche.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
40. Als ich klein war, habe ich gerne Rollenspiele mit anderen Kindern gespielt.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
41. Ich sammele gerne Informationen zu Kategorien einer Sache, z.B. zu Autotypen, Vogelarten, Zugtypen oder Pflanzenarten.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
42. Mir fällt es schwer, mich in andere Personen hineinzuversetzen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
43. Ich plane Sachen, die ich unternehmen will, immer sehr gründlich.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
44. Ich genieße soziale Ereignisse.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
45. Mir fällt es schwer zu erkennen, was andere Menschen vorhaben.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
46. Unbekannte Situationen ängstigen mich.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
47. Ich lerne gerne neue Leute kennen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu
48. Ich bin sehr diplomatisch.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

49. Ich erinnere mich schlecht an Geburtstage.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

50. Mit fällt es leicht, Rollen- oder Phantasiespiele mit Kindern zu spielen.	ich stimme eindeutig zu	ich stimme ein wenig zu	ich stimme eher nicht zu	ich stimme überhaupt nicht zu

Vielen Dank für das Ausfüllen des Fragebogens! Bitte, gehen Sie die Antworten nochmals durch und sehen Sie nach, ob Sie alle so beantwortet haben, wie Sie es gerne wollten.

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Affidavit

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