Degree project

Autism and Theory of Mind: Effects on Emotion Understanding, Empathy, and Relationships

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Abstract

Autism spectrum disorder is often associated with impaired Theory of Mind (ToM), which involves reasoning about others' mental states. A proposed reason for this impairment is altered brain activity in the temporoparietal junctions (TPJ) in autistic individuals compared to typically developed individuals. This systematic review aimed to investigate ToM in autistic individuals further and its relation to emotion understanding, empathy, and relationships, which were found to possibly be related to ToM and the TPJ. Five studies relevant to the aim were included and most of the results showed associations between ToM and different aspects of emotion understanding, empathy, and relationships. Nonetheless, further research on the topic must be done before these results can be generalized.

Keywords: autism, theory of mind, emotion understanding, empathy, relationships

Autism and Theory of Mind: Effects on Emotion Understanding, Empathy, and Relationships

One out of 270 individuals worldwide is estimated to be diagnosed with autism spectrum disorder (ASD, World Health Organization, 2021), which is categorized as a neurodevelopmental disorder. ASD affects males between two and four times as often as females, however, females are frequently affected to a greater extent than males. ASD can be caused by both environmental and genetic factors and the symptoms may vary greatly in degree. Previously there was a subtype of ASD known as Asperger's disorder that was considered relatively mild in the degree of symptoms. At present, however, the unified concept of ASD is used for all degrees of symptoms. The symptoms of ASD are usually noticeable from early childhood and remain throughout life, although their severity may change due to experience. ASD symptoms are classified by impairments in communication, socialization, and motor behavior. Typical for autistic individuals are e.g., social difficulties, resistance to change, repetitive behaviors, and noticeably specific interests. Diagnosis is based on the severity of one's symptoms, which can be classified as mild, moderate, or severe (Morrison, 2014). In DSM-5 the symptom categories socialization and communication have been merged together, so the individual is assessed on social communication and on restricted, repetitive behaviors. The severity of symptoms is determined by the amount of support needed for the individual within each of these two categories respectively (American Psychiatric Association, 2015).

When ascribing unobservable mental states to another person or oneself and assimilating these into a framework that helps us predict and understand the actions and behaviors of said person, humans use their Theory of Mind (ToM, Saxe & Wexler, 2005). ToM can be divided into early-developing components and late-developing components. The former components include concepts such as feelings, goals, desires, and perceptions, and are typically present in young children up to the age of four. From this age, children seem to comprehend the late-developing components of ToM, such as beliefs and thoughts (Saxe & Powell, 2006). Cognitive ToM relates to intentions, thoughts, and desires, while affective ToM relates to feelings and emotional states (Schlaffke et al., 2015).

Two brain areas that have been consistently associated with ToM are the medial prefrontal cortex (MPFC) and the temporoparietal junctions (TPJ) bilaterally. Brain activation in the MPFC and TPJ in typically developing (TD) individuals have been found in relation to ToM tasks in studies using positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), and these regions have been considered a core network concerning all types of ToM (Gallagher et al., 2000; Schurz et al., 2014). PET is a functional brain imaging method that detects biologically targeted radiotracers and their distribution at

a molecular level (Foster et al., 2014). It is non-invasive and it can be imaged with a spatial resolution within 1.5 and 5 millimeters and a temporal resolution around 30 seconds (Zimmer, 2009). fMRI is another method used for functional imaging of the brain that can be made susceptible to changes in blood volume, regional blood perfusion, blood oxygenation, and co-occurring neuronal activity in the brain. By using blood oxygenation level-dependent (BOLD) fMRI, one can acquire brain imaging with just a few seconds of temporal resolution and a spatial resolution of a few millimeters (Matthews & Jezzard, 2004). fMRI studies have shown that when subjects reason about the mental states of others, e.g., their beliefs and thoughts, the TPJ is recruited (Saxe & Kanwisher, 2003; Saxe & Powell, 2006).

Another non-invasive technique for tracking brain activity is magnetoencephalography (MEG), which has a temporal resolution of a millisecond. MEG monitors activation in the cortex and is susceptible to the synchronization of electrical brain currents (Hari et al., 2010). In a MEG study that measured the neural underpinnings of ToM, decreased activity in the left TPJ was indicated in autistic individuals compared to TD individuals (Yuk et al., 2018). Lower activity in the right TPJ in autistic individuals compared to TD individuals has been found in multiple studies examining the functional roles of the core network of ToM using fMRI (Lombardo et al., 2011; Murdaugh et al., 2014). However, no difference was found in the MPFC (Murdaugh et al., 2014).

What could be described as the starting point for the investigation of ToM in individuals with ASD was a study published by Baron-Cohen et al. in 1985. The results of this study implied that autistic children compared to TD individuals and children with Down's syndrome failed to utilize their ToM. The main conclusion of this study was that autistic individuals were unable to represent mental states. It was also concluded that individuals with ASD had difficulties predicting others' behavior due to an inability to attribute beliefs.

This theory, frequently known as the mindblindness theory, has since then been further investigated and the notion of mindblindness leading to impairments regarding communication and social skills in individuals with ASD has been supported (Frith, 2001). However, the specific metaphor "mindblindness" for this theory has been criticized and questioned. It has been suggested that this metaphor has a negative undertone and that it contributes to seeing deficits in autistic individuals instead of differences (Dinishak & Akhtar, 2013). Furthermore, it has been implied that this theory regarding impaired ToM in ASD alone cannot represent all aspects of ASD. Concerning this, an additional theory regarding cognitive alterations in autistic individuals involving weak central coherence, i.e., the ability to process diverse information and being able to understand the meaning and context of it, has been suggested (Frith & Happé, 1994).

In 1991 Baron-Cohen conducted an experiment that tested emotion understanding in autistic individuals. According to Salomone et al. (2019), emotion understanding can be described as the comprehension, estimation, and reasoning regarding one's own or other's emotions. In autistic individuals, an association between their cognitive functioning and individual differences in emotion understanding is probable. Baron-Cohen (1991) found that autistic individuals struggled to understand emotions caused by beliefs compared to TD individuals. Furthermore, an impairment concerning recognizing complex emotions, such as gloating and envy, has been indicated in individuals with ASD and correlates with both affective and cognitive ToM (Shamay-Tsoory, 2008).

Another important process in social cognition along with ToM is empathy. Cognitive empathy (CE) involves the recognition of the feelings of another individual and is strongly associated with affective ToM. Emotional empathy (EE) involves an appropriate emotional reaction in an individual to the mental states of another (Shalev & Uzefovsky, 2020). In an fMRI study that examined brain activations related to ToM and empathy, the TPJ was found to be a common area of activation in both empathy and ToM (Völlm et al., 2006). Impairments in CE have been indicated in autistic individuals. However, the same difficulties have not been reported concerning EE (Shalev & Uzefovsky, 2020).

The understanding of beliefs, which is a part of ToM, has been shown to correlate with social competence and its development (Razza & Blair, 2009). Autistic individuals often wish for relationships with others but may struggle with establishing and sustaining them. This increases the risk of feeling lonely, and loneliness in autistic individuals has been associated with a decrease in self-esteem and life satisfaction and an increase in anxiety and depression (Mazurek, 2014). These difficulties regarding relationships can be partly due to impaired ToM, and improvement in social skills has been associated with ToM training (Adibsereshki et al., 2015).

ASD is a common diagnosis, and it is often associated with ToM impairments. These impairments could be the result of altered activity in the TPJ in individuals with ASD compared to TD individuals (Lombardo et al., 2011; Murdaugh et al., 2014; Yuk et al., 2018). The TPJ has been related to reasoning about others' mental states and beliefs (Saxe & Kanwisher, 2003; Saxe & Powell, 2006), and both emotion understanding and social competence have been associated with understanding beliefs (Baron-Cohen, 1991; Razza & Blair, 2009). Furthermore, empathy has been shown to activate the TPJ (Völlm et al., 2006). The fact that the TPJ or belief understanding has been associated with emotion understanding, empathy, and social competence gives reason for a systematic review that further investigates the possible relationship between these concepts and ToM.

As for the possible consequences of the social difficulties that autistic individuals can struggle with, such as increased anxiety and depression and decreased self-esteem and life satisfaction (Mazurek, 2014), it would be easier to aid them with this by finding out what effects certain brain processes, such as ToM, have on certain social abilities, such as emotion understanding, empathy, and relationships.

Therefore, this systematic review aims to investigate the relationship between ToM in autistic individuals and emotion understanding, empathy, and relationships. The main question is therefore how ToM in autistic individuals can affect emotion understanding, empathy, and relationships.

Methods

Search Strategy

For the final search, which was conducted by the author alone on March 15th, 2021, the same set of keywords but differently used Boolean operators were used in the databases Scopus and PubMed. The search string used in Scopus was: autism AND "theory of mind" AND "emotion understanding" OR empathy OR relationships OR "test of emotion comprehension" OR "empathy quotient" OR "false-belief task". This search was based on title, abstract, and keywords, and limited to articles, open access results, and publications from the years 2011-2021. This search resulted in 118 documents. The search string used for PubMed was: autism, "theory of mind" OR autism, "theory of mind", "emotion understanding" OR autism, "theory of mind", empathy OR autism, "theory of mind", relationships OR autism, "theory of mind", "test of emotion comprehension" OR autism, "theory of mind", "empathy quotient" OR autism, "theory of mind", "false-belief task". The search was based on titles and abstracts and limited to journal articles, free full-text results, and publications from the years 2011-2021. This search produced 266 results. For a more detailed description including the final search string in PubMed, see **Appendix A**.

After searching for articles in these databases, the total amount of 384 documents were exported to the web application Rayyan QCRI (Ouzzani et al., 2016). After deleting duplicates there were 325 articles left of which the titles and abstracts were scanned through. After the first selection process, 21 articles remained that were assessed for eligibility by reading through the full text. After the second selection, five chosen articles remained. The literature search process was documented in a PRISMA flow diagram (See Fig. 1).

Inclusion & Exclusion Criteria

Regarding inclusion criteria for this review, original research articles that were published between the years 2011-2021 were included. Articles with participants either diagnosed with ASD or considered TD were also included, as well as articles including either children or young adults. Additionally, articles that showed an association between ToM and emotion understanding, empathy, and/or relationships were included.

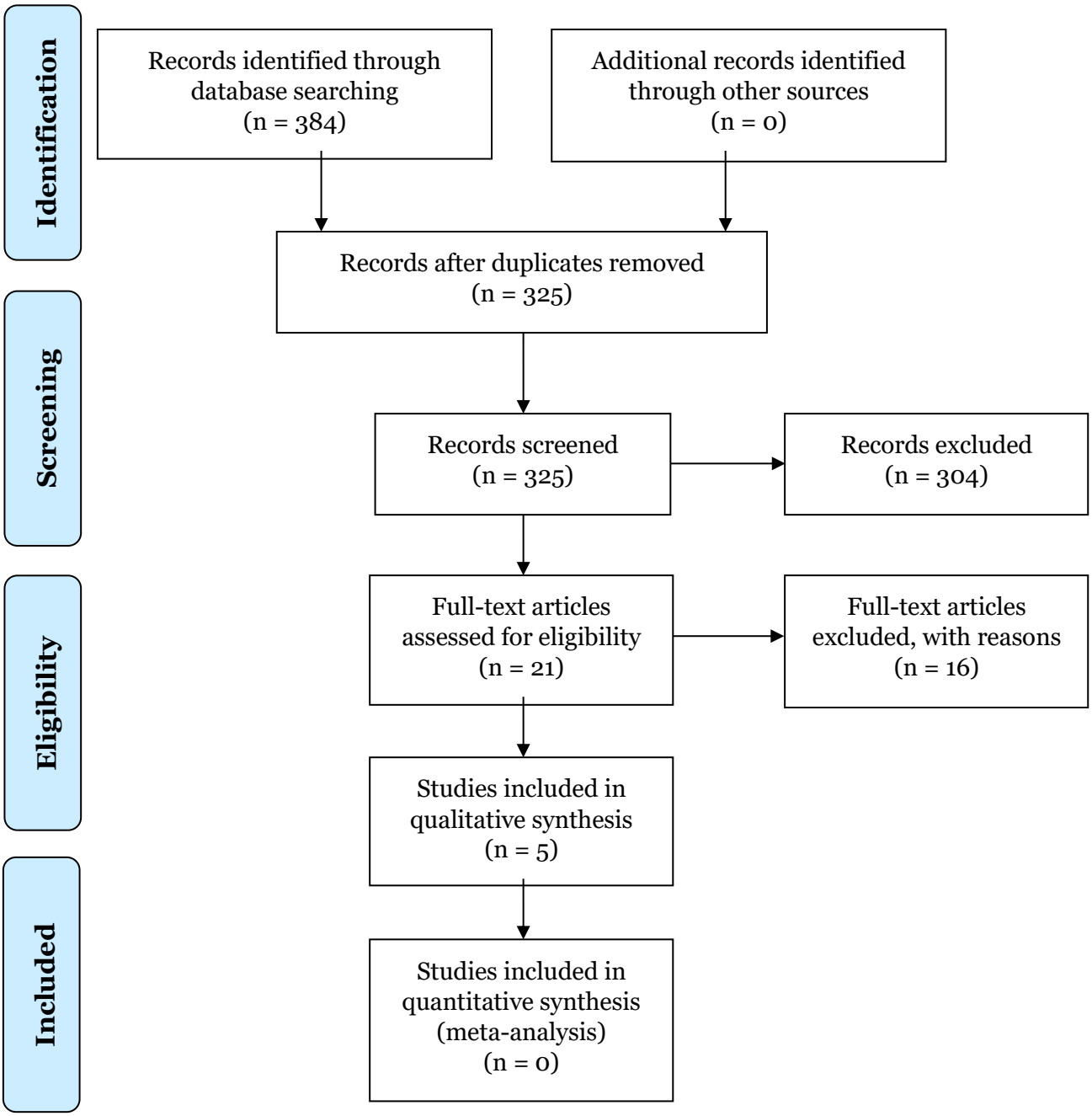
Concerning exclusion criteria, 304 documents were excluded during the first selection process. 63 were excluded due to wrong publication type, e.g., reviews, 92 due to the wrong population, e.g., schizophrenia, 148 due to wrong study design, e.g., not examining relevant variables for this review, and one due to foreign language. During the second selection process, 16 records were excluded. Three were excluded due to wrong publication type, one due to addressing a closely related subject but not the actual topic of this review, 11 due to the focus of it being too narrow, only focusing on one of the review's topics, and one due to not being assessed as reliable as a result of continuous grammatical errors.

Data Extraction

Data that will be included in the results section will measure the effects of ToM training on ToM skills, emotion understanding, empathy and empathic responsiveness, and social skills in individuals with ASD. Data assessing the relationship between social functioning and social cognition in autistic individuals will also be included. Furthermore, data assessing differences between autistic and TD individuals in socially adaptive behavior, pragmatic abilities, and ToM knowledge will be presented. There will also be data in which the interaction among social cognition components is measured and the importance of these components in a social cognition network will be investigated and compared between TD and autistic individuals. Different measurements of ToM, emotion understanding, empathy, and different aspects of social skills, such as socially adaptive behavior, social problems, and pragmatic abilities will be included.

Figure 1

PRISMA 2009 Flow Diagram



Note. Standard flow diagram used to document the literature search process. Citation: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Results

Five articles were included in this systematic review, for details regarding the search process see Fig 1. Three studies were cross-sectional (Bishop-Fitzpatrick et al., 2017; Rosello et al., 2020; Vagnetti et al., 2020), and two were randomized controlled trials (Begeer et al., 2011; Holopainen et al., 2019). Furthermore, three of the studies included only participants diagnosed with ASD (Begeer et al., 2011; Bishop-Fitzpatrick et al., 2017; Holopainen et al., 2019), while two of them included both autistic and TD individuals (Rosello et al., 2020; Vagnetti et al., 2020). The ASD diagnosis was based on diagnostic criteria from DSM-IV-TR (American Psychiatric Association, 2000; Begeer et al., 2011; Holopainen et al., 2019) and DSM-5 (American Psychiatric Association, 2013; Rosello et al., 2020; Vagnetti et al., 2020). However, DSM was not mentioned in Bishop-Fitzpatrick et al. (2017). Concerning age, the participants were between 7 and 27.5 years old (Begeer et al., 2011; Bishop-Fitzpatrick et al., 2017; Holopainen et al., 2019; Rosello et al., 2020; Vagnetti et al., 2020). One study including 89 participants did not mention gender (Rosello et al., 2020), however, the other four studies consisted of 405 participants in total, out of which 372 (92%) were males and 33 (8%) were females (Begeer et al., 2011; Bishop-Fitzpatrick et al., 2017; Holopainen et al., 2019; Vagnetti et al., 2020).

Regarding interventions, two types of ToM training were used. The Theory of Mind training (Steerneman et al., 1996) is an intervention program that targets the development of social skills and ToM. The training includes 21 weekly group sessions of 60 minutes that focus on developing ToM by e.g., learning to evaluate social situations and recognizing others' intentions. This training is offered to children, but parents are involved in five monthly sessions where they are informed about different aspects of ToM. The Mini ToM intervention (Begeer et al., 2015) is based on the Theory of Mind training (Steerneman et al., 1996), but is shorter and consists of only eight weekly group sessions of 60 minutes. To measure ToM, the ToM Behavior Checklist (ToMBC, Begeer et al., 2015), was filled out by parents who reported their observations of their child's behavior related to ToM. Additionally, the ToM Test (Muris et al., 1999) was used. This test measures ToM understanding, and more specifically ToM precursors, elementary ToM, and advanced ToM, in children. The Advanced Theory of Mind task (A-ToM, Blair & Cipolotti, 2000) which is an Italian version of a task introduced by Happé (1994) was also used. This task assesses ToM based on comprehension and justification of a character's mental state. Furthermore, the first-order false belief task Sally-Anne (Baron-Cohen et al., 1985) that examines ToM in a participant by assessing whether they can take another individual's false belief into account or not, was used. Two second-order false belief tasks were also used, the John-Mary- and the Peter-Jane experiment (Baron-Cohen, 1989). These tasks assess ToM by examining if an individual can recognize another individual's false belief about somebody else's belief. The

Eyes Task (ET, Baron-Cohen et al., 2001) which is a revised version of the Reading the Mind in the Eyes Test (Baron-Cohen et al., 1997), was also used. In this task, it is assessed if an individual correctly can identify the mental state of a depicted person. Additionally, the subtests of affect recognition and ToM from the social perception domain of the NEPSY-II (Korkman et al., 2007), which is a developmental neuropsychological assessment battery, were used. The affect recognition subtest examines the identification of emotions, and the ToM subtest assesses understanding of feelings, intentions, thoughts, and beliefs different from one's own, and the ability to put oneself in the place of somebody else and reflect on what that person is feeling in a specific situation. Lastly, the Spanish adaptation of the Theory of Mind Inventory (ToMI, Hutchins et al., 2014; Pujals et al., 2016) which assesses ToM competence in children was filled out by caregivers.

The Levels of Emotional Awareness Scale for Children (LEAS-C, Bajgar et al., 2005) was used to measure emotion understanding. This scale assesses emotional awareness and the complexity and structure of it based on performance related to e.g., emotion comprehension and emotion expression.

For measuring empathy, the Basic Empathy Scale (BES, Jolliffe & Farrington, 2006), which measures cognitive and affective empathy, was used. The affective subscale (AES) assesses emotion congruence, and the cognitive subscale (CES) measures the capacity to understand others' emotions. The Empathy Quotient (EQ, Baron-Cohen & Wheelwright, 2004) was also used. The EQ is a self-report questionnaire that assesses different features of empathy. It is divided into the emotional subscale (EEQ), the cognitive subscale (CEQ), and the social skills subscale (SSQ). Furthermore, the Index of Empathy for children and adolescents (Bryant, 1982) which examines different emotional reactions and empathy with self-reports was used.

To measure social skills, the Children's Social Behavior Questionnaire (CSBQ, Hartman et al., 2006), which investigates the degree of socially problematic behavior, was filled out by parents. The subscale of social problems of the Child Behavior Checklist (CBCL, Achenbach & Edelbrock, 1981) which measures the absence or presence of social, behavioral, and emotional problems, was also used and filled out by parents. Additionally, the Vineland Adaptive Scales (VABS, VABS-II ed; Sparrow et al., 1984; Sparrow et al., 2005) investigate adaptive behaviors and consist of the socialization-, daily living skills-, communication- and motor skills domains, of which the first two were filled out by parents. Lastly, the Children's Communication Checklist Second Edition Manual (CCC-2, Bishop, 2003) which examines communication characteristics, was filled out by parents and measured pragmatic abilities.

Summarized information regarding participants, interventions, comparisons, outcomes, and study design are included in Table 1.

Table 1

A summary of the presented studies.

Author, year	Participants	Intervention	Comparison	Outcome	Study design
Begeer et al. (2011)	N = 36 (n = 33 males) Intervention group (n = 19, n = 18 males) Diagnosed with ASD Mean age: 10.3, SD: 1.3	- The Theory of Mind training - The ToM Test - LEAS-C - The Index of Empathy for Children and Adolescents - CSBQ	Waitlist control group (n = 17, n = 15 males) Diagnosed with ASD Mean age: 10.3, SD: 1.1	Measure the effect of ToM training on ToM skills, emotion understanding, empathy and social skills.	Randomized controlled trial
Bishop-Fitzpatrick et al. (2017)	N = 108 (n = 94 males) Diagnosed with ASD Mean age: 17.5, SD: 4.6	- VABS - CBCL - First-order false belief task (Sally-Anne) - Second-order false belief tasks (John-Mary & Peter-Jane)	None	Measure the relationship between social functioning and social cognition.	Cross-sectional study
Holopainen et al. (2019)	N = 135 (n = 119 males) Intervention group (n = 72, n = 63 males) Diagnosed with ASD Mean age: 9.6, SD: 1.65	- Mini ToM Intervention - Structured observations of empathic responsiveness - ToMBC	Waitlist control group (n = 63, n = 56 males) Diagnosed with ASD Mean age: 9.4, SD: 1.7	Measure the effect of ToM training in empathic responsiveness.	Randomized controlled trial

Continued on next page.

Author, year	Participants	Intervention	Comparison	Outcome	Study design
Rosello et al. (2020)	N = 89 * Diagnosed with ASD (n = 52) Divided into two groups: Higher ToM skills (n = 22) Lower ToM skills (n = 30) Age range: 7-11 years old **	- NEPSY-II - ToMI - VABS-II ed - CCC-2	TD (n = 37) Age range: 7-11 years old ** Controls were matched on age, IQ and levels of vocabulary.	Measure differences in ToM knowledge, socially adaptive behavior, and pragmatic abilities in autistic and TD individuals.	Cross-sectional study
Vagnetti et al. (2020)	N = 126 *** Diagnosed with ASD (n = 65) Mean age: 21.43, SD: 2.06	- BES - ET - EQ - A-ToM - Graph analysis	TD (n = 61) Mean age: 21.52, SD: 1.97	Measure the interaction among social cognition components and establish their importance in the social cognition network in autistic and TD individuals.	Cross-sectional study

* Gender was not mentioned. ** Mean age was not mentioned. *** All males.

LEAS-C = The Levels of Emotional Awareness Scale for Children; CSBQ = The Children's Social Behavior Questionnaire; VABS = The Vineland Adaptive Scales; CBCL = The Child Behavior Checklist; ToMBC = The ToM Behavior Checklist; ToMI = The Theory of Mind Inventory; CCC-2 = The Children's Communication Checklist Second Edition Manual; BES = The Basic Empathy Scale; ET = The Eyes Task; EQ = The Empathy Quotient; A-ToM = The Advanced Theory of Mind Task.

Two of the studies investigated the effectiveness of ToM training on ToM skills, emotion understanding, social skills, empathy, and empathic responsiveness in autistic individuals (Begeer et al., 2011; Holopainen et al., 2019). The Theory of Mind training was used in one study (Begeer et al., 2011), and the Mini ToM Intervention was used in the other (Holopainen et al., 2019). The participants were randomly assigned to either a waitlist control group or an intervention group in both studies. It was found that the Theory of Mind training improved the understanding of complex and mixed emotions, e.g., feeling happy for oneself but sad for somebody else, significantly, as well as conceptual ToM. Concerning self-reported empathy and social skills reported by parents, no changes were found (Begeer et al., 2011). However, the Mini ToM Intervention led to a significant, although small, improvement in empathic responsiveness (Holopainen et al., 2019). Holopainen et al. (2019) used the ToMBC to assess ToM, while Begeer et al. (2011) used the ToM test. Structured observations in which an experimenter expressed surprise or excitement, were used to measure empathic responsiveness (Holopainen et al., 2019), while the Index of Empathy for Children and Adolescents was used to measure empathy, the CSBQ was used to assess social skills, and the LEAS-C was used for examining emotional awareness (Begeer et al., 2011).

Bishop-Fitzpatrick et al. (2017)'s study examined the interaction between social cognition, in this case meaning ToM, and social functioning, in this case meaning the extent of social problems and socially adaptive behavior, in individuals with ASD. ToM was assessed with a first-order false belief task (Sally-Anne) and two second-order false belief tasks (John-Mary and Peter-Jane). Social problems were measured with the social problems subscale of the CBCL, and socially adaptive behavior was evaluated with the socialization domain from the VABS. A significant relationship was found between social cognition and social functioning, and an association was found specifically between social functioning and second-order false belief tasks at trend-level. Additionally, a link between a higher degree of social functioning and older age was observed.

Rosello et al. (2020) measured and compared ToM knowledge in TD and autistic individuals and assessed its effect on socially adaptive behavior and pragmatic abilities. The autistic individuals were divided into two groups based on their ToM skills assessed with the subtests of affect recognition and ToM from the social perception domain of the NEPSY-II, and the ToMI. Based on the ToMI-results the TD group struggled less with basic emotion understanding, complex social judgments, second-order inferences, and in differentiating between mental and physical, than both ASD groups. Socially adaptive behavior was measured with VABS-II ed., and pragmatic abilities were measured using the CCC-2. It was found that the participants with lower ToM skills had poorer pragmatic abilities and worse socially adaptive behavior than the participants with higher ToM abilities.

Vagnetti et al. (2020) examined the interaction among social cognition components and their importance in the social cognition network and compared this between autistic and TD individuals. The social cognition components were affective and cognitive empathy, ToM, and social skills. Affective empathy was measured with AES and EEQ, cognitive empathy with CEQ and CES, ToM with A-ToM and ET, and social skills with SSQ. The TD group had significantly higher measure scores on all components compared to the ASD group. To investigate the interaction between these components as a social cognition network, graph analysis was used. It was shown that the components were connected in the TD group, but disconnected in the ASD group, which suggests poorer communication in the ASD network. Furthermore, the connection was especially higher between the ToM and social skills components in the TD group compared to the ASD group.

Discussion

The main question of this systematic review was how ToM in autistic individuals can affect emotion understanding, empathy, and relationships. Concerning emotion understanding, it was presented that it can be significantly improved by training ToM (Begeer et al., 2011). However, this was only found in one study and therefore more research must be done for the finding to be more reliable. It was also found that TD individuals struggled less than autistic individuals with emotion understanding (Rosello et al., 2020), however, this finding was based on parent observations and a less subjective measure could have produced different results.

Regarding empathy, different results were found. One study reported no change in self-reported empathy after training ToM (Begeer et al., 2011), while another study found an improvement, although small, in empathic responsiveness (Holopainen et al., 2019). It was also presented that TD individuals scored higher on measures of both affective and cognitive empathy than autistic individuals, as well as on measures of ToM. Furthermore, these components, among others, were connected in a social cognition network in TD individuals but disconnected in individuals with ASD (Vagnetti et al., 2020). Based on these results, it is not unreasonable to hypothesize that ToM can be associated with empathy, but further research needs to be done. It could be of value to use more objective measures than self-reports and structured observations in this as well. It would also be of value to investigate the link between ToM functioning and empathy alone, without other social cognition components included, to get a better understanding of how these two social cognition components interact with each other.

Concerning relationships, it was mentioned in the introduction that individuals with ASD may struggle with establishing and sustaining them. It was also mentioned that ToM

training has been shown to improve social skills (Adibsereshki et al., 2015), which most of the results presented in this review are in line with.

Bishop-Fitzpatrick et al. (2017) found a significant association between ToM and the extent of social problems and socially adaptive behavior. Specifically, a link between second-order false belief tasks and social functioning was found as well as an association between age and degree of social functioning. Furthermore, it was presented that individuals with lower ToM skills experience more difficulties with pragmatic abilities and socially adaptive behavior than individuals with higher ToM abilities (Rosello et al., 2020). Additionally, it was found that autistic individuals struggle more with social skills than TD individuals (Vagnetti et al., 2020). In this study, social skills were part of a social cognition network among other social cognition components, in which poorer communication among the different components was suggested in autistic compared to TD individuals. In this network, the connection was specifically high between ToM and social skills, implying that these two components are especially important when it comes to differences in the social cognition network between autistic and TD individuals. However, Begeer et al. (2011) found no improvement in social skills after ToM training. Nevertheless, social skills were reported by parents in this study, and as previously mentioned it could be of value to measure them more objectively. Based on these results, it is reasonable to say that ToM does affect social skills, such as socially adaptive behavior and social problems, which can affect relationships. Based on Bishop-Fitzpatrick et al. (2017)'s findings, it would be of interest to investigate the association between second-order false belief tasks and social functioning further to establish e.g., how a possibly helpful ToM-intervention could be structured. Additionally, it would be of interest to further examine the association between age and social functioning to get a better understanding of how ToM may change as individuals age. Knowledge regarding this could also be helpful when creating ToM-interventions.

In the introduction of this review, it was presented that emotion understanding, empathy, and social competence could be related to the TPJ or the understanding of beliefs that the TPJ is involved in (Baron-Cohen, 1991; Razza & Blair, 2009; Saxe & Kanwisher, 2003; Saxe & Powell, 2006; Völlm et al., 2006). Altered brain activity in the TPJ in autistic individuals compared to TD individuals was also mentioned as a possible reason for impaired ToM in individuals with ASD (Lombardo et al., 2011; Murdaugh et al., 2014; Yuk et al., 2018). However, since the focus of the five studies included in this review was not on brain imaging, it is not possible to draw any direct conclusions regarding the relationship between ToM and emotion understanding, empathy, and relationships based on the TPJ and its involvement in these processes. Nonetheless, since most results showed that these concepts are associated with and affect each other, it would be of interest to include brain imaging in future studies of

this topic to more directly investigate the role of the TPJ. It would also be interesting to investigate if ToM training can result in increased TPJ activity in individuals with ASD.

Apart from brain imaging, it would also be of interest to further investigate connectivity between the TPJ and other relevant brain areas such as the cerebellar Crus II, which is involved in social cognition and mentalizing (Van Overwalle et al., 2020). An fMRI study that examined and compared the functional connectivity between the TPJ and the cerebellum in TD and autistic individuals found significantly lower connectivity between the right TPJ and the left cerebellar Crus II in individuals with ASD (Igelström et al., 2017). Voxel-based morphometry (VBM), a method used to measure gray matter (GM) concentration in the brain (Ashburner & Friston, 2000), was used in another study on the cerebellar Crus II in TD and autistic individuals (Riva et al., 2013). In this study, a significant correlation between the cerebellar Crus II and reciprocal social communication was found, as well as reduced GM in this area in individuals with ASD compared to TD individuals.

The TPJ is not alone responsible for the functioning of these different processes of social cognition but appears to be part of a network involving other brain areas such as the cerebellar Crus II. By examining brain activity and connectivity in brain regions as the TPJ and the cerebellar Crus II during different tasks related to ToM, emotion understanding, empathy, and relationships, valuable knowledge could be found. Further knowledge of the role of the TPJ in these processes could e.g., help develop useful interventions. However, as already mentioned no direct conclusions regarding the role of the TPJ in emotion understanding, empathy, and relationships can be made based on this review. Nevertheless, it would be of interest to investigate how these mentioned brain areas interact with each other, as well as how they function alone, and which of these processes they both appear to be involved in, and what they contribute with concerning this. By examining other brain areas that appear to be involved in the same processes, the specific role of the TPJ in these processes could become clearer.

As mentioned in the introduction, the severity of ASD symptoms can decrease with age as an individual learns how to manage the things they struggle with (Morrison, 2014). However, for this to happen support must be available for the individual as soon as possible after diagnosis. If someone does not get the right type of support, they may struggle so much with e.g., relationships that they become lonely. As mentioned earlier in this review, loneliness has been associated with decreased self-esteem and life satisfaction and increased anxiety and depression in autistic individuals (Mazurek, 2014). Furthermore, one out of 270 individuals worldwide is estimated to be autistic (World Health Organization, 2021), meaning that ASD is relatively common. Seen from a societal perspective, this could lead to a bigger demand for psychological and medical care, which could lead to higher costs for

society. Furthermore, if an individual feels like he or she does not fit in with others they may keep to themselves and not contribute much to society.

The fact that consent was mostly obtained from caregivers instead of the actual participants of the presented studies since most of them were minors, as shown in Table 1, and therefore could not give consent, can be seen as ethically problematic. From a legal perspective, there is no problem with this, but when including someone in a study without their actual consent, there is a risk that their autonomy is violated. However, it is important to examine individuals of different ages if one wants to better understand how e.g., ToM can work in ASD and how it potentially can change with age. Therefore, the problem of consent and autonomy in minors is not easy to solve. Nonetheless, it is important to reflect on and try and figure out a solution that does not violate anyone's autonomy.

Furthermore, if someone does not give their consent to participating in a study, the researcher cannot surely know that the individual fully comprehends what he or she is a part of. Based on those premises, it can be ethically problematic to include individuals in a study if they have not agreed to consent.

There are multiple limitations to this review, one of which is the low number of females in the studies as seen in Table 1. As mentioned in the introduction, males are more often diagnosed with ASD, but females are often affected to a greater extent (Morrison, 2014). Often females are misdiagnosed or diagnosed with ASD at a later age compared to boys or even never, e.g., due to conceptions of traditionally feminine traits and behaviors (Bargiela et al., 2016). As a result, these individuals do not receive the support and aid that is necessary for them to manage their symptoms and their difficulties may just get worse with time. Therefore, it can be difficult to recruit more female participants, however, it would be of value for future studies to include more females. If it were established that females with ASD struggle even more with e.g., ToM, studying more of them could lead to important knowledge concerning the main question of this thesis. If the participants consisted of more females, it would also be easier to generalize the results.

Another possible limitation of this review is that the included studies used diagnostic criteria for ASD from different editions of DSM (American Psychiatric Association, 2000, 2013). However, the differences between the two editions, i.e., the merging of symptom categories and the unification of four independent diagnoses; Asperger's disorder, autistic disorder, childhood disintegrative disorder, and pervasive developmental disorder – not otherwise specified, are not drastic and so it should not have had too big of an impact.

Furthermore, only five studies, with different interventions and outcomes, were included in this review as seen in Table 1. This is yet another reason why the results

presented in this study must be considered with some caution. For more representative and clear results, it is suggested that future research examines bigger samples with more similar interventions and outcomes. It is also worth bearing in mind that there can be a difference between the implication of a test result and a person's actual actions in real life. Therefore, it is of interest to develop measures that investigate the application of e.g., ToM knowledge in real-life situations, and not only assess conceptual ToM knowledge.

Conclusion

This systematic review investigated the relationship between ToM in autistic individuals and emotion understanding, empathy, and relationships. Five studies were included and most of the results showed associations between ToM and different aspects of emotion understanding, empathy, and relationships. However, the sample size was small, and the studies used different interventions and had different outcomes. Therefore, future research is needed for more generalizable results. Concerning future studies, it is of interest to e.g., involve brain imaging and to include more female participants and participants of different ages.

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Appendix A

Search process in PubMed

The final search string in the database PubMed was created by using the advanced window and entering search strings with the available “add button”. The final search string as written in the query box was: ((((((autism, "theory of mind"[Title/Abstract]) OR (autism, "theory of mind", "emotion understanding"[Title/Abstract])) OR (autism, "theory of mind", empathy[Title/Abstract])) OR (autism, "theory of mind", relationships[Title/Abstract])) OR (autism, "theory of mind", "test of emotion comprehension"[Title/Abstract])) OR (autism, "theory of mind", "empathy quotient"[Title/Abstract])) OR (autism, "theory of mind", "false-belief task"[Title/Abstract])