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The relationship between alexithymia and theory of mind: A systematic review

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ABSTRACT

Theory of Mind (ToM), the ability to represent the mental states of oneself and others, is an essential social skill disrupted across many psychiatric conditions. The transdiagnostic nature of ToM impairment means it is plausible that ToM impairment is related to alexithymia (difficulties identifying and describing one's own emotions), as alexithymia is seen across psychiatric conditions. Whilst many studies have examined links between alexithymia and ToM, results are mixed. Therefore, the purpose of this systematic review is to provide a taxonomy of ToM tests and assess their relationship with alexithymia. Tests are grouped according to whether they assess propensity to engage spontaneously in ToM or accuracy of ToM inferences, with tests further subdivided into those that do, and do not, require emotion recognition. A review of 63 suitable studies suggests that alexithymia is often associated with reduced ToM, and inaccurate ToM when tasks require emotion recognition. This latter finding appears due to impaired emotion recognition, rather than ToM impairment *per se*. Further directions and considerations for future research are discussed.

1. Introduction

The ability to represent one's own mental states and those of other people - 'theory of mind' (ToM) – is generally considered to be a crucial ability which underpins the vast majority of social interaction (Brüne, 2005a; Happé and Frith, 1996). ToM impairments have been reported across a number of psychiatric conditions associated with social interaction difficulties, including schizophrenia (Brüne, 2005b), autism spectrum disorder (Baron-Cohen et al., 1985), anorexia nervosa (Russell et al., 2009; but see Tchanturia et al., 2004), depression (Bora and Berk, 2016), and substance use disorders (Sanvicente-Vieira et al., 2017), raising the possibility that ToM impairments may contribute towards reduced social functioning in individuals with these conditions.

Although difficulties with ToM are documented in a number of psychiatric conditions, most empirical work has been focused on individuals with ASD, with numerous studies reporting difficulties across a range of ToM tasks (Baron-Cohen et al., 1985; Baron-Cohen, 2000a,b; Beaumont and Newcombe, 2006; Frith and Happé, 1994). Given this body of research it is often assumed that difficulties with ToM are a key feature of ASD, accompanying claims of difficulties in other areas of social interaction including empathy (Baron-Cohen, 2009), emotion recognition (Uljarevic and Hamilton, 2013) and social reciprocity (Lord et al., 2001; Pohl et al., 2019). However, there is considerable heterogeneity in the pattern of strengths and weaknesses seen in the population of individuals with ASD. In recent years there has been a growing appreciation that certain co-occurring conditions may account for some of this heterogeneity, such that what were previously thought to be symptoms of ASD are now recognised as present only in those individuals with autism who also have the relevant co-occurring condition. For example, an ample body of research indicates that co-occurring alexithymia is responsible for a large degree of the heterogeneity within the ASD population, particularly within the emotional domain.

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Alexithymia is a sub-clinical condition characterised by difficulties identifying and describing one's own emotions, coupled with an externally-oriented thinking style (Nemiah, 1977; Sifneos, 1973), that frequently co-occurs with autism (Berthoz and Hill, 2005) and other clinical disorders (e.g., Leweke et al., 2012; Ricciardi et al., 2015; Zappa et al., 2010).

The prevalence of alexithymia is much higher within psychiatric conditions than in typical populations; for example, while approximately 50 % of individuals with ASD (Berthoz and Hill, 2005) and ~60 % of individuals with anorexia nervosa (Cochrane et al., 1993; Corcos et al., 2000) meet criteria to be considered alexithymic, this is true for less than 10 % of the typical population (Linden et al., 1995; Salminen et al., 1999). In line with the hypothesis that alexithymia is responsible for some of what were considered to be symptoms of ASD (e.g., Bird and Cook, 2013; Brewer et al., 2015a,b), when the independent contributions of alexithymia and ASD are dissociated, it is alexithymia and not ASD diagnosis or severity that is associated with difficulties with empathy, eye contact and emotion recognition ability (e.g., Bird et al., 2011, 2010; Cook et al., 2013; Cuve et al., 2021). Alexithymia explains atypical spatiotemporal dynamics of eye gaze in autism. Cognition, 212, 104710.), with a similar pattern observed across other conditions characterised by elevated rates of alexithymia (e.g., eating disorders; Brewer et al., 2015a,b).

Given the evidence that alexithymia accounts for multiple social impairments across psychiatric conditions, it is possible that co-occurring alexithymia is also responsible for the difficulties with ToM seen across these conditions. There are an extremely high number of psychiatric and neurological conditions that are characterised by an increased prevalence of both alexithymia and ToM impairment (e.g., eating disorders; Cochrane et al., 1993; Russell et al., 2009; depression; Bora and Berk, 2016; Honkalampi et al., 2000; schizophrenia; Brüne, 2005b; Heshmati et al., 2010; and neurological disorders such as Parkinson's disease; Bodden et al., 2010; Costa et al., 2010; dementia and Alzheimer's disease; Laisney et al., 2011; Ricciardi et al., 2015). If alexithymia is associated with deficits in ToM, then it is possible that it is alexithymia, and not the disorder per se, that accounts for ToM difficulties across all of these conditions. As such, understanding whether alexithymia contributes towards ToM impairments may help to understand phenotypic heterogeneity across psychological and neurological disorders.

The first step necessary in examining this hypothesis is to test the association between alexithymia and ToM performance. Whilst many studies have examined the link between alexithymia and ToM, results are mixed: with some studies reporting an association between alexithymia and ToM, and others reporting no association (e.g., Aloi et al., 2017; Christopher and McMurran, 2009; Grynberg et al., 2010; Milosavljevic et al., 2016). The nature of such mixed results is also reflected by the different effect sizes reported in the studies that have investigated this relationship; for example, Berenson et al. (2018) observed a small effect size (r = -0.031), whilst Schonenberg et al. (2014) reported a large effect size (r = -0.731) between ToM and alexithymia. It is the studies assessing the relationship between ToM and alexithymia that are the topic of this review. However, it is not a straightforward process to examine the body of work in this area, primarily because 'tests of ToM' likely consist of (at least) three distinct types.

1.1. Categorising tests of theory of mind

At the conceptual level, as detailed previously, ToM is typically defined as the ability to represent one's own mental states, and those of other people. However, as has recently been noted by Conway and colleagues, such a definition leaves very little room for individual differences in ToM (Conway et al., 2019; Conway and Bird, 2018) – individuals either can, or cannot, represent mental states (see also Hughes and Dunn, 1997; Hughes and Devine, 2015 for discussion). Paradoxically, tests of ToM typically assess the accuracy (or typicality) of mental state inferences, and therefore it is assumed that mental states can be represented. In such tasks, participants are exposed to an experimental stimulus, whether a picture, movie, sound, or vignette, and typically asked to infer the mental state of a character portrayed by the stimulus. The 'correct' answer is often deemed to be so according to consensus (i.e., the test authors, or a large number of neurotypical volunteers, decide on the character's most likely mental state). Besides the fact that such tests could be argued to measure how typical, rather than accurate, mental state inferences are, a binary correct/incorrect classification per trial does not address the inferential process or its quality, or individual differences therein.

One practical consequence of this conceptual issue is that an individual's 'ToM ability' may vary greatly depending upon the type of information available to make a mental state inference. An obvious example is the presence or absence of cues to emotion. For example, when attempting to infer mental states in situations where non-verbal cues to an individual's emotional state are unavailable, such as when communicating by text message or email, individuals may be less likely to make correct inferences about mental states than when emotional cues are available. The degree to which accurate mental state inference is aided by the presence of emotional cues is likely to vary across individuals as a function of their ability to decode accurately such emotional cues, and their propensity to use cues to emotion when making mental state inferences.

A variable influence of the presence or absence of cues to emotion on the accuracy of mental state inference is not only to be expected due to individual differences across individuals, one may also expect the particular situation to moderate the degree to which availability of cues to emotion improve the accuracy of mental state inference. For example, a child who has been waiting in their bedroom for their mother to come home may infer much about whether their mother knows that they broke her favourite vase while she was out of the house from her tone of voice when they hear a request to "come down here" upon her return. In other situations, being able to recognise another's emotional state does not aid in the inference of their mental state – if we know that Derek is the only person who learned some information, and that he has told nobody, then we may make the inference that Rodney is unaware of the information and we are not aided in making this inference by knowing his emotional state. As such, whilst the ability to recognise accurately the other's emotional state may sometimes be beneficial for ToM inferences, emotion recognition is not synonymous with ToM and is best considered an adjunctive process that may contribute towards the accuracy of mental state inferences in certain tasks.

Given the likelihood of variability between the accuracy of mental state inference in the presence and absence of emotional cues, it seems prudent to distinguish between tests of ToM that do, or do not, require emotion recognition in order to make accurate mental state inferences (Oakley et al., 2016; Turner and Felisberti, 2017). This distinction between emotional and non-emotional ToM tests may be especially relevant in studying the relationship between alexithymia and ToM, given that alexithymia is defined as an inability to identify one's own emotions and is associated with an inability to recognise the emotions of others from their facial expression (Grynberg et al., 2012) or tone of voice (Heaton et al., 2012).

A second distinction between tests of ToM that may be of theoretical interest is between those that measure the ability to infer accurately the mental states of others, and those that measure the propensity to make mental state inferences (e.g., Birch and Bloom, 2004; Cage et al., 2013; Conway et al., 2019; Epley et al., 2004; Happé et al., 2017). One of the defining features of alexithymia is an externally-oriented thinking style, i.e. a tendency to avoid thinking about internal states and instead to focus thoughts on external matters. It is therefore possible that individuals with alexithymia are less likely spontaneously to interpret behaviour in terms of mental states, or to make mental state inferences in general, but are perfectly able to make accurate mental state inferences when required to do so in experimental situations.

Table 1
A table illustrating emotion and non-emotion ability and propensity Theory of Mind (ToM) tasks identified from relevant publications.

Title	No. of papers	Reference
Reading the Mind in the Eyes Task (RMET)	30	Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" Test Revised Version: A Study with Normal Adults, and Adults with Asperger Syndrome or High-functioning Autism. Journal Of Child Psychology And Psychiatry, 42(2), 241−251. https://doi.org/10.1017/s0021963001006643.
Movie for the Assessment of Social Cognition (MASC)	4	Dziobek, I., Fleck, S., Kalbe, E., Rogers, K., Hassenstab, J., & Brand, M. et al. (2006). Introducing MASC: A Movie for the Assessment of Social Cognition. Journal Of Autism And Developmental Disorders, 36(5), 623−636. https://doi.org/10.1007/s10803−006-0107−0.
Interpersonal Reactivity Index - Perspective Taking (IRI-PT)	19	Davis, M. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. Journal Of Personality And Social Psychology, 44(1), 113−126. https://doi.org/10.1037//0022−3514.44.1.113.
Combined False Belief task	1	Milosavljevic, B., Leno, V. C., Simonoff, E., Baird, G., Pickles, A., Jones, C. R., Erskine, C., Charman, T., & Happé, F. (2016). Alexithymia in adolescents with autism spectrum disorder: its relationship to internalising difficulties, sensory modulation and social cognition. Journal of autism and developmental disorders, 46(4), 1354−1367.
Faux pas	2	Baron-Cohen, S., O'Riordan, M., Jones, R., Stone, V.E. & Plaisted, K. (1999). A new test of social sensitivity: Detection of faux pas in normal children and children with Asperger syndrome. Journal of Autism and Developmental Disorders, 29, 407−418.
Frith-Happé Animations Task	5	Abell, F., Happé, F., & Frith, U. (2000). Do triangles play tricks? Attribution of mental states to animated shapes in normal and abnormal development. Cognitive Development, 15(1), 1−16; Castelli, F., Happé, F., Frith, U., & Frith, C. (2000). Movement and mind: a functional imaging study of perception and interpretation of complex intentional movement patterns. Neuroimage, 12(3), 314−325.
Strange Stories Film Task	1	Murray, K., Johnston, K., Cunnane, H., Kerr, C., Spain, D., Gillan, N., Hammond, N., Murphy, D., & Happé, F. (2017). A new test of advanced theory of mind: The "Strange Stories Film Task" captures social processing differences in adults with autism spectrum disorders. Autism Research, 10(6), 1120−1132.
Strange Stories Task	1	Happé, F. G. (1994). An advanced test of theory of mind: Understanding of story characters' thoughts and feelings by able autistic, mentally handicapped, and normal children and adults. Journal of autism and Developmental disorders, 24(2), 129−154.
Attribution of Intention test	1	Brunet, E., Sarfati, Y., Hardy-Baylé, M.-C., 2003. Reasoning about physical causality and other's intentions in schizophrenia. Cognit. Neuropsychiatry 8, 129–139. https://doi.org/10.1080/13,546,800,244,000,256; Sarfati, Y., Hardy-Baylé, M.-C., Besche, C., Widlocher, D., 1997. Attribution of intentions to others in people with schizophrenia: a non-verbal exploration with comic strips. Schizophr. Res. 25, 199–209. https://doi.org/10.1016/S0920−9964(97)00,025-X.
Questionnaire of cognitive and affective empathy (QCAE) - Cognitive empathy	1	Reniers, R.L.E.P., Corcoran, R., Drake, R., Shryane, N.M., Völlm, B.A., 2011. The QCAE: a Questionnaire of Cognitive and Affective Empathy. J. Pers. Assess. 93, 84–95. https://doi.org/10.1080/00223891.2010.528484.
Thematic Apperception Test (TAT)	1	Murray HA (1943) Thematic Apperception Test manual. Cambridge, MA: Harvard University Press.
Advanced Test of ToM (ATT)	1	Prior, M., Marchi, S., & Sartori, G. (2003). Social cognition and behavior. A tool for assessment. Cognizione sociale e comportamento. Uno strumento per la misurazione. Padova, Italy: Upsel Domenighini Editore.
Theory of mind picture sequence	1	Brüne, M. (2003). Theory of mind and the role of IQ in chronic disorganized schizophrenia. Schizophrenia Research, 60, 57–64. http://dx.doi. org/10.1016/S0920−9964(02)00162−7
Emotion attribution task	1	Blair, R. J., & Cipolotti, L. (2000). Impaired social response reversal. A case of 'acquired sociopathy'. Brain: A Journal of Neurology, 123, 1122–1141. https://doi.org/10.1093/brain/123.6.1122
Theory of Mind Test	1	Steerneman P, Meesters C, Muris P (2003). TOM-test. Garant: Apeldoorn, The Netherlands; Baron-Cohen S, Leslie AM, Frith U (2007). Does the autistic child have a 'theory of mind'? Cognition 21, 37–46.
False belief picture sequencing task	1	Langdon, R., & Coltheart, M. (1999). Mentalising, schizotypy, and schizophrenia. Cognition, 71(1), 43−71.
Conflict Beliefs	1	Shaw, P., Lawrence, E. J., Radbourne, C., Bramham, J., Polkey, C. E., & David, A. S. (2004). The impact of early and late damage to the human amygdala on 'theory of mind'reasoning. Brain, 127(7), 1535−1548.
Mind-mindedness	1	Meins, E., Fernyhough, C., Russell, J., & Clark-Carter, D. (1998). Security of attachment as a predictor of symbolic and mentalising abilities: A longitudinal study. Social development, 7(1), 1−24.
Mental State Stories Task	2	Saxe, R., & Kanwisher, N. (2003). People thinking about thinking people: the role of the temporo-parietal junction in "theory of mind". Neuroimage, 19(4), 1835−1842.

Accordingly, the aim of this systematic review is to to determine whether alexithymia is associated with deficits in ToM. Given heterogeneity in the measures used to quantify theory of mind, we provide a taxonomy of ToM measures. We first consider the degree to which the measure assesses the propensity to infer mental states, versus the accuracy of those inferences. Second, as measures of ToM may also be influenced by the emotion recognition requirements of the task, we also consider whether the test requires intact emotion recognition ability or not. Using this grouping system, we assess the relationship between alexithymia and ToM across these categories in order to determine whether alexithymia is associated only with tasks with emotional demands, or whether difficulties extend beyond this. By doing so, we aim to shed light on whether alexithymia contributes to both atypical and typical social cognition.

2. Methods

2.1. Inclusion/exclusion criteria

This systematic review followed the guidelines recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Moher et al., 2009). The following databases were accessed: MEDLINE, PsychINFO, PubMed and Web of Science on the 7th May 2020. Relevant publications were accessed from each database using the following search strategy: (Alexithymia/ OR Affective awareness OR "emotional blindness" OR "difficulties describing feelings" OR "difficulties identifying feelings" OR "externally oriented thinking") AND ("Theory of Mind"/ OR Mentaliz(s)ing OR Mentalisation OR "ToM" OR "IRI" OR "Interpersonal reactivity index" OR Mentalization). Search terms were selected using synonyms from a PICO framework (Schardt et al., 2007). The full search strategy can be found in Supplementary Material 1 (S1). The Alexithymia and "Theory of Mind" search terms were expanded for all database searches. No limits on publication year were imposed. Additional searches including further terms ("mindreading" and "perspective taking") conducted at the request of anonymous reviewers on 19th August 2021 did not identify additional papers. For ToM measures, the authors had to specifically state that the measure used reflected ToM or some form of mental state/mentalising (the name of all measures used, and their frequency of use, is reported in Table 1). All alexithymia measures were accepted for

Table 2
A table illustrating the alexithymia measures identified from relevant publications.

Title	No. of papers	Reference
Toronto Alexithymia Scale (20 items) (TAS-20)	56	Bagby, R. M., Parker, J. D., & Taylor, G. J. (1994). The twenty-item Toronto Alexithymia Scale. I. Item selection and cross-validation of the factor structure. Journal of Psychosomatic Research, 38(1), 23e32. https://doi.org/10.1016/0022−3999(94) 90005−1.
Toronto Alexithymia Scale (26 items) (TAS-26)	4	Taylor, G. J., Ryan, D., & Bagby, M. (1985). Toward the development of a new self-report alexithymia scale. Psychotherapy and psychosomatics, 44(4), 191−199.
Bermond-Vorst Alexithymia Questionnaire (BVAQ)	3	Vorst HC, Bermond B. Validity and reliability of the Bermond-Vorst Alexithymia Questionnaire. Pers Individ Dif (2001) 30:413–34. doi:10.1016/S0191−8869(00)00033−7

inclusion (the measures used by each individual study are reported in Table 2).

Whilst the aim of this review was to be as comprehensive as possible, the following exclusion criteria were adopted. At stage one of screening, studies that were not in English, or did not measure both ToM and alexithymia were removed. At stage two, studies that met the criteria for stage one but did not report formal analyses between alexithymia and measures of ToM were excluded. Formal analyses of either linear relationships between variables (i.e., correlation between ToM measures and alexithymia) or group comparisons (e.g., t-tests comparing high vs. low alexithymic individuals on ToM measures) were accepted for inclusion (hereafter 'primary analyses'). Verbal reports without summary statistics were also included so long as the direction of the effect was reported. As not all relevant studies included analyses addressing the relationship between alexithymia and ToM, we took multiple steps to ensure relevant studies were included. First, where possible, inferential statistics were calculated from descriptive statistics when not explicitly reported. Second, authors were contacted for data and/or summary statistics relating to the simple relationship between alexithymia and ToM (see Table 3). Studies that did not report the simple relationship between alexithymia and ToM (e.g., a regression analysis controlling for other measures was reported only) were not included but are reported in Appendix A.

In addition to primary analyses several studies also reported secondary analyses (e.g., regression analyses controlling for other variables). However, as the control variables included in these analyses differed across studies, for consistency the same level of analysis was adopted for all studies; if alexithymia was associated with ToM at the correlational or group comparison level but this relationship was absent when controlling for other variables this was noted as an initial significant relationship ('effect found in primary analysis but not secondary analysis'; Fig. 1). Where applicable the items controlled for in regression analyses and the effect on the relationship between ToM and alexithymia are reported in text. Likewise, several studies also investigated the relationship between ToM and alexithymia in both neurotypical (hereafter 'typical) and clinical/atypical[2] samples. Where inconsistent results are reported across groups (e.g., a relationship was observed in one sample but not the other) these results are listed as ambiguous ('effect found in one group, not the other'; Fig. 1), and the results from control and clinical/atypical samples are discussed separately.

Fig. 2 illustrates the selection processes from the initial database search to the final studies included in this review (note that some studies used multiple measures of ToM but for the purpose of this review each measure and its relationship with alexithymia is discussed separately given that measures may quantify different aspects of ToM; see Section 2.2 'Review Structure').

[2] We use the term 'clinical/atypical' throughout to reflect that not all target populations examined are individuals with a clinical diagnosis of a physical or mental health condtion.

2.2. Review structure

Prior to outlining the research examining the relationship between ToM and alexithymia we first provide a taxonomy of the tasks used to quantify ToM. Second, we then describe the questionnaires used to quantify alexithymia. Third, after outlining the measures used to quantify both ToM and alexithymia, we then report on the evidence examining the impact of alexithymia on ToM split using the categories described above and below: 1) measures of ToM ability that require emotion recognition ability 2) measures of ToM ability that have minimal emotion recognition demands; 3) measures of the propensity to engage in ToM that require emotion recognition ability and 4) measures of ToM propensity that have minimal emotion recognition demands. ToM and alexithymia tests, tasks and rating scales were reviewed independently by three authors (JM, SP, and JC), with further input from other authors (EM and GB) where appropriate. Disagreement was resolved through discussion. Notably, however, no included studies fell into the third category described above (see below).

2.3. Theory of Mind tasks: Multiple types of test

In this section we provide an overview of the tests used to quantify ToM included in this review, and categorise these according to the extent to which they assess one's propensity to engage in ToM or the accuracy of mental state inferences (Table 1). Note that when describing tests as assessing the accuracy of mental state inferences, several of these tests may be better described as tests assessing the typicality of an individual's mental states inferences. While acknowledging this, we use the term accuracy for brevity. ToM tasks that quantify participants' accuracy when explicitly asked to engage in mental-state processing were classified as tests of ToM ability. Unlike measures of ToM propensity that assess an individual's spontaneous use of mental-state language or mental state inferences, these tasks explicitly require individuals to represent the mental states of others and assess accuracy against predetermined criteria. In contrast to ability-focused ToM tasks, propensity-focused ToM tasks determine an individual's propensity to engage spontaneously in mental state processing and/or to adopt mentalistic explanations of behaviour. These measures differ from ability-focused tasks in that participants are not explicitly instructed to engage in mental-state processing, and pure measures of ToM propensity just assess whether mental state inferences are made, not whether those mental state inferences are accurate or typical.

For measures of ToM ability, we also categorised tests according to the extent to which they require (or performance is aided by) emotion recognition ability. Whilst tasks of ToM propensity may in principle also be influenced by emotion recognition ability (e.g., some people might be more likely to attribute/infer mental states in the presence of emotion cues) no tasks included in this review assess this possibility. As such, only the impact of emotion recognition ability on tests of ToM ability is considered. Measures of ToM that require (or performance is aided by) recognition of emotional states depicted by either emotional facial expressions, scenes or vignettes were classified as measures of ToM ability

Table 3
A table detailing all analyses between alexithymia and theory of mind tasks from the 63 relevant publications identified.

		Outcome measures		Sample characteristics					
Dimension	Study	Alexithymia	ToM	N	Indication	Age	Data	Results	Effect
	Adenzato et al. (2012)	TAS-20	RMET	62	Anorexia Nervosa and Depression	19.73; 20.47 (typical)	Reported	There was no significant correlation between TAS-20 and RMET.	No relationship reported
	Al Aïn et al. (2013)	TAS-20	RMET	107	Typical individuals	23.9	Reported	There was a negative correlation between TAS-20 total scores and RMET.	r = -0.26, $p < 0.05$
	Aloi et al. (2017)	TAS-20	RMET	58	Bing eating disorders (BED)	43.8 (BED obese); 42.5 (BED sub-obese); 50.6 (BED non-obese)	Reported	There was no significant correlation between TAS-20 total scores and RMET.	No relationship reported
	Berenson et al. (2018)	TAS-20	RMET	173	Personality disorders (BPD, borderline personality disorders; APD, avoidant personality disorders)	15.3 (BPD); 15.6 (APD); 17.3 (typical)	Reported	There was a negative correlation between TAS-20 total scores and RMET across samples.	r = -.031, $p < 0.05$
	Campanella et al. (2014)	TAS-20	RMET	71	Brain tumours (frontal brain tumour, parietal brain tumour, temporal brain tumour)	49.81 (frontal); 55 (parietal); 45.7 (temporal)	Reported	There was no significant correlation between RMET and TAS-20 total scores.	p = 0.415
	Chalah et al. (2017)	TAS-20	RMET	38	Multiple sclerosis	56 (median)	Reported	There was no correlation between RMET and TAS-20 scores.	No relationship reported
	Demers and Koven (2015)	TAS-20	RMET	86	Students	18.9	Reported	There was a significant negative correlation between TAS-20 scores and RMET. Correlation TAS-20 and RMET likely driven by EOT	p <0.001
Emotion ability	Di Tella et al. (2015)	TAS-20	RMET	81	Fibromyalgia syndrome (women only)	41.29; 40.72 typical)	Data provided	There was a significant negative correlation between TAS-20 total scores and RMET performance in typical individuals and whole sample, but this relationship was not significant in patients.	Typical individuals, $p < 0.001$; whole sample, p < 0.001 Patients, p = 0.229
	Etchepare et al. (2019)	BVAQ	RMET	214	Schizophrenia	36.7; 36.5 (typical)	Data provided	There was a significant negative correlation between BVAQ and RMET in the whole sample. There was no significant correlation between BVAQ and RMET in the control and patient groups.	Whole sample, r = -0.235, $p <$ 0.001; healthy controls and patient group, $p > 0.05$
	Gökçen et al. (2016) - study 1	TAS-20	RMET	121	General population	18.43	Reported	There was a significant negative correlation between TAS-20 scores and RMET performance. Controlling for age, intelligence and autistic traits changed this relationship and TAS-20 did not significantly predict RMET performance.	r = -0.303, $p < 0.01$
	Lane et al. (2015)	TAS-20	RMET	89	Somatic symptom disorder	19–60 (year range)	Reported	There was a significant negative correlation between TAS-20 and RMET. After adjusting for PANAS negative and positive scores, the TAS-20 and RMET relationship did not hold significant.	$p < 0.01$; after adjustment for PANAS scores, p = 0.83
	Lombardo et al. (2007)	TAS-20	RMET	60	Autism Spectrum Disorders	29.13; 29.93 (typical)	Reported	There was a significant negative correlation between TAS-20 and RMET performance in both groups.	Both groups (i.e., ASD and typical) r = -0.43, $p < 0.001$
		TAS-20	RMET	60	Autism Spectrum Disorders	29.13; 29.93 (typical)	Reported		r = -.043, $p < 0.001$

(*continued on next page*)

Table 3 (*continued*)

Dimension	Study	Outcome measures		Sample characteristics				Results	Effect
		Alexithymia	ToM	N	Indication	Age	Data		
	Lombardo et al. (2012)							There was a significant negative correlation between TAS-20 and RMET.	
	Luminet et al. (2011)	TAS-20	RMET	60	Typical individuals (only male adults) divided by Alexithymia scores	21.08	Reported	Low alexithymia group were better at identifying negative emotions on the RMET compared to the high alexithymia group, but this was marginally significant.	$p = .07$
	Lyvers et al. (2017)	TAS-20	RMET	102	Students	22.18	Reported	There was a significant negative correlation between TAS-20 scores and RMET.	$p < 0.05$
	Lyvers et al. (2019b)	TAS-20	RMET	242	Non-clinical/atypical sample of alcohol-using participants	23.22	Reported	There was a significant negative correlation between TAS-20 scores and RMET.	$p < 0.05$
	Lyvers et al. (2018)	TAS-20	RMET	161	Students	22.64	Reported	There was a significant negative correlation between the TAS-20 subscale DIF, and EOT and RMET.	$p < 0.05$
	Lyvers et al. (2019a)	TAS-20	RMET	291	Non-clinical/atypical sample of alcohol-using participants	26	Reported	There was a significant negative correlation between TAS-20 scores and RMET.	$p < 0.05$
	Moseley et al. (2019)	TAS-20	RMET	103	Autism Spectrum Disorders with current self-harm, /historic self-harm and no self-harm	41.2 (current self-harm), 43.5 (historic self-harm); 43 (no self-harm)	Data provided	There was a significant negative correlation between TAS-20 and RMET in whole sample, and in both ASD and typical individuals. in ASD with current self-harm group, in the control with current self-harm, and in typical individuals without self-harm.	Whole sample, $p < 0.001$; ASD, $r = -.282$, $p = 0.006$; typical individuals, $r = -.230$, $p = 0.001$. ASD concurrent self-harm, $p < 0.001$; typical current self-harm $p = 0.001$; typical without self-harm $p = 0.022$
	Oakley et al. (2016)	TAS-20	RMET	43	Autism Spectrum Disorders	30.89; 30.13 (typical)	Reported	The alexithymia group had worse RMET performance compared to non-alexithymia group.	Significant difference reported
	Raimo et al. (2017)	TAS-20	RMET	80	Multiple sclerosis	40.58; 40.2 (typical)	Reported	There was a significant negative correlation between TAS-20 and RMET in both typical individuals and patients.	Typical individuals, $r = -0.38$, $p < 0.01$; patient group, $r = -0.33$, $p < 0.01$.
	Riem et al. (2018)	TAS-20	RMET	53	Outpatients (with unexplained somatic symptoms)	42.56	Reported	There was no significant association between TAS-20 scores and RMET performance.	No relationship reported
	Rothschild-Yakar et al. (2019)	TAS-20	RMET	114	Anorexia Nervosa and Depression	17.58 (anorexia); 15.58 (depression); 17.63 (typical)	Reported	There was no significant correlation between TAS-20 and RMET.	$p > 0.05$
	Samur et al. (2017)	BVAQ	RMET	366	General population	36.66	Reported	There was a significant negative correlation between TAS-20 and RMET.	Significant relationship reported
	Schimmenti (2017)	TAS-20	RMET	792	General population	35.75	Reported	There was a significant negative correlation between TAS-20 and RMET.	$r = -0.30$, $p < 0.01$
	Schimmenti et al. (2019)	TAS-20	RMET	799	General population	35.78	Reported	There was a significant negative correlation between TAS-20 total scores (and all TAS-20 subscales) and the RMET.	Significant relationship reported
	Stonnington et al. (2013)	TAS-20	RMET	89	Conversion disorder (CD); Functional Somatic Syndrome (FSS)	(CD) 42.4; (FSS) 43.4; 45 (typical)	Data provided	There was a significant negative correlation between TAS-20 and RMET	$r = -0.32$, $p = 0.002$.
	Cucchi et al. (2018)	TAS-20	RMET	229			Reported		No relationship reported

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Table 3 (*continued*)

Dimension	Study	Outcome measures: Alexithymia	Outcome measures: ToM	N	Sample characteristics: Indication	Age	Data	Results	Effect
					Eating disorders (ED) with/ without self-harm (SH)	33.3 (ED_noSH); 28.4 (ED_SH); 37.8 (typical)		There was no significant correlation between TAS-20 and RMET.	
	Van Randenborgh et al. (2012)	TAS-26	RMET	59	Episodic depression and chronic depression	41.6 (episodic); 42.04 (chronic)	Reported	There was no correlation between TAS-20 total scores and RMET.	No relationship reported
	Vellante et al. (2012)	TAS-20	RMET	200	Students	24.1	Reported	There was no significant correlation between TAS-20 and RMET in the whole sample. People with high alexithymia scored lower on the RMET than those with no alexithymia interval, but the difference was not statistically significant. There was only a significant negative correlation between TAS-20 and RMET in males but not in females.	Significant difference reported in males, but not females.
	Raimo et al. (2017)	TAS-20	Emotion Attribution Test	80	Multiple sclerosis	40.58; 40.2 (typical)	Reported	There was no significant correlation between TAS-20 and emotion attribution test in either group.	No relationship reported
	Schönenberg et al. (2014)	TAS-20	MASC (affective/ emotion subscale)	38	Persistent somatoform pain disorder	47.05; 46.21 (typical)	Reported	There were significant correlations between TAS-20 and the MASC, i.e. between TAS-20 and the 'affective' subscales only in patients.	r = -0.731, $p < 0.001$
	Swart et al. (2009)	BVAQ	Conflict Beliefs (emotion)	43	Alexithymia	20.1; 19.3 (typical)	Reported	The Alexithymia group were worse at first order emotion only compared to the non-Alexithymia group. There was no difference between groups for second order emotion ($p = 0.29$).	First order emotion, $p = 0.002$
	Murray et al. (2017)	TAS-20	Strange Stories Film Task	60	Autism Spectrum Disorders	30.6; 30.65 (typical)	Reported	There was no significant correlation between TAS-20 and Strange Stories Film Task in either patients or typical individuals.	No relationship reported
	Schonenberg et al. (2015)	TAS-20	MASC	30	Psychogenic nonepileptic seizures	32.34; 32.2 (typical)	Reported	The DIF subscale of the TAS-20 was associated with increased undermentalising in patients but not in typical individuals. There was no significant correlation with total or other subscales.	Significant relationship reported in patients only
Non-emotion ability	Schönenberg et al. (2014)	TAS-20	MASC	38	Persistent somatoform pain disorder	47.05; 46.21 (typical)	Reported	There were significant correlations between TAS-20 and the MASC, i.e. between TAS-20 and the 'cognitive' subscale, between TAS-20 and 'hypo-mentalising' and 'hyper-mentalising' subscales. This was true only in patients.	TAS-20 and cognitive subscale, r = -0.654, $p = 0.002$; TAS-20 and hypo-/hyper-mentalising, r = 0.509, $p = 0.026$; $r = 0.722$, p <.001 respectively
	Gökçen et al. (2016)	TAS-20	MASC	121	Autism Spectrum Disorders	18.43	Reported	There was a significant negative correlation between TAS-20 and MASC performances. TAS-20 scores significantly predicted MASC together with IQ but Age was not significant. When AQ	Significant relationship reported

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Table 3 (*continued*)

Dimension	Study	Outcome measures			Sample characteristics				
		Alexithymia	ToM	N	Indication	Age	Data	Results	Effect
								scores were entered this relationship was not significant anymore.	
	Oakley et al. (2016)	TAS-20	MASC	43	Autism Spectrum Disorders	30.89; 30.13 (typical)	Reported	High and low alexithymic group did not differ in performance on the MASC	$t(39) = 1.01$, $p = .318$.
	Milosavljevic et al. (2016)	TAS-20	Strange stories	88	Autism Spectrum Disorders (ASD) and Alexithymia	15.41 (ASD -Alexithymia); 15.49 (ASD + Alexithymia); 15.5 (typical)	Reported	ASD participants were classified into Alexithymia and non-Alexithymia. There was no difference on the Strange Story Task between high and low alexithymia (). Anxiety and VIQ controlled for made no difference.	$p = .607$
	Stonnington et al. (2013)	TAS-20	Mental state stories	89	Conversion disorder (CD); Functional Somatic Syndrome (FSS)	42.4 (CD); 43.4 (FSS); 45 (typical)	Data provided	There was no significant correlation between TAS-20 and Mental Stories in both objects and people.	$p > 0.05$
	Lane et al. (2015)	TAS-20	Mental state stories	89	Somatic symptom disorder (SoM)	19–60 (range in years)	Reported	There was no significant correlation between TAS-20 total scores and ToM subscales of the Mental Stories task; MSS1 (people ToM) and MSS3A negative correlation between MSS2 (people fact) and TAS total scores and a significant positive correlation between MSS4 (object fact) and TAS total scores was observed. After controlling for PANAS and IQ, only a significant positive relationship between MSS4 and TAS-20 sum scores remained ($b =$ -23.33 (10.09), $p = .02$).	TAS-20 and MSS1, $r(88)= -.1$, $p>.05$); TAS-20 and MSS3 (object inference), ($r(88) = .04$, $p > .05$); TAS-20 and MSS2, $r(88)= -.25$, $p < .01$; TAS-20 and MSS4, $r(88) = .37$, $p < .001$
	Wastell and Taylor (2002)	TAS-20	False Belief Picture Sequencing Task	45	Students	22.2	Reported	Students were screened for alexithymic traits with TAS-20. Their performance on the ToM test did not differ from that of individuals, drawn from the general population, who did not report alexithymic traits.	No difference reported
	Raimo et al. (2017)	TAS-20	Theory of Mind Picture Sequence	80	Multiple sclerosis	40.58; 40.2 (typical)	Reported	No significant correlation between TAS-20 and Theory of mind picture sequence test in both groups.	No relationship reported
	Pluta et al. (2018)	TAS-20	Faux pas	68	Borderline personality disorder	27.3; 25.6 (typical)	Reported	There was no significant correlation between TAS-20 and Faux pas in both groups.	No relationship reported
	Etchepare et al. (2019)	BVAQ	Faux pas	214	Schizophrenia	36.7; 36.5 (typical)	Data provided	There was a significant negative correlation between BVAQ and Faux Pas test in patients with Schizophrenia and in the whole sample. There was no significant correlation between the two scales in the control group.	Patients, $r = -0.270$, $p = 0.007$; typical individuals, $p > 0.05$; whole sample, $r = -0.268$, $p < 0.001$
	Raimo et al. (2017)	TAS-20	Advanced Test of ToM	80	Multiple sclerosis	40.58; 40.2 (typical)	Reported	There was no significant correlation between TAS-20 and	No relationship

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Dimension	Study	Outcome measures: Alexithymia	Outcome measures: ToM	N	Sample characteristics: Indication	Age	Data	Results	Effect
								the advance test of ToM in either group.	
	Wingbermühle et al. (2012)	TAS-20	Theory of Mind (ToM) Test	80	Noonan syndrome	29.1; 33.8 (typical)	Data provided	No significant correlation between ToM test and TAS-20 or BVAQ in the whole sample. There was only a trend approaching significance in the clinical group between BVAQ-A and ToM score second order.	Patients, r = -0.310, p = 0.055; whole sample, no relationship reported
	Moriguchi et al. (2006)	TAS-20	Animation task (Frith-Happe) - appropriateness subscale	38	Students (divided according to Alexithymia scores)	20.2 (alexithymia); 20.8 (non-alexithymia)	Reported	The Alexithymia group had worse performance on the Animation task (appropriateness subscale) compared those with did not have Alexithymia.	p = 0.026.
	Eddy and Richards (2015)	TAS-26	Animation task (Frith-Happe) - appropriateness subscale	70	Huntington's disease (HD) (pre-manifest HD; manifest HD)	54.64 (manifest HD), 42.57 (pre-manifest HD); 55.52 (manifest HC), 40.53 (pre-manifest HC)	Reported	There was no significant correlation between TAS-26 and the Animation task (appropriateness subscale).	No relationship reported
	Swart et al. (2009)	BVAQ	Conflict Beliefs (cognition)	43	Students (divided according to Alexithymia scores)	20.1; 19.3 (typical)	Reported	There were no differences between Alexithymia and Non-Alexithymia group in either first or second order cognitions.	p > 0.05
	Milosavljevic et al. (2016)	TAS-20	Combined False Belief Task	88	Autism Spectrum Disorders (ASD) and Alexithymia	15.41 (ASD-Alexithymia); 15.49 (ASD + Alexithymia); 15.5 (typical)	Reported	There was no difference between groups on the combined false belief task.	No difference reportetd
	Etchepare et al. (2019)	BVAQ	Attribution of intention	214	Schizophrenia	36.7; 36.5 (typical)	Data provided	There was a significant negative correlation between BVAQ and the Attribution of Intention test in the whole sample. There was no significant correlation between BVAQ and the Attribution of intention test in the control and patient groups.	Whole sample, r = -0.196, p = 0.003; controls and patient, both p > 0.05.
Emotion propensity									
	Alkan Härtwig et al. (2013)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	78	Alexithymia	36.95; 35.03 (typical)	Reported	High Alexithymia group scores significant lower on the IRI-PT compared to the Low Alexithymia group.	Significant difference reported
Non-emotion propensity	Banzhaf et al. (2018)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	70	Major depressive disorders (divided by high and low alexithymia scores - 'HA' and 'LA' respectively)	39.4 (HA); 47.6 (LA); 60.5 (HA typical); 42.8 (LA typical)	Reported	Participants were divided into High and Low alexithymia. High alexithymia group were worse than Low alexithymia group on the perspective taking (IRI-PT).	p = 0.001; $\eta 2$ = 0.16
	Chau et al. (2018)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	166	Brain lesions (anterior insula, AI; inferior frontal gyrus, IFG)	63.01 (AI); 62.94 (IFG); 63.7 (other); 63.26 (typical)	Data provided	There was a significant negative correlation between TAS-20 and IRI-PT for all individual groups and for whole sample.	all p < 0.05
	Christopher and McMurran (2009)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	79	Adult male offenders (non-sexual offenders)	32	Reported	There was no significant correlation between TAS-20 and IRI-PT.	No relationship reported
		TAS-20		76	Multiple sclerosis	42.3; 39.3 (typical)	Reported		No relationship reported

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Dimension	Study	Outcome measures			Sample characteristics				
		Alexithymia	ToM	N	Indication	Age	Data	Results	Effect
	Gleichgerrcht et al. (2015)		Interpersonal reactivity inventory (perspective taking subscale)					There was no significant correlation between TAS-20 and IRI-PT.	
	Grynberg et al. (2010)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	645	Typical individuals	21.19	Reported	There was a significant negative correlation between TAS-20 total scores and perspective taking (IRI-PT). TAS-20 total scores, DDF and EOT scores are negatively correlated with perspective taking when controlling for anxiety and depression.	$r = -.28$, $p < .001$
	Guttman and Laporte (2002)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	204	Borderline personality disorders (BPD) and anorexia nervosa (AN)	32 (BPD); 22 (AN); 21 (typical)	Reported	Those with high alexithymia scores reported lower perspective taking (IRI-PT) scores than those without alexithymia traits.	Significant difference reported
	Kang et al. (2012)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	237	Obsessive-Compulsive Disorders	27.5; 26 (typical)	Data provided	There was a significant negative correlation between TAS-20 total scores and the perspective taking component of the IRI in both typical individuals and patients and in the whole sample as well.	Typical individuals, $p < 0.001$; patient group, $p = 0.034$; whole sample $p < 0.001$.
	Martínez-Velázquez et al. (2020)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	60	High and low empathy	21; 21.1 (low empathy)	Data provided	There was a significant negative correlation between TAS-20 and IRI-PT for the whole sample. No correlations between TAS-20 and IRI-PT for high empathy or low empathy group.	Whole sample, Spearman's rho = -.466, $p < 0.001$
	Maurage et al. (2011)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	60	Alcoholism	46.67; 43.12 (typical)	Data provided	There was no significant correlation between TAS-20 and IRI-PT in total sample (N = 60):), in patients (N = 30):), or in typical individuals (N = 30):).	Whole sample, $r = -.189$, $p = .149$; patients, $r = -.270$, $p = .150$; typical individuals, $r = -.124$. $p = .514$
	Moriguchi et al. (2006)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	30	Students (divided according to Alexithymia scores)	20.2; 20.8 (typical)	Reported	Alexithymia group had lower scores than the Non-alexithymia group on IRI-PT	Significant difference reported
	Neumann et al. (2014)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	120	Traumatic brain injury (TBI)	40.98; 40.64 (typical)	Reported	There was a significant negative relationship between EOT and IRI-PT in TBI patients only.	Patients, $r = -0.387$, $p < 0.05$
	Patil and Silani (2014)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	295	General population	24.96	Reported	There was a significant negative correlation between TAS-20 and perspective taking (IRI-PT). Controlling for age and gender made no difference to this relationship.	Significant relationship reported
	Silani et al. (2008)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	30	Autism Spectrum Disorders	36.6; 33.7 (typical)	Reported	There was a significant negative correlation between TAS-20 and perspective taking (IRI) in typical individuals only.	Significant relationship reported
	Van Randenborgh et al. (2012)	TAS-26	Interpersonal reactivity inventory (perspective taking subscale)	59	Episodic and chronic depression	41.6; 42.09 (typical)	Reported	There was significant correlation between TAS-20 and IRI-PT.	$p < 0.01$

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Table 3 (*continued*)

Dimension	Study	Outcome measures		N	Sample characteristics			Results	Effect
		Alexithymia	ToM		Indication	Age	Data		
	Yang et al. (2020)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	820	Students	20.1	Data provided	There was a significant negative correlation between TAS-20 total scores and IRI-PT, and between all TAS-20 subscales and IRI-PT-.	r = -0.18, p < 0.001; TAS-20 DIF, r = -0.11, p = 0.008; TAS-20 DDF, r = -0.09, p = 0.027; TAS-20 EOT, r = -0.25, p <0.001.
	Lyvers et al. (2017)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	102	Students	22.18	Reported	There was a significant negative correlation between TAS-20 total scores and IRI-PT.	p < 0.001
	Lyvers et al. (2018)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	161	Students	22.64	Reported	There was a significant negative correlation between TAS-20 EOT subscales and the IRI-PT.	r = -0.30, p < 0.05
	Bird et al. (2010)	TAS-20	Interpersonal reactivity inventory (perspective taking subscale)	36	Autism Spectrum Disorder (ASD)	34.6; 35 (typical)	Reported	There was a significant negative relationship between the TAS-20 and the IRI-PT.	p < 0.01
	Eddy and Richards (2015)	TAS-26	Animation task (Frith-Happe)	70	Huntington's disease (HD) (pre-manifest HD; manifest HD)	54.64 (manifest HD), 42.57 (pre-manifest HD); 55.52 (manifest HC), 40.53 (pre-manifest HC)	Reported	There was no significant correlation between TAS-26 and the Animation task (intentionality subscale).	No relationship reported
	Lockwood et al. (2013)	TAS-20	Animation task (Frith-Happe)	110	Typical individuals	21.9	Reported	There was no significant correlation between TAS-20 and the Animation task.	r = -0.120, p > 0.05
	Moriguchi et al. (2006)	TAS-20	Animation task (Frith-Happe)	30	Alexithymia	20.2; 20.8 (typical)	Reported	The Alexithymia group had worse performance on the Animation task (intentionality subscale) compared those with did not have Alexithymia.	P = 0.030
	Szpak and Bialecka (2015)	TAS-20	Mind-mindedness	128	Students	22.22	Reported	There was no difference in Mind-mindedness according to Alexithymia scores.	No relationship reported
	Zunhammer et al. (2015)	TAS-26	Animation task (Frith-Happe)	60	Chronic somatoform pain	50.2; 47.2 (typical)	Reported	There was no significant correlation between TAS-26 and Animation task (intentionality subscale).	No relationship reported
	Inslegers et al. (2012)	TAS-20	Thematic Apperception Test	74	Mixed patients	39.41	Reported	There was no significant correlation between TAS-20 and TAT	No relationship reported
	Grzegorzewski et al. (2019)	TAS-20	Questionnaire of Cognitive and Affective Empathy - Cognitive empathy	68	Borderline personality disorder - women only	27.3; 25.6 (typical)	Reported	There was a significant negative correlation between EOT and questionnaire of cognitive and affective empathy – cognitive empathy (QCAE-CE) in typical individuals. There was a significant negative correlation between TAS-20 total scores and QCAE-CE scores in BPD group.	Significant relationship reported
	Koelkebeck et al. (2010)	TAS-26	Animation task (Frith-Happe)	46	Schizophrenia	24.5; 26.8 (typical)	Reported	The use of ToM-related vocabulary (intentionality) regarding the goal-directed video sequences correlated positively with scores on the TAS subscale 1 (difficulties in identifying feelings) in schizophrenia patients and inversely with scores on the	Patients, r = 0.49, p = 0.02; typical individuals (externally oriented thinking; r = −0.45, p = 0.03)

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Table 3 (*continued*)

Dimension	Study	Outcome measures		Sample characteristics			Data	Results	Effect
		Alexithymia	ToM	N	Indication	Age			
								TAS subscale in typical individuals.	
	Milosavljevic et al. (2016)		Animation task (Frith-Happe)	88	Autism Spectrum Disorders (ASD) and Alexithymia	15.41 (ASD -Alexithymia); 15.49 (ASD + Alexithymia); 15.5 (typical)	Reported	There was no difference between high and low alexithymic group on the intentionality scale of the animation task.	No difference reported

TAS-20 = Toronto Alexithymia Scale with 20-items. TD = Typically developing. RMET = The Reading the Mind in the Eyes Task. ASD = Autism Spectrum Disorder. TAS-EOT = Externally Oriented Thinking subscale of the Toronto Alexithymia Scale. PANAS = Positive and Negative Affect Schedule. AN = Anorexia Nervosa. Chronic dep. = Chronic depression. Episodic dep. = Episodic depression. TAS-26 = Toronto Alexithymia Scale with 26-items. MASC = The Movie for the Assessment of Social Cognition. PSPD = Persistent somatoform pain disorder. ToM = Theory of Mind. +ALX = High alexithymia. -ALX = low alexithymia. IRI-PT = Perspective-Taking subscale of the Interpersonal Reactivity Index. MS = Multiple sclerosis. TAS-DIF = Difficulty Identifying Feelings subscale of the Toronto Alexithymia Scale. TAS-DDF = Difficulty Describing Feelings subscale of the Toronto Alexithymia Scale. IQ = Intelligence quotient. AQ = Autism quotient. PANAS = Positive and Negative Affect Schedule. MSS1 = Inferences about mental states subscale of the Mental Stories task. MSS2 = Facts about people subscale of the Mental Stories task. MSS3 = Inferences about objects subscale of the Mental Stories task. MSS4 = Facts about people subscale of the Mental Stories task.

that required (or performance is aided by) emotional abilities (‘*Emotion ability*’). Measures that included an emotional component, but which predominantly quantified other non-emotional aspects of ToM, or where the recognition of emotion was not necessary (or helpful) for ToM inference, were classified as tests of ToM ability with minimal emotion recognition demands (‘*Non-emotion ability*’).

It is important to note, however, that whilst there are differences *between* tasks of ToM in the extent to which they quantify ability vs. propensity, and for measures of ToM ability the extent to which they require (or are aided by) intact emotion recognition ability, there are also differences *within* tasks regarding the extent to which items/subscales fall into these categories. Where tasks have multiple subscales assessing different aspects of ToM (e.g., propensity vs. ability) these subscales are classified into the relevant category where possible. However, tasks do not always fall neatly into the categories described above. For example, a portion of the stimuli in a certain task may depict emotional expressions whilst most stimuli do not; or subscales assessing different aspects of ToM may be grouped together into a total score. In these instances, measures are classified according to what the majority of the measure assesses.

Across the 63 studies that met inclusion criteria, 19 measures of ToM were employed:

2.3.1. *Reading the mind in the eyes task*

The Reading the Mind in the Eyes Task (RMET; Baron-Cohen et al., 2001) is thought to measure an individual’s ability to infer the mental state of an actor using the eye region alone. On each trial participants are presented with an eye region and four mental state/emotion words (e.g., *disgusted, interested, suspicious,* and *flustered)*. The participants’ task is to select the most appropriate mental state term to describe the expression of the eye-region from the four given options. Accuracy on this task is quantified by how many of the target adjectives, created by the authors and validated in a group of eight independent raters, the participant correctly selects for the 36 photographs displayed. The test-retest reliability of the RMET has been reported as 0.833, as measured using the intraclass correlation coefficient (Vellante et al., 2013). It should be noted that whether this task assesses mental state inference, or emotion recognition, is currently a matter of debate (Oakley et al., 2016). However, it is included in this review for completeness given it is frequently employed as a measure of ToM. As this task assesses one’s ability, and has emotion recognition demands, it is classified as a measure of *ToM Ability with Emotion Demands (“Emotion ability”)*.

2.3.2. *Movie for the assessment of social cognition*

The Movie for the Assessment of Social Cognition (MASC; Dziobek et al., 2006) quantifies an individual’s ability to infer the mental states (i.e., intentions and desires) and emotions of actors depicted in a social situation. Participants watch a 15-minute film depicting four actors socializing with one another. At certain points in the film the video is interrupted, and participants are required to answer either a control question (e.g., What time are they meeting?) or mental state question (e.g., What is Sandra thinking?) by selecting one of four given options. Out of the questions asked (the exact number of questions varies across studies but in the studies included in this review 45 mental state questions were asked) the number correctly selected is taken as a measure of accuracy. Accuracy was predetermined using two methods: 1) first, a judgement was made regarding the correspondence between the answer given and the intended mental state as detailed in the film script and the actors’ display; and 2) second, from pilot data gathered from a group of typical raters (and therefore results could be argued to reflect the typicality rather than accuracy of mental state attributions). In addition to accuracy scores, errors in this task can also be split into three types: insufficient mental state inference (‘hypo-mentalising’), excessive inference (‘hyper-mentalising’), and non-mental state inferences, although the type of errors made are not always reported. Nevertheless, as accuracy is predetermined, this measure is deemed to quantify

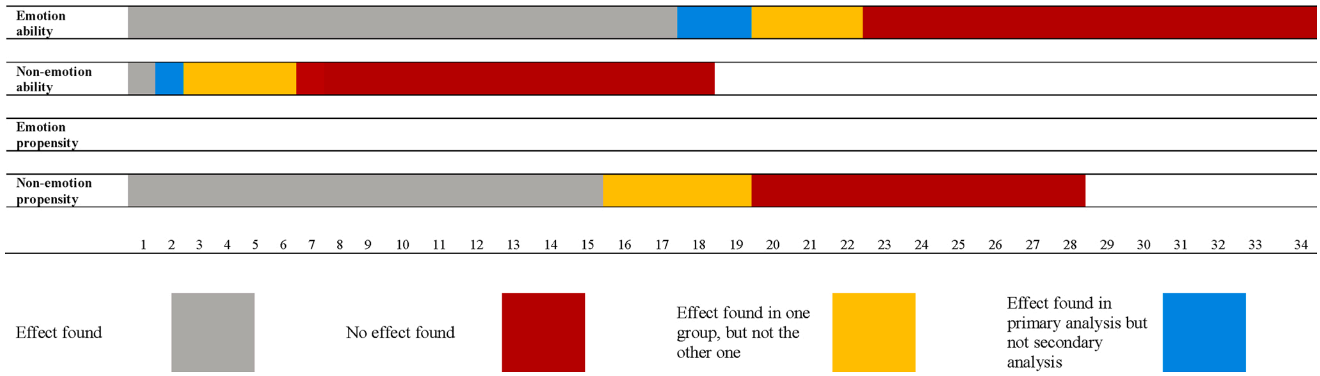

Fig. 1. Depicts the results reported in all papers included in this review organised along the two dimensions (accuracy vs propensity; emotional vs non-emotional) (see text for details). Studies that found evidence for an association between ToM and alexithymia in primary analyses are indicated by grey bars. Studies reporting an association in primary analyses that were absent when control variables were included, are listed as ambiguous (blue). Likewise, studies reporting associations in one sample (e.g., in the control but not clinical sample) are also included as ambiguous (yellow). Studies reporting no association, or trend level results, are listed as no effect found (red).

accuracy, rather than one's propensity to make mental state attributions and is therefore classified as a measure of ToM ability. The MASC has been shown to have high internal consistency (Cronbach's alpha = 0.84) and reliability (test-retest, ICC = 0.97) (Oakley et al., 2016).

Furthermore, the mental state questions included in the MASC can be split into those which require emotion recognition ability and those which do not (e.g., Montag et al., 2010; Oakley et al., 2016; Shah et al., 2017), although separate scores are not always reported. Where reported separately, the scales are separated into the relevant sections (*ToM Ability with Emotion Demands ("Emotion Ability")* and *ToM Ability without Emotion Demands, ("Non-emotion ability")*, respectively). However, as the majority of mental state questions do not require emotion recognition ability (Dziobek et al., 2006), those studies reporting only total scores are classified as ToM measures which do not predominantly require the ability to identify the protagonist's emotional state.

2.3.3. *The conflicting beliefs about emotions task*

The Conflicting Beliefs about Emotions Task was designed to measure both cognitive and emotional aspects of ToM (Shaw et al., 2004). Participants are presented with vignettes involving two protagonists in a social scenario. In the story, one character holds a true first order belief, and the other holds a false second order belief. Both types of beliefs are

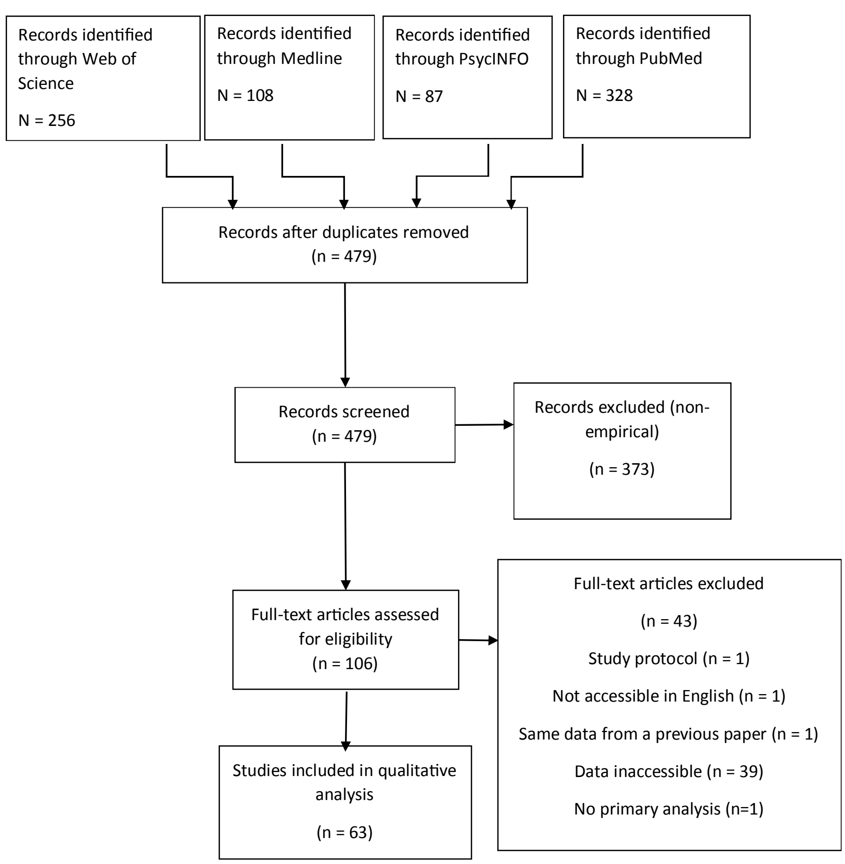

Fig. 2. A flowchart illustrating the process of limiting publications from the initial systematic literature database search. To access papers, the chosen search terms were entered into several databases with only limits for English language included, identifying 779 publications. Following the removal of duplicates (N = 479) between databases and non-empirical publications (N = 373), only experimental papers which specifically measure both alexithymia and Theory of Mind, were classified as relevant (N = 106). Remaining papers which conducted formal analyses or responded to requests for data (N = 63) between alexithymia and Theory of Mind were then divided into one of four sub-groups; +Emotion Ability (N = 34), -Emotion Ability (N = 18), +Emotion Propensity (N = 0) and -Emotion Propensity (N = 28). Of these 63 studies, the authors of 10 studies provided their data via email when contacted for further information.

associated with an emotional state and those states are in conflict. Participants are asked a series of questions assessing their understanding of the beliefs and conflicting emotional states (first order-cognitive, first order-affective, second order-cognitive, second order-affective) as well as some control questions. In first order questions, participants are asked to recognise the belief (first order cognitive) and the emotional state of the characters in the story (first order affective); whilst in second order questions, they are required to understand the false belief and its consequences on the actor's thoughts (second order cognitive) and the actor's emotional state associated with the false belief (second order affective). The first order beliefs are coded as correct or incorrect, with the second order beliefs coded using a 0–2 scale (incorrect, partially, correct). As accuracy is predetermined this task, it is classified as a measure of ToM ability, with the affective subscales classified as measures requiring emotion recognition ability *(ToM Ability with Emotion Demands ("Emotion Ability")*, and the cognitive subscales classified as measures that do not require emotion recognition ability *(ToM Ability without Emotion Demands, ("Non-emotion ability")*.

2.3.4. The strange stories film task

The Strange Stories Film Task (Murray et al., 2017) is a newer measure of ToM based on the original Strange Stories Task (see Section 2.3.6; "Strange Stories Task"). Each video briefly depicts a social interaction in which understanding the interaction requires a mental state inference (12 videos; e.g., jokes or pretence) or a control interaction which does not require mental state inference (3 videos, e.g., economic decision making, natural phenomena). After the presentation of each video clip, three questions are asked to participants; Intention ("Why did X say that?"), Interaction ("If you were in Y's [other character i.e., not X] situation, what would you say next?"), and Memory (a non-mentalistic control question; e.g., "What instrument was X playing?"). This test shows good reliability (Cronbach's alpha, Intention, alpha = .57; Mental State Speech, alpha = .48; Interaction, alpha = .55) (Johansson Nolaker et al., 2018). Scoring of the task is on a 0–2 scale (incorrect, partially correct, correct) for each question type except the Memory questions, which are scored as correct or incorrect. As accuracy is pre-determined, this task is classified as a task of ToM ability. Whilst it is difficult to determine how much emotion recognition ability is required in this task, since participants are presented with stimuli depicting emotional expressions it is categorised as a measure of ToM ability with emotion recognition demands ("*Emotion ability*").

2.3.5. Mental states stories task

The Mental States Stories Task (Happé, 1994; Saxe and Kanwisher, 2003) measures an individual's ability to make inferences about the mental states of a protagonist on the basis of a short story about the experiences of the protagonist. In the format used in the study investigating the relationship between alexithymia and ToM, participants were presented with a short story on each trial followed by a 'fill-in-the-blank' question relating to the story. Stories are categorised into four categories: ToM measure: mental state inferences; control measures: facts about people, inferences about objects, and facts about objects. ToM ability is quantified in this task by the responses to the mental state inference stories, with higher scores representing better ToM (see Lane et al., 2015). Given that accuracy in this task is predetermined, and emotion recognition demands are minimal, this task is classified as a measure of ToM Ability with minimal Emotion Demands ("*Non-emotion ability*").

2.3.6. The strange stories task

The Strange Stories Task (Happé, 1994) measures an individual's ability to make mental state inferences about a protagonist detailed in a short story. In the original version (Happé, 1994), participants read 24 short vignettes, which are accompanied with a comprehension and justification question ("Was it true, what X said?; Why did X say that?"). The vignettes correspond to 12 story-types which require mental state understanding (e.g., joke, pretend, sarcasm), with a set of six additional control stories also used. The accuracy of responses to mental state stories are scored out of 24. The control stories are not included in the total score. The Strange Stories Task has good inter-rater reliability ($r = 0.73$) (Clemmensen et al., 2016). Adjustments to the original have, however, been made; for example, in some studies, a smaller number of stories are utilised, and scores are rated along a different scale (0–2: incorrect, partially correct or correct; e.g., Milosavljevic et al., 2016). Nevertheless, as accuracy is pre-determined and emotion recognition demands are minimal this task is classified as a ToM measure with minimal emotion recognition demands, (i.e. "*Non-emotion ability*"). In the study that was included in this review, participants read 6 stories followed by a question about the text (Milosavljevic et al., 2016). Of the 6 stories presented, 4 stories required mental state inference and 2 were control questions. Scores were rated on a scale of 0–2 (incorrect, partially correct, correct) with the average score across the 4 ToM items taken as a measure of performance.

2.3.7. Animations task

The Frith-Happé Animations task (Abell et al., 2000; Castelli et al., 2000; note, sometimes referred to as the Frith-Happé animations, Animations task, Visual Animations Task for ToM, and the Moving-Shapes Paradigm), measures an individual's ability and propensity to use mental state terms when describing social interactions. Based on work by Heider and Simmel (1944), on each trial the participant observes a silent animation depicting a pair of cartoon triangles interacting. Animations either portray interactions involving mental states, such as seducing, mocking and coaxing, or control animations demonstrating goal-directed but not mentalistic interactions, such as fighting, or random movement sequences (note, that which animations are used to compare to mental state animations differ across studies). The participants' task is to describe the interaction. They are not prompted to adopt mental-state descriptions. This task has good inter-rater reliability (Cohen's kappa, length = 0.81, intention = 0.82, accuracy = 0.84) (Eddy and Cavanna, 2015). In all the studies examining the relationship between alexithymia and ToM, Castelli et al.'s (2000) scoring system is used: 1) ToM-intentionality (scored on a 0–5 scale) which refers to the use of mental state language; 2) ToM-appropriateness (scored on a 0–3 scale) which refers to whether the individual has inferred the correct mental-state; 3) the certainty of the explanation given (scored on a 0–3 scale); and 4) ToM-length which assesses the number of clauses used each answer (scored on a 0–4 scale). ToM-intentionality and ToM-length are therefore the most appropriate measures of the propensity to engage in ToM ("*Non-emotion propensity*") available from this task, with ToM-appropriateness assessing ToM- ability with minimal emotion recognition demands ("*Non-emotion ability*"). It should be noted that not all studies report all four types of score.

2.3.8. Combined false belief task

The Combined False Belief task (see Milosavljevic et al., 2016) measures an individual's false belief understanding using vignettes, and is a combination of both first- and second-order false belief tasks inspired by previous measures of false belief comprehension (Baron--Cohen, 1989; Bowler, 1992). Responses are scored on a 0–2 scale for first-order questions, and a 0–3 scale for second-order questions. As this measure explicitly requires individuals to make a mental state inference (i.e., they are asked what Mary is "thinking") and scoring of the task relates to the appropriateness of the mental state inference, it is included here as test of ToM ability with minimal emotion recognition demands ("*Non-emotion ability*").

2.3.9. False belief picture sequence task

In the False Belief Picture Sequencing Task (Langdon and Coltheart, 1999; Langdon et al., 1997) participants are presented with cartoon-style cards depicting an activity or set of actions. Participants are asked to arrange these cards into a logical sequence. In the study assessing the relationship between alexithymia and ToM, cartoons either require false belief understanding or are control stories with no mentalising component. Performance on the false belief subscale is taken as a measure of mentalising ability. Participants receive 2 points for correct positioning of the first and last cards, and 1 point each for the second and third cards (Wastell and Taylor, 2002). As accuracy is predetermined and emotion recognition demand is minimal, this task is classified as a measure of ToM ("*Non-emotion ability*").

2.3.10. Interpersonal reactivity index (Perspective taking)

The Perspective-Taking subscale of the Interpersonal Reactivity Index (IRI-PT; Davis, 1983) measures an individual's self-reported propensity to engage in mental-state inference (e.g., Bodden et al., 2013). Responses are made on a 5-point Likert scale (i.e., Does not describe me well to Describes me very well). The IRI was found to have good internal consistency for all the sub-items (test-retest reliability correlation from 0.62 to 0.71) (Davies, 1983). The IRI-PT is classified as a measure of ToM propensity ("*Non-emotion propensity*"), as it quantifies an individual's self-reported tendency to spontaneously adopt the standpoint of others.

2.3.11. Mind-mindedness

The Mind-mindedness interview (Meins et al., 2006, 2001) requires participants to describe a close friend and measures the participant's tendency to reflect on their emotions, mental life and intellect, termed mind-mindedness. The data is divided into single phrases or adjectives which are classified as mentalistic, behavioural, physical, or general (Meins et al., 2006, 2001). Scores for each category are expressed as a proportion of the total number of descriptions. Inter-rater reliability for this task was high ($k = 0.96$) (Meins et al., 2008). As accuracy is not pre-determined on this measure, it is classified as a measure of ToM propensity ("*Non-emotion propensity*").

2.3.12. Faux pas test

The Faux Pas Test (Baron-Cohen et al., 1999) requires participants to read 10 test stories containing faux pas and 10 control stories that do not. After reading the stories, participants answer questions about the presence or absence of faux pas and its content. Where presence of faux pas is detected, follow-up questions are asked to probe understanding of the faux-pas. Answers to the stories were deemed correct if the individuals correctly identified the presence or absence of faux pas in line with pre-specified answers. Reliability of this test was shown to be high (Cronbach's alpha 0.905) (Söderstrand and Almkvist, 2012). This test is classified as ToM ability with minimal emotion recognition demands ("*Non-emotion ability*").

2.3.13. Emotion attribution test

The Emotion Attribution Test (EAT) (Blair and Cipolotti, 2000; Blair, 1995) consists of short stories designed to elicit emotional attributions if mental states are attributed correctly. Scores are given for each correct response. In the study included in this review (Raimo et al., 2017), a short version was employed with 35 stories. Given the emphasis on participants' ability to recognise different emotions, and as accuracy is pre-determined, this test was included in the category *ToM ability with emotional demands ("Emotion ability")*.

2.3.14. Advanced test of theory of mind

The Advanced Test of ToM (ATT) (Prior et al., 2003) is based on the Strange Stories Task described above (Happé, 1994). Scores range from 0 to 13, where a higher score reflects more accurate mental state inference. As accuracy is pre-determined in this task and emotion recognition demands are minimal, this test was included in the category ToM ("*Non-emotion ability*").

2.3.15. Thematic appreciation test

In the Thematic Appreciation Test (TAT) (Murray, 1943) participants are shown cards depicting multiple ambiguous characters and situations. In the TAT participants are required to generate a series of stories using the cards presented to them, describing specific aspects such as what is happening at the moment, the thoughts and feelings of the characters involved, what led to that situation and what the outcome of the story will be. In the study included in this review (Inslegers et al., 2012), the scoring system followed Westen et al.'s (1990) criteria which is based on 5 response levels (from 'level 1' or low performance to 'level 5' or best performance) according to four domains: complexity of representations of people, affect-tone of relationship paradigms, capacity for emotional investment, and understanding of social causality (Westen et al., 1990). In this study, 6 cards were utilised, and participants' performance is classified based on their tendency to engage in the representation of self and others and social context in relation to these stories. For this reason, the TAT was included in the ToM category of "*Non--emotion propensity*".

2.3.16. Questionnaire of cognitive and affective empathy (Cognitive empathy)

The Questionnaire of Cognitive and Affective Empathy (QCAE) (Reniers et al., 2011) is a questionnaire measuring empathy and is divided into two subscales: cognitive and affective empathy. Only cognitive empathy relates to ToM, specifically the tendency to adopt another's perspective, and so it alone was included in this review. The cognitive empathy sub-item of this scale showed high reliability (Cronbach's alpha = 0.85). Due to the minimal involvement of emotion recognition, and as accuracy is not pre-determined, this measure was included in the category of *propensity to engage in ToM* ("*Non-emotion propensity*").

2.3.17. Attribution of intention test

The Attribution of Intention test (Brunet et al., 2003; Sarfati et al., 1997) tests understanding of three stories depicted graphically, each of which require accurate mental state inference to be understood. Scores range from 1 to 3 reflecting the number of stories correctly understood. The stories do not require emotion recognition, and so this test is classified as a measure of ToM ability with minimal emotion recognition demands ("*Non-emotion ability*").

2.3.18. Theory of mind test

The Theory of Mind test is a battery of ToM tasks designed to assess general ToM abilities (Wingbermühle et al., 2012). It includes vignettes, drawings and stories and participants are required to infer characters' mental states. There is little emphasis on emotion recognition, and so this task was classified as a measure of ToM ability requiring minimal emotion recognition ("*Non-emotion ability*").

2.3.19. Unclassified

A small number of measures were excluded from this review as they were not deemed to be measures of ToM. For completeness, these measures and the relationship with alexithymia are reported in Supplementary material (Supplementary Material 2, S2).

2.4. Alexithymia measures

Having outlined the measures used to quantify ToM we now consider the measures used to quantify alexithymia. Across the 63 studies that met inclusion criteria, three different measures of alexithymia were employed (although most studies – 85.7 % - utilise the 20-item Toronto Alexithymia Scale; Bagby et al., 1994).

2.4.1. Toronto Alexithymia Scale – 20 items

The Toronto Alexithymia Scale (TAS-20; Bagby et al., 1994) is a 20-item measure with three core factors: Difficulty Identifying Feelings (DIF), Difficulty Describing Feelings (DDF) and Externally-Oriented Thinking (EOT; Taylor et al., 2000). The standard cut-off for high alexithymia on the TAS-20 total score is >61, out of a potential total score of 100 (Parker et al., 2003; Taylor et al., 1997). The strategy used to group individuals into high and low alexithymic groups differs across studies, however, with some using different cut-offs and others using a median split of available scores. For completeness, the cut-off scores are listed for all studies employing group comparisons, where reported. Cronbach's alpha for the full scale is 0.81 (Bagby et al., 1994).

2.4.2. Toronto Alexithymia Scale – 26 items

The Toronto Alexithymia Scale 26 (TAS-26) is an earlier version of the TAS-20 which includes 26 items (TAS-26; Taylor et al., 1985a,b) and an additional core factor - Reduced Daydreaming (RD). There is currently no predetermined cut-off indicating high alexithymia for the TAS-26, however, with a total score of 130, a score of >74 is regarded as the most statistically conservative cut-off score for determining high alexithymia, whilst maximising diagnostic validity, whilst <62 is thought to indicate the absence of alexithymia (Taylor et al., 1988a,b). The TAS-26 is positively correlated with TAS-20 (e.g., $r = 0.89$, $p < 0.02$ L; Wise et al., 2000) and there are medium to strong correlations between the different factors of these two scales (Zimmermann et al., 2005).

2.4.3. Bermond-vorst alexithymia questionnaire

The Bermond–Vorst Alexithymia Questionnaire (BVAQ; Bermond and Oosterveld, 1994; Vorst and Bermond, 2001) is a 40-item self-report measure composed of five subscales – based on the items and subscales of the TAS-20 (i.e. identifying, verbalising, analysing, fantasising, and emotionalising). Specifically, the analysing subscale measures the tendency of the participant to try and explain emotional reactions; whilst the emotionalising subscale reflects the extent to which someone can be emotionally aroused. These subscales are typically grouped into two superordinate subscales reflecting cognitive and affective alexithymia. The former is obtained by adding the scores on the identifying, analysing and verbalising subscales; whilst the latter results from adding the scores on the fantasising and emotionalising subscale (Vorst and Bermond, 2001). For all scales in the BVAQ, higher scores indicate higher levels of alexithymia. Cut-off scores to identify the presence or absence of alexithymic traits range from 50 to 53 and 43–45 respectively (Deborde et al., 2008; Loas et al., 2015). The BVAQ typically shows a medium-strong association with the TAS-20 ($r = 0.59$, $p < 0.001$; Morera et al., 2005).

2.5. Data extraction and meta-analysis

Data was extracted by one Reviewer (see Table 3), with correlation coefficients and descriptive statistics extracted where reported (studies that did not report summary statistics were excluded). Sample characteristics and study details are reported in Table 3, please refer to this table for more information.

Where the relationship between alexithymia and ToM had been assessed in K > 10 studies, meta-anaylses were conducted (for details see supplement [S4]). Studies were included regardless of participant group due to lack of available data for individual groups (i.e., patients and neurotypical individuals). Effect sizes were pooled using inverse method, random-effects restricted maximum-likelihood estimator which accounts for between-study heterogeneity. Where significance values (i.e., p values) or means and standard deviations were only available, these were converted into a correlation coefficient, i.e., r value. Data analysis was conducted in R (Version 4.0.3) using the meta package; summary measures were expressed in untransformed correlations where studies reported r values as the effect size. Cochran Q and I^2 were applied to compute heterogeneity (Higgins et al., 2003; Pereira et al., 2010) and publication bias was assessed using Egger's regression test and inspection of funnel plots (Egger et al., 1997).

3. Results

3.1. The relationship between Alexithymia and ToM

Having outlined the measures of ToM and alexithymia we now review the evidence investigating the impact of alexithymia on ToM. For each measure, initially we report studies finding an effect of alexithymia in primary analyses; those that have examined the relationship in typically developing populations followed by studies that include clinical/atypical samples. We then report the studies that did not find an effect of alexithymia on ToM performance, with studies in typically developing populations followed by studies that include clinical/atypical samples. Where secondary analyses were conducted, we report the influence of these analyses on the relationship between alexithymia and performance.

3.2. ToM ability with emotion demands

33 studies investigated the relationship between alexithymia and ToM using measures classified as *ToM ability with emotion demands*, this included five measures: the RMET, MASC (emotion subscale), the conflicting beliefs about emotions task, strange stories film task, and the emotion attribution test. As one study used more than one task, 34 comparisons are described below.

3.2.1. The reading the mind in the eyes task

26 publications reported analyses examining the relationship between alexithymia and the RMET, and four study authors responded to requests for data that was not reported in text, resulting in 30 studies. 21 of these found a significant negative relationship between alexithymia and the RMET in primary analyses (see Figs. 1 and 2).

Of the 10 studies that investigated the relationship between alexithymia and RMET performance in typical individuals, 8 studies indicated that increasing alexithymia was associated with worse performance on RMET, with this effect remaining significant in most of those with secondary analyses. Demers and Koven (2015) reported a negative relationship between RMET performance and TAS-20 total scores with follow up analyses indicating associations were driven by the EOT subscale of the TAS-20 which explained unique variance after controlling for individual differences on both the Questionnaire of Emotional Empathy and vocabulary scores. Likewise, Schimmenti (2017) found a negative correlation between RMET performance and TAS-20 total scores in a large sample (N = 792), a result also observed by Al Aïn et al. (2013); Lyvers et al. (2017) and Schimmenti et al. (2017) in smaller samples. In line with the above results, Lyvers et al. (2018), also reported a negative correlation between the RMET and the DIF and EOT sub-scales of the TAS-20. Specifically, after controlling for age, gender and negative mood using a regression, they found that the EOT subscale significantly predicted RMET scores. Gökçen et al. (2016) also reported a negative correlation between the TAS-20 and RMET performance in primary analyses. This association remained after controlling for both intelligence and age, but when autistic traits were added to the model the association between the RMET and TAS-20 was reduced to trend level ($p = .075$). However, alexithymia remained the best predictor of RMET performance. Of these 8 studies reporting a relationship between alexithymia and the RMET, only one employed the BVAQ to measure alexithymia in a sample drawn from the general population (Samur et al., 2017). They also observed that higher alexithymia scores led to poorer RMET performance.

In studies including clinical/atypical samples (N = 21), similar reports of associations between poor performance on the RMET and alexithymia have been observed. Using the standard cut-off on the TAS 20 (>61), Oakley et al. (2016) found that adults, both with and without autism, who had higher levels of alexithymia performed significantly worse than adults with lower levels of alexithymia on the RMET. No influence of autism was observed. Using the TAS-20 as a continuous measure, Lombardo et al. (2007) and Lombardo et al. (2012) also observed a negative relationship between alexithymia and RMET performance in a combined sample of individuals with autism and neurotypical controls. In a sample of ASD participants with or without concurrent self-harm, Moseley et al. (2019) found a negative relationship between RMET performance and alexithymia traits in the total sample, as well as separately in ASD participants and controls with concurrent, but not historic, self-harm. Poor performance on the RMET has also been associated with high alexithymia scores in individuals with somatisation disorders (Lane et al., 2015). However, after adjusting for positive and negative affect scores the relationship between alexithymia and the RMET in somatisation disorders was not significant. A negative association between alexithymia and RMET scores has also been reported in a number of other clinical/atypical populations, including individuals with personality disorders (i.e. borderline and avoidant personality disorders; Berenson et al., 2018), patients with multiple sclerosis (Raimo et al., 2017) and conversion disorders (Stonnington et al., 2013). Finally, Lyvers et al. (2019a) and Lyvers et al. (2019b) also observed a negative relationship between RMET performance and alexithymia in a sample of alcohol-using participants. No initial relationship between RMET performance and alexithymia was identified in 2 of the 10 studies conducted in typical individuals. Luminet, Grynberg, Ruzette, & Mikolajczak (2011) examined the effect of alexithymia (continuous scores) and oxytocin administration on RMET performance. No significant effects of alexithymia were observed, however, a trend was present whereby higher TAS-20 scores resulted in worse performance on the RMET in the placebo, but not the oxytocin administration condition ($p = .07$). In follow-up analyses using a median split to assign participants to high and low alexithymia groups, a significant effect of alexithymia was found whereby participants with higher rates of alexithymia were poorer at identifying 1) negative and 2) high intensity items from the RMET in the placebo, but not the oxytocin administration condition. No correlation between the RMET and alexithymia in another typical sample (N=200) was also reported by Vellante et al. (2013), with this result remaining when comparing those who scored above cut off (N = 9) to the rest of the sample. However, follow up analyses did indicate a significant negative association between RMET performance and alexithymia in the male, but not female, participants.

In clinical groups, the relationship between the TAS-20 and the RMET was not significant in a sample of 62 females with anorexia nervosa (Adenzato et al., 2012), and the relationship between the TAS-26 and RMET performance was not significant in a sample of individuals with chronic or episodic depression (van Randenborgh et al., 2012). Likewise, no relationship between alexithymia and RMET performance was reported in a group of individuals who had undergone surgery to remove brain tumours (when examining the average pre-post test scores; Campanella et al., 2014) or in a sample of individuals with binge eating disorder (Aloi et al., 2017). The absence of a relationship between the RMET and alexithymia has also been reported in patients with eating disorders with or without self-harm (Cucchi et al., 2018) (Cucchi et al., 2018), fibromyalgia syndrome (Di Tella et al., 2015), schizophrenia (Etchepare et al., 2019), anorexia and depression (Rothschild-Yakar et al., 2019), and in outpatients (Riem et al., 2018). One study, Chalah et al. (2017), conducted in patients with multiple sclerosis also did not observe a significant correlation between the RMET and the TAS-20, which contrasts the findings from Raimo et al. (2017). These results are summarised following description of the remaining measures.

3.2.1.1. Meta-analysis. As 30 studies assessed the relationship between the RMET and alexithymia, a meta-anaylsis was conducted on data from 5003 individuals. Across the whole sample, there was a significant negative relationship between the RMET and the TAS-20 (random effects model: r = -0.104, p = 0.023), however there was substantial heterogeneity ($I^2 = 86.9$ %, Q $(26) = 218.43$, $p <$ 0.0001; see supplement [S4]) and inspection of the funnel plot and Egger's test suggest presence of significant publication bias (p = 0.002) (see supplement [S4] for funnel plot).

3.2.2. The movie for the assessment of social cognition: emotion scale

Four studies investigated the relationship between alexithymia and MASC performance with only one study reporting the relationship between alexithymia and performance on the emotional items of the MASC separately from the non-emotional items. Schönenberg et al. (2014) observed a negative relationship between alexithymia and performance on the emotional MASC items in a small sample (N = 19) of females with persistent somatoform pain disorder (PSPD). However, no relationship was observed in the control sample.

3.3.3. Conflicting beliefs about emotions task: emotion subscale

One study investigated the relationship between alexithymia and the Conflicting Beliefs about Emotions task. Swart et al. (2009) used the BVAQ to assess alexithymia and divided their sample of typical individuals into high (cut-off score > 26) and low (cut-off score < 17) alexithymia groups based on the BVAQ. They found that participants in the high alexithymia group performed worse than the latter group on first-order emotions; however, no difference between groups were observed for second-order emotions.

3.2.4. Strange stories film task

Only one study employed the Strange Stories Film task, examining performance in participants with ASD and typically developing individuals, matched on age, gender, and verbal ability (Murray et al., 2017). Across all subscales, no correlation between alexithymia and performance was found in either the control or clinical group.

3.2.5. Emotion attribution test

One study examined how patients with multiple sclerosis attribute emotional states compared to typical individuals (Raimo et al., 2017). The correlation between the EAT and TAS-20 total scores was not significant in either group.

3.2.6. Summary: ToM with emotion demands

A review of the available literature demonstrates that 23 of 34 comparisons found a significant relationship between alexithymia and performance on tasks of ToM ability with emotion demands, with the majority of this evidence provided from studies utilising the RMET.

21 studies noted a relationship between the RMET – a measure of ToM ability that requires emotion recognition ability - and alexithymia in primary analyses, whereby higher levels of alexithymic traits were associated with worse performance (Fig. 1). This was confirmed by a meta-anaylsis on available data. It is, however, important to consider why this pattern of results was not observed in 9 studies. First, the 9 studies reporting the absence of a relationship were conducted in clinical/atypical samples (Adenzato et al., 2012; van Randenborgh et al., 2012) suggesting that the relationship between alexithymia and emotional ToM ability may vary depending on the population examined. However, as these correlations were examined only in clinical/atypical samples, it is equally possible that the elevated rates of alexithymia observed in these populations limited the distribution of alexithymia scores and therefore obscured associations; in some studies, control samples were either not employed (van Randenborgh et al., 2012; Campanella et al., 2014; Riem et al., 2018; Chalah et al., 2017; Aloi et al., 2017) or not included in the target analyses (Adenzato et al., 2012), limiting the range of scores analysed. Consistent with the proposal that a limited range of scores may obscure associations, two studies reported a negative correlation between alexithymia and RMET performance when analyses were conducted across the entire sample (i.e., including both clinical/atypical and control participants; Di Tella et al., 2015; Etchepare et al., 2019), but did not observe associations when analyses were restricted to the clinical/atypical sample (Di Tella

et al., 2015; Etchepare et al., 2019) or the control sample (Etchepare et al., 2019).

Second, the measures used may contribute to discrepancies; in one of the studies reporting an absence of a relationship the TAS-26 was employed (van Randenborgh et al., 2012). As evidence indicates that the TAS-26 has reduced internal consistency and explanatory variance in comparison to the TAS-20 (the measure employed by all studies reporting a relationship; Wise et al., 2000) it is possible that use of the TAS-26 contributed to a failure to find an association between alexithymia and RMET performance. Third, whilst no significant difference was observed by Luminet et al. (2011) it is notable that a trend was observed whereby individuals with a higher degree of alexithymia exhibited worse performance on the RMET than those with lower levels (p =.07), with significant effects of alexithymia found when examining either negative or intense emotional items of the RMET. Finally, it is also important to acknowledge that two studies reporting a significant association between alexithymia and RMET performance in primary analyses reported that this association was not significant when co-occurring traits were controlled for. For example, Gökçen et al. (2016) found that alexithymia no longer significantly predicted RMET performance when autistic traits, age and intelligence were entered into the model (although a trend did remain for alexithymia to predict poor performance, with alexithymia the best predictor). A similar lack of an association between the RMET and alexithymia was noted in somatisation disorder when scores were adjusted for positive and negative affect (Lane et al., 2015). However, it is possible that a different pattern of results may have been observed when examining the unique variance explained by these factors.

Using other measures, 2 of the 4 investigations found that alexithymia was associated with performance on tasks of ToM ability with emotion recognition demands. Alexithymia was associated with poorer performance on the emotional subscale of the MASC (Schönenberg et al., 2014), and poorer performance on the first-order (but not second order) emotion subscale in the Conflicting Beliefs task (Swart et al., 2009). In contrast, alexithymia was not associated with performance on the Emotion Attribution Test or the Strange Stories Film Task (Murray et al., 2017; Raimo et al., 2017).

Therefore, whilst alexithymia appears to be associated with poor performance on tasks requiring the ability to identify emotions and mental states, at least as measured by the RMET, the predictive value of alexithymia in determining emotional ToM ability may depend on having sufficient range of alexithymia scores to detect this relationship.

3.3. ToM Ability with minimal emotion recognition demands

15 studies investigated the relationship between alexithymia and ToM using measures classified as ToM ability with minimal emotion demands. This set included 12 measures: the MASC (cognitive subscale or total scores), the Strange Stories Task, the Mental State Stories task, the Faux Pas task, the False Belief Picture Sequencing task, the Theory of Mind picture sequence task, the Theory of Mind test, the Advanced Test of ToM, the Frith-Happe animations task (appropriateness subscale), the Combined False Belief task, the Conflicting Belief about emotion task (cognitive subscale) and the Attribution of Intention test. As three studies used more than one task, 18 comparisons are described below.

3.3.1. The movie for the Assessment of Social Cognition: cognitive subscale and total scores

Four studies reported formal analyses of the relationship between performance on the MASC and alexithymia, three of these finding a relationship in primary analyses. In typically developing populations, Gökçen et al. (2016) found a negative relationship between performance on the MASC and alexithymia as measured by the TAS-20. However, like the RMET, this relationship was absent when intelligence, age and autistic traits were controlled for. In contrast to results obtained using the RMET, the relationship between alexithymia and MASC performance did not reach trend level after controlling for these factors.

In clinical populations, a negative relationship between performance on the cognitive subscale of the MASC and alexithymia was reported in a small sample (N = 19) of females with persistent somatoform pain disorder (PSPD). However, this association was not observed in the control sample (Schönenberg et al., 2014). Similarly, a significant relationship was observed between the DIF subscale of the TAS-20 and the MASC 'under-mentalising' error type in patients with psychogenic non-epileptic seizures, but this was not observed in typical individuals (Schonenberg et al., 2015).

In contrast to studies that found a relationship between alexithymia and the MASC, Oakley et al. (2016) found no significant difference in MASC performance (total scores or cognitive subscale) in adults with and without autism between those with high (>61, TAS-20 score; Parker et al., 2003) and low alexithymia (<61, TAS-20 score).

3.3.2. The mental states stories task

Two studies reported relevant analyses, with neither finding a relationship between alexithymia and ToM performance. Lane et al. (2015) failed to find a significant association between performance on the Mental State Stories task and alexithymia in either typical individuals or those with somatic disorders, while Stonnington et al. (2013) failed to find a significant relationship in typical individuals and in those with conversion disorders and functional somatic syndrome.

3.3.3. Happé's strange stories task

One study reported the relationship between alexithymia and performance on Happé's Strange Stories task in a sample of adolescents with autism (Milosavljevic et al., 2016). No difference in performance was found between individuals scoring >51 on the TAS-20 and those that scored <51, with this result unaffected after controlling for both verbal IQ and anxiety.

3.3.4. Combined false belief task

The association between alexithymia and performance in the Combined False Belief task was examined in a sample of adolescents with autism. No differences in performance were observed on either the first or second order false belief task as a function of alexithymia (comparing those who scored above >51 with those scoring <51 on the TAS-20), and this was unaffected when controlling for anxiety and verbal IQ (Milosavljevic et al., 2016).

3.3.5. Faux pas test

Etchepare et al. (2019) reported a negative correlation between alexithymic traits (assessed by the BVAQ) and the Faux Pas task. This was observed in the total sample, and in a sample of individuals with schizophrenia, but not in the control group. In contrast, Pluta et al. (2018) examined the relationship between alexithymia and performance on the Faux Pas task in a sample of individuals with borderline personality disorder and typical individuals. No correlation was observed in either the clinical or the control group.

3.3.6. Conflicting Beliefs about Emotion task: cognitive subscale

One study reported the relationship between performance on the Conflicting Beliefs about Emotions task and alexithymia (Swart et al., 2009). In this study, participants were divided into two groups based on BVAQ scores (≤17 were assigned to low-alexithymia group, whilst those with scores ≥26 were assigned to the high alexithymia group). No differences between groups was observed.

3.3.7. Attribution of intention test

The relationship between alexithymia and the Attribution of Intentions test was assessed by Etchepare et al. (2019) in a sample of individuals with schizophrenia and typical individuals. A negative correlation was observed in the total sample (N = 214), but in neither group when analysed separately.

3.3.8. Advanced test of ToM

One study used the Advanced Test of ToM in patients with multiple sclerosis and typical individuals (Raimo et al., 2017). No significant relationship was reported between alexithymia and ToM ability in either the atypical or control samples.

3.3.9. Theory of mind test

One study employed this test battery and computed a composite score (Wingbermühle et al., 2012). The relationship between alexithymia (measured with both the BVAQ and TAS-20) and ToM ability was examined in people with Noonan syndrome and typical individuals. No significant associations between alexithymic traits and ToM ability were observed in the whole sample or in the typical group. There was, however, a trend towards significance for a negative correlation between the BVAQ and the ToM ability second order tasks in the atypical group ($p = 0.055$).

3.3.10. Theory of mind picture sequence test

In a sample of individuals with multiple sclerosis and typical individuals, no association was reported between alexithymia and ToM ability in the control or clinical group, or in the whole sample (Raimo et al., 2017).

3.3.11. False belief picture sequencing test

Wastell and Taylor (2002) employed this test in a sample of students ($N = 45$) who reported high levels of alexithymia as measured by the TAS-20 (score ≥ 61). Alexithymic individuals' performance on the False Belief Picture Sequencing test did not systematically differ from individuals with a low level of alexithymic traits.

3.3.12. Frith-Happe Animations task: appropriateness

Two studies examined ToM ability using the appropriateness subscale from the Frith-Happe Animations task. Moriguchi et al. (2006) divided participants ($N = 38$) into two groups: those with alexithymia (scores of 61–74) and those without (scores of 26–38), based on TAS-20 scores. Participants in the alexithymia group performed worse than non-alexithymic individuals. Conversely, Eddy and Rickards (2015), who examined the relationship between alexithymia and ToM appropriateness in a clinical sample of Huntington's disease, did not find any association between alexithymia and performance on the Frith-Happe Animation task in either the clinical or control group (an analysis for the whole sample was not reported).

3.3.13. Summary: ToM ability with minimal emotion recognition demands

In summary, three studies did, and one did not, find a significant relationship between alexithymia and MASC performance in primary analyses, with all of those finding an association reporting no relationship in secondary analyses or across clinical and typical samples. Eleven studies (14 comparisons as some studies employed multiple tasks) assessed the relationship between alexithymia and a range of other ToM tasks. In 11 of 14 comparisons, no relationship was observed between alexithymia and ToM performance.

Of those studies reporting a significant relationship between alexithymia and ToM ability, three utilised the MASC (Schönenberg et al., 2014; Schonenberg et al., 2015; Gökçen et al., 2016), one used the Faux Pas and the Attribution of Intention test (Etchepare et al., 2019), and one used the Frith-Happe Animation task (Moriguchi et al., 2006). Of three of the studies employing the MASC, it is notable that in one study the relationship between alexithymia and poor performance on the MASC was absent when autistic traits, intelligence and age were controlled for (Gökçen et al., 2016). In the other, the relationship between alexithymia and poor performance on the MASC was observed only in the clinical, and not in the control sample, with the clinical sample scoring significantly higher on the measure of alexithymia (Schönenberg et al., 2014). A similar pattern of results was also observed in Schonenberg et al. (2015) who found a significant negative association between the DIF TAS-20 subscale and the "undermentalising" subscale of the MASC in the clinical, but not typical, group. These data suggest that the relationship between poor performance on the MASC and alexithymia may be driven by co-occurring traits and differ across clinical populations. However, as mentioned previously, it is important to acknowledge that the MASC does involve a certain degree of emotion recognition ability (Dziobek et al., 2006) and therefore it remains a possibility that any observed relationship between alexithymia and performance on the MASC is driven in part by the emotional items on this measure. Although one study did find a relationship between alexithymia and both the cognitive and affective subscales of the MASC, this was only found in a small clinical sample ($N = 19$; Schönenberg et al., 2014). Therefore, further work is required to examine the contribution of alexithymia to performance on the MASC.

In terms of discrepancies across other tests, Etchepare et al. (2019) found a relationship between alexithymia and ToM ability assessed with the Faux Pas test in the whole sample and in patients with schizophrenia but no relationship was observed in typical individuals. In contrast, Pluta et al. (2018) did not observe such a relationship in either of their groups (borderline personality disorder vs. typical individuals), or in the whole sample. As Etchepare et al. (2019) observed that the relationship between alexithymia and performance was present only in patients with schizophrenia and not in typical individuals, it is possible that the clinical sample examined (schizophrenia vs. borderline personality disorder) may account for the conflicting results. Likewise, differences in the measure used across these studies may account for this discrepancy; whilst the former employed the BVAQ as a measure of alexithymia, the latter used the TAS-20. The utilisation of the BVAQ may also account for the negative relationship between alexithymia and the Attribution of Intention test observed by the same authors (Etchepare et al., 2019).

In contrast to most of the other tasks, significant relationships between alexithymia and performance on the Frith Happé Animations task (appropriateness subscale) were reported. In a group of 38 students divided into alexithymic ($N = 16$) and non- alexithymic groups ($N = 14$), Moriguchi et al. (2006) observed worse ToM ability in the alexithymic group. This finding conflicts with the findings of Eddy and Richards (2015) who did not observe such a relationship in typical individuals, in the clinical group (Huntington's disease) or in the whole sample. However, as Eddy and Richards (2015) utilised the TAS-26 and a clinical sample, it is possible that the alexithymia measure used, or sample employed, may account for this discrepancy.

In summary, based on the available evidence across 18 comparisons, with 12 out of 18 comparisons reporting no relationship, it appears that alexithymia is not typically associated with ToM ability on tasks that do not require the ability to identify another's emotional state.

3.4. ToM propensity

27 studies investigated the relationship between alexithymia and measures aimed at assessing the propensity to engage in ToM. These included five measures: the IRI, the Frith-Happe Animations task (intentionality and length subscales), the Questionnaire of Cognitive and Affective Empathy – cognitive empathy subscale, the Thematic Apperception Test, and the Mind-mindedness Interview. As one study used more than one task (Milosavljevic et al., 2016), 28 comparisons are described below.

3.4.1. The interpersonal reactivity index: perspective-taking subscale

The IRI-PT subscale quantifies an individual's tendency to spontaneously adopt the standpoint of others and is therefore expected to be negatively associated with alexithymia if alexithymia is characterised by poor ToM propensity. A negative relationship was reported by 16 of the 19 publications included in this review. Of these 16 studies, eight studies were conducted in the general population, and all reported a significant negative association between alexithymia (measured with the TAS-20) and the perspective taking subscale of the IRI. Moriguchi et al. (2006)

found reduced perspective-taking in individuals scoring above their cut-off for alexithymia (>60) in comparison to low levels of alexithymia (<39). This finding was replicated by Alkan Härtwig et al. (2013), using a different cut-off (>56 vs <40). Martínez-Velázquez et al. (2020) classified participants into high vs. low empathy trait groups according to their scores on a modified version of the IRI. They observed a negative correlation between alexithymia and perspective taking in the whole sample, however not in each of the groups when analysed separately. Five further studies observed a negative correlation between alexithymia and the IRI-PT (Grynberg et al., 2010; Lyvers et al., 2018, 2017; Patil and Silani, 2014; Yang et al., 2020). Specifically, in the largest study examining this relationship in typically developing individuals (N = 645), Grynberg et al. (2010) found a negative correlation between total TAS-20 scores and scores on the perspective-taking subscale. Follow-up analyses suggested this association was driven by all three subscales of the TAS-20. However, when controlling for depression and anxiety in subsequent analyses, whilst TAS-20 total scores were associated with reduced perspective-taking, only the DDF and EOT subscales were significantly associated with scores on the perspective-taking subscale of the IRI. Similarly, Lyvers et al. (2018) found that the externally-oriented thinking subscale of the TAS-20 was the only subscale significantly correlated with perspective taking: the more an individual tends to think about external events rather than focusing on their own experience the less the tendency to take others' perspective.

The remaining eight studies that found a relationship between alexithymia and the perspective taking subscale of the IRI examined this association in clinical samples. Using continuous scores in a sample of individuals with and without a diagnosis of autism, Bird et al. (2010) observed a negative relationship between alexithymia and perspective taking. This was found also by Van Randenborgh et al. (2012) in a sample of individuals with chronic and episodic depression, by Guttman and Laporte (2002) in a sample of individuals with anorexia and with personality disorders, by Kang et al. (2012) in a large sample (N = 237) of people with obsessive-compulsive disorders and typical individuals, and by Chau et al. (2018) in a sample of patients with various brain lesions. Similar results were also reported by Banzhaf et al. (2018) who divided their clinical sample of patients with depression into high (>53−52) and low (<52-53) alexithymics. They found that those with high levels of alexithymia scored lower on the IRI PT than those with low levels of alexithymia. Two studies reported discrepant results across clinical and control participants. Silani et al. (2008) observed an association between the IRI-PT in typical individuals, but not in a sample with ASD. Likewise, Neumann et al. (2014) found that higher levels of externally-oriented thinking were negatively correlated with perspective taking in a sample of patients with traumatic brain injury only.

Of the 19 studies that utilised the perspective-taking component of the IRI, only three studies did not find a relationship between this component and alexithymia. One publication including patients with multiple sclerosis (which only reported correlations in their clinical sample) did not find a significant relationship between the IRI perspective-taking subscale and any of the TAS-20 subscales (the relationship with total TAS-20 scores was not reported; Gleichgerrcht et al., 2015), suggesting that the relationship between perspective-taking and alexithymia may not be present in certain clinical populations. However, as noted, correlations were not reported in the control sample (matched on age, gender and education), it is equally possible that a restricted distribution of scores contributed towards this null result. Similarly, two other studies conducted in adult male offenders (Christopher and McMurran, 2009) and alcohol-use patients (Maurage et al., 2011) did not find a negative correlation between IRI perspective-taking and TAS-20 subscales. Maurage et al. (2011) did not find a relationship in either of their groups (i.e., typical individuals and alcohol patients). However, again Christopher and McMurran (2009) did not employ control groups which may have limited the distribution of scores, making associations difficult to observe.

3.4.1.1. *Meta-analysis.*

As more than 10 studies assessed the relationship between the IRI-PT and alexithymia, a meta-anaylsis was conducted. Across the whole sample, there was a negative relationship between the IRI-PT and alexithymia (random effects model: $r = -0.177$, $p = 0.009$), however there was substantial heterogeneity ($I^2 = 89.5$ %, Q (13) = 123.87, $p < 0.001$; see supplement [S4]). Inspection of the funnel plot and Egger's test suggest no publication bias ($p = 0.887$) (see supplement [S4] for funnel plot).

3.4.2. *The frith-happé animations task: intentionality and length*

One study was excluded from assessment as it did not report formal analyses examining the relationship between the intentionality or length subscales of the Frith-Happé animations task and alexithymia. 6 studies reported formal analyses, with two of these finding a relationship between Animation task scores and alexithymia. Using cut-off scores in the typical population, Moriguchi et al. (2006) found that individuals with high alexithymia (>60) had significantly lower scores on both appropriateness and intentionality than individuals with low alexithymia (<39; with scores quantified using the system described in Castelli et al. (2000); see section 1.3; Length was not reported in this experiment). Using a similar scoring system (with one difference - appropriateness was scored on a 0–2 scale), Koelkebeck et al. (2010) found a negative correlation between the EOT subscale of the TAS-26 and ToM-intentionality in their control sample; however, a positive relationship was observed between the DIF subscale of the TAS-26 and intentionality in individuals with schizophrenia.

In contrast, four studies found no relationship between performance on the Animations task and alexithymia. The absence of a relationship between alexithymia, as measured by the TAS-20, and the Animations task (ToM-appropriateness (0–3 scale) and intentionality (0–5 scales)) was reported in typically developing samples (Lockwood et al., 2013) using a continuous measure; a pattern that remained after controlling for autistic traits, intelligence and psychopathy. Similar results have also been reported in clinical populations. In a sample of adolescents with autism, Milosavljevic et al. (2016) observed no difference between high and low alexithymics (grouped as >51 and <51, indicative of high and low rates of alexithymia) in ToM intentionality (scored on a 0–5 scale; other scales were not examined). Likewise, using the scoring system described by Castelli et al. (2000); Eddy and Rickards (2015) observed no relationship between alexithymia (TAS-26) on Animation task performance in a sample of individuals with a positive genetic predisposition to Huntington's Disease, with the absence of a relationship found across all three subscales (intentionality, appropriateness and length). Similarly, Zunhammer et al. (2015) found no relationship between alexithymia (TAS-26) and ToM intentionality (scored on a 0–5 scale; other scales were not examined) in chronic somatoform pain patients or in typical individuals.

3.4.3. *The mind-mindedness interview*

One study utilised the Mind-mindedness Interview and examined the relationship between alexithymia and propensity to engage in ToM in students. Szpak and Białecka-Pikul (2015) examined this relationship in Polish students (N = 128). They divided the participants into present vs absent mind-mindedness based on their performance. No difference in alexithymia scores were observed between these two groups.

3.4.4. *Thematic apperception test*

Inslegers et al. (2012) employed the Thematic Apperception Test (TAT) in a sample of psychiatric patients. They did not find any relationship between alexithymia and the propensity of engaging in ToM on the TAT.

3.4.5. *Questionnaire of cognitive and affective empathy – cognitive empathy*

One study used the Questionnaire of Cognitive and Affective Empathy (QCAE) in a sample of female patients with borderline personality disorder (Grzegorzewski et al., 2019). In the patient group, they observed a negative correlation between TAS-20 total scores and the cognitive empathy subscale of the QCAE. Whilst, in typical individuals, the authors found a negative correlation between the externally oriented thinking subscale of the TAS-20 and the cognitive empathy subscale of the QCAE.

3.4.6. Summary: ToM – non-emotion propensity

Of the 27 publications reporting formal analyses, 19 observed a relationship between alexithymia and propensity to engage in ToM, with another at trend level. Of studies observing a relationship, the majority (17/19) utilised self-report measures of ToM. Taking each task in turn, first, the majority (16/19) of studies demonstrate that alexithymic individuals report reduced perspective-taking on the IRI-PT, a result confirmed by the meta-anaylsis conducted. The absence of a relationship in clinical/atypical groups such as multiple sclerosis (Gleichgerrcht et al., 2015), alcoholism (Maurage et al., 2011) and in male offenders (Christopher and McMurran, 2009) may reflect a genuine difference in the relationship between alexithymia and self-reported ToM propensity in certain clinical/atypical groups, or it may reflect a restricted range of alexithymia scores in the clinical/atypical group. Second, whilst two studies indicate that alexithymic individuals perform poorly on the Frith-Happé Animations task (Koelkebeck et al., 2010; Moriguchi et al., 2006), this relationship was not significant in four other studies, and in the Koelkebeck et al. (2010) study discrepant results were reported across clinical and control participants. The EOT subscale of the TAS-26 correlated with poor ToM-intentionality in the control group, whereas in the clinical group the DIF subscale was positively correlated with ToM-intentionality. There therefore remains some ambiguity regarding the relationship between alexithymia and performance on the Frith-Happé Animations task (intentionality and length subscales) with most studies (4/6) reporting no association. Providing an overview is difficult however, as inconsistent scoring criteria are used with this task which makes studies difficult to compare. In terms of less frequently used measures, one study utilised the Mind-mindedness Interview and no relationship between alexithymia and mental state inferences was observed (Szpak and Białecka-Pikul, 2015). Likewise, one study employed the Questionnaire of Cognitive and Affective Empathy – cognitive empathy subscale (QCAE; Grzegorzewski et al., 2019) in a sample of individuals with borderline personality disorder and typical individuals. Whilst a negative association with alexithymia was observed in both groups, this was observed for total scores in the clinical sample and EOT scores in the control sample. Finally, one study employing the Thematic Apperception Test (TAT; Insleger et al., 2012) in a mixed clinical sample did not observe a relationship between alexithymia and TAT performance. It is possible that the population examined (a mixed clinical sample without a control group) may have contributed towards a limited distribution of scores or it may be that poor reliability or validity of the TAT (for which a consensus regarding scoring is yet to be reached; Lilienfeld et al., 2000) may underlie this discrepancy.

Overall, the majority of comparisons suggest alexithymia is associated with a reduced propensity to engage in ToM (N = 19/28), with the majority of those reporting an association utilising self-report measures. Whilst one possibility is that this represents a discrepancy between self-report and objective measures of ToM propensity, an alternative is that laboratory tasks are insensitive to any reduced propensity to engage in ToM that may be present an individual's everyday life.

4. Discussion

The aim of this systematic literature review was to establish whether alexithymia is associated with ToM. A distinction was made between measures assessing the propensity to represent mental states and those assessing the ability to make accurate (or at least typical) mental state inferences, which were labelled tests of ToM ability. For tasks of ToM ability, measures were further subdivided into those that require emotion recognition ability, and those that do not. The results of this review suggest that alexithymia is associated with specific aspects of ToM, although a great deal of uncertainty remains. Specifically, whilst the majority of studies indicate that alexithymia is associated with ToM deficits when emotion recognition ability is required to infer mental states, deficits are not routinely observed in ability-focused tasks that do not require emotion processing. Ambiguity arises, however, for propensity-based measures: the majority of these studies suggest that alexithymia is associated with a reduced propensity to engage in ToM (67.8 % of studies report an association), though the majority of studies have utilised self-report measures. In the following sections, we discuss each of these findings in turn.

The majority of evidence regarding the relationship between alexithymia and ToM ability on tasks with emotion demands was provided from studies using The Reading the Mind in the Eyes task (Baron-Cohen et al., 2001). Of all the measures included in this review, this task was used most frequently by studies investigating the relationship between alexithymia and ToM ability, with the majority finding that increasing rates of alexithymia are associated with poorer performance on the RMET (Al Aïn et al., 2013; Berenson et al., 2018; Di tella et al., 2015; Etchepare et al., 2019; Lombardo et al., 2007, 2012; Lyvers et al., 2017, 2018, 2019a, 2019b; Moseley et al., 2019; Raimo et al., 2017; Samur et al., 2018; Schimmenti et al., 2019; Stonnington et al., 2013; Vellante et al., 2012; Demers and Koven, 2015; Gökçen et al., 2016; Oakley et al., 2016; Lane et al., 2015; Schimmenti, 2017; but see Adenzato et al., 2012; van Randenborgh et al., 2012; Luminet et al., 2011). Given a body of evidence suggesting that alexithymia is associated with emotion recognition difficulties (Cook et al., 2013; Kessler et al., 2006; Lane et al., 1996, 2000), and the findings from this review that alexithymia is not routinely associated with ability-focused ToM tasks that do not require emotion recognition abilities (see Section 2.1), the association between alexithymia and RMET performance is likely due to the emotion recognition component of this task. Indeed, consistent with this proposal, in typical individuals RMET performance often correlates with performance on emotion recognition tasks (e.g., de Achával et al., 2010; Henry et al., 2006). Given these findings, it could be argued that the RMET is a measure of emotion recognition rather than theory of mind (Oakley et al., 2016), although it is certainly possible that emotion recognition abilities contribute towards ToM in everyday life (Brüne, 2005a). In support of the claim that performance on the RMET reflects emotion recognition rather than ToM ability is the finding that performance on the RMET only correlates modestly, or not at all, with other measures of ToM (e.g., the MASC; $r = .29$; Gökçen et al., 2016; Strange Stories; $r = .27$ ($r = .02$ when IQ controlled for); Frith-Happé animations; $r = .46$ ($r = .30$ when IQ controlled for; Hollocks et al., 2014); see also Wilson et al. (2014) for correlations between ToM measures). At a minimum it must be acknowledged that, at present, the relative contribution of emotion recognition to RMET performance is unknown but likely to be substantial (Oakley et al., 2016).

If, as proposed above, performance on the RMET is determined to a large extent by emotion recognition abilities, it is important to question why a negative relationship between alexithymia and RMET performance was not seen in all studies, given the association between alexithymia and emotion recognition. First, almost all of the studies that did not observe a negative relationship were conducted in clinical populations (Campanella et al., 2014; Cucchi et al., 2018; van Randenborgh et al., 2012; Adenzato et al., 2012; Aloi et al., 2017; Rothschild-Yakar et al., 2019; Riem et al., 2018; Chalah et al., 2017; Vellante et al., 2012), whilst in one study it is notable that a trend was observed for alexithymia to predict poor performance on the RMET (Luminet et al., 2011). Although sample size, power, and the distribution of alexithymia scores may explain why studies conducted in clinical populations did not observe the typical pattern of results, it is noteworthy that the relationship between RMET performance and emotion recognition ability reported in control samples is absent in certain clinical populations (e.g., following traumatic brain injury; Henry et al., 2006, in fibromyalgia patients; Di Tella et al., 2015, or in patients with schizophrenia; de Achával et al., 2010). It is therefore possible that different strategies may be employed when completing the RMET, and the extent to which emotion recognition ability contributes towards performance differs depending on the population examined. Second, two studies observed the expected relationship in primary analyses but not in secondary analyses controlling for additional factors such as IQ and autistic traits (Gökçen et al., 2016; Lane et al., 2015). One explanation for this pattern is that overlap between these additional factors and alexithymia may contribute towards discrepancies between primary and secondary analyses (e.g., common symptom profiles between alexithymia and other traits such as autism may result in collinearity when controlled for statistically). However, if RMET performance is solely determined by emotion recognition ability these results are at odds with previous studies reporting a negative relationship between emotion recognition and alexithymia even when various other traits are controlled for (e.g., gender, age, autistic traits and IQ; Cook et al., 2013). An alternative possibility is that RMET performance is determined both by emotion recognition capabilities and additional factors such as language skill or general problem-solving ability (e.g., IQ is related to performance on the RMET; see Baker et al., 2014), that are either not predicted by alexithymia or share common variance with alexithymia (e.g., more recent evidence suggests a possible link between language ability and alexithymia; Hobson et al., 2019; Hobson et al., 2018). If the RMET is to be used as a measure of ToM, it is important for future research to uncover the exact psychological processes it measures, and the contribution of ToM to successful task performance. Such studies will be useful for understanding the exact contribution of alexithymia to ToM ability, and whether the relationship between alexithymia and RMET performance is solely driven by the emotion recognition component of this measure.

Beyond the RMET, two of the four studies that utilised different ToM measures thought to involve emotional demands (i.e. the affective subscale of the MASC, the Conflict Beliefs task, Strange stories film task, and the Emotion attribution test) reported an association between alexithymia and ToM (Schonenberg et al., 2014; Swart et al., 2009) in line with the proposal that alexithymia may contribute towards performance on ToM tasks that involve emotion recognition or understanding. Though it is notable that in the Swart et al. (2009) study alexithymia only related to poor performance in the first (emotion recognition; consistent with previous findings, e.g., Cook et al., 2013), but not second order (understanding of the actor's emotional state), subscale. Likewise, in two studies utilising the Strange stories film task and the Emotion attribution test, no relationship between alexithymia and ToM was observed (Murray et al., 2017; Raimo et al., 2017). Whilst it is only possible to speculate as to why no relationship was observed in these studies, it is notable that in the Strange stories film task participants are required to understand the scenario and identify mental states such as beliefs and intentions, which may be achievable in the absence of emotion recognition ability. Likewise, understanding of another's emotional state in the conflict belief task and emotion attribution test may be possible using other mechanisms (e.g., contextual information). As such, whilst the results of these studies are inconsistent with the majority of studies in this category (predominately the RMET), the complexity of these tasks means that it is possible that there are multiple routes towards achieving comparable performance on these tasks. In principle therefore, it may be worthwhile considering as distinct those ToM tests for which accurate emotion recognition is *necessary* for accurate mental state inference, and those for which emotion recognition may aid in the accurate inference of mental states but is not necessary.

Twelve tasks were used to assess the ability to make accurate mental state inferences without relying on emotion processing (see Table 3). Out of the 18 comparisons, the majority (11/18) did not observe a significant negative relationship between alexithymia and ToM ability when emotion recognition demands were minimal. The most commonly used measure included in this category was the MASC, where (contrary to the majority of studies in this category), three out of four studies found a relationship between alexithymia and task performance (Schönenberg et al., 2014, 2015; Gökçen et al., 2016). However, in two of these studies relationships were only observed in the clinical sample (Schönenberg et al., 2014, 2015) and in the other no relationship was observed when autism, IQ and age were controlled for (Gökçen et al., 2016). Such a pattern suggests that any observed relationship between alexithymia and MASC performance may be driven in part by co-occurring traits, which may be condition specific. An alternative possibility, however, is that alexithymia may contribute towards the emotional components in the MASC. Indeed, although performance on the MASC involves predominantly non-emotional questions, just under 50 % of the items that contribute towards the total score are emotional (Dziobek et al., 2006). As such, it remains a possibility that alexithymia is related to performance on some, but not all, items of the MASC, contributing also towards the discrepancies across studies.

Beyond the MASC a wide variety of tasks were employed to examine the relationship between alexithymia and ToM using tasks with minimal emotional demands. Of 14 comparisons not employing the MASC, three observed a relationship between alexithymia and ToM, when using the Frith-Happé Animations Task – appropriateness subscale (Moriguchi et al., 2006), the Faux pas test (Etchepare et al., 2019) and the Attribution of Intention test (Etchepare et al., 2019). Whilst it is only possible to speculate as to why relationships were observed in these studies, it is possible that the measure of alexithymia employed (e.g., the BVAQ employed by Etchepare et al., 2019) and the samples examined (clinical vs. typically developing individuals) may contribute towards discrepancies; for example, whilst Moriguchi et al. (2006) observed poorer performance on the Frith-Happé Animations Task (appropriateness subscale) in high vs. low alexithymic individuals drawn from the typical population, no such relationship was observed in a clinical sample with Huntington's disease (Eddy and Rickards, 2015). Overall, given that 66.6 % of studies support the absence of a relationship between alexithymia and non-emotional ToM tasks, the results reported across both emotional and non-emotional ToM tasks lend support to the idea that alexithymia is not associated with ToM ability *per se* but impacts upon the emotional component inherent in certain ToM tasks.

As well as distinguishing between emotional and non-emotional ToM tasks, this review also considered an important distinction between tasks that quantify one's ability to make accurate mental state inferences and one's propensity to engage in ToM. Such an ability/propensity distinction has been useful in many areas of psychology (e.g., imitation; Rowberry et al., 2015; Vivanti, 2015; Young et al., 2011), and its importance has previously been acknowledged in the ToM literature (e.g., Conway et al., 2019; Flavell, 2004; Happé et al., 2017), where it has been noted that, for some individuals, there may be a discrepancy between one's ability to recruit certain processes when explicitly required to do so, and one's propensity to recruit those processes in everyday life (see Young et al., 2011 for a discussion regarding imitation). However, of the 63 publications included in this review, none were deemed to be both propensity-focused *and* rely upon emotion recognition ability or understanding. Whilst this means that no propensity-focused tasks are confounded by emotion recognition ability, whether alexithymia is associated with such measures remains unclear. Nevertheless, like the MASC, it may be possible to separate existing propensity-focused tasks into subscales that do, or do not, involve emotional abilities, to examine this relationship in the future.

Despite the absence of studies examining the relationship between alexithymia and propensity-focused tasks requiring emotional abilities, several studies have examined the relationship between alexithymia and ToM using propensity-focused measures that do not have an emotional component. Similar to the relatively clear picture regarding the relationship between emotion ability-focused tasks and alexithymia, the majority of the comparisons (19/28) reported a relationship between alexithymia and a reduced propensity to engage in ToM, whilst nine did not (see Table 3). It is notable that 17 studies reporting a relationship between alexithymia and propensity to engage in ToM utilised a self-report measure (the perspective-taking subscale of the IRI; Moriguchi et al., 2006; Grynberg et al., 2010; Härtwig et al., 2013; but see Gleichgerrcht et al., 2015; or the QCAE; Grzegorzewski et al., 2019; see Table 3). Whilst not an objective measure of ToM propensity, this suggests that individuals with alexithymic traits consistently report that they are less likely to spontaneously engage in ToM.

In terms of objective measures, only two of the nine studies reported a significant relationship between alexithymia and measures of ToM propensity, with significant results restricted to studies using the Frith-Happé Animations task intentionality subscale (Moriguchi et al., 2006; Koelkebeck et al., 2010). No relationship was observed in four studies utilising the Frith-Happé animations task intentionality/length subscales (Eddy and Rickards, 2015; Lockwood et al., 2013; Zunhammer et al., 2015; Milosavljevic et al., 2016), in one study using the mind-mindedness interview (Szpak and Białecka-Pikul, 2015) or one study using the Thematic apperception test (Inslegers et al., 2012). Overall, these results suggest a discrepancy between objective and self-report measures. One possibility for the discrepancy between studies using self-report measures (e.g., the IRI-PT and QCAE-cognitive), and those using objective measures of ToM, is that there may be little relationship between objective and self-report measures of ToM propensity (Byom and Mutlu, 2013; possibly because the IRI-PT and QCAE-cognitive also include items that may index different abilities, such as empathy; Davis, 1983). Conversely, it may be that objective measures of propensity are simply not sensitive enough to capture the difficulties individuals with alexithymia experience in their everyday lives. Whether the differential relationships between alexithymia and self-report vs. objective measures reflects these factors, or instead reflects methodological factors (e.g., shared method variance, increased power in studies utilising self-report measures or a more complete distribution of scores) is a question for future research.

Overall, this review highlights the importance of considering the exact processes quantified by measures of ToM when examining whether individual differences on these tasks are predicted by alexithymia. Indeed, as demonstrated by this review, the relationship between alexithymia and ToM appears to differ depending on the degree of emotion processing required, and whether the measure quantifies an individual's spontaneous processing of mental states, of the accuracy/typicality of mental state inference. Such fractionation is consistent with previous reports of only modest or absent correlations between performance on different measures of ToM (e.g., Gökçen et al., 2016; Hollocks et al., 2014; Wilson et al., 2014). In the case of alexithymia, it appears that alexithymia is routinely associated with measures that involve an emotional component but is not reliably associated with measures that do not involve emotional ability. Whether alexithymia is associated with a reduced propensity to engage in ToM, however, remains somewhat unclear, though alexithymics appear to consistently self-report a reduced propensity to adopt the perspective of others.

Evidence of a link between alexithymia and ToM would be of theoretical and clinical importance; as alexithymia is associated with multiple psychiatric conditions (e.g., eating disorders; Russell et al., 2009; anxiety disorders; Leweke et al., 2012; depression; Honkalampi et al., 2000; and neurological disorders such as Parkinson's disease; Costa et al., 2010; and dementia Ricciardi et al., 2015) it remains a possibility that alexithymia may account for certain ToM deficits reported across clinical populations. However, as noted throughout this review the relationship between alexithymia and ToM differed depending on the population examined and was at times absent when co-occurring traits were statistically controlled for. The exact reason for this inconsistency remains unclear, however, to fully understand the contribution of alexithymia to ToM in clinical populations it is important that future research employ control samples, matched for alexithymia (as per Oakley et al., 2016), to fully elucidate the contribution of alexithymia to aspects of ToM. Indeed, it is also possible that other factors, not examined by studies included in this review (e.g., trauma, executive functioning or language deficits; Nazarov et al., 2014; Vissers, and Koolen, 2016; Aboulafia-Brakha et al., 2011) may moderate this relationship, and thus matched groups are important for understanding the contribution of alexithymia to aspects of ToM.

5. Limitations

It is important to acknowledge certain limitations of this review. The first is that, due to the variety of outcome measures used to assess ToM ability, and the substantial between-study heterogeneity in both meta-analyses ($I^2 > 80$ %), the conclusions that can be drawn are limited. Second, the issue of publication bias may also contribute towards discrepant results across studies. Indeed, over half of the relevant publications identified did not report the relationship between alexithymia and ToM (Appendix A). Although steps were taken to minimise the influence of publication bias (as authors were contacted for unreported data), we cannot rule out that publication bias may contribute towards the patterns observed in this systematic review. Indeed, the presence of publication bias in the RMET meta-analysis suggests caution is required when interpreting these results. Whether this applies to other tasks remains an outstanding question, though it is notable that no evidence of publication bias was observed for the meta-anaylsis conducted on the IRI-PT and its relationship with alexithymia. Third, the alexithymia measure employed, and cut-off strategy utilised, differed across studies. This variance has been noted throughout the review, and it is possible that these differences may inflate or conceal true relationships between alexithymia and ToM. Indeed, it is equally possible that the psychometric properties (particularly reliability) of measures used to assess ToM and alexithymia may also influence the presence or absence of relationships. Fourth, in certain studies the relationship between alexithymia and ToM measures was driven by a particular subscale of alexithymia. However, as not all studies reported relationships across subscales it is not possible to conclude that a particular subscale of alexithymia is related to aspects of ToM. Fifth, whilst classifying measures of ToM is a strength of this review, classification was achieved through discussion and thus is subjective. The inter-rater reliability of classification, and the extent to which measures can be neatly classified given that measures often bridge multiple categories (e.g., the MASC includes both emotional and non-emotional items), makes classification difficult. Sixth, all alexithymia measures have cut-off scores for alexithymia (> 61 for the TAS-20; >74 for the TAS-26; >50–53 for the BVAQ). As the range of alexithymia scores was not reported by most studies, it remains unclear whether an adequate distribution of scores was present for all studies. This too highlights an important consideration for future research: when examining the relationship between alexithymia and psychological processes, it is imperative that both ends of the alexithymia distribution are represented in the sample. Finally, evidence available from neuroimaging has largely been neglected in this review, as behavioural data on ToM ability/propensity is not typically collected in these studies. However, it should be acknowledged the vast majority of studies of the neural correlates of alexithymia identify structural and functional abnormalities of the anterior cingulate cortex and insula (areas associated with interoceptive or emotional processing; Craig, 2002) rather than regions thought to part of the ToM network (e.g., Silani et al., 2008; Bernhardt et al., 2013). Thus, the results of neuroimaging studies are consistent with the conclusion that alexithymia is not associated with impairment of ToM ability for non-emotional tasks.

6. Conclusion

In conclusion, alexithymia is routinely associated with ToM measures that require emotional ability. The available evidence suggests however that alexithymia is not associated with a ToM deficit *per se*, and any deficits on ToM tasks are likely caused by the requirement to identify another's emotion. In contrast, the relationship between propensity-based measures of ToM and alexithymia is less clear, although the majority of studies included suggest alexithymia is associated with a reduced propensity to engage in ToM, at least as assessed by self-report measures. Overall, mixed results are reported across studies that have either controlled for co-occurring traits or have examined this relationship in clinical populations. Future research should aim to discover the relative contribution of alexithymia to ToM after controlling for factors such as intelligence, verbal ability and executive function, and to determine whether alexithymia contributes towards ToM difficulties across a range of clinical disorders characterised by high rates of alexithymia.

Author contributions

EM and SP conducted the literature search. JM, SP and EM drafted the paper. CC, JC and GB provided manuscript revisions.

Declaration of Competing Interest

The authors declare no conflict of interest.

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Appendix A. Studies removed for missing or incomplete analyses

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Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.neubiorev.2021.09.036.

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