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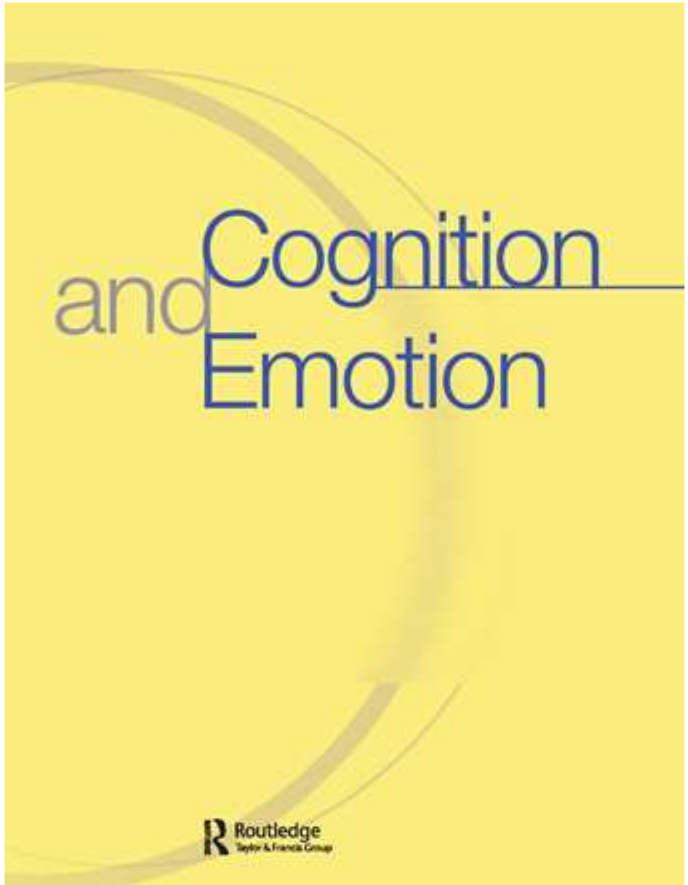

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Consistent Evidence of a Link between Alexithymia and General Intelligence

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The data that support the findings of this study are available on the Open Science Framework https://osf.io/67zda/

Abstract

Alexithymia is a personality construct characterised most notably by a difficulty in identifying and expressing feelings. Although the emotional difficulties in alexithymia are well established, to date little work has examined its relationship to broader cognitive abilities, such as general intelligence. Across three independent, healthy adult samples (Ns = 389, 318, & 273), we examined whether alexithymia was associated with general intelligence. In all three samples, we observed a significant negative association between alexithymia and general intelligence. In two of the samples, general intelligence was a significant predictor of alexithymia even when accounting for performance on tests of facial emotion recognition ability and supramodal emotion recognition ability (measured with faces, bodies, and voices). From a theoretical perspective, these results suggest that models of alexithymia need to incorporate a role for more generalised cognitive functioning. From a practical perspective, studies examining links between alexithymia and clinical disorders, many of which have known links to general intelligence, should consider including a measure of general intelligence in order to adjust for this potentially confounding factor.

Keywords: alexithymia; emotion recognition; general intelligence; face perception

Introduction

Alexithymia is a stable, sub-clinical personality construct characterised by difficulties with emotional awareness, and comprising three components including difficulties in identifying feelings, difficulties in expressing feelings to others, and an externally-oriented style of thinking (Preece, Becerra, Allan, Robinson, & Dandy, 2017). Alexithymia is an important individual differences construct as it has known links to broader psychological difficulties (Mattila, Salminen, Nummi, & Joukamaa, 2006). Indeed, many studies have reported wide-ranging associations with clinically-relevant disorders, such as depression (Grynberg et al., 2012), anxiety (Korkoliakou et al., 2014), eating disorders (Brewer, Cook, Cardi, Treasure, & Bird, 2015), autism spectrum disorder (Cook, Brewer, Shah, & Bird, 2013), atypical empathy (Bernhardt & Singer, 2012), alcohol dependence (Lyvers, Onuoha, Thorberg, & Samios, 2012), and medically unexplained somatic symptoms (De Gucht & Heiser, 2003).

To date, most studies of alexithymia have considered it a deficit in emotion processing. For example, Bird and colleagues (2010) described alexithymia as a "subclinical phenomenon marked by difficulties in identifying and describing feelings and difficulties in distinguishing feelings from the bodily sensations of emotional arousal" (p. 1516). While this description does indeed appear to capture key features of alexithymia, here we sought to address a largely unexamined issue: the possibility that the alexithymia construct might to some extent reflect individual differences in general intelligence.

There are several reasons to posit this broader psychological footprint. Firstly, it has been noted that alexithymia is related to non-emotional interoceptive abilities, with individuals higher in alexithymia showing a poorer ability to accurately count their own heartbeat (Herbert, Herbert, & Pollatos, 2011). A more recent study has bolstered this earlier finding, reporting that alexithymia is negatively correlated with other interoceptive abilities; specifically, the ability to accurately gauge if a drinking solution is saltier than a target solution, to estimate and balance the weights of two-rice filled buckets in each hand, and to gauge the strength of one's own respiratory output (Murphy, Catmur, & Bird, 2018). Such findings indicate that alexithymia cannot be adequately characterised by emotion-related processes alone.

Secondly, several of the items in the most widely-used measure of alexithymia, the Toronto Alexithymia Scale (TAS-20), appear to capture, at least in part, the ability to understand and integrate complex information, which of course is one of the cardinal features of general intelligence (Gottfredson, 1998). For example, agreement with the following items ‘I prefer to analyse problems rather than just describe them’ (reverse-scored) and ‘I prefer to just let things happen rather than to understand why they turned out that way’ both reflect higher levels of alexithymia. Stronger agreement to these items may indeed reflect difficulty with emotional awareness. Equally, it seems plausible that such agreement, at least in part, might reflect difficulties in processing complex contingencies and thus general intelligence.

Thirdly, there are a number of abilities and clinically-relevant disorders that are known to be related both to alexithymia and general intelligence. These include emotion recognition ability in the normal population (Lewis, Lefevre, & Young, 2016) and clinical conditions such as depression (Honkalampi et al., 2000), eating disorders (Lopez, Stahl, & Tchanturia, 2010; Brewer et al., 2015), schizophrenia (Gawęda & Krężołek, 2019), and dementia (Sturm & Levenson, 2011). These again suggest that a link between alexithymia and general intelligence is plausible.

Only a handful of studies have examined this putative link, and these have mainly relied on measuring more focal aspects of intelligence. For example, negative associations have been noted with vocabulary (N=81: Bagby, Taylor, & Ryan, 1986; N=115: Hsing, Mohr, Stansfield, & Preston, 2013). Similarly, Lumley and colleagues (2005) noted a moderate inverse link between verbal ability and the Externally Oriented Thinking subscale of the TAS-20 (N=140: Lumley, Gustavson, Partridge, & Labouvie-Vief, 2005). In a recent study comprising three samples (Ns=296, 131, & 121), alexithymia was associated with poorer memory for neutral words and poorer executive functioning, as measured by the Trail-making Tests, the Symbol Digit Modalities Test, and a test of category fluency (Correro, Paitel, Byers, & Nielson, 2019). Finally, in a number of large-scale community studies, alexithymia has shown negative associations with level of education (N=2297: Kauhanen, Kaplan, Julkunen, Wilson, & Salonen, 1993; N=5028: Kokkonen, Karvonen, Veijola, Läksy, & Jokelainen, 2001), consistent with a link to general intelligence (Deary, Strand, Smith, & Fernandes, 2007). However, not all studies have reported a link between alexithymia and intelligence (or related) measures. For example, Parker, Taylor, and Bagby (1989) found no association of the TAS-26 scale to the Shipley Institute of Living Scale, which comprises both vocabulary and abstract reasoning subscales.

These studies have provided grounds for further examination of how alexithymia might relate to general intelligence; but a number of weaknesses in their study designs necessitate further work. For example, a number of the empirical samples have been small (N≤140) and often limited to university students (e.g. Lumley et al., 2005; Hsing et al., 2013). Many of them use a proxy measure for general intelligence (e.g. Kauhanen et al., 1993, Kokkonen et al., 2001) or use a measure that taps only a limited aspect of intelligence, such as reading ability (Lumley et al., 2005). A comprehensive measure tapping the broad range of intelligence is needed to fully explore a possible link with alexithymia, and may be why Lumley et al. (2005) observed a link between verbal ability and only one of the TAS-20 subscales. Moreover, most of the above studies do not include a good measure of emotion recognition ability (that is, the ability to accurately recognise emotional expressions in other people). Given that emotion recognition ability has been linked to both general intelligence and alexithymia (Lewis et al., 2016), it is important to adjust for this variable to validly assess a link between alexithymia and intelligence. That is, any association that might emerge between alexithymia and intelligence could be attributed to their widely noted mutual link with emotion recognition ability.

With this in mind, we sought here to provide a strong test of the proposed link between alexithymia and general intelligence using well-established measures. Study 1 involved a retrospective analysis of data collected for other purposes from two adult samples (each with N>300). Study 2 was pre-registered to give a sample (N>270) derived from power calculations based on the effect sizes observed in Study 1.

Study 1

In two adult samples (N>300), we tested whether general intelligence and alexithymia are negatively associated. We also examined the extent to which any such association provides incremental prediction over and above facial and supramodal emotion recognition ability (i.e. measures of emotion recognition ability that incorporate stimuli from more than one sensory modality: Study 1a: face and body; Study 1b: face and voice).

Methods

Participants

Study 1a: 400 participants were recruited from Amazon's Mechanical Turk (MTurk) service as part of an unrelated study that included a measure of alexithymia and general intelligence (Lewis et al., 2016). We excluded participants who showed evidence of lack of attention, for example if the same response key was used repeatedly, or who scored below chance level on two or more of the emotion recognition ability tasks. This resulted in the omission of 11 participants, producing a final sample size of 389 (131 men). Mean age of participants was 37.0 years (SD = 11.7), and ethnicity was reported as follows: White (n=290), Hispanic (n=14), Asian (n=22), Black (n=11), Native American (n=2), Other (n=32) and Undisclosed (n=18).

Study 1b: 412 participants were recruited from Amazon's Mechanical Turk service as part of an unrelated study that included a measure of alexithymia and of general intelligence (Connolly, Lefevre, Young, & Lewis, 2020). The exclusion criteria were the same as above, with the addition of participants also being excluded if they failed an auditory test at the beginning of the survey. This resulted in the omission of 94 participants, producing a final sample size of 318 (159 men). Mean age of participants was 35.9 years, and ethnicity was reported as follows: White (n=254), Hispanic (n=21), East Asian (n=14), Black (n=22), Native American (n=2), South Asian (n=1), and Other (n=4).

These participant demographics represent the typical pattern observed for MTurk samples (Huff & Tingley, 2015).

Stimuli

Facial Emotion Recognition Ability (Face Emot):

Study 1a: Stimuli were static images taken from the Facial Expressions of Emotion: Stimuli and Tests (FEEST) set (Young, Perrett, Calder, Sprengelmeyer, & Ekman, 2002), and were morphed to differing intensities of expression, from 25% (a morph that involved a 75% neutral and 25% emotional expression) to 100% (representing the prototype expressions from the Ekman series). They were piloted across different levels of emotional intensity in a previous study (Lewis et al., 2016), and in order to try and avoid floor or ceiling effects, exemplars for each emotion with appropriate means and variabilities were selected. In Study

1a, the modality block comprised 50 selected items (10 items for each of the 5 basic emotions: anger, disgust, fear, happiness, and sadness) shown twice to the participants. Split half reliability was r=.69.

Study 1b. For the participants in Study 1b the block comprised an abbreviated subset of stimuli, which were fully outlined in a previous study (Connolly et al., 2020). The subset block comprised 15 items (3 items for each emotion) shown once each. Split half reliability was r=.53.

Alice Heim 4 Test of General Intelligence (AH4):

Study 1a: This test consists of 65 items which are either numerical or verbal in nature. Half of the questions require multiple-choice responses (from a choice of 5), and half require open entry 'creative answers'. The participants have a maximum time limit of 10 minutes to complete as many of the items as they can, after which the page automatically advances to the next section of the survey. They are encouraged to complete the questions in the order in which they are given, but are also told they may skip to the next questions if they become stuck. The participants were awarded one point for every correct answer, and their total score was generated out of a maximum of 65. This test is suitable for the current research question given that it is considered a good test of *general* intelligence as it corporates elements of both crystallized knowledge (vocabulary) and fluid intelligence (online manipulation of novel information). It is also easy and relatively quick to administer online, and relates well to other measures of g (e.g. Tombaugh, 2006).

Study 1b: The identical procedure as for Study 1a was followed.

Toronto Alexithymia Scale (TAS-20): The TAS-20 is a 20-item instrument that assesses alexithymic traits in three broad sub-domains: Difficulty Identifying Feelings (7 items), Difficulty Describing Feelings (5 items), and Externally Oriented Thinking (8 items) (Bagby, Parker, & Taylor, 1994). Participants in both Studies 1a and 1b completed this test. They respond on a 5-point Likert scale, with 1 being ‘strongly disagree’, and 5 being ‘strongly agree’. A total score was generated by summing the responses from all 20 items: a higher score indicates a greater degree of alexithymic traits. Scale scores for each individual sub-scale were also generated. Cronbach’s alpha for both datasets was good for the total scale (α=.89; α=.89, respectively), and the Difficulty Identifying Feelings (α=.91; α=.94) and Difficulty Describing Feelings (α=.84; α=.83) sub-scales. The Externally-Oriented Thinking (EOT) subscale had a relatively low alpha in both samples (α=.67; α=.61), consistent with reports from other studies (e.g. Preece et al., 2017). This is of minor concern here, though, given that we did not analyse this measure at the subscale level, and factor analytic work has consistently shown evidence for a latent general factor of alexithymia across the three sub-scales (Meganck et al., 2008; Preece et al., 2020).

Additionally in Study 1a, a measure of body emotion recognition ability was included, and in Study 1b, a measure of voice emotion recognition ability was included. These are outlined below.

***Point-light Bodily Emotion Recognition Ability*: ** Stimuli were dynamic point-light walker stimuli previously described by Atkinson, Dittrich, Gemmell, and Young (2004). In short, 10 actors were recorded performing each of five emotions, and subsequent rendering removed all information other than high visibility patches from each video, resulting in a short video clip of light points whose combined movement simulated a human body expressing a natural, dynamic emotion. Video clips lasted between 4.2 and 8 seconds. As with the facial emotion stimuli selected for Study 1a, 10 stimuli for each emotion were chosen (i.e., total N=50) that showed adequate means and variances following a pilot experiment in a previous study (Lewis, Lefevre, & Young, 2016). Participants in Study 1a were shown the 50-item block of bodily emotion stimuli twice.

Vocal Emotion Recognition Ability: Stimuli were short audio clips from the Montreal Affective Voices (MAV) set (Belin, Fillion-Bilodeau, & Gosselin, 2008), which comprises actors portraying different emotions in vocal bursts, with each audio burst lasting between 1.45 and 2.23 seconds. To ensure that this set was in line with the other emotion stimuli, it was first piloted in a previous study (Connolly et al., 2020) to select appropriate items for the five basic emotions, and then to select 15 items (3 for each emotion) with psychometric properties comparable to the other two expressive domains. Participants in Study 1b were presented with the 15-item block of vocal emotion stimuli once.

Procedure

In both samples, the emotion recognition blocks were first presented to the participant (faces and bodies in Study 1a, faces and voices in Study 1b), with the within-block presentation order being fully randomised. In a five alternative-choice paradigm, participants had to select the emotion they perceived was being portrayed. Stimuli presentation consisted of a black screen for 500ms, a fixation cross for 750ms, and a further 500ms black screen that preceded the onset of the stimulus. Facial stimuli in both samples were presented for 1000ms. Bodily (Study 1a) and vocal (Study 1b) stimuli lasted for the duration of each individual video or audio clip. Participants could respond at any point following the stimulus onset. Following the emotion recognition blocks, participants completed as much of the general intelligence test as possible in the maximum time of 10 minutes allowed. Following this, they completed the alexithymia questionnaire. Participants were debriefed following completion.

Results

First, we explored links to facial emotion recognition, as this has been a focus in previous theorising. A similar pattern of associations was noted across both samples.

Alexithymia was significantly negatively correlated with general intelligence (Study 1a: *r*=-.11, *p*=.026; Study 1b: *r*=-.38, *p*=<.001) and with facial emotion recognition ability (Study 1a: *r*=-.28, *p*=<.001; Study 1b: *r*=-.35, *p*=<.001). Additionally, facial emotion recognition ability was significantly positively correlated with general intelligence (Study 1a: *r*=.28, *p*=<.001; Study 1b: *r*=.38, *p*=<.001).

For completeness, we then investigated links to emotion recognition ability more generally, by examining the correlations when emotion recognition ability was based on a composite supramodal score derived from the face and body emotion recognition scores (Study 1a) (split half reliability r=.61) or face and voice emotion recognition scores (Study 1b) (split half reliability r=.58). Alexithymia was significantly negatively correlated with supramodal emotion recognition ability (Study 1a: *r*=-.18, *p*=.003; Study 1b: *r*=-.36, *p*=<.001). Additionally, supramodal emotion recognition ability was significantly positively correlated with general intelligence (Study 1a: *r*=.38, *p*=<.001; Study 1b: *r*=.45, *p*=<.001).

Hierarchical regression analysis then enabled our other hypotheses to be tested. In the first step, age and sex were entered as predictors of alexithymia. In Study 1a, neither of these variables were significant predictors. In Study 1b, age was a significant negative predictor of alexithymia (β=-.11, *p*=.046), whereas sex was not. In the second step, facial emotion recognition ability was entered into the respective models. In both samples, this was a significant negative predictor of alexithymia (Study1a: β=-.27, *p*<.001; Study 1b: β=-.34, *p*<.001). In Study 1a, this was the only significant predictor, but in Study 1b, age also remained a significant negative predictor (β=-.12, *p*=.031).

In the critical third step, general intelligence was entered into the model. In Study 1a, this variable was not a significant predictor of alexithymia, but facial emotion recognition remained a significant negative predictor (β=-.26, *p*<.001). Including intelligence in the model did not improve the overall fit (R^2 changed from .081 to .082, p=.560). In Study 1b, however, both general intelligence (β=-.29, p<.001) and facial emotion recognition ability (β=-.23, p<.001) were significant negative predictors of alexithymia, and the inclusion of general intelligence significantly improved the fit of the model (R^2 changed from .135 to .205, p<.001). The full results of both regression analyses are shown in Tables 1 (Study 1a) and 2 (Study 1b). It should also be highlighted that Step 3 in both Tables 1 and 2 show that emotion recognition ability and alexithymia are significantly associated independent of general intelligence.

Table 1: Multiple regressions predicting alexithymia scores from age, sex, facial emotion recognition ability (Face Emot), and general intelligence in Study 1a.

	Step 1		Step 2		Step 3	
Independent Variables	**β**	**Sig**	**β**	**Sig**	**β**	**Sig**
Age	-.08	.119	-.05	.302	-.05	.285
Sex	.09	.068	.04	.439	.04	.413
Face Emot			**-.27**	**<.001**	**-.26**	**<.001**
General Intelligence					-.03	.560

Table 2: Multiple regressions predicting alexithymia scores from age, sex, facial emotion recognition ability (Face Emot), and general intelligence in Study 1b.

	Step 1		Step 2		Step 3	
Independent Variables	**β**	**Sig**	**β**	**Sig**	**β**	**Sig**
Age	**-.11**	**.046**	**-.12**	**.031**	-.10	.059

Sex	-.10	.081	-.04	.513	-.04	.406
Face Emot			**-.34**	**<.001**	**-.23**	**<.001**
General Intelligence					**-.29**	**<.001**

Again, for completeness, we ran the regression models with 'supramodal' emotion recognition ability scores derived from a composite of either face and body emotion recognition (Study 1a) or face and voice emotion recognition (Study 1b). The results were highly similar to the models that tested face emotion recognition ability alone. That is, they followed the exact pattern as in the outputs in Tables 3 and 4: the magnitude of the beta values were not appreciably different and the same predictor variables at each step were significant as in the facial emotion regression models.

Discussion

We observed the expected negative association between alexithymia and emotional emotion recognition in both samples (i.e. Studies 1a and 1b). Importantly, we also observed a significant negative correlation between alexithymia and general intelligence across samples. Of note, though, in Study 1a, general intelligence was not a significant predictor of alexithymia over and above that of emotion recognition ability. In contrast, in Study 1b, both general intelligence and emotion recognition ability were significant predictors when entered in the model simultaneously. These patterns held regardless of whether emotion recognition ability was measured from facial expressions alone or from supramodal performance involving faces and voices or bodies.

These findings clearly leave unanswered the question as to whether intelligence has a *unique* association with alexithymia once adjusting for emotion recognition ability. In order to provide a more definitive answer to this research question, we addressed this issue using an independent sample and a pre-registered study plan.

Study 2

Methods

Participants

This pre-registered study (https://osf.io/67zda/) sought to provide 80% power with an alpha level of .05 to detect an increase in R^2 of .03. It also sought to provide 80% power with an alpha of .05 (one-tailed) to test for a zero-order association of $r \geq .15$. These effect sizes allowed us to provide a strong test of the results observed in Study 1b. A power analysis indicated that an N of 270 was required to achieve sufficient power under these conditions and so we recruited participants until the desired N was reached after removing those who met our exclusion criteria. Therefore, a total of 357 participants were recruited from Amazon's Mechanical Turk service. A proportion of participants failed the pre-survey auditory test and were excluded before completing the survey (N=25). We also excluded participants who showed evidence of lack of attention, e.g. using the same response key repeatedly, or chance level performance on at least two of the emotion recognition batteries (N=53). Finally, a small number of participants indicated that they had not completed the survey seriously and were thus excluded (N=6). This resulted in an omission of 84 participants, producing a final sample size of 273 (138 men). Participants gave informed consent and ethical approval was granted by the Royal Holloway Ethics Committee.

Mean age of participants was 38.5 years (SD = 12.2, Range=19-74), and ethnicity was reported as follows: White (n=192), Hispanic (n=18), Asian (n=18), Black (n=36), Native American (n=1), Middle Eastern (n=1), Other (n=6) and Undisclosed (n=1). As with the previous two samples, these participants represent the typical demographic pattern for MTurk samples (Huff & Tingley, 2015).

Stimuli

Facial Emotion Recognition Ability (Face Emot): The same facial emotion battery was used as in Study 1b; i.e. a subset of items from Study 1a taken from the FEEST set (Young et al., 2002). The subset block comprised 15 items (3 items for each basic emotion) that were shown to participants once each. Split-half reliability was r=.55.

Bodily Emotion Recognition Ability**:** Bodily emotional stimuli were taken from the same battery used in Study 1a (Atkinson et al., 2004). In line with the facial and vocal batteries, a subset of these 50 items were piloted in a previous study to ensure suitability for individual differences research, and 15 items with appropriate psychometric properties were selected. This abbreviated battery comprised 15 items (3 items for each basic emotion) shown to participants once. Split-half reliability was r=.67.

Vocal Emotion Recognition Ability: The same vocal stimuli battery was used as in Study 1b (Belin et al., 2008). The battery comprised 15 items (3 items for each basic emotion) presented to participants once. Split-half reliability was r=.63.

Alice Heim 4 Test of General Intelligence (AH4): This same 65-item general intelligence was used as in Studies 1a and 1b.

Toronto Alexithymia Scale (TAS-20): The same 20-item alexithymia measure was used as in Studies 1a and 1b. Cronbach's alpha for our data was good for the total scale (α=.91) and for the Difficulty Identifying Feelings (α=.94) and Difficulty Describing Feelings (α=.83) sub-scales. As with the previous two samples, the alpha for the Externally-Oriented Thinking subscale was relatively low (α=.67).

Procedure

The emotion recognition blocks were first presented to the participant in the same fixed order (voice, face, body), with the within-block presentation order being fully randomised. Stimulus presentation duration and response format were identical to the previous samples. Following the emotion recognition blocks, participants completed as many items on the general intelligence test as they were able to in 10 minutes. Finally, they completed the alexithymia questionnaire. Participants were debriefed following survey completion.

Analysis

The same analyses were conducted as in Studies 1a and 1b, but with one difference. In both Studies 1a and 1b, emotion recognition ability comprised either facial emotion stimuli alone, or a composite supramodal score across two different expressive modalities (faces and bodies in Study 1a; faces and voices in Study 1b). In Study 2, all participants were tested on facial, bodily, and vocal emotion recognition, and therefore, emotion recognition ability was measured as both facial (in line with the previous two samples) and as a supramodal score (derived from facial, vocal, and bodily emotion recognition ability, and intended as a more ecologically generalisable measure). Therefore, each of the following analyses was carried out twice, with either facial or supramodal emotion recognition ability measures, in line with our pre-registered protocol.

Firstly, we assessed the association between our variables of interest, in order to answer our first research question of whether alexithymia is negatively correlated with intelligence and (facial or supramodal) emotion recognition ability. Secondly, hierarchical regression analyses were used to examine the unique associations of general intelligence and emotion recognition ability to alexithymia. As in the previous two samples, we conducted a three-step multiple regression analysis with alexithymia as the dependent variable.

Results

Pre-registered analyses

As seen in Study 1, alexithymia was significantly negatively correlated with both general intelligence (*r*=-.42, *p*<.001) and with facial emotion recognition ability (*r*=-.22, *p*<.001). Facial emotion recognition was significantly positively correlated with general intelligence (*r*=.35, *p*<.001).

A very similar pattern of results was also observed for supramodal emotion recognition ability. Alexithymia was significantly negatively correlated with supramodal emotion recognition ability (*r*=-.35, *p*<.001). Supramodal emotion recognition ability was significantly positively correlated with general intelligence (*r*=.51, *p*<.001).

We next used hierarchical linear regression to test whether general intelligence was a predictor of alexithymia over and above emotion recognition ability (and other variables). In the first of these models, age and sex were entered as predictors of alexithymia in the first step. Neither of these variables reached statistical significance. In the second step, facial emotion recognition ability was entered, which was a significant negative predictor of alexithymia (β=-.20, *p*=.001). In the third step, general intelligence was entered into the model. This variable was a significant predictor of alexithymia (β=-.40, *p*<.001), but facial emotion recognition was then no longer statistically significant. Inclusion of general intelligence in the model significantly improved model fit (R^2 changed from .054 to .191, *p*<.001). The full results of the regression analysis are shown in Table 3.

Table 3: Multiple regressions predicting alexithymia scores from age, sex, facial emotion recognition ability (Face Emot), and general intelligence in Study 2.

	Step 1	Step 2	Step 3

Independent Variables	β	Sig	β	Sig	β	Sig
Age	-.03	.614	-.03	.672	-.03	.576
Sex	-.11	.068	-.08	.209	-.10	.094
Face Emot			**-.20**	**.001**	-.06	.317
General Intelligence					**-.40**	**<.001**

In the second of these models, age and sex were first entered as predictors of alexithymia: the results were of course identical to those above. In the second step, supramodal emotion recognition ability was entered and was observed to be a significant negative predictor of alexithymia (β=-.34, p<.001). In the third step, general intelligence was entered into the model. General intelligence was a significant predictor of alexithymia (β=-.33, p<.001), and supramodal emotion recognition also remained a significant negative predictor (β=-.17, p=.008). The full results of this regression analysis are shown in Table 4.

Table 4: Multiple regressions predicting alexithymia scores from age, sex, supramodal emotion recognition ability (Supra Emot), and general intelligence in Study 2.

	Step 1		**Step 2**		**Step 3**	
Independent Variables	**β**	**Sig**	**β**	**Sig**	**β**	**Sig**
Age	-.03	.614	-.05	.391	-.04	.449
Sex	-.11	.068	-.06	.324	-.08	.156
Supra Emot			**-.34**	**<.001**	**-.17**	**.008**
General Intelligence					**-.33**	**<.001**

Of additional note, in contrast to Studies 1a and 1b, *face* emotion recognition ability did not show a significant unique association with alexithymia (i.e. independent of general intelligence) (Step 3 in Table 3). However, *supramodal* emotion recognition ability did show a significant unique relationship with alexithymia (i.e. independent of general intelligence) (Step 3 in Table 4).

Subsidiary Exploratory Analyses

As an exploratory step to complement the pre-registered analyses, we examined the correlations between general intelligence and the three alexithymia subscales across all three of our sets of data.

In Study 1a, only the Externally Oriented Thinking (EOT) subscale showed a significant negative association with intelligence: r=-.13, p=.014). Neither the Difficulty Identifying Feelings (DIF) nor the Difficulty Describing Feelings (DDF) subscales showed significant associations with intelligence (DIF: r=-.09, p=.077; DDF: r=-.06, p=.251). In Study 1b, all three of the subscales were significantly and negatively associated with intelligence (DIF: r=-.38, p<.001; DDF: r=-.25, p<.001; EOT: r=-.26, p<.001).

In Study 2, all three of the alexithymia subscales were significantly and negatively correlated with intelligence (DIF: r=-.38, p<.001; DDF: r=-.31, p<.001; EOT: r=-.34, p<.001). The results from across the three samples therefore suggest that the association between total alexithymia score and general intelligence is not being solely driven by any particularly cognitively oriented items, for example, those in the Externally Oriented Thinking subscale.

Secondly, in light of an interesting recently proposed perspective, involving the idea of verbal difficulty giving rise to the alexithymia construct, we carried out some exploratory post-hoc analyses that were also not included in our original pre-registration plan. Hobson and colleagues (2019) recently proposed the alexithymia-language hypothesis positing that verbal impairment may be one of several mechanisms underpinning the aetiology of the alexithymic phenotype. This idea arose from the finding that language processes are widely considered to contribute to typical emotional development (Ornaghi & Grazzani, 2013). Indeed, Hobson et al. (2019) report evidence from clinical populations in which early speech and language difficulties are associated with emotion processing difficulties in later life, for example in deaf or autistic children, and cite alexithymia as a key mediator between linguistic and emotional capabilities (Hobson, Brewer, Catmur, & Bird, 2019).

Since our measure of general intelligence included both verbal and nonverbal components, we sought to provide a test of this alexithymia-language hypothesis by assessing whether the verbal intelligence sub-score was more predictive of alexithymia than nonverbal intelligence. In Study 1a, the correlations between the verbal and nonverbal components with alexithymia were -.11 (p=.039) and -.11 (p=.028), respectively, which did not differ significantly from each other (p=.50). In Study 1b, the correlations between the verbal and nonverbal components with alexithymia were -.40 (p<.001) and -.33 (p<.001), respectively, which did significantly differ from each other (p=.023). In Study 2, the correlations between the verbal and nonverbal components with alexithymia were -.43 (p<.001) and -.37 (p<.001), respectively, and whilst these did not statistically differ from each other (p=.053), interpreting p values close to the nominal threshold should be done with caution. Overall, then, these results suggest that alexithymia is associated with general intelligence and that this association is not driven by a specific relationship with verbal intelligence. However, we discuss this interpretation in more depth below.

General Discussion

The construct of alexithymia as an impairment in emotional understanding has been studied in some depth, especially in clinical populations. To date, however, little work has examined the relation of alexithymia to broader cognitive abilities. In the current study, across three independent samples, we consistently observed a significant negative association between alexithymia and general intelligence, and the magnitude of this association was moderate-to-large in two of our three samples.

Regarding the question of whether alexithymia and intelligence have an independent association, over and above the effects of emotion recognition ability, the results were somewhat more mixed. However, on the balance of evidence – that is, the results from Study 1b and our pre-registered Study 2 – we conclude that general intelligence is uniquely associated with alexithymia, over and above emotion recognition ability. This finding is important because it indicates that the psychological footprint of alexithymia extends beyond affect/emotion-relevant processes and abilities, and that a full understanding of individual differences in alexithymia will likely require including a role for general intelligence.

We also observed a consistent link between emotion recognition ability and alexithymia independent of general intelligence (although in Study 2 this link was only evident for supramodal emotion recognition ability). This result is important because it indicates that the link between emotion recognition ability and alexithymia is not explained away by their common links to general intelligence, and thus the alexithymia construct appears to reflect cognitive ability across (at least) two levels of abstraction, enriching our understanding of this trait.

In addition to our core research questions, data from the current study enabled us also to test a recent hypothesis in the literature that posited a specific link between verbal intelligence and alexithymia (Hobson et al., 2019). Across the three samples, we observed relatively limited evidence in favour of this hypothesis. In Study 1a, we observed a nominally significant difference between the verbal and non-verbal associations with alexithymia in the predicted direction. In Study 1b, we did not see this difference. In Study 2, we observed a 'marginally' significant difference in the predicted direction. These mixed results, along with the modest observed effect sizes, indicate that verbal intelligence does not seem to be a special relative of alexithymia, in contrast to the model proposed by Hobson et al. (2019).

What might underlie the observed association between alexithymia and general intelligence? There are several proposed aetiologies of alexithymia, one of them concerning difficulties in evaluating an emotional response, as posited by the attention-appraisal model (Preece et al., 2017). In this model, it is proposed that alexithymic individuals have under-developed emotion schemas, and as such, they experience an emotional response but do not attend to it or evaluate it appropriately, leading to difficulties such as poor emotional regulation. Given that the development of emotion schemas depends on sufficient cognitive development (Izard, 2011), it is plausible that poor development of cognitive structures may underlie the difficulties in both emotion recognition and general intelligence. For example, if an individual is poor at evaluating complex information, this would have an adverse effect on their general cognitive ability and their recognition of emotional stimuli.

Our findings have some practical implications for examining alexithymia in clinical disorders that are known to show an association with general intelligence, including schizophrenia (Fett, Viechtbauer, Penn, van Os, & Krabbendam, 2011) and depression (Marazziti, Consoli, Picchetti, Carlini, & Faravelli, 2010). In these populations, what may appear to be alexithymic traits may actually reflect deficits in broader cognitive ability, and given the associations reported here, it will be important in future to adjust for general intelligence to eliminate this potential confound.

Some potential limitations of the current work require mention. Firstly, the studies reported here were carried out online on a commonly used data collection platform: Amazon's Mechanical Turk (MTurk). Although there have been concerns raised about the quality of online data, other studies have suggested that they provide reliable, replicable results in a cost- and time-efficient way (Miller, Crowe, Weiss, Maples-Keller, & Lynam, 2017). Indeed, there may be benefits to online testing over traditional lab-based student samples; for example larger, more diverse samples that are more representative of the general US population and who have high internal motivation to respond honestly and accurately (Gosling, Vazire, Srivastava, & John, 2004). Our choice of the MTurk platform is bolstered by the extensive use of it in previous work (e.g. Ramsey, Thompson, McKenzie, & Rosenbaum, 2016; Mortensen & Hughes, 2018). That said, it will likely be of value to extend these findings to broader populations to ensure replicability and generalisability.

Secondly, we have observed that the alexithymia construct extends beyond emotion abilities. However, alexithymia may not reflect general intelligence at the broad level examined here but perhaps instead at a more intermediary level somewhere in between emotion recognition ability and general intelligence, such as meta-cognitive awareness. Although this perspective does not invalidate our core argument – namely, that alexithymia clearly extends beyond the emotion sphere itself - further work will now be required to examine this possibility and thus further refine our understanding of the alexithymia construct.

Finally, future work should build on the association we report by including a measure of mood. Recent factor analytic evidence suggests that some of the variance of the DIF subscale of the TAS-20 captures an individual's distress level (and some captures their alexithymia) (Preece et al., 2020). Given also that there exists an association between cognitive ability and depression (Rock, Roiser, Riedel, & Blackwell, 2014), it would be appropriate to adjust for a measure of negative affect to assess if and how the association between alexithymia and intelligence changes with the inclusion of this potential confound.

Conclusion

In summary, across three independent healthy samples, we observed significant negative associations between alexithymia and general intelligence. Importantly, in two of the samples, intelligence was a significant predictor of alexithymia even after adjusting for emotion recognition ability. These results suggest that to achieve a full understanding of the alexithymia construct, theorists will need to engage with broader cognitive abilities and processes.

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Table 1: Multiple regressions predicting alexithymia scores from age, sex, facial emotion recognition ability (Face Emot), and general intelligence in Study 1a.

	Step 1		Step 2		Step 3	
Independent Variables	**β**	**Sig**	**β**	**Sig**	**β**	**Sig**
Age	-.08	.119	-.05	.302	-.05	.285
Sex	.09	.068	.04	.439	.04	.413
Face Emot			**-.27**	**<.001**	**-.26**	**<.001**
General Intelligence					-.03	.560

Table 2: Multiple regressions predicting alexithymia scores from age, sex, facial emotion recognition ability (Face Emot), and general intelligence in Study 1b.

	Step 1		**Step 2**		**Step 3**	
Independent Variables	**β**	**Sig**	**β**	**Sig**	**β**	**Sig**
Age	**-.11**	**.046**	**-.12**	**.031**	-.10	.059
Sex	-.10	.081	-.04	.513	-.04	.406
Face Emot			**-.34**	**<.001**	**-.23**	**<.001**
General Intelligence					**-.29**	**<.001**

Table 3: Multiple regressions predicting alexithymia scores from age, sex, facial emotion recognition ability (Face Emot), and general intelligence in Study 2.

	Step 1		Step 2		Step 3	
Independent Variables	**β**	**Sig**	**β**	**Sig**	**β**	**Sig**
Age	-.03	.614	-.03	.672	-.03	.576
Sex	-.11	.068	-.08	.209	-.10	.094
Face Emot			**-.20**	**.001**	-.06	.317
General Intelligence					**-.40**	**<.001**

Table 4: Multiple regressions predicting alexithymia scores from age, sex, supramodal emotion recognition ability (Supra Emot), and general intelligence in Study 2.

	Step 1		Step 2		Step 3	
Independent Variables	**β**	**Sig**	**β**	**Sig**	**β**	**Sig**
Age	-.03	.614	-.05	.391	-.04	.449
Sex	-.11	.068	-.06	.324	-.08	.156
Supra Emot			**-.34**	**<.001**	**-.17**	**.008**
General Intelligence					**-.33**	**<.001**