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Corresponding Author: Hannah M. Hobson, Department of Psychology, Social Work & Counselling, University of Greenwich, Park Row, London SE10 9LS

Email: h.hobson@greenwich.ac.uk

Title: The role of language in alexithymia: moving towards a multi-route model of alexithymia

Authors: Hannah Hobson[1], Rebecca Brewer[2], Caroline Catmur[3], Geoffrey Bird[4,5]

[1] Department of Psychology, Social Work & Counselling, University of Greenwich, Park Row, London SE10 9LS. Email: h.hobson@greenwich.ac.uk

[2] Department of Psychology, Royal Holloway University of London, Egham, Surrey, TW20 0EX. Email: rebecca.brewer@rhul.ac.uk

[3] Department of Psychology, Institute of Psychology, Psychiatry and Neuroscience, King's College London, De Crespigny Park, London, SE5 8AF. Email: caroline.catmur@kcl.ac.uk

[4] Department of Experimental Psychology, University of Oxford, 15 Parks Rd, Oxford, OX1 3PH. Email: geoff.bird@psy.ox.ac.uk

[5] Social, Genetic and Developmental Psychiatry Centre, Institute of Psychiatry, Psychology and Neuroscience, King's College London, De Crespigny Park Rd, London, SE5 8AF.

Abstract

Alexithymia is characterised by difficulty identifying and describing one's own emotion. Identifying and describing one's emotion involves several cognitive processes, so alexithymia may result from a number of impairments. Here we propose the *alexithymia language hypothesis* - the hypothesis that language impairment can give rise to alexithymia - and critically review relevant evidence from healthy populations, developmental disorders, adult-onset illness and acquired brain injury. We conclude that the available evidence is supportive of the alexithymia-language hypothesis, and therefore that language impairment may represent one of multiple routes to alexithymia. Where evidence is lacking, we outline which approaches will be useful in testing this hypothesis.

Keywords: Alexithymia; Emotion development; Emotion recognition; Language.

The role of language in alexithymia: moving towards a multi-route model of alexithymia

Alexithymia is characterised by difficulties identifying and describing one's emotions, and a tendency towards externally oriented thinking (Nemiah, Freyberger, & Sifneos, 1976). Research has demonstrated the negative impact of alexithymia across a broad range of cognitive domains, in both typical and clinical populations, including decision making (Kano, Ito, & Fukudo, 2011), recognition of emotional facial expressions (Brewer, Cook, Cardi, Treasure, & Bird, 2015; Cook, Brewer, Shah, & Bird, 2013; Grynberg et al., 2012), empathy (Grynberg, Luminet, Corneille, Grèzes, & Berthoz, 2010), moral judgements (Patil, Melsbach, Hennig-fast, & Silani, 2016; Patil & Silani, 2014a, 2014b), reward processing (Foulkes, Bird, Gökçen, McCrory, & Viding, 2015) and pro-social behavior (FeldmanHall, Dalgleish, & Mobbs, 2013). While alexithymia severity varies in the general population, it is elevated in multiple psychiatric conditions, including schizophrenia, autism spectrum disorder, substance and alcohol abuse, and feeding and eating disorders, as well as in neurodegenerative disorders and populations with traumatic brain injury (Berthoz & Hill, 2005; Henry, Phillips, Crawford, Theodorou, & Summers, 2006; Pinard, Negrete, Annable, & Audet, 1996; Schmidt, Jiwany, & Treasure, 1993; Sturm & Levenson, 2011; Thorberg, Young, Sullivan, & Lyvers, 2009; van 't Wout, Aleman, Bermond, & Kahn, 2007). Additionally, alexithymia is associated with emotion regulation impairment, increased risk of self-harm, and poorer therapy outcomes for some forms of psychological interventions (Norman & Borrill, 2015; Ogrodniczuk, Piper, & Joyce, 2011; Pandey, Saxena, & Dubey, 2011).

Understanding the causes of alexithymia therefore has clear implications for theories of emotion, decision-making and social cognition, and practical applications for mental health services. Work is beginning to address which cognitive processes are necessary in order to identify and describe one's own emotions, and therefore which cognitive impairments may give rise to alexithymia. Much research has focused on interoception (the perception and recognition of the internal state of one's body; Craig, 2002, 2003, 2009). Nonetheless, the impairments associated with alexithymia are complex and high-level skills that presumably rely on, and interact with, a number of cognitive processes. The interoception hypothesis presents one account of how deficits in one cognitive process - interoception - may impact on the ability to identify one's emotions. However, there are likely multiple cognitive routes to alexithymia, which may exist independently of each other, or interact with each other.

The current paper proposes that language impairment may contribute to alexithymia. At first glance, the role of language in alexithymia seems obvious, and even tautological. Alexithymia literally translates from Greek as "lack of words for emotion", and a core element of alexithymia is a difficulty expressing (including talking about) emotions. However, there are deeper theoretical reasons to expect language to contribute to alexithymia, beyond this superficial overlap. Most, if not all, theories of emotions posit that language processes contribute to emotion processes, though the nature of this contribution varies between nativist and constructivist theories. According to constructionist theories, language processes may drive the categorization of emotional experience, and emotion words act as key components in children's development of emotion concepts (see Lindquist, MacCormack, & Shablack, 2015). From a nativist

viewpoint, while emotion categories are innately specified, language still plays an influential role in the development of emotion schemas, emotional decision making and regulation (Izard, 2007b; see section "A role for language in theories of emotion" below).

A recent review by Welding and Samur (2018) has highlighted the abnormalities in emotion-related language in alexithymia. However, in order to examine whether alexithymia arises due to broader language-related deficits, it is crucial to examine performance on non-emotional language tasks. If alexithymia is unrelated to language, other linguistic processes should be unaffected. In contrast, abnormalities in non-emotional language would suggest a broader underlying linguistic deficit.

Despite the hypothesized link between language and emotion processing, there has been very limited study of language abilities in alexithymia. This may be due to the finding that those with alexithymia are impaired on emotion recognition tasks that are non-verbal in design, suggesting that impairments are not limited to the language domain (Lane et al., 1996). However, this argument ignores the potential role of language in the initial development of emotional understanding. Furthermore, even tasks that do not include verbal stimuli or require verbal responses can be affected by language abilities. For example, acquired language impairment affects putatively "non-verbal" tasks: in a large group of individuals with acquired aphasia, language impairment influenced performance on picture-based reasoning tasks usually described as capturing "non-verbal IQ" (Baldo, Paulraj, Curran, & Dronkers, 2015). Indeed, it has been argued that "There is no such thing as 'nonverbal' ability—only abilities that are expressed nonverbally" (McGrew and Flanagan, 1998, p. 25).

Aims and scope

The aim of this review is to provide an overview of the existing evidence relevant to the *alexithymia-language hypothesis*, which suggests that language deficits contribute to increased alexithymia. While previous reviews have described *emotion-related* language abnormalities in alexithymia (Welding & Samur, 2018), the current article examines evidence for problems in language beyond simply emotion-related language, with the aim of ascertaining whether language problems might provide a causative explanation for alexithymia.

First, we introduce the *alexithymia-interoception hypothesis*. Under this 'multiple routes to alexithymia' model, we predict that some populations may have alexithymia due to interoceptive impairment, while other populations may have alexithymia due a language problem. We then establish the theoretical basis for the role of language in emotion in more depth, under both nativist and constructionist perspectives. This is not a full review of theories of emotion, but is used to demonstrate that language impairment is expected to affect emotion processing under most, if not all, theoretical perspectives. We then address the challenges surrounding the contribution of language skills to the measurement of alexithymia.

We then review the available evidence relevant to the alexithymia-language hypothesis, from typical adults and patient populations with late-occurring or neurodegenerative conditions, respectively. We also outline why the hypothesis of a link between alexithymia and language impairment should be investigated with developmental groups, particularly in developmental language disorder (DLD) and

children with language difficulties acquired as a result of hearing loss. Where direct evidence is currently lacking, we outline why a link would be expected in these populations, and why gathering direct evidence of alexithymia in these groups is of theoretical importance.

Given the growing evidence relating interoception to alexithymia, we outline a theoretical model of how language impairment and/or interoceptive deficits may give rise to alexithymia. We suggest that interoception and language may play distinct, but potentially interacting, roles in the development of alexithymia, and that the contribution of each may vary across clinical and developmental populations. Further challenges that should be addressed and avenues for future research are then discussed.

For clarity, it is worth noting other constructs that are closely related to, or overlap with, alexithymia. These include emotion differentiation/granularity, and emotional awareness. Emotional granularity (often referred to interchangeably as emotional differentiation; see Smidt & Suvak, 2015) describes the extent to which an individual can distinguish between emotional states (Barrett, 2004). A simple definition of emotional awareness is the conscious experience of emotions (Gu, Hof, Friston & Fan, 2013). One could consider alexithymia to represent a trait, while other constructs may be thought of as more specific abilities, which are negatively associated with the broader trait of alexithymia: i.e. in cases of high alexithymia, there is lower emotional granularity and emotional awareness. This paper focuses on alexithymia, but many of the arguments made for the role of language in alexithymia could be applied to the more narrowly-defined constructs of emotional granularity and awareness.

In addition, while the definition of alexithymia pertains to a difficulty processing one's own emotions, there have been several other sociocognitive difficulties and demonstrated to be (moderately or strongly) associated with alexithymia (Grynberg, Berthoz & Bird, 2018). These include interpersonal difficulties, particularly decreased empathy (Grynberg, etal., 2010), poor emotion regulation (Pandey et al., 2011), poor mental health, difficulties recognizing others' emotions (Brewer et al., 2015; Cook, et al., 2013; Grynberg et al., 2012), and increased somatization (De Gucht & Heiser, 2003; Mattila et al., 2008). These problems in and of themselves are not definitive markers for alexithymia. However, in the absence of direct investigation of alexithymia in a given population, the presence of such problems make it plausible that levels of alexithymia are increased. As a consequence, this work should be considered both as a review of the available research, and as an opinion piece that advances a specific hypothesis and the ways in which it might be tested.

Interoception and alexithymia

Contemporary theories suggest that alexithymia may be, at least in part, a consequence of a primary deficit in interoception, the ability to perceive and recognize internal body states, including signals of fatigue, hunger, thirst, heart rate, respiratory effort, and pain (Brewer, Cook, & Bird, 2016; Herbert, Herbert, & Pollatos, 2011; Murphy, Brewer, Catmur, & Bird, 2017; Murphy, Brewer, Hobson, Catmur, & Bird, 2018; Pollatos, Kirsch, & Schandry, 2005; Wiens, 2005). Thus, individuals who struggle to identify their own emotions may also struggle to detect and distinguish non-emotional interoceptive states, such as thirst, hunger and tiredness. Indeed, individuals with alexithymia are objectively worse at perceiving their own heartbeat (Herbert et al., 2011;

Shah, Hall, Catmur, & Bird, 2016), muscular effort and taste (Murphy, Catmur, & Bird, 2018), are less likely to rely on interoceptive cues to gauge respiratory effort (Murphy et al., 2018). They also report difficulties recognising interoceptive cues associated with a broad range of internal states (Brewer et al., 2016; Longarzo et al., 2015). Individuals with alexithymia also report difficulties differentiating between emotion-related and non-emotion-related interoceptive signals (Brewer et al., 2016). Relatedly, alexithymia is associated with increased somatising and unexplained medical symptoms (e.g. De Gucht & Heiser, 2003; Mattila et al., 2008), theorised to be due to misinterpretation of benign interoceptive signals as troubling medical symptoms (Larsen, Brand, Bermond, & Hijman, 2003; Taylor, Bagby, & Parker, 1991). Indeed, the links between somatisation and alexithymia extend back to the very conception of alexithymia in the 1970s (Sifneos, 1973). In addition to behavioural work suggesting a link between interoception and alexithymia, neuroimaging and lesion studies indicate that alexithymia is associated with functional and structural abnormalities or damage to cortical areas involved in interoception, in particular the anterior insula and anterior cingulate cortex (Bush, Luu, & Posner, 2000; Goerlich-Dobre, Bruce, Martens, Aleman, & Hooker, 2014; Gu et al., 2012; Hogeveen, Bird, Chau, Krueger, & Grafman, 2016; Ihme et al., 2013; Moriguchi et al., 2007; Silani et al., 2008).

Furthermore, a number of the conditions that are characterised by an increased prevalence of alexithymia also show abnormalities in interoception. Objective impairments in interoception in clinical groups have been demonstrated using widely-used cardiac measures of interoception, such as the heartbeat tracking and heartbeat discrimination tasks (in anxiety and panic disorder; Ehlers & Breuer, 1992; Paulus &

Stein, 2010; Yoris et al., 2015; in alcohol and substance abuse; Naqvi & Bechara, 2010; Paulus & Stewart, 2014; Paulus, Tapert, & Schulteis, 2009; Verdejo-Garcia, Clark, & Dunn, 2012; in depression; Dunn, Dalgleish, Ogilvie, & Lawrence, 2007; Harshaw, 2015; Pollatos, Traut-Mattausch, & Schandry, 2009; in somatoform disorders; Schaefer, Egloff, & Witthöft, 2012; in autism; Garfinkel, Tiley, et al., 2016; Shah et al., 2016; in OCD; Lazarov, Dar, Oded, & Liberman, 2010; Stern, 2014; in eating disorders; Klabunde, Acheson, Boutelle, Matthews, & Kaye, 2013; and in schizophrenia; Ardizzi et al., 2016). In addition, other evidence highlights unusual interoception in clinical conditions. For example, patients with eating disorders atypical neural responses during the perception of hunger and satiety signals (Santel, Baving, Krauel, Münte, & Rotte, 2006). According to care-giver reports and free-feeding observations, patients with frontotemporal dementia show a disturbance in their food preferences and satiety levels (Ikeda, Brown, Holland, Fukuhara, & Hodges, 2002; Woolley et al., 2007). Substance and alcohol abuse is related to reduced sensitivity to reward signals and poor awareness of intoxication levels (for a review, see Volkow, Wang, Fowler, Tomasi, & Baler, 2010).

In sum, there is compelling evidence for the role on interoception in the development of alexithymia. Nonetheless, it seems improbable that all cases of alexithymia will be able to be reduced to an impairment in interoception, or that an interoceptive difficulty can account for all clinical populations in which alexithymia is elevated. Interoception has long been considered to be necessary for emotion (Darwin, 1965; Gendron & Barrett, 2009; James, 1894; Lange, 1885), but language is also considered to underpin emotion processing (although the precise role of language is a

matter of debate). In the following section, we outline why a language impairment may be affect emotion processing, and ultimately result in alexithymia.

A role for language in theories of emotion

Over the decades, many different theories of emotion have been proposed (see Brosch, Portois & Sander, 2010, and Moors, 2009, for comprehensive reviews of theories of emotion). While there are numerous ways of categorizing this broad spectrum of theories, one approach is to place these theories on a continuum anchored by nativist theories at one extreme and constructionist theories at the other. Both types of theory ascribe some role for language in the development of emotion processes, although they differ in the extent to which language is considered "foundational" for emotion categorization (see Sauter, 2018, for a recent discussion).

Nativist theories of emotion, such as Differential Emotion Theory (DET), argue that certain discrete emotion categories ("basic emotions") are innate, having evolved for their adaptive value (Ekman, 1992; Izard, 2007a, 2009). These categories cannot be created, taught, or learned via cognitive processes. Even so, language is still afforded a central role in emotion-related processes within nativist theories: while language may not have a role in the ontogeny of basic emotions themselves, theories such as DET argue that language is crucial in the development of emotion schemas, which involve emotion interacting dynamically with perception and cognitive processes. Emotion schema development is considered important, as dysfunctional connections between emotion, cognition and action are thought to lead to psychopathology (Izard, Youngstrom, Fine, Mostow, & Trentacosta, 2006). Furthermore, recent reviews that outline evidence against

linguistic relativity of emotions still acknowledge a role for language in later-occurring cognitive processes central to emotion. For example, Sauter (2018) suggests that verbal processes may affect decision-making during emotion categorization, even if the categories themselves are not the product of linguistic processes.

At the other end of the spectrum, constructionist accounts such as Conceptual Act Theory (CAT) (Barrett, 2006), or the circumplex model of affect (Posner, Russell & Peterson, 2005), suggest that the "natural kinds" of emotion proposed by nativist accounts do not exist. Rather, discrete emotion categories are the result of conceptual processes acting on underlying dimensional, non-specific affect. Emotion categories are not considered to be pre-destined by evolution but rather to emerge, dependent upon culture and development.

Accounts such as CAT do not argue that the structure of individuals' emotional experiences is wholly determined by linguistic factors. Rather, language is one of many factors that contribute to emotional development. One proposed mechanism by which this occurs is that emotion words support the acquisition of conceptual knowledge, just as labels support category acquisition and the development of conceptual knowledge in other domains (for instance, in learning abstract spatial relations between objects; see Casasola, 2005. See also Althaus & Mareschal, 2014; Plunkett, Hu, & Cohen, 2008). For example, a child may hear the word "angry" in several scenarios, which have little perceptually in common: they may witness a friend get "angry" at the theft of a toy, they may be told their caregiver is "angry" at them, or their own behavior may be labeled as "angry" during a tantrum. The phonological form "angry" links together these perceptual and behavioral experiences of a child's own and other people's anger, in a variety of

scenarios (see Lindquist et al., 2015). Emotion words thus act as a catalyst in developing acquired equivalence between category members. In support of this position, children's use of emotion words correlates with behavioral performance in categorising emotions; children's increased production of different emotion labels during free labeling corresponds with increasingly differentiated and adult-like categorical perception of emotional facial expressions (Widen & Russell, 2003, 2008), and the presence of emotion labels facilitates the categorisation of emotions in childhood (a label superiority effect; Russell & Widen, 2002).

In addition to this developmental evidence, it has been suggested that language continues to contribute to emotion processes in adulthood (Lindquist, 2017). It is argued that cues to another's emotional state (e.g. a person's facial expression) are variable and ambiguous, and that verbal labels act to reduce this ambiguity and therefore assist in efficient processing of emotion information (Barrett, Lindquist, & Gendron, 2007; Lindquist, Barrett, Bliss-Moreau, & Russell, 2006; see also Lindquist, Satpute & Gendron, 2015, for a review).

Clearly, under either account, language plays an important role in emotion processes, and language difficulties would be predicted to disrupt emotional abilities. According to constructionist accounts, a language deficit may prevent or delay the development of conceptual categories for labeling one's core affect, and negate the advantageous contextual effects on emotion recognition provided by emotion language in adulthood (Lindquist et al., 2006). Within nativist models, a language deficit would leave the innately-endowed discrete basic emotions untouched, but could lead to abnormal emotion schemas, leading to poor recognition of one's own emotions, and emotion

regulation difficulties. The notion that alexithymia could be a product of language deficits is therefore in keeping with both nativist and constructionist approaches; the alexithymia-language hypothesis does not depend on the adoption of any particular theory of emotion.

The measurement of alexithymia

One requirement for research examining the relationship between language ability and alexithymia is the careful consideration of how alexithymia should be measured. Alexithymia is usually assessed via self-report questionnaires, which may be problematic (Gaigg, Cornell & Bird, 2016). Potential issues with self-report measures are not limited to those with language problems. Even for those without language difficulties, highly alexithymic individuals may lack insight into their emotion-specific difficulties, causing individuals with alexithymia to fail to identify and report their own deficits. Furthermore, it is also possible that those with low alexithymia rate their levels of alexithymia as high, due to low self-esteem or a positively-biased representation of others' abilities.

In addition to these general concerns, the current self-report measures for alexithymia may be particularly problematic for language-impaired samples. First, for individuals with pronounced language difficulties, self-report data may be inaccurate unless questionnaires have limited language demands. Second, there is conceptual overlap between language and emotional problems in some questionnaire items. For example, the Toronto Alexithymia Scale's "Difficulty Describing Feelings" subscale includes items such as "It is difficult for me to the find the right words for my feelings", and (the reverse-coded) "I am able to describe my feelings easily" (Taylor et al., 1988).

Control items that assess how easily an individual finds it to describe other, non-emotional things, or to find other classes of words, would reduce this issue, but are currently not assessed by self-report alexithymia measures.

In some cases, measurement issues may be overcome by gathering multiple sources of information about alexithymia, including parent- or observer-report, but these approaches come with their own additional considerations. First, developmental language impairments have been shown to run in families (Bishop, 2006). Thus it is possible that parents of children with language impairment also have some language or literacy difficulties. Second, self-report and observer-report measures of alexithymia do not always agree (e.g. Griffin, Lombardo, & Auyeung, 2016). Discrepancies could arise for multiple reasons; some individuals with alexithymia may lack the metacognitive ability and insight into their own impairments to rate themselves as having alexithymia, while these problems may be readily apparent to close relatives. Alternatively, given that individuals with alexithymia produce fewer emotional facial expressions, find expressing emotions harder and less beneficial, and have more interpersonal problems (Loiselle & Dawson, 1988; Lumley, 2004; Spitzer, Siebel-Jürges, Barnow, Grabe, & Freyberger, 2005; Trevisan et al., 2016), parents or partners may lack insight into the emotional abilities of the child or spouse.

Despite these concerns, self-report measures of alexithymia are highly predictive of emotional abilities (Lumley, Neely, & Burger, 2007), suggesting that many individuals with alexithymia do have good insight into their difficulties. It may be the case that self-report measures are more appropriate for some individuals than others. Those with particularly severe language or interoceptive difficulties, for example, may struggle to

recognize and report alexithymic tendencies. The development of objective tests for alexithymia is therefore a clear priority for such research with these populations. One possibility is that explored by Gaigg et al. (2016); participants' galvanic skin response (GSR) was monitored while participants viewed emotion-inducing stimuli and rated their emotional response along a simple scale. Correlations between participants' GSR and emotional ratings were strongly associated with self-reported alexithymia (r = -.57), suggesting that the discrepancy between physiological responses and emotional ratings might provide an alternative measure of alexithymia that is less demanding of verbal skills than self-report questionnaires.

In summary, measurement of alexithymia in language-impaired samples currently poses a challenge. Potential solutions include: routinely including control items in self-report measures that capture broader linguistic difficulties; gathering observer-report alexithymia measures as well as participants' self-report; and the development and validation of tests that do not rely on self-report.

Existing Evidence for the alexithymia-language hypothesis: Language and alexithymia in non-clinical adult samples

Although alexithymia is thought to be a dimensional trait, individuals who score above a clinically-significant cut-off on measures such as the Toronto Alexithymia Scale (Taylor et al., 1988) are considered to be alexithymic, and constitute approximately 8-10% of the general population in Western samples (Franz et al., 2008; Linden, Wen, & Paulhus, 1995; Salminen, Saarijärvi, Äärelä, Toikka, & Kauhanen, 1999). While few in

number, studies on language abilities in relation to alexithymia in typical adults have been conducted.

Several studies report that individuals with alexithymia produce fewer emotion-related words than those without (Luminet, Rime, Bagby, & Taylor, 2004; Roedema & Simons, 1999; Wotschack & Klann-Delius, 2013), although only one study has measured the production of other word categories. This is important, as reduced expression of emotion may reflect the fact that those with alexithymia are generally less verbally expressive than those without, rather than specifically less expressive about emotion. The available evidence supports a general reduction in expressivity; individuals with alexithymia are also more likely to not respond to non-emotional stimuli. In two studies the difference in the absolute number of emotion words produced by those with alexithymia can be accounted for statistically by their total word production (Roedema & Simons, 1999; Wotschack & Klann-Delius, 2013). Where differences in the proportion of emotion words (rather than just absolute number of emotion words produced) have been found (Luminet et al., 2004), there may nonetheless be other word categories with reduced expressivity. Emotion words represent a class of abstract words, which are typically acquired later and show evidence of slower processing than concrete words (Schwanenflugel, 1991). Alexithymia may be associated with reduced use of abstract words in general, rather than emotion words specifically, but differences in use of abstract words would not be apparent from the coding of the data used in studies thus far.

Evidence for a relationship between verbal IQ and alexithymia also suggests that verbal abilities may have a mediating role in the association between alexithymia and poor performance on emotion-related tasks. Significantly lower verbal IQ scores have

been reported in those with alexithymia, compared to control participants, and controlling for verbal IQ reduced the effect of alexithymia on processing of emotional facial expressions to non-significance in some cases (Hsing, Mohr, Stansfield, & Preston, 2013; Montebarocci, Surcinelli, Rossi, & Baldaro, 2011; see review by Grynberg et al., 2012). Weaker verbal IQ may reflect abnormalities in language skills, such as vocabulary, syntactical skills, verbal reasoning, receptive or expressive abilities. However, as no studies have examined the association between alexithymia and specific structural language abilities in the general population, the exact nature of this verbal weakness in alexithymia remains unclear.

Existing evidence for the alexithymia-language hypothesis: Acquired brain injury and adult-onset neurodegenerative conditions

The alexithymia-language hypothesis would predict that emotion processes would be detrimentally affected by acquired language disorders. Studying groups such as those who have acquired brain injuries or neurodegenerative conditions may elucidate the biological basis of alexithymia, specifically the potential role of brain regions thought to support language. Furthermore, evidence from adult populations, with presumably typical language and emotional development until the onset of illness or brain trauma, may reveal the role of language processes "online" in emotion tasks. That is, if language only plays a role in alexithymia during the *acquisition* of emotion concepts and knowledge – and language is no longer necessary to support emotion processing once this knowledge has been acquired – then an acquired language impairment may leave conceptual knowledge or emotion schemas intact. If, however, language processes continue to

contribute to emotion processing, then even late-acquired deficits in language should disrupt emotional processes and lead to alexithymia.

A straightforward prediction of the alexithymia-language hypothesis would be that aphasia following stroke, in which key language regions suffer damage leading to lasting language impairment, would result in impaired emotion processes. Specifically, there should be more severe alexithymia in aphasic compared to non-aphasic stroke survivors. Although alexithymia has been examined in relation to stroke and suggested to be an important factor in the development of post-stroke depression (Hung, Chou, & Su, 2015; Spalletta et al., 2001), no research has examined emotion processing abilities in aphasia following stroke. Instead, patients with aphasic symptoms are commonly excluded from such studies.

Despite the lack of study of alexithymia in aphasia following stroke, other acquired or late-occurring conditions do provide evidence for an association between language and alexithymia. This includes evidence from patients with Traumatic Brain Injury (TBI). In such samples, verbal measures correlate significantly with alexithymia traits, and verbal abilities differ significantly between groups of TBI patients with and without alexithymia (Henry et al., 2006; Wood & Williams, 2007). Data from the large Vietnam Head Injury Study has recently demonstrated that damage to the inferior frontal gyrus, a key language region of the brain, is associated with alexithymia (Hobson et al., 2018). Furthermore, this study demonstrated that patients with naming deficits suffered more severe alexithymia than those with intact naming abilities. This extends findings in the same TBI sample demonstrating a role for the anterior insula, a region considered crucial to interoception, in alexithymia (Hogeveen et al., 2016). Together, these findings

suggest that damage to either interoception-related or language-related brain regions may contribute to alexithymia. However, TBI samples commonly do not have focal lesions, but damage to several areas. Indeed, the proximity of the inferior frontal gyrus to the anterior insula makes it difficult to disentangle the role of language disruption (due to inferior frontal gyrus damage) from interoceptive failure (caused by anterior insula damage).

Where neurodegenerative conditions are concerned, current data from frontotemporal dementia (FTD) suggest that either interoceptive or language impairments may underpin alexithymia. FTD is usually split into behavioural and language subtypes. In the behavioural variant of FTD (bv-FTD), the presenting difficulties at symptom onset are changes in personality, usually including a loss of empathy and emotional blunting. The language variants of FTD include progressive non-fluent aphasia and semantic dementia. In progressive non-fluent aphasia, speech becomes non-fluent, containing grammatical errors, and patients' understanding of complex sentence structures is compromised, although word-level comprehension is usually preserved. In semantic dementia, speech is fluent but there is a loss of semantic knowledge, reflected in word-finding difficulties and poor comprehension of previously known words (Bonner, Ash, & Grossman, 2010). As well as elevated rates of alexithymia (Sturm & Levenson, 2011), patients with FTD exhibit emotional difficulties associated with alexithymia, such as poor recognition of others' emotions from faces and voices (Keane, Calder, Hodges, & Young, 2002), and reduced carer-reported empathy (Eslinger, Moore, Anderson, & Grossman, 2011). These difficulties are considered particularly characteristic of bv-FTD, but

emotion processing problems have been observed in all three FTD subtypes (Kumfor & Piguet, 2012).

While alexithymia in FTD has been reported to be elevated relative to controls (Sturm & Levenson, 2011), there has been no direct comparison of alexithymia between the different FTD subtypes. However, indirect evidence from emotional difficulties associated with alexithymia supports the idea that different cognitive problems may underpin emotional impairments in the different subtypes. Specifically, we propose that emotion impairments are associated with interoceptive abnormalities in bv-FTD, but with language difficutlies in semantic dementia. For example, although facial emotion recognition is impaired in both semantic dementia and bv-FTD, controlling for verbal ability specifically reduces deficits seen in semantic dementia (Miller et al., 2012). Emotion word comprehension is impaired in semantic dementia, and correlates with comprehension of non-emotional abstract words, suggesting poor emotion word performance is driven by broader language disability in semantic dementia. These emotion word deficits are absent in bv-FTD (Hsieh et al., 2012). Conversely, the profile of impairments seen in bv-FTD is more in keeping with an underlying interoceptive cause. Interoceptive atypicalities in bv-FTD have been reported, including reduced responses to pain and temperature, feeding dysregulation and eating despite satiety, and increased sugar cravings (Fletcher et al., 2015; Miller, Darby, Swartz, Yener, & Mena, 1995; Woolley et al., 2007). Furthermore, the anterior insula, a brain region considered key to both interoceptive and emotional processes, has been found to be particularly affected in bv-FTD compared to other FTD subtypes (Rosen et al., 2002; Seeley, 2010). Indeed, insula degeneration has been linked to interoceptive deficits (Woolley et al.,

2007) and emotional deficits (Cerami et al., 2014) in FTD. Taken together, these findings suggest that in semantic dementia, emotion processing impairments may be largely accounted for by patients' language difficulties, while in bv-FTD alexithymia may be associated with a more 'pure' interoception deficit. Drawing together the evidence from TBI patients and language-subtypes of FTD, acquired language disorders appear to affect emotional processes in adulthood. This suggests that linguistic processes are not just required for the development of emotional concepts, but that language continues to contribute to the processing of emotions in adulthood. In addition, the behavioral profiles of other adult populations, such as patients with bv-FTD, highlight the fact that alexithymic difficulties can occur in the apparent absence of a language problem. Collectively, these findings demonstrate that acquired interoceptive and linguistic deficits may each be sufficient to cause increasing levels of alexithymia in adult populations.

Populations of Interest: Language-impairment, hearing-impairment and autism

The alexithymia-language hypothesis predicts that language impairment during development will interfere with the acquisition of typical emotional knowledge and emotional functioning, and thus predicts developmental associations between language and alexithymia, with worse language resulting in more severe alexithymia. Here we consider whether such predictions are borne out by the available developmental evidence, including studies with autistic[1], language-impaired and deaf populations. While there is very little direct evidence relating to the contribution of language impairment to

[1] To respect the wishes of autistic individuals and report the study in line with scientific parlance, we use language preferred by clinical professionals (e.g., 'individuals with autism'), as well as the term 'autistic', a term endorsed by many individuals with ASD (see Kenny et al., 2016).

alexithymia in these populations, the indirect evidence is reviewed here, as these populations are extremely interesting with respect to the alexithymia-language hypothesis and should be important foci for future research. The alexithymia-language hypothesis has clear predictions: if emotional development is dependent upon good language ability, then alexithymic traits should characterize all children with developmental language disorder (DLD) (previously known as Specific Language Impairment). In autistic and deaf populations however, language ability is highly heterogeneous. Therefore, if language impairment results in alexithymia, then one would expect language ability and alexithymia to co-vary in autistic and deaf populations.

Alexithymia *per se* has not been studied directly in language-impaired children, although cohort studies provide evidence for a link between speech and language delays and alexithymia in later life (Karukivi et al., 2012; Kokkonen et al., 2003). Nonetheless, many difficulties common to children with language impairment fit with the notion that these children have alexithymia; children with language impairments show difficulties recognizing facial emotion (Merkenschlager, Amorosa, Kiefl, & Martinius, 2012; Nelson, Welsh, Trup, & Greenberg, 2011), difficulties with emotion regulation (Fujiki, Brinton, & Clarke, 2002) and social difficulties (Mok, Pickles, Durkin, & Conti-Ramsden, 2014; St Clair, Pickles, Durkin, & Conti-Ramsden, 2011), and are at an increased risk for poor mental health outcomes (Beitchman et al., 2001). Thus, the constellation of emotional difficulties reported in DLD is in keeping with higher rates of alexithymia than in the typical population. Indeed, clinicians have suggested that speech and language professionals ought to consider the impact that language deficits may have on children's emotional processing, with explicit reference to alexithymia as a potential explanation for

links between poor language and emotional problems (Way, Yelsma, Van Meter, & Black-Pond, 2007).

Evidence for the role of language in emotion and alexithymia can also be drawn from research with deaf children. Deaf or hearing-impaired populations present an intriguing opportunity to study the relationships between language development and emotion processes. First, while in DLD it is assumed there is some cognitive deficit that underlies the language learning problems, this is not presumed to be the case in deafness. Second, language difficulties are related to early linguistic experience, which varies in the deaf population; there is reduced opportunity for linguistic experience if deaf children are born to hearing families, whereas deaf children born to deaf parents experience rich conversational input through sign language from the start of life. Language delay is a key factor in impaired emotion recognition and empathy in hearing-impaired individuals, and group differences in emotion recognition and empathy between hearing impaired and control groups are removed when verbal ability is controlled for (Dyck, Farrugia, Shochet, & Holmes-Brown, 2004; Netten et al., 2015). There is also evidence, albeit limited, that linguistic input can ameliorate the emotion recognition impairment in this population (see Dyck & Denver, 2003).

Reduced linguistic input for some hearing-impaired children thus leads to language delay, reducing understanding of others' emotions. However, language delay may also affect deaf individuals' ability to recognize and manage their *own* emotions. Indeed, children and adolescents with hearing problems show limited emotion regulation strategies (Rieffe, 2012). No studies have directly examined rates of alexithymia in deaf populations, or the potential role of alexithymia in the emotional processing deficits seen

in this group. The profile of emotional difficulties in deaf individuals, however, make a compelling case for investigating the role of alexithymia in emotional difficulties experienced by some deaf individuals.

The population that has received the greatest research interest in terms of alexithymia is that of individuals with autism spectrum disorder (henceforth autism). The prevalence of alexithymia in autism is estimated to be around 50% (Berthoz, Lalanne, Crane, & Hill, 2013; Hill, Berthoz, & Frith, 2004). Autism and alexithymia are thus distinct but commonly co-occurring. Previous inconsistent findings regarding emotional deficits in autism, including difficulties with emotion recognition and empathy, may be related to the high but not universal co-occurrence of alexithymia and autism (Bird & Cook, 2013; Bird et al., 2010; Brewer, Happe, Cook, & Bird, 2015; Cook et al., 2013; Oakley, Brewer, Bird, & Catmur, 2016). Language functioning is very heterogeneous in autism; some individuals acquire age-appropriate language skills, while a significant proportion of autistic individuals remain essentially nonverbal (Howlin, Goode, Hutton, & Rutter, 2004; Kjelgaard & Tager-Flusberg, 2001; Tager-Flusberg, Paul, & Lord, 2005).

A seemingly straightforward prediction is that alexithymia will be associated with the language status of autistic children, but the wide variation of language skills in autism has yet to be capitalized upon by researchers. Language heterogeneity could contribute to the variability in terms of alexithymia seen in autism, but instead language or verbal IQ more generally is usually considered an extraneous variable to be controlled. Existing evidence also relies on less than ideal language measures. As in non-clinical alexithymic samples, participants with autism who also have alexithymia have lower verbal IQ than participants with autism but without alexithymia, and verbal IQ correlates with

alexithymia in the autistic population (although this may have been due to the inclusion of individuals with intellectual disability; Milosavljevic et al., 2016). As discussed in relation to alexithymia in the general population, verbal IQ measures alone do not allow for alexithymia to be related to specific language abilities.

The pattern of emotional and social difficulties seen in children with disorders of language and communication is consistent with alexithymia playing a mediating role between poor language and emotional problems, and we predict that future investigation will uncover elevated rates of alexithymia in these groups. There is a clear theoretical case for examining alexithymia across these diverse developmental language-impaired groups. This would allow researchers to tease apart the contribution of specific language problems without known cognitive deficits (deaf children), specific language problems arising from cognitive deficits (DLD), and language problems in the context of a condition with broader social-communicative problems (autism) to emotion processes.

Incorporating language into the interoception hypothesis of alexithymia: A multiple route model

Substantial evidence exists for a link between interoceptive impairment and alexithymia (e.g. Murphy et al., 2017; Murphy et al., 2018; Shah et al., 2016; Brewer et al., 2016; Herbert et al., 2011; Pollatos et al., 2005; Wiens, 2005). Although there has been limited direct study of the role of language, this review suggests that linguistic abilities are also likely to contribute to alexithymia. Given these two rather divergent streams of evidence, determining how they may be combined is likely to contribute to our understanding of alexithymia.

The ability to identify and express emotion is a high-level skill that presumably relies on many cognitive processes. The constructionist theory of emotion CAT argues that "core affect" (as it is termed in these theories) is categorized, and that the categorization processes involve language. While interoceptive failure is not explicitly discussed in CAT, core affect incorporates interoceptive information, and therefore arguably a failure of interoception is as likely to cause alexithymia as a failure in categorization processes. It thus seems likely that alexithymia may arise through impairment in any one of a number of processes, including interoception and language.

While the interoception and language hypotheses of alexithymia are not mutually exclusive, a 'multiple routes model of alexithymia' would need to consider how these two abilities work together to influence the development of alexithymia. First, interoception and language problems may have additive and independent effects on alexithymia, and deficits in either domain may lead to an alexithymic profile at the behavioral level. This would suggest that aetiological subtypes of alexithymia may exist, in which either interoception or language is functioning typically. For example, alexithymia is elevated in eating disorder populations (Berthoz, Perdereau, Godart, Corcos, & Haviland, 2007; Lopez, Stahl, & Tchanturia, 2010), but individuals with anorexia nervosa are thought to have generally higher IQ and better scholastic achievement than typical individuals, factors highly related to verbal abilities. A language impairment therefore seems relatively unlikely to explain alexithymia in anorexia.

Alternatively, interoception and language impairment may interact, and thus these two processes may not be entirely independent. For example, verbal labelling of children's states by caregivers during development (e.g. "You must be hungry", and

"You are so tired today") may refine and tune categorization of interoceptive signals, as well as emotional states (Heyes & Bird, 2007). Poor performance on interoception tasks may thus arise as a downstream consequence of language problems that interfere with the processing and acquisition of these labels, and the ability to associate them with internal stimuli. Indeed, even in adulthood, language processes could continue to contribute to online interoceptive abilities. The ability to recognize a state could depend, to some extent, on one's ability to rapidly verbally label the internal, and contextual, cues associated with that state. Beyond interoception itself, there may be an online role for language in tasks assessing interoception; for example, verbal working memory may be involved in the commonly used heartbeat detection task, while verbally labelling respiratory or muscular effort may aid performance on tasks assessing interoception in these domains (e.g. Murphy, Catmur et al., 2018; Garfinkel et al., 2016).

Alternatively, interactive effects between interoception and language may arise if poor interoception impacts on a child's language development. Certainly, an interoceptive impairment may mean that a child's own internal states are poorly distinguished and therefore an unreliable target for the ascription of verbal labels. Thus, impoverished emotion vocabulary may be a secondary consequence of poor interoception. It is more difficult, however, to explain how poor interoception could lead to a *general* language impairment beyond specifically emotion or interoception-related language. Arguably, from a developmental perspective, interoceptive failure could lead to social abnormalities that reduce or interfere with key language learning experiences (i.e. interoceptive failure may reduce social engagement, and could lead to an individual being more excluded and thus reduce the opportunities for language learning experiences; see

Quattrocki & Friston, 2014, and corresponding commentary by Brewer et al., 2015). While acknowledging the possibility that an interoceptive impairment may result in social impairments that limit the opportunity for general language learning, it seems more likely that any interaction effect between interoceptive and language impairment is due to a general language problem impacting the development of accurate interoception, rather than an interoceptive impairment affecting solely emotion and interoceptive-related language.

Challenges to the study of language and alexithymia and outstanding questions for future research

The theories and evidence reviewed here identify a number of opportunities for future study. In addition, however, reviewing the available literature on linguistic ability and alexithymia revealed several challenges to this line of enquiry, including the measurement issues outlined previously. Further challenges are outlined here.

The finding that alexithymia is elevated in language-impaired groups, or can be accounted for in other groups by considering language deficits, leads us to consider how "pure" alexithymia should be defined. If a child with language impairment has difficulty expressing themselves generally, a difficulty expressing their emotions is to be expected, especially given that emotions are abstract concepts, which may be particularly reliant on language during their acquisition. The same is true of a patient with a neurodegenerative illness whose language abilities have deteriorated. These individuals may technically score highly on an alexithymia measure, but should they be considered to have a different type of alexithymia to that which arises due to pure interoceptive failure? Is alexithymia

only “pure” if basic language (and other cognitive) deficits have been accounted for? The implication is that an alexithymia-like behavioral profile may, in some cases, be a secondary consequence of other non-emotion related cognitive decline, and not comparable to alexithymia in the absence of these broader deficits.

This issue of what is “pure” alexithymia may be further illustrated by considering children who undergo schooling in their non-native language. These children may have a genuine difficulty with language in a certain context, which likely includes difficulty communicating their emotions (in a sense, a context-specific alexithymia). However, they would have a different cognitive profile to those with generalized language impairment or interoceptive deficits, and under the alexithymia language hypothesis would still be expected to have appropriate emotion concepts, and typical emotion recognition and empathy. Under our current conception of alexithymia, we would not regard these children as being alexithymic, but, as above, agreement needs to be reached with regard to what constitutes “pure” alexithymia.

There are also significant methodological challenges when investigating alexithymia and its associated cognitive deficits in multiple developmental and clinical populations. Not least is the fact that, in several clinical conditions, language impairment is only part of a constellation of cognitive deficits. Research aiming to isolate the specific contribution of language to alexithymia should therefore control for other cognitive deficits that could feasibly contribute to alexithymia. Successfully isolating the contribution of language to alexithymia also requires consideration of the analytical approach. Several studies of alexithymia have claimed (e.g. Montebarrocci et al., 2011, Miller et al., 2012, Netten et al., 2015), on the basis of Analysis of Covariance

(ANCOVA) analyses in which verbal ability or performance on a language task has been the covariate, that differences between groups in terms of alexithymia or associated emotional abilities can be accounted for by verbal abilities. However, despite such approaches being widespread, the use of ANCOVA to address such questions is inappropriate (see Miller & Chapman, 2001). Better approaches include having multiple comparison groups that are matched versus unmatched on verbal abilities and also matched versus unmatched on other cognitive abilities (indeed it is very common in DLD research to have both a chronological age matched control group and a language age matched control group to control for cognitive and language abilities respectively), or to have a clinical group that can be dissociated on the basis of their language abilities (e.g. individuals with autism with and without accompanying language impairment) in the hope that the groups will be otherwise equivalent with respect to cognitive factors other than language.

Of course, it must be recognized that much of the research on alexithymia to date has been performed in a limited set of cultural contexts. This feature of the existing research is important, as alexithymia prevalence has been shown to vary across cultures (e.g. Zhu et al., 2007; Ryder et al., 2008). While there has been debate about the extent to which alexithymia can be readily translated into different cultural contexts (see Dere, Falk & Ryder, 2012; Fukunishi, Nakagwa, Nakamura, Kikuchi & Takubo, 1997), it has been argued that alexithymia is present in a comparable form in a variety of cultures (Parker, Shaughnessy, Wood, Majeski, Eastabrook, 2005), but that culture-specific tools may be required to assess it. Differences in the prevalence of alexithymia may be expected given cultural variations in the importance placed on emotions or parental

socialization of emotional expression, both of which may contribute to cultural variations in alexithymia (Dere et al., 2012; Le, Berenbaum & Raghavan, 2002). As yet, cross-cultural research into alexithymia has not considered variations in emotion labels as a potential explanation for differences in alexithymia. Variation in emotion terms across cultures, and how this does, or does not, impact on emotion perception, has been a central issue in the debate between nativist and constructivist theories of emotion (as discussed in Section 2.0). One prediction would be that rates of alexithymia over cultures would pattern with the number of words for emotion in that culture's language(s). However, any investigation looking to isolate the effect of emotion lexicon size on alexithymia will also need to control for other cultural factors that may affect alexithymia. Indeed, such cultural factors and linguistic factors may not be independent; cultures that place less importance on the sharing of emotion may have fewer words for emotions. Nonetheless, research into the inter-relationships between culture, language and alexithymia could represent a way to study the relationship between emotion language and alexithymia, in those for whom typical brain development is assumed. Such research would be significant for understanding alexithymia, but also has clear relevance to the competing theories of emotion described in this article.

Although these issues will need consideration, there are currently several intriguing lines of enquiry for future research to consider. First, this review has highlighted a number of populations in which the alexithymia-language hypothesis could be tested. In particular, alexithymia has yet to be directly studied in children with DLD, or adults with aphasia following stroke. Work with these populations represents a means to examine the role of developmental or late-acquired language disruption on alexithymia

and emotion processing more broadly. In addition, in exploring the literature on neurodegenerative conditions for this review, we noted the increased rates of alexithymia in HIV (Bogdanova, Diaz-Santos, & Cronin-Golomb, 2010), multiple sclerosis (Prochnow et al., 2011), and Parkinson's Disease (Costa, Peppe, Carlesimo, Salamone, & Caltagirone, 2010). While language has received little study in these conditions, there is evidence that language processes are disrupted in multiple sclerosis (Friend et al., 1999; Lethlean & Murdoch, 1997; Prakash, Snook, Lewis, Motl, & Kramer, 2008) and in HIV (Chan, Kandiah, & Chua, 2012; McCabe, Sheard, & Code, 2007; Woods et al., 2006; Woods, Moore, Weber, & Grant, 2009). In Parkinson's Disease, the majority of patients have speech problems, particularly affecting voice and articulation (Ho, Iansek, Marigliani, Bradshaw, & Gates, 1999), but these motoric speech-related problems are arguably quite distinct from the language processes that would be predicted to affect emotional functioning. Thus, Parkinson's Disease may present a useful population to which those with multiple sclerosis and HIV-related dementia can be contrasted. Variation in language functioning, both in the aspects of language that are affected and in the severity of the deterioration, in these conditions represents promising avenues for future research, offering the potential to test different models of how language and alexithymia may be affected in different neurodegenerative diseases.

Second, it will be crucial to understand which distinct aspects of language are related to alexithymia. Clearly, deficits in emotion-related language must be considered in the context of broader language ability, and if alexithymia is associated with some form of non-emotional language impairment, then investigation is required into whether

these difficulties extend to all language processes, or only to particular sub-skills, such as vocabulary, syntactic skills, pragmatic ability, or abstract language skills.

Third, the relationship between language and interoception is as yet unclear, and the role language plays in the development of interoception and vice versa remains to be determined. Indeed, the factors required for the development of interoceptive skill are largely unknown at present. If language is found to shape interoceptive processes, this would contribute to the debate concerning constructivist and nativist accounts of emotion, as some nativist accounts argue that interoceptive experiences are innately given (e.g. Eckman & Cordaro, 2011; Tooby & Cosmides, 2008). Thus, understanding the inter-relationships between alexithymia, interoception and language has implications not just for research on alexithymia and clinical populations, but also emotion theory.

Summary

Alexithymia is a construct that may not be reducible to one basic cognitive deficit across the wide array of populations in which it is observed. It seems not only possible, but probable, that there are multiple routes to the alexithymia phenotype. This review has put forward the case for language problems being one potential route to alexithymia, drawing upon competing emotion theories, and evidence from acquired and developmental clinical conditions in both children and adults. Alexithymia may be more likely to arise due to interoceptive difficulties in some clinical or developmental groups, and due to language difficulties in others. This model clearly requires explicit investigation, using identical methodologies across a range of populations. The current review highlights key issues around the measurement and conceptual nature of

alexithymia, but the proposals outlined here generate many testable questions for future research, including the separate and potentially interacting influences of interoceptive and language abilities on the development of alexithymia.

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