Demystifying alexithymia:

An empirical approach and roadmap for remediation

By

Rachel Aaron

Dissertation

Submitted to the Faculty of the

Graduate School of Vanderbilt University

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

in

Psychology

August, 2016

Nashville, TN

Approved:

Sohee Park, PhD

Jo-Anne Bachorowski, PhD

Steven Hollon, PhD

Craig Smith, PhD

ACKNOWLEDGEMENTS

First I would like to thank the many patients whom I was honored to work alongside through my clinical training. It was my utmost privilege to join you for a small part of your journey, to share the pain of your challenges and celebrate the joy of your victories. Your resilience, whether it came with ease or with immense struggle, motivated and inspired me every step of the way. I am immeasurably grateful for the opportunity to work with you; the lessons you taught me will forever enrich my life.

This work would not be possible without the many people who supported me along the way; particularly my mentor, Sohee Park. Thank you for adopting me into your lab when I needed a research home, and mentoring me with boundless creativity and wisdom.

Thank you to the other members of my dissertation committee – Steve Hollon, Jo-Anne Bachorowski, and Craig Smith – for your support and encouragement, and for always challenging me to expand my perspective. Our many stimulating conversations about this work were invaluable to its development.

Thank you to the members of the Park lab, particularly to my fellow graduate students. To Joel Peterman, thank you for being the best sounding board for all things research and life, and for spearheading the occasional impromptu overnight road trip. To Taylor Benson, thank you for taking me under your wing four years ago when I joined the lab, and for introducing me to the alexithymia construct.

Immense thanks to undergraduate members of the lab, Matthew Snodgress and Scott Blain, for being amazing human beings, and for each of your many contributions to this work. It has been an absolute joy to have a role in mentoring you. I learn from you constantly and am awed by your intellect and maturity.

Thank you to my supportive parents, Nick and Jan Aaron, for your unwavering confidence in my success. Thank you for teaching me that a good work ethic is best accompanied by the ability to stop and smell the roses, and flawlessly modeling both as long as I can remember.

As I strive to do most things, I present this work in loving memory of my best friend, Kate Crockett. Your unparalleled enthusiasm of my academic journey brought me needed courage when you were here, and remains a treasured memory that brings me daily strength and inspiration.

And to my dear husband, Alex Ferrer. From the bottom of my heart, thank you for the extraordinary support you have offered me throughout graduate school. Thank you for the many sacrifices you have made, big and small. Your unconditional patience and steadfast faith in me has been an invaluable foundation through the ups and downs of this experience. I couldn't have done it without you.

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CHAPTER I

Introduction

Alexithymia refers to the inability to label and describe one's own emotional experience. The term was originally coined by Sifneos (1973), literally translated into a "lack of words for emotions" (a – lack, lexis – words, thymos – emotions). The construct was initially used to describe patients with somatic symptom disorders who exhibited marked difficulty verbalizing their feelings and observed struggling to differentiate emotional and physiological cues (Sifneos, 1973) to the chagrin of their psychotherapists (e.g., Krystal, 1982; McDougal, 1982; Overbeck, 1977).

After nearly 45 years of research examining the construct, alexithymia is no longer considered a deficit in emotional vocabulary *per se*, but considered a general deficit in the cognitive processing of emotional experience (Lane, Ahern, Schwartz, & Kaszniak, 1997). Alexithymia is thought to involve impoverished emotion concepts (Kashdan, Barrett & McKnight, 2015; Lindquist & Barrett, 2008), or mental representations of experiences, situations and actions that accompany particular emotional states (for discussion of emotion concepts, see Barrett, 2006; Niedenthal, 2008). Such knowledge is critical for the formulation of an individual's experience of the world and subsequent behaviors.

Conceptual knowledge is accessed when correlates of an emotional experience exceed a critical threshold (Niedenthal, Winkielman, Mondillon & Vermeulen, 2009). Alexithymia may be associated with an abnormally high threshold by which emotionally relevant information crosses into conscious awareness (Lane et al., 1997; Nook, Lindquist & Zaki, 2015). For example, alexithymia is associated with with altered interoceptive awareness (Herbert, Herbert & Pollatos, 2011), or awareness of internal bodily states

(Cameron, 2011), which is critical for the formulation of subjective feelings states (Craig, 2009; Critchley, Wiens, Rotshtein, Öhman & Dolan, 2004; Damasio, 1994; Damasio, 2003). Niedenthal et al. (2009) describe emotion as embodied; that retrieving relevant conceptual information about emotion involves partial reenactment of emotional states in the somatosensory systems. Some argue that alexithymia is, at it's core, a deficit in interoceptive awareness, and that this deficit interrupts normal range emotional processes such as the embodied experience of emotion (Herbert & Pollatos, 2012).

Alexithymia is dimensional (Taylor, Bagby, & Parker, 1999) and transdiagnostic. Longitudinal studies show that though absolute levels of alexithymia can change over time, they remain relatively stable (see Cameron, Ogrodniczuk, & Hadjipavlou, 2014). Less is known about how alexithymia changes throughout development, largely due to a lack of validity of measures in youth (i.e., <18, Parker, Eastabrook, Keefer & Wood, 2010) and older adult (i.e., >60, Henry, Phillips, Maylor, Hosie, Milne & Meyer, 2006) populations. Based on clinician observations, measurement cutoff scores were established to indicate a clinically problematic level of alexithymia (Taylor et al., 1999). In normative populations, 10% of individuals meet criteria (e.g., Salminen, Saarijärvi, Äärelä Toikka, & Kauhanen, 1999). A meta-analysis of gender effects concluded that though results across studies are inconsistent and the effect small, men do generally score higher on measures of alexithymia (Levant, Hall, Williams & Hasan, 2009).

Because knowledge of one's emotional experience facilitates effective coping (Fukunishi & Rahe, 1995; Gohm & Clore, 2002; Moriguchi et al., 2007; Parker, Taylor, & Bagby, 1998; Salavoy et al., 1995; Swart, Kortekaas, Aleman, 2009), which is closely related to health outcomes (Desteno, Gross, & Kubzansky, 2013 for review), it is not surprising that clinical levels of alexithymia are much higher in myriad mental and physical health disorders compared to normative samples (Leweke, Leichsenring, Kruse & Hermes, 2011; Lumley, Beyer & Radcliffe, 2008). The construct is also associated with a range of problematic psychosocial features (Aaron, Benson & Park, 2015; Grynberg, Luminet, Corneille, Grèzes & Berthoz, 2010; Vanheule, Desmet, Meganck & Bogaerts, 2007).

A Case for Studying Alexithymia

Continuing to elucidate the alexithymia construct has important public health implications. Thousands of studies demonstrate the overlap between alexithymia and mental and physical health outcomes, yet still, little is known about their relationship and how alexithymia affects long-term outcomes, including success of psychotherapy.

Alexithymia is elevated in clinical populations. Alexithymia is related to problematic health behaviors and outcomes in a many important domains. It is elevated in psychiatric populations including major depressive disorder (Honkalampi, Hintikka, Laukkanen, & Viinamäki, 2001), schizophrenia (van't Wout, Aleman, Bermond, & Kahn, 2007), and posttraumatic stress disorder (Yehuda et al., 1997). It is prevalent in approximately 50% of individuals with autism spectrum disorders (Bird et al., 2010; Silani et al., 2008). It is ubiquitous in disorders involving utilization of problematic coping behaviors, including substance abuse (Coriale et al., 2011), eating disorders (Pinna, Sanna & Carpiniello, 2015; Taylor, 2000) and aggression (Velotti et al., 2016).

In general populations, it is associated with decreased use of effective coping skills, such as reappraisal, emotional expression, and seeking social support (Fukunishi & Rahe, 1995; Moriguchi et al., 2007; Parker, Taylor, & Bagby, 1998; Swart et al., 2009). Instead, those with heightened levels of alexithymia rely on ineffective coping strategies, including emotional suppression and avoidance (Panayiotou et al., 2014; Parker et al., 1998; Swart et al., 2009). This pattern of coping is associated with risk of psychopathology and adverse health outcomes (see Aldao, Nolen-Hoeksema, & Schweizer, 2010 and Desteno, Gross, & Kubzansky, 2013 for reviews).

Alexithymia is elevated in populations with medical complaints, particularly in somatic symptom disorder and related disorders, independently of other psychopathological symptoms such as depression (Mattila et al., 2008). Baudic et al. (2016) show that alexithymia prior to breast cancer surgery is the best predictor of developing chronic pain in women one-year post-surgery, more so than a variety of psychological factors including catastrophizing, repression and body image. This longitudinal study adds empirical support to theories postulating alexithymia confers risk for the development of physical health conditions. Taylor & Bagby (2004) argue that alexithymia may lead to misperceiving the physiological correlates of emotion as signs of physical illness. In turn, heightened focus on aspects of physiological arousal can increase their perceived physical intensity. This increases risk of harmful appraisals and cognitive elaborations, particularly about health outcomes (Garland et al., 2011; Kano & Fukudo, 2013).

Alexithymia and empathy. Alexithymia is associated with reduced empathy. Those with heightened alexithymia show reduced activation of regions involved in empathic processing in imaging studies (Bird et al., 2010; Moriguchi et al., 2007; Silani et al., 2008). Self report studies consistently show that alexithymia is associated with reduced forms of "mature empathy," including perspective taking and empathic concern (e.g., Aaron et al., 2015; Grynberg et al., 2010; Silani et al., 2008; Sonnby-Borgstrom, 2009). This association may help explain findings that alexithymia is associated with elevated interpersonal problems (e.g., Vanheule et al., 2007).

Compelling work in the field of autism spectrum disorders (ASD) demonstrates how consideration of alexithymia can shed light on long-held assumptions about clinical populations. Despite the widespread assumption that ASD is associated with decreased empathy, landmark work by Bird et al. (2010) and Silani et al. (2008) shows that only ASD participants with elevated levels of alexithymia demonstrate empathic deficits. Bird and Cook (2013) propose "the alexithymia hypothesis," arguing that emotional symptoms of ASD are due to the high co-occurrence of alexithymia in this population and not due to ASD *per se.* The same may be true for other disorders as well: Aaron et al. (2015) show that alexithymia accounts for the established correlation between empathic deficits and schizotypy, personality traits that indicate a predisposition towards schizophrenia (Claridge, 1990; Lenzenweger, 2006, 2011). Similarly, Brewer and colleagues (Brewer, Cook, Cardi, Treasure & Bird, 2015) show that facial emotion recognition deficits in eating disorders are attributable to alexithymia and not an eating disorder diagnosis. Continuing to investigate how alexithymia contributes to established deficits in various psychiatric diagnoses has the potential to illuminate inconsistencies in research and guide targeted remediation (Bird & Cook, 2013).

Alexithymia influences psychotherapy outcomes. Despite much conjecture, there is a dearth of evidence examining patterns of directionality between alexithymia and physical and mental health outcomes; however, with thousands of cross-sectional studies, the link between them is undeniable. Considering their vast overlap, it is exceedingly important to understand this relationship from a psychotherapeutic standpoint. This is particularly true given most modern psychotherapeutic orientations emphasize emotional processes (Grabe, Spitzer, & Freyberger, 2004). Though alexithymia first emerged to characterize individuals who demonstrated poor outcomes in traditional talk therapy and elicited frustration in therapists (e.g., Krystal, 1982; McDougal, 1982; Overbeck, 1977), it is still associated with poor psychotherapy outcomes (Ogrodniczuk, Piper, & Joyce, 2011 for review).

Fortunately, intervention generally improves relative levels of alexithymia. A recent review of 23 treatment studies concluded that general psychotherapeutic intervention results in reductions of alexithymia in many different clinical populations, including depression, anxiety, eating disorders, and mixed psychiatric samples (Cameron et al., 2014) using a wide variety of clinical approaches. More work is needed to determine whether functional changes accompany alexithymia reductions; at least one study suggests they do; Tulipani et al., 2010 show that pain levels and alexithymia decrease simultaneously following a 6-month cognitive and emotion-focused intervention for individuals diagnosed with cancer.

A recent review (Pinna et al., 2015) examines alexithymia in the context of interventions for eating disorders, spanning a wide variety of treatment approaches (e.g., weekly cognitive behavioral therapy, inpatient psychoanalysis, pharmacological treatment). Consistent with Cameron et al. (2014), Pinna et al. (2015) show relatively stable levels of alexithymia with absolute reductions in some treatment groups; however, they observe those with high alexithymia at baseline show poorer therapy outcomes overall. Conversely, Morie et al. (2015) show that alexithymia is associated with *increased* likelihood of cocaine abstinence in an internet-delivered cognitive behavioral therapy

(CBT) treatment for individuals with cocaine use disorder. These findings highlight the likely moderating impact of alexithymia on treatment outcomes; depending on treatment parameters and clinical diagnosis, alexithymia may be associated with better or worse outcome.

Early intervention may have the potential to reduce alexithymia. Brackett et al. (Brackett, Rivers, Reyes, & Salovey, 2012) show that a curriculum designed to promote awareness, expression and regulation of emotions improves social skills and academic performance among 5th and 6th graders. Kircanski, Lieberman & Craske (2012) train individuals to label their emotions when approaching a feared stimulus, a spider. Compared to other emotion regulation strategies (reappraisal, distraction), those coached to employ emotion labeling showed reduced anxiety and increased willingness to approach the spider. Alexithymia generally improves in response to tasks that are not formal interventions. Biekie (2008) shows that a 4-week expressive writing paradigm resulted in reduced doctor's visits, reduced depression scores, and reduced sleep disturbances among those with elevated alexithymia. Constantinous et al. (2014) show that physiological and subjective aspects of emotional experience normalize in those with elevated alexithymia when participants are instructed to engage in deep emotional processing.

It is likely that alexithymia has moderating and mediating effects on interventions that vary by intervention design and clinical population. As evidence about how intervention influences alexithymia emerges, so do theories and recommendations for improving psychotherapeutic outcomes in individuals with elevated alexithymia. Cameron et al. (2014) recommend structured skill-based therapies such as CBT as well as a treatment approach that places emphasis on emotional processes. From the provider's perspective, they highlight the potential utility of increased reflective listening and empathic resonance, as well as managing counter-transference when frustration arises.

Pinna et al. (2015) put forward a similar set of recommendations, and highlight the need of adapting interventions to better serve individuals with eating disorders, a population in which rates of alexithymia are high (Taylor, 2000). Morie et al.'s (2015) intervention highlights the potential utility of internet-delivered interventions for those with elevated alexithymia, which are in line with the recommendation to offer a structured approach with reduced one-on-one participation demand.

Early accounts of alexithymia suggested the trait prevents meaningful change in response to psychotherapy; fortunately, intervention research demonstrates this is not the case. Those with heightened alexithymia across clinical diagnoses have the potential to benefit from psychotherapy, and it is essential the field determine how to best help these individuals improve. A critical next step in this field is to examine recommendations from experts empirically, and to investigate factors that promote seeking, adherence to, and benefit from psychotherapeutic interventions. Consideration of intervention approach, design, and clinical population is crucial in this line of work, as well as attention to the moderating and mediating effect of alexithymia on modern psychotherapeutic approaches.

Measuring Alexithymia

Alexithymia is typically assessed using self-report questionnaires or interviews. The most common tool for assessing alexithymia is by far the 20-item Toronto Alexithymia Scale (TAS-20; Bagby, Parker, & Taylor, 1994) which is lauded for making wide-scale alexithymia research possible. It is comprised of three factors: difficulty identifying feelings (DIF), difficulty describing feelings (DDF), and externally oriented thinking (EOT).

The first two scales assess one's ability to reflect on their own emotional experience. The EOT scale reflects a cognitive style with preference for focusing on the details of everyday life, rather than internal processes such as thoughts, feelings, and fantasies. The TAS-20 measure has been translated in over 20 languages, and its three-factor structure has been cross-validated by confirmatory factor analysis in Western European, East Asian, and Middle Eastern countries (Taylor & Bagby, 2013).

Vorst & Bermond (2001) developed an additional questionnaire measure of alexithymia, the Bermond-Vorst Alexithymia Questionnaire (BVAQ), to address the critique that the TAS-20 lacks a factor related to "experience of emotional feelings." The BVAQ includes two additional scales measuring affective experience: reduced fantasizing and reduced experiencing of emotional feelings. The validity and reliability of this measure is less clear than that of the TAS-20, and the inclusion of the two additional factors is questioned (see Taylor, Bagby, & Luminet, 2000; Lumley, Neely, & Burger, 2007; Morera, Culhand, Watson & Skewes, 2005). Factor analyses demonstrate that variance in fantasizing is accounted for in the TAS-20, and some researchers suggest "reduced experiencing of emotional feelings" is more aptly characterized as a correlate of alexithymia, rather than a core feature (Zech, Luminet, Rime, & Wagner, 1999). Thus, the TAS-20 remains the most common tool for assessing alexithymia.

Additional interview measures exist as well. The Beth Israel Hospital Psychosomatic Questionnaire (Sifneos, 1973) is a 17-item questionnaire completed by an interviewer or observer. Although this measure demonstrates concurrent validity with the previous versions of the TAS-20, it lacks reliability good inter-rater reliability (Taylor & Bagby, 2004). Other interview-based assessments of alexithymia include the 24-item Toronto

Structured Interview for Alexithymia (TSIA; Bagby, Taylor, Parker, & Dickens, 2006), which correlates modestly with self-reported alexithymia. The 33-item Observer Alexithymia Scale (OAS; Haviland, Warren, & Riggs, 2000) relies on collateral ratings from family members, friends, and therapists. The latter observer measures are relatively new and have not been widely tested (Lumley et al., 2007). As interview measures, administrations of these batteries can be cumbersome. Though they can be useful in clinical settings, they are generally not efficient for research purposes.

Early developments in interview-based assessments of alexithymia were essential for laying a foundation for this body of research. The advent of self-report measures, easily administered and interpreted, to assess alexithymia facilitated wide-scale alexithymia research. However, existing measurement tools have significant limitations. People with a high degree of alexithymia may not be reliable in assessing their own affective deficits on a self-report scale (Leising, Grande, & Faber, 2006). High negative affect associated with alexithymia may confer negative self-bias that could increase endorsement of alexithymic characteristics. In addition, reliance on these measures limits experimental manipulation, essential for determining causal pathways. An important next step in this field is developing an objective laboratory-based assessment task to avoid the pitfalls of self-report and promote more experimental alexithymia research.

Affective Experiences in Alexithymia

Accumulating behavioral research points towards patterns of abnormal emotional experiences in alexithymia. In particular, utilization of imaging methodology in alexithymia research yields valuable information regarding its neural correlates, and recent reviews of the literature have helped pave the way for a more coherent framework. However, still much is unknown about the how the construct relates to behavioral phenomena, and inconsistencies in the literature limit the generation of clear themes.

Neurological abnormalities in alexithymia. The anterior cingulate cortex (ACC) and anterior insular cortex (AIC) have entered the spotlight of alexithymia research. The ACC and AIC are involved in interpreting physiological cues of one's emotional experience, and integrating this information into a subjective representation of one's emotional state (Bechara & Naqvi, 2004), visually depicted in Figure 1. Gu et al. (2013) propose that the AIC serves to integrate bottom-up interoceptive information from top-down information from the ACC and prefrontal cortex. Together, the AIC and ACC are thought to comprise an "interoceptive cortex" (Craig, 2002), facilitating and integrating awareness of interoceptive cues, and contributing to the sense of self.

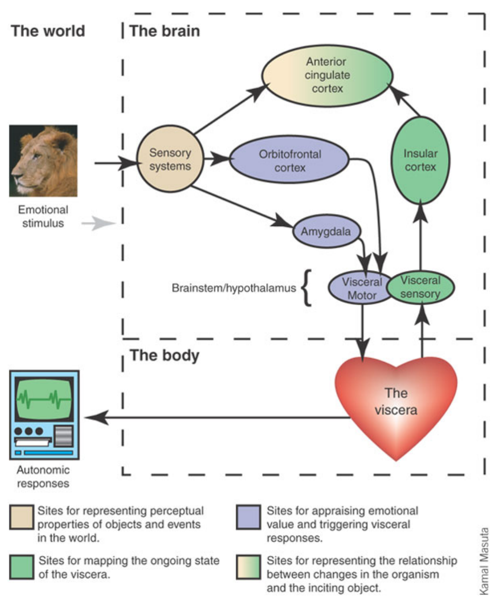

Figure 1. Summary of the role of the AI and ACC in integrating interoceptive information to create an emotional state. From Bechara & Navqui (2004); image created by Kamul Masuta.

The ACC is associated with many functions correlated with consciousness, including attention and response selection (Lane et al., 1998). Lane et al. (1987) propose the ACC mediates the association between alexithymia and impaired conscious awareness of one's emotional state. This is consistent with the high prevalence of alexithymia in somatization disorders, as abnormal ACC activation may reflect amplification of physical sensations. Abnormal ACC activity in alexithymia in well-established (Berthoz, et al., 2002; Kano, Hamaguchi, Itoh, Yanai, & Fukudo, 2007;. Karlsson, Näätänen, & Stenman, 2008; Moriguchi et al., 2007; for review, see van der Velde et al., 2013).

The ACC, along with the medial prefrontal and insular cortices, form a network characterized by the presence of Von Economo neurons (spindle cells) found only in highly complex and social species including humans, higher primates and elephants. This network area is thought to contribute to the sense of self (Craig, 2009; Craig, 2009b). The AIC receives information from internal bodily states, and integrates these sensations into a subjective feeling (Craig, 2009; Damasio, 1994). Alexithymia is associated with reduced AIC activation in response to various emotional stimuli (Bird et al., 2010; Kano et al., 2003; Reker et al., 2010; Silani et al., 2008). Theories endorsing the role of the AIC in alexithymia suggest alexithymic traits might be the result of a failure to engage the AIC under affective context or situation, and subsequently, a failure to represent important bodily states within the insula (Silani et al., 2008; Singer & Lamm, 2009).

Because the ACC and AIC commonly co-activate (see Gu et al., 2013), it has been difficult to parse their specific contributions to the alexithymia construct. Hogeveen and colleagues (2016) present compelling evidence bringing the AIC to the forefront. They measured alexithymia in Vietnam war veterans who sustained varying degrees of AIC damage following penetrating brain injuries and showed that severity of AIC damage predicted alexithymia, or resulted in "acquired alexithymia." This relation occurred independently of ACC activation.

Behavioral abnormalities in alexithymia. Since the advent of the TAS-20, the field has burgeoned with laboratory-based studies exploring behavioral abnormalities in alexithymia across myriad fields of psychology and neuroscience. These studies are critical for understanding exactly how alexithymia alters one's emotional experiences, though still, there are many inconsistencies and much is still unknown.

Findings related to physiological arousal serve as a good example of inconsistencies in the field, as results are mixed. In response to emotional stimuli, a good deal of evidence suggests alexithymia is associated with physiological hypoarousal (e.g., Constantinou et al., 2014; Pollatos, Schubö, Herbert, Matthias & Schandry, 2008; Roedema & Simons, 1999), hyperarousal (Infrasca, 1997; Stone & Nielson 2001), while other studies demonstrate no differences in arousal levels (Bausch et al., 2001; Eastabrook, Lanteigne & Hollenstein, 2013; Friedlander, Lumley, Farchione, & Doval, 1997). Similar inconsistencies limit conclusions about how alexithymia alters subjective report of arousal (Peasley-Miklus et al., 2015, Roedema & Simons 1999). More consistent are findings comparing self-report and physiological arousal, which consistently demonstrate disparity in responses (e.g., Constantinou et al., 2014; Franz, Schaefer, Schneider, Sitte & Bachor, 2003; Pollatos et al., 2011; Stone and Nielson, 2001; Vanman, Dawson & Brennan, 1998).

Research addressing evaluation of valence in alexithymia is also inconsistent, with some demonstrating intact evaluation of valence (McDonald & Prkachin, 1990; Roedema & Simons, 1999; Whemer, Brejnak, Lumley & Stettner, 1994) and others showing deficits (Koven, 2014; Vanman, Dawson & Brennan, 1998). A similar pattern emerges with regards to intensity ratings. Where some report no effect of alexithymia on intensity ratings (Koven, 2014; Fantini-Hauwel, Luminet, & Vermeulen, 2015 [in women]), others report decreased intensity ratings in response to sad stimuli (Mantani, Okamoto, Shirao Okada Yamawaki. 2005) and others report increased intensity ratings (Fantini-Hauwel et al., 2015 [in men]; Lee and Guajardo, 2011). Following emotion induction, some studies show that alexithymia is associated with reduced generation of emotion words to describe the experience (Luminet, Rimé, Bagby & Taylor, 2004; Páez, Velasco & González, 1999; Roedema & Simons, 1999) while others suggest this ability may be intact (Constantinous et al. 2014).

Alexithymia is consistently associated with reduced facial emotion recognition (e.g., Brewer, Collins, Cook & Bird, 2015; Nook, Lindquist & Zaki, 2015; Prkachin, Casey & Prkachin, 2009) and abnormal early processing of emotional body postures (Borhani, Borgomaneri, Làdavas, & Bertini, 2016). Interestingly, Nook et al. (2015) ameliorated deficits in facial emotion recognition in alexithymia by providing emotion word labels. They conclude emotion labels facilitate access to conceptual knowledge about emotions and normalize behavior.

Response Time. Response time is a valuable measure of emotional processing (Fazio, 1990); as an indirect measure, it is generally unbiased by demand characteristics (Lischetzke, Cuccodoro, Gauger, Todeschini & Eid, 2005). Findings on response time in alexithymia are limited and mixed. Ihme et al. (2014) show that observer-rated (but not self-report) alexithymia was associated with slower response time for identifying negative affect in a facial recognition task. Other studies report no relationship between response time and alexithymia during retrieval of emotional memories (Lundh, Johnsson, Sundqvist & Olsson, 2002) or recall of emotional words (Luminet et al., 2006).

Lischetzke et al. (2005) show that faster response time may be adaptive; individuals respond faster to affective questions about which they are more certain. They use response time as a measure of “emotional clarity,” or an individual’s meta-knowledge of his or her own affective state (Boden et al., 2013). Taylor (2004) argues emotional clarity is a core dimension of alexithymia. Faster response time to mood questions in the laboratory is associated with greater daily mood regulation, measured using experience sampling method (Lischetzke, Angelova & Eid, 2011), though slower response time can reflect the presence of mixed affect (i.e., presence of both pleasant and unpleasant experiences; Lischetzke et al., 2005).

Emotional complexity in alexithymia. Emotional complexity is a multidimensional construct (see Grühn, Kotter-Grühn, & Röcke, 2010; Grühn, Lumley, Diehl, & Labouvie-Vief, 2013) that captures a wide range of emotional experiences, including alexithymia. Constructs within include precision of one’s emotional experience, explicit knowledge of emotional experiences, and an individual’s perspective on their own degree of complexity (Lindquist and Barrett, 2008). Despite the relevance of emotional complexity to alexithymia, little research has examined their overlap.

Emotion granularity (also referred to as emotion differentiation), for example, refers to the ability to make fine-grained distinctions between emotional experiences. Individuals with a high degree of granularity use precise vocabulary to capture the nuances of diverse emotional experiences (Barrett, 1998; Barrett, Gross, Christensen, & Benvenuto, 2001; Tugade, Fredrickson & Barrett, 2007). High granularity is associated with increased well-being and psychological health (Erbas, Ceulemans, Pe, Koval & Kuppens, 2014; Kashdan, Barrett & McKnight, 2015). Better emotion granularity may promote cognitive distancing in response to distressing feelings and bodily sensations (Kashdan et al., 2015), facilitating effective emotion regulation and allocation of resources towards pursuit of values. A proposed pathway by which granularity interrupts adaptive emotion regulation is depicted in Figure 2.

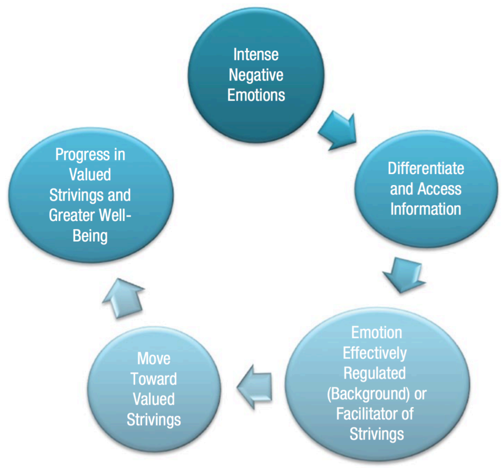

Figure 2. Proposed pathway by which emotion granularity facilitates regulation of negative affect, pursuit of values and ultimately, wellbeing. From Kashdan et al., 2015.

Emotion granularity is quantified as an average inter-correlations between emotion words endorsed on Likert scales, either throughout the day in experiencing sampling methods (e.g., Barrett et al., 2001; Kashdan & Farmer, 2014), or in the laboratory(e.g., Boden, Thompson, Dizén, Berenbaum & Baker, 2013; Erbas et al., 2014). Smaller correlations indicate increased granularity. Like emotional awareness, granularity is associated with improved emotion regulation, especially negative granularity (Barrett et al., 2001; Demiralp et al., 2012; see Tugade & Fredrickson, 2007 for benefits of positive granularity). Similar to the alexithymia construct, low emotion granularity is associated with major depressive disorder (Demiralp et al., 2012) and depressive symptoms in a non-clinical sample (Erbas et al., 2014). It is associated with disorders marked by difficulty regulating emotions, including eating disorders (Selby et al., 2013), borderline personality disorder (Suvak et al., 2011), aggression (Pond et al., 2012) and alcohol use (Kashdan, Ferssizidis, Collins & Muraven et al., 2010). It is also present in schizophrenia (Kimhy et al., 2014) and autism spectrum disorders (Erbas, Ceulemans, Boonen, Noens, & Kuppens, 2013).

Erbas et al. (2014) show that alexithymia, particularly the DIF and DDF subscales of TAS-20, are associated with reduced negative granularity. Based on their degree of relatedness, they conclude that though the two overlap, they represent distinct emotional constructs. Kashdan et al. (2015) explain that following intense negative affect, a period of emotion differentiation emerges which launches subsequent emotion regulation. A lack of emotional awareness (i.e., alexithymia) may limit the process of differentiating an affective experience.

Another aspect of emotional complexity, dialecticism, refers to one's tendency to simultaneously experience pleasant and unpleasant states (Bagozzi, Wong, & Yi, 1999). Dialecticism is a core concept of dialectical behavioral therapy (DBT; Linehan, 1993), in which participants are encouraged to synthesize opposites (e.g., "acceptance" and "change"). DBT has been successful in improving clinical outcomes in borderline personality disorder (Panos, Jackson, Hasan & Panos, 2013), with growing evidence for its efficacy treating other disorders (Öst, 2008). Compared to emotional granularity, much less work has investigated the psychological correlates of dialecticism alone, though some evidence suggests dialecticism promotes stress reduction and emotion regulation (Davis, Zautra, & Smith, 2004; Ong & Bergeman 2004; Reich, Zautra, & Davis, 2003). Both granularity and dialecticism increase across the lifespan (Carstensen, Pasupathi, Mayr & Nesselroade, 2000; Widen & Russell, 2008).

Interoceptive Awareness and Alexithymia

Deficits in interoception are thought to reflect a core component of alexithymia (Bird et al., 2010; Herbert & Pollatos, 2012; Herbert et al., 2011). Interoception refers to afferent information that arises from within the body that affects the cognition or behavior of an organism (Cameron, 2001; Craig, 2002); an individual's metacognitive awareness of interoceptive signals in considered "interoceptive awareness." An individual's ability to accurately detect these signals is considered "interoceptive accuracy" (see Garfinkel & Critchley, 2013; Garfinkel, Seth, Barrett, Suzuki & Critchely, 2015). Awareness of one's bodily cues is critical for formulation of a sense of self (Craig, 2002; Damasio, 2003), for formulation of embodied emotional concepts (Herbert & Pollatos, 2012) and the generation of subjective emotional states (Damasio, 2003).

Interoceptive awareness is measured using a variety of behavioral tasks, the most common of which are heartbeat detection tasks. In Schandry's (1981) heartbeat tracking task, participants are asked to estimate how many times their heart beats in a given period of time. This estimation is compared to objective measures of heart rate. Similarly, in the heartbeat discrimination task, participants are presented with tapping noises and asked whether noises are synchronous or asynchronous with their own heartbeat (Whitehead, Dresher, Heiman, & Blackwell, 1977). Others rely on neuroimaging data from the "interoceptive cortex" (Craig, 2009; Critchley et al., 2004) to quantify measures of interoceptive awareness. Others rely on response time to questions about physiological state as an index of interoceptive accuracy (Silverstein, Brown, Roth & Britton, 2011), though little evidence supports this approach.

Alexithymia is associated with reduced interoceptive accuracy on the heartbeat tracking test (Herbert et al., 2011; Shah, Hall, Catmur, & Bird, in press) and shows abnormal activation in and structure of the interoceptive cortex (Bird et al., 2010; Frewen et al. 2006; Ihme et al., 2013; Kano et al. 2003; Kano et al. 2007; Karlsson et al. 2008; Reker et al., 2010; Silani et al., 2008; Strigo et al., 2013). Because of the vast overlap between interoceptive awareness and alexithymia, and because interoceptive awareness is considered critical in the generation of subjective emotional experiences (Damasio, 2003), some argue that interoceptive deficits are a precursor to the development of alexithymia (Herbert et al., 2011) or that alexithymia is best characterized as an interoceptive deficit (Bird et al., 2010; Herbert & Pollatos, 2012; Silani et al., 2008).

Like alexithymia, interoceptive awareness is responsive to intervention. A good deal of evidence shows that long-term mindfulness meditation training results in neural changes suggesting enhanced interoceptive awareness (Farb et al., 2010; Farb, Segal, & Anderson, 2013; Hölzel et al., 2008; Hölzel et al. 2011; Lazar et al., 2005). Laboratory-based studies also show that feedback about one's heart rate improves accuracy (Schandry & Weitkunat, 1990), as does the presence of self-referential stimuli in the testing room (e.g., a mirror; Ainley, Maister, Brokfeld, & Tsakiris, 2013; Ainley, Tajadura-Jiménez, Fotopoulou, & Tsakiris, 2012).

Current Study

The major aim of this project was to develop a laboratory-based task to facilitate measurement of a wide range of emotional experiences in alexithymia. Though overlapping, emotion constructs are distinct, and collecting multiple measurements in the same study offers importance nuances (Grühn et al., 2013). In the paradigm, participants view video clips designed to elicit a particular emotional state, and asked a series of questions about their emotional experiences. From these questions measures of subjective emotional experience (i.e., labeling primary emotional experience, subjective arousal, subjective intensity), implicit measures of emotional experience (i.e., response time) and aspects of emotional complexity (i.e., granularity and dialecticism) will be collected. Many of these measures have been minimally studied in alexithymia, and hold promise for further elucidating the construct.

This paradigm will address the hypothesis that alexithymia is associated with abnormal emotional concepts, or access to such concepts. Participants will be asked to identify their primary emotional experience, with the option of selecting "I experienced no emotion." This question will provide insight into the use of conceptual emotional information in alexithymia. If alexithymia is associated with impoverished conceptual knowledge about emotional states, it may be associated with selecting a greater variety of emotional experiences as primary, or endorsing incongruent emotion words. If alexithymia is associated with an abnormally high threshold by which physiological and subjective cues about emotional experience enter consciousness, I hypothesize the construct will be associated with greater selection of "no emotion" as primary emotional experience.

Inconsistencies of past research suggest that experimental design and demand characteristics could confer heavy influence on measures of subjective experience including arousal or intensity ratings (see Helmes, McNeill, Holden & Jackson, 2008 for discussion of social desirability in alexithymia). These inconsistencies preclude specific hypotheses, though in general, I expect alexithymia to be associated with abnormal patterns of responding on subjective measures and that different behavioral patterns will emerge for different alexithymia subscales.

I expect alexithymia will show more consistent deficits in measures of emotional complexity, which reflect mature developmental processes (Carstensen et al., 2000; Widen & Russell, 2008) as well as implicit measures, which may be less vulnerable to experimental parameters and more difficult to manipulate. Specifically, I expect alexithymia will be associated with reduced granularity and dialecticism of emotional experience. I hypothesize alexithymia will be associated with either faster or slower response time; decreased response time would indicate reduced emotional clarity (Lischetzke et al., 2005), though increased response time may reflect reduced mixed-emotion or reduced time contemplating emotional states.

A second goal of this project was to examine how interoceptive awareness interacts with emotional correlates of alexithymia and to investigate the effects of mindfulness meditation on improving deficits in alexithymia. Participants will be randomly assigned to receive either a brief mindfulness meditation or control recording. Before and after, they will complete measures of interoceptive accuracy. Mindfulness practices encourage individuals to attend to present-focused internal experiences, such as bodily sensations, thoughts, and emotions (Kabat-Zinn, 1990). As a therapeutic tool, mindfulness involves cultivating a nonjudgmental awareness of the present moment.

Cross-sectional evidence supports a negative correlation between mindfulness and alexithymia (e.g., Baer, Smith, & Allen, 2004; Bruin, Topper, Muskens, Bögels, & Kamphuis, 2012). Mindfulness meditation enhances interoceptive awareness: Far, Segal & Anderson (2013) show that an 8-week mindfulness protocol (Mindfulness Based Stress Reduction; Kabat-Zinn, 1990) increases activity in the interoceptive cortex compared to wait-list controls. Long-term meditators also show greater activation of the interoceptive cortex compared to non-meditating controls (Hölzel et al., 2008; Lazar et al., 2005). Mindfulness interventions may also have the potential to reduce alexithymia levels. Experiment two will examine how mindfulness meditation affects performance of major task variables, and whether alexithymia moderates or interacts with these effects.

I expect to replicate previous findings that alexithymia is associated with reduced interoceptive accuracy. Based on the theory that alexithymia is associated with intact ability to attend to internal stimuli but reduced tendency to do so (Panayiotou et al., 2015), I expect mindfulness meditation will improve interoceptive accuracy in alexithymia. I hypothesize mindfulness meditation will result in increases in measures of emotional complexity, particularly as mindfulness is used as a tool to promote dialectical thinking (Linehan, 1993). If mindfulness meditation is effective for normalizing this and other emotional experiences, I expect alexithymia will be associated with improvements in performance in the meditation condition. It may also be the case that mindfulness is not an efficacious intervention approach for those with elevated alexithymia, in which deficits in emotional processing may remain the same, or improve minimally in contrast to those with low alexithymia.

Through the development of a novel laboratory-based design to assess behavioral correlates of alexithymia, the current study will facilitate measurement of a range of subjective, implicit, and complex emotional experiences, further delineating the nature of emotional processing deficits in alexithymia. Experiment two will examine how these measures relate to interoceptive accuracy, and whether they are responsive to a brief mindfulness meditation intervention. By collecting a range of emotional experiences, this paradigm will serve as a platform for future development of a laboratory-based assessment of alexithymia.

CHAPTER II

Experiment 1: Delineating emotional processing abnormalities in alexithymia through a novel laboratory-based design

Aims

1) To determine whether alexithymia influences normative selection of emotion labels following well-validated emotion induction film clips.
2) To assess how alexithymia relates to measures of subjective emotional processing.
3) To investigate the role of emotional granularity and dialecticism in alexithymia.
4) To measures response time as an implicit measure of emotional processing in alexithymia.
5) To develop a versatile laboratory-based task that can easily be used to measure behavioral correlates of alexithymia in the future.

Method

Participants

113 undergraduates (68% women) were recruited and received course credit for their participation. Exclusion criteria were a past or current diagnosis of depression, anxiety, or substance use disorder. Data were excluded from two participants for not following instructions, and three participants due to equipment problems. Of the remaining participants, the average age was 19.31 (standard deviation = 0.89). 50% identified as Caucasian, 24% Asian American or Asian, 14% African American or African, 2% Hispanic, 8% as "Multiracial," and 2% as "other." Written informed consent was

obtained from all participants, as approved by the Vanderbilt Institutional Review Board (IRB).

Materials

Apparatus and stimuli. Questionnaires and stimuli were presented via Eprime 2.0 using a 15" X 10" inch laptop with a black background in a darkened room. Participants wore Audio-Technica noise cancelling headphones through the video portion of the experiment. Stimuli included the 14 film clips identified as reliably eliciting one of 7 prototypical emotions (amusement, anger, contentment, disgust, fear, sadness, and surprise); there were two clips for each emotion category (Gross & Levenson, 1995; see Appendix A for details). Participants also viewed one video from the same battery designed to induce a "neutral" state during inter trial intervals. Participants were given one practice trial during which they viewed a non-standardized film clip from the movie *Zoolander.*

Questionnaires. Participants completed the Toronto Alexithymia Scale (TAS-20; Bagby, et al., 1994). This scale consists of 20 items and measures three dimensions of the alexithymia construct: difficulty identifying feelings (DIF), difficulty describing feelings (DDF), and externally- oriented thinking (EOT). Participants rate to what extent they agree with statements using a five-point Likert scale. Cronbach's alpha was 0.64 in the present study. Participants were also asked to report the intensity with with they experienced primary and secondary emotions on a 1-9 Likert scale, as well as subjective arousal using a 1-9 self-assessment manikin scale (SAM; Bradley & Lang, 1994).

Design and Procedure

After written informed consent was obtained, participants completed a demographic form and questionnaire battery. They were randomly assigned to one of two counterbalanced run orders. In both, positive and negative emotion eliciting videos were evenly distributed. They received instructions for the task and were asked to read aloud a list of relevant emotion words to ensure familiarity (see Appendix B). While the experimenter was present, they completed a full practice trial during and after which they were given opportunities to ask questions. Participants then completed 14 trials. After each video, participants responded to a series of questions about their primary and secondary emotional experiences.

Emotion induction task. ***Primary Emotion.*** After a 5s "neutral" film clip, participants were presented with one of fourteen emotion inducing clips. Afterwards, they were asked which of 16 emotions they experienced the most (amusement, anger, arousal, confusion, contempt, contentment, disgust, embarrassment, fear, happiness, interest, pain, relief, sadness, surprise, and tension), replicating Gross and Levenson's (1995) original design. In addition, they were given the option to select: "I did not experience any emotion," and "the emotion I experienced is not listed here." A "target emotion" variable was formed reflecting the percentage of times a normative emotional response was selected, based on intended induction as well as a few exceptions outlined in Gross and Levenson's (1995) original paper (see Appendix A). Next, participants were asked to report the intensity of their primary emotion and subjective arousal. Response times were collected for all responses. Response time was defined as the duration between stimulus onset to participant response. This portion of the experiment is visually depicted in Figure

3 and a summary of these variables and all other task variables are summarized in Appendix C.

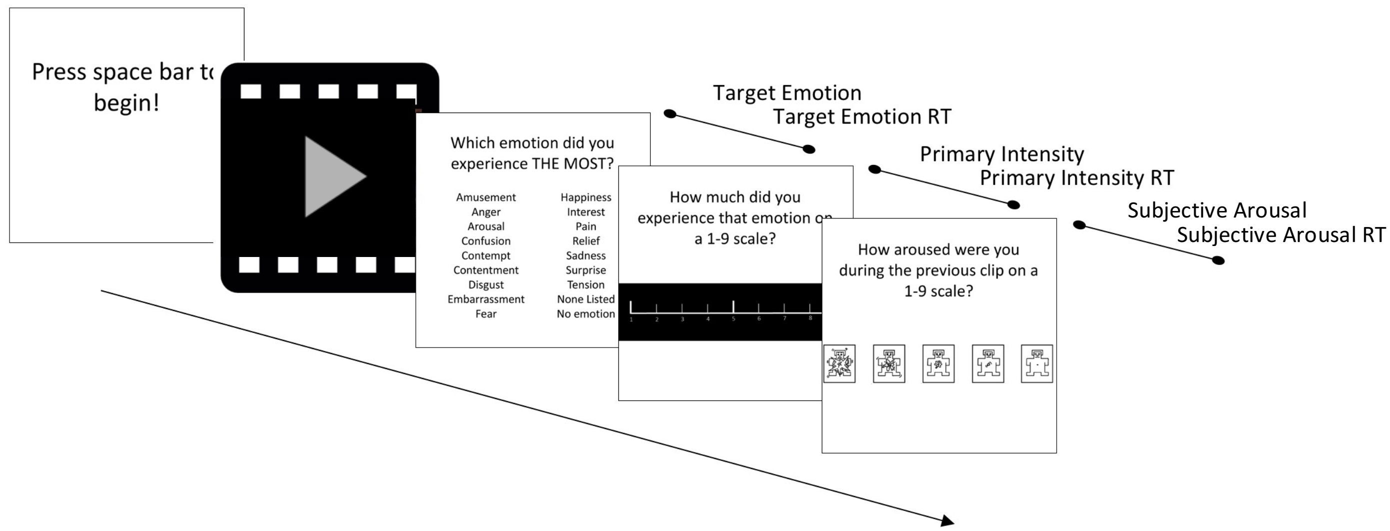

Figure 3. A trial of the primary emotion portion of the experiment and variable labels.
Note. Text here is abbreviated.

Secondary Emotions. Next, participants were presented with a serial list of 29 additional emotion words and asked how much they experienced each on a scale of 1-9, on which 1 indicated "I did not experience this emotion at all." These included the 16 emotion words described above, non-overlapping words from the Positive and Negative Affect Scales (PANAS; Watson, Clark & Tellegen,1988) and two additional words added after piloting the experiment (calm, pity). Words are summarized in Appendix B. Emotions rated >1 were considered a positive endorsement of that emotion. From secondary emotion responses, variables were created for intensity of secondary emotions and total secondary emotions endorsed. At the end of each trial, participants were asked to indicate whether they had seen the film previously. They were asked to press a space bar to begin the next trial. The secondary emotion portion of the experiment is depicted in Figure 4.

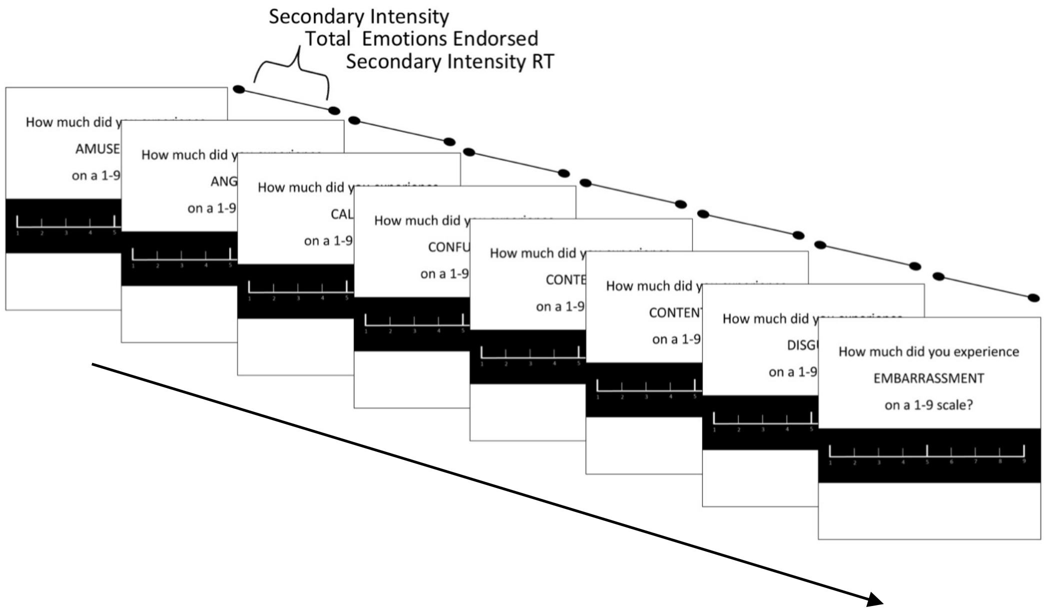

Figure 4. An abbreviated trial of the secondary emotion portion of the experiment and variable labels. *Note:* In actuality, 29 different words are presented to participants; Text here is abbreviated.

The secondary emotions portion of this experiment is used to calculate measures of emotional complexity, including granularity and dialecticism. Erbas et al. (2014) showed a negative relationship between alexithymia and negative granularity. The current study expands these findings by assessing positive granularity, and by using more complex and intense emotional stimuli (video clips versus static images and names of friends and family); this is an important step, as simple cues may be more likely to tap into rudimentary knowledge of emotional concepts, facilitating normative self-report (Lindquist & Barrett, 2008).

Data Analyses

Missing and outlying data. Because of technical errors that caused the task program to fail, .007% of performance data points were missing. Eight participants were missing data from one of fourteen emotion induction trials; in this case, data from an induction congruent trial was used as a proxy to calculate overall aggregate variables. A ninth participant was missing data from both surprise induction trials; in this case, overall mean data from other trials was imputed for surprise trials. Response time variables were influenced by outliers. To address this, outliers were defined as data points 6 SDs greater than the mean, and were winsorized (Ghosh & Vogt, 2012). A total of .003% of these variables were adjusted. After adjustment, all task variables met assumptions of linear regression (Tabachnick & Fidell, 2007).

Elastic net regression models. To explore secondary emotional variables, elastic net regression was employed. This approach is a form of automatic variable selection, used to identify predictive variables within large data sets while utilizing shrinkage estimates to reduce predictive errors and avoid overfitting. An extension of ridge regression (Hoerl and Kennard, 1988) and least absolute shrinkage and selection operator (LASSO; Tibshirani, 1996), Zou and Hastie (2005) developed the elastic net approach to better accommodate data sets in which predictors outweigh number of participants. Elastic net combines the penalties applied in ridge and LASSO regression, facilitating variable selection by shrinking non-relevant regression coefficients to 0 and grouping similar variables, allowing collinear variables in the same model.

This approach is ideal for examining variables in the secondary emotion condition. This condition yielded a large number of response variables (RTs and intensity ratings for 29 emotion words across 14 inductions). Though some permeations are collapsed and presented in ordinary least squares analysis in the present study, elastic net is used as an exploratory supplement facilitating consideration of specific secondary emotion words.

Eventually, this information can be used to develop a more parsimonious version of the task presented, as well as guide interpretation of relevant themes present in alexithymia.

Results

Descriptive

Mean TAS-20 was 45.75 (SD = 8.51). Mean DDF score was 12.42 (SD = 2.30); DIF was 14.71 (SD = 4.00); and EOT was 18.62 (SD = 3.70).

Task Performance. Means and standard deviations by emotion category for main performance variables are depicted in Table 1 and response time variables in Table 2. Repeated-measures analysis of variance (ANOVA) was used to test the effect of emotion category (amusement, anger, contentment, disgust, fear, sadness, surprise). As expected based on Gross and Levenson's (1995) findings, emotion category had a significant effect on all performance variables. There were no significant category by TAS-20 interactions on performance. Results presented in Table 1.

	Target Emotion	Primary Intensity	Subjective Arousal	Secondary Intensity	Total Secondary Emotions
Amusement	0.77 (.31)	5.85 (1.49)	4.62 (1.75)	1.94 (.52)	8.94 (4.74)
Anger	0.47 (.35)	5.62 (1.73)	5.21 (1.64)	2.90 (.87)	15.21 (5.25)
Contentment	0.36 (.41)	3.40 (1.93)	1.88 (1.65)	1.55 (.50)	5.41 (4.14)
Disgust	0.72 (.31)	6.06 (1.97)	5.05 (1.67)	2.00 (.63)	9.44 (4.55)
Fear	0.89 (.22)	4.55 (1.87)	5.18 (1.77)	2.11 (.57)	11.82 (4.70)
Sadness	0.91 (.24)	6.00 (1.67)	4.67 (1.57)	2.23 (.67)	13.34 (4.67)
Surprise	0.52 (.35)	4.65(1.73)	4.54 (1.69)	1.88 (.58)	10.92 (4.57)
$F(6,42)$	53.73***	64.98***	83.48***	152.19***	185.04***

Table 1. Descriptive performance data for videos based on emotion induction category. *F* values depict effect of emotion category on performance. *Note.* ***$p < .001$

ANOVA analyses also revealed significant main effect of emotion category on all response time variables as well. Means, standard deviations, and *F* statistics reported in Table 2. There were no significant group by alexithymia interactions on performance variables. Because of the lack of interactions between TAS-20 and emotion category for performance and RT variables, emotion categories were collapsed for all future analyses.

	Target Emotion RT	Primary Intensity RT	Subjective Arousal RT	Secondary Intensity RT
Amusement	6.49 (.34)	9.81 (.58)	7.07 (.31)	1.40 (.44)
Anger	10.13 (.58)	17.04 (.12)	6.87 (.30)	1.69 (.50)
Contentment	13.9 (.91)	13.69 (.85)	8.21 (.33)	1.11 (.44)
Disgust	6.44 (.34)	7.74 (.46)	6.91 (.30)	1.37 (.41)
Fear	9.18 (.45)	13.39 (.72)	9.67 (.57)	1.63 (.49)
Sadness	6.33 (.40)	9.79 (.58)	7.86 (.38)	1.60 (.46)
Surprise	9.34 (.51)	14.12 (.83)	10.38 (.58)	1.47 (.43)
$F(6, 42)$	32.35***	20.96***	15.71***	78.70***

Table 2. Descriptive response time data for videos based on emotion induction category. *F* values depict effect of emotion category on performance. *Note.* ***$p < .001$; RT = response time.

Validating Findings

Patterns of responding are consistent with original findings of Gross and Levenson (1995). There is a deviation in target emotion for the disgust video depicting an arm amputation: in the original study, 80% of participants identified disgust as their primary emotion following this video, and only 57% chose so in the current study. A greater proportion (24%) selected “interest” as primary, possibly reflecting high proportion of pre-medical students in Vanderbilt undergrad psychology courses. Also unlike original findings in other studies, there was no relationship between intensity and previous experience with videos ($ps > .35$).

Relationship between performance variables

Spearman correlations between major task variables are presented in Table 3. All RT variables were strongly and positively inter-correlated. Secondary intensity was correlated with primary intensity RT. Primary and secondary intensity were positive correlated with secondary intensity RT. Finally, primary and secondary intensity were positively correlated with subjective arousal. There were no gender differences in performance with the exception of a statistical trend between males (mean= 9.33s, sd = 2.22) and females (mean = 8.44s, sd = 2.61) for target emotion RT; it took males longer to identify primary emotional experience ($t(108)=1.73$, $p<.10$).

	2	3	4	5	6	7	8
1. Target emotion	-0.15	-0.12	0.05	0.01	-0.06	0.00	0.07
2. Primary intensity		-0.43**	0.64***	0.12	-0.15	0.00	0.23*
3. Subjective arousal			0.33***	0.02	0.03	0.06	1.30
4. Secondary intensity				0.00	-.21*	-0.04	0.36***
5. Target emotion RT					0.55***	0.42***	0.51***
6. Primary intensity RT						0.50***	0.53***
7. Subjective arousal RT							0.55***
8. Secondary intensity RT							

Table 3. Spearman correlations between major task variables.; *$p < .05$; **$p < .01$.; ***$p < .001$

Testing interaction of TAS-20. Where there were significant correlations between task variables, the effect of TAS-20 total score was assessed using Hayes's (2013) PROCESS macro for moderation. No significant moderating effects of TAS-20 total emerged. Thus, alexithymia was associated with similar patterns of emotional processing.

Relationship between TAS-20 and performance variables

Overview of performance variables. Because of the ordinal nature of the target emotion variable and total secondary words endorsed, spearman correlations were employed to assess overall relationships between TAS-20 and performance variables. Overall, TAS-20 total was correlated with reduced likelihood of selecting target emotion ($\rho = -0.21$, $p < .05$) and reduced subjective arousal ($\rho = -0.23$, $p < .05$). It was also associated with faster RTs to questions about intensity of primary ($\rho = -0.25$, $p < .01$) and secondary ($\rho = -0.28$, $p < .01$) emotions. Correlations between performance variables and TAS-20 subscales are reported in Table 4.

	TAS-20 Subscales		
	DDF	DIF	EOT
Target Emotion	-0.17†	-0.14	-0.16†
Primary Intensity	-0.09	-0.16	-0.04
Subjective Arousal	-0.22*	-0.12	-0.19*
Secondary Intensity	-0.07	-0.05	-0.11
Total Secondary Words	-0.04	0.03	-0.18†
Target Emotion RT	-0.01	-0.22*	-0.05
Primary Intensity RT	-0.12	-0.26**	-0.21*
Subjective Arousal RT	-0.09	-0.10	-0.07
Secondary Intensity RT	-0.13	-0.25*	-0.26**

Table 4. Spearman correlations between TAS-20 total score and subscales. *Note.* †$p < .10$; *$p < .05$; **$p < .01$.

DDF was associated with reduced arousal overall and reduced likelihood of selecting target emotion at the trend level. DIF was negatively associated with RT variables including: identifying primary emotion RT, primary intensity and secondary intensity RTs. EOT was associated with reduced arousal and faster response times for primary and secondary emotional intensity. EOT was associated with reduced likelihood of selecting the target emotion and endorsing fewer secondary emotion words overall at the trend level.

Because of the gender difference for selecting target emotion RT, the relationship between DIF and selecting target RT was re-run controlling for gender. The relationship remained significant. RT variables were also assessed with "no emotion" as a covariate, as selecting "no emotion" might have prompted participants to answer subsequent questions without contemplation, skewing RT. All relationships remained significant.

Group differences in selecting target emotion. Participants were divided into high (1 SD above the mean, 54, n = 21) and low (1 SD below the mean, 37, n = 19) TAS-20 scores in a *post hoc* analysis investigating qualitative differences in selecting target emotions, to better understand why TAS-20 was associated with reduced likelihood of selecting the target emotion (ρ = -.211, p < .05). Visual inspection suggested similar response patterns, with the majority selecting the target emotion in both groups; however, it seemed visually that the high alexithymia group showed a greater range of responses. Indeed, the low alexithymia group endorsed on average fewer non-target primary emotions (2.86) compared to the high alexithymia group (4.26; (t(40)=-2.68, p<.05). Figure 5 depicts an example.

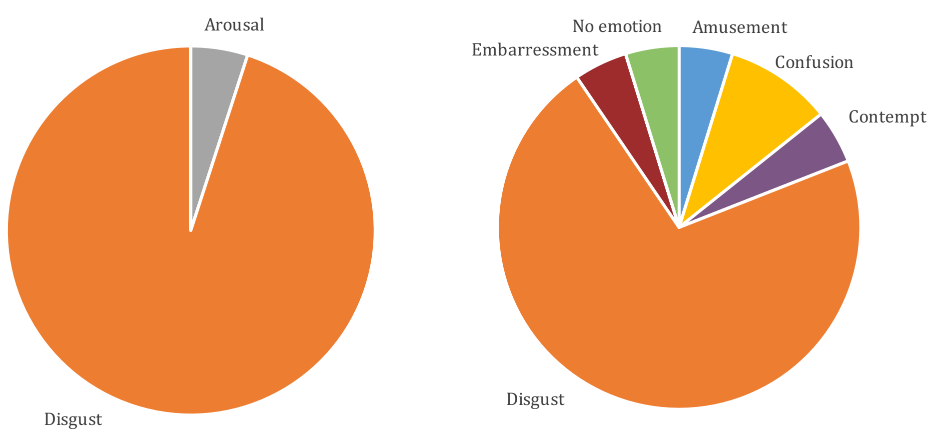

Figure 5. Example of variability in primary emotions selected in high alexithymia. This figure depicts target emotion selected following a disgust induction, in which a woman eats her dog's feces. The graph on the left represents those with low TAS-20 total (1 SD below the mean); the right represents those with high TAS-20 total (1 SD above the mean).

To assess patterns in selecting primary emotions, 11 t-tests were conducted comparing frequency of endorsing non-target primary emotional states between high and low alexithymia, depicted in Table 5. The high alexithymia group was associated with more frequent selection of "no emotion" (t (40) = -2.92, p < .001) and "confusion" (t(40) = -2.03, p

< .05) as primary emotional state. To better understand how frequency of these emotion words contributed to the significant correlation between TAS-20 total score and target emotion (ρ = -.211, p < .05), a composite score of their combined frequencies was entered into a partial correlation analysis. With introduction of the composite term, the significant relationship between TAS-20 and accuracy became non-significant (ρ = -.07, p = .48).

	Low Alexithymia	High Alexithymia	
	Mean (SD)	Mean (SD)	*t*
Arousal	0.16 (.37)	0.14 (.36)	0.13
Confusion	0.21 (.42)	0.71 (1.01)	-2.03*
Contempt	0.11 (.32)	0.29 (.56)	-1.24
Embarrassment	0.05 (.23)	0.14 (.36)	-0.94
Happiness	0.21 (.42)	0.38 (.50)	-1.17
Interest	0.68 (.95)	0.67 (1.02)	0.06
Pain	0.05 (.23)	0.05 (.22)	0.07
Relief	0.32 (.67)	0.33 (.66)	-0.08
Tension	0.21 (.42)	0.19 (.40)	0.15
Not Listed	0.21 (.42)	0.19 (.40)	0.15
No Emotion	0.21 (.42)	1.29 (1.55)	-2.92**

Table 5. Group differences in endorsing non-target primary emotions. *Note*: "Not Listed" refers to the item, "the emotion I selected is not listed here." *p < .05; **p < .01.

For subsequent analyses, the frequency of selecting "no emotion" and "confusion" as primary emotional experience were combined into a "target composite" variable. TAS-20 total was positively correlated with target composite (ρ = -.30, p < .01), as well as EOT (ρ = -.31, p < .001). DDF and DIF were positively correlated at the trend level (for both, ρ = -.17, p < .10).

TAS-20 and Emotional Complexity

To assess the relationship between alexithymia and measures of emotional complexity, variables for granularity and dialecticism were formed. Emotion granularity variables were formed by calculating intraclass correlations with absolute agreement between intensity ratings of each word in the secondary emotion portion of the experiment, and calculating an average correlation (Barrett et al., 2001). Separate measures were calculated for positive granularity (assessing correlations between positive words only) and negative granularity (assessing correlations between negative words only). The average correlation coefficient was then subject to Fisher's *z* transformation, which for for ease of interpretation, was subtracted from one, such that a greater score indicates higher granularity (this reflects standard calculation of granularity indices; Barrett et al., 2001; Boden et al., 2013; Tugade et al., 2004).

Negative granularity was associated with greater likelihood of selecting the target emotion (ρ = -0.24, $p < .05$), reduced target composite (ρ = -0.21, $p < .05$), fewer secondary words endorsed overall (ρ = -0.34, $p < .05$), reduced intensity of secondary emotion words (ρ = -0.34, $p < .05$) and slower response time for arousal (ρ = -0.21, $p < .05$). Negative granularity was associated with positive granularity at the trend level (ρ = 0.17, $p < .10$); no other variables were related to positive granularity. For a complete correlation table of task variables in experiment 1, see Appendix D.

Dialecticism variables were formed by calculating a ratio of incongruent emotion endorsements to congruent emotion endorsements for positive inductions and negative inductions. Positive dialecticism was calculated as the ratio of positive endorsements in a negative emotion induction category to negative endorsements in a negative induction category. Negative dialecticism was calculated as the ratio of negative endorsements in a positive emotion induction category to positive endorsements in a positive induction category. Because resulting variables were significantly positively skewed, $\log_{10}$ transformations were applied to normalize their distribution.

Positive and negative dialecticism were associated with greater number of secondary words endorsed ($\rho = 0.26$, $p < .01$ and $\rho = 0.54$, $p < .001$, respectively), greater intensity of secondary words endorsed ($\rho = 0.25$, $p < .01$ and $\rho = 0.47$, $p < .001$, respectively) and slower RT to questions about secondary intensity ($\rho = 0.36$, $p < .01$ and $\rho = 0.31$, $p < .001$, respectively). RT findings are consistent with previous literature that response time is slower following ambiguous stimuli (Hock & Krohne, 2004; Hock, Krohne, & Kaiser, 1996; Lischetze et al., 2005). In addition, negative dialecticism was also associated with greater arousal ($\rho = 0.24$, $p < .05$) and primary intensity at the trend level ($\rho = 0.20$, $p < .10$). Positive dialecticism was associated with reduced likelihood of selecting the target emotion ($\rho = -0.19$, $p < .10$).

TAS-20 total score was associated with reduced negative granularity ($\rho = -0.20$, $p < .05$), but not positive granularity. It was negatively correlated with negative dialecticism at the trend level ($\rho = -0.19$, $p < .10$) but not positive dialecticism. Correlations with specific TAS-20 subscales are reported in Table 6. Males demonstrated significantly lower positive granularity ($t(106) = -2.34$, $p < .05$) and positive dialecticism ($t(106) = -2.18$, $p < .05$) compared to females, but showed no difference between negative granularity and dialecticism.

	TAS-20 Subscales		
	DDF	DIF	EOT
Negative Granularity	-0.14	-0.17†	-0.12
Positive Granularity	-0.01	-0.13	0.05
Negative Dialecticism	-0.08	-0.11	-0.26*
Positive Dialecticism	-0.11	-0.07	-0.04

Table 6. Measures of emotional complexity correlated with TAS-20 subscales. *Note.* †$p < .10$; *$p < .05$

Predictive Value of Overall Performance Variables.

To determine the value of performance variables and aspects of emotional complexity for predicting alexithymia subscales, multiple regression models were performed. Variables were entered into the model as predictors if they were correlated with respective subscales, as are presented in Table 4 and Table 6. Results of regression models are shown in table 7. All predictors and outcomes met assumptions of multivariate analysis (Tabachnick & Fidell, 2007). All models remained significant when controlling for gender and previous exposure to videos.

	t	β	df	F	R^2
DIF			(5, 101)	2.27†	0.06
Negative Granularity	-1.77†	-0.18			
Secondary Intensity RT	-1.71†	-0.22			
Target Emotion RT	-0.28	-0.04			
Primary Intensity RT	-0.60	-0.08			
Target Composite	-0.40	-0.04			
DDF			(2, 104)	4.17*	0.07
Subjective Arousal	2.51*	0.24			
Target Composite	0.71	0.07			
EOT			(6, 100)	3.90**	0.14
Negative Dialecticism	-2.32*	-0.24			
Target Composite	2.56*	0.26			
Primary Intensity RT	-1.23	-0.16			
Secondary Intensity RT	-0.04	-0.01			
Number Endorsed	-0.04	-0.02			
Subjective Arousal	0.60	0.06			

Table 7. Predicting TAS-20 subscales from performance variables using multiple regression. *Note.* β represents standardized beta coefficient; R^2 represents adjusted R squared; these models remained significant when controlling for gender and previous experience. *$p < .05$; **$p < .01$.; † $p < .10$

To develop more parsimonious models for future testing, a second set of models was generated using only variables that contributed to models significantly and statistical trends. Results are depicted in Table 8.

	t	β	df	F	R^2
DIF			(2, 105)	5.25	0.07
Secondary Intensity RT	-2.83**	-0.26			
Negative Granularity	-1.76†	-0.16			
DDF			(1, 106)	7.88**	0.06
Subjective Arousal	2.81**	0.26			
EOT			(2, 105)	10.10***	0.15
Target Composite	3.43***	0.31			
Negative Dialecticism	-2.63**	-0.24			

Table 8. Parsimonious multiple regression models using performance variables and emotional complexity to predict alexithymia. *Note.* β represents standardized beta coefficient; R^2 represents adjusted R squared

Overall, DIF was best predicted by faster secondary intensity RT and reduced negative granularity. DDF was best predicted by subjective arousal. EOT was best predicted by reduced negative dialecticism and increased frequency of selecting “no emotion” and “confusion” as primary emotional experiences.

Exploratory Analysis of Secondary Emotions Condition.

To explore response patterns of secondary emotions, elastic net regression was utilized. Table 9 reports summary of regression coefficients that remain significant after penalty, all of which present values e^{-6}. Blank values represent coefficients shrunk to 0 after applied penalty. Only secondary emotion words with predictive value are presented in the table, organized by TAS-20 subscale, intensity and RT ratings, and values following positive and negative emotion inductions. Secondary emotion words that did not predict TAS-20 subscales include: anger, calm, confusion, contempt, contentment, enthusiasm, happiness, inspiration, jittery and pride.

	DDF				DIF				EOT			
	Intensity		RT		Intensity		RT		Intensity		RT	
	+	-	+	-	+	-	+	-	+	-	+	-
Amusement					-9.88						-1.93	
Disgust									-3.33			
Distress											-6.16	
Embarrassment									-4.05			
Excitement				-2.93				-4.70				-9.64
Fear									-1.66			
Guilt									-8.35			
Hostility			-2.09				-6.34		-1.52			
Interest			-1.27	-1.98			-2.04	-3.17				-2.55
Irritability			-7.81	-5.80			-1.37	-5.23				
Nervousness												-2.80
Pain									-2.20			-2.03
Pity						-2.19		-2.37	-1.06		-7.76	-3.34
Relief							-1.14					
Sadness							-4.28		-2.73			
Shame			-9.14				-1.58	-2.48			-4.67	
Surprise								-3.18				
Tension												-1.59
Upset									-3.52			-1.51

Table 9. Identifying secondary words with predictive value based on elastic net procedure. *Note.* "+" indicates variables following a positive emotion induction; "-" indicates variables following a negative emotion induction.

Post-Experiment Questions

TAS-20 total score was associated with perceiving the task as more challenging (ρ = 0.21, $p < .05$) and at the statistical trend level, less enjoyable (ρ = 0.18, $p < .10$). Challenge was driven by DIF (ρ = 0.24, $p < .05$) and DDF at the statistical trend level (ρ = 0.18, $p < .10$). Enjoy was driven by EOT at the statistical trend level (ρ = -0.16, $p < .10$).

Discussion

The current study investigated the role of alexithymia in emotion processing with a novel laboratory-based experiment. Participants viewed video clips standardized to elicit a particular emotional state then responded to a series of questions about their subjective experience. From these responses, various performance measures were generated, including subjective experiences, implicit measures of emotion processing (i.e., response time) and aspects of emotional complexity. In addition to subjective arousal, well studied in this field, labeling primary emotion, response time, emotional granularity and dialecticism emerged as important predictors of alexithymia. Relationships between alexithymia and these factors have been minimally studied and thus hold promise for further elucidating the construct through future research. Results speak to the disparate theoretical underpinnings of TAS-20 subscales, and provide a basis for multiple avenues of further research.

Overall Performance

Alexithymia was associated with various abnormalities in overall performance. Emotion-inducing videos utilized in this study are well validated for eliciting a particular emotional state, or "target" emotion; alexithymia was associated with reduced likelihood of selecting this target emotion. In part, this was due to greater variability in primary emotional experience; those with heightened alexithymia selected more non-target emotions as primary. Individuals with low alexithymia evidenced greater consistency in selecting the intended primary emotion, consistent with accessing normative emotional concepts to make sense of their internal emotional experiences. Consistent with the theory that alexithymia is associated with impoverished or decreased access to conceptual information about emotions (Kashdan et al., 2015; Nook et al., 2015), alexithymia was associated with selecting a wider range of primary emotions. For example, whereas a video of a woman eating her dog's feces unambiguously and quickly elicited the concept "disgust" for most participants, those with high alexithymia endorse "embarrassment," "contempt," "confusion," "no emotion" and even "amusement" as primary emotional experience.

Reduced likelihood of selecting the target emotion was also driven by greater frequency of selecting "no emotion" and "confusion" as primary among individuals with elevated alexithymia, and was among the best predictors of the EOT subscale. It is impressive that this pattern emerged, considering contextual cues aid emotion identification (Nook et al., 2015; Halberstadt & Niedenthal, 2001), a wealth of which were provided in the current study (e.g., inclusion of simple and familiar themes, such as death; provision of emotion label words) that could have facilitated a response based on external (rather than internal) information. This suggests alexithymia involves a lack of awareness of internal emotional states, even in response to relatively intense and discrete inductions accompanied by numerous contextual cues.

Selecting "no emotion" may result from having an increased threshold through which emotionally relevant cues enter consciousness. If individuals recognize the presence of an emotional state, but lack refined conceptual knowledge about emotion, they may be likely to endorse "confusion" as primary emotional experience. It could also be the case that alexithymia is truly associated with experiencing "no emotion" in response to the film clips in this study; however, a wealth of evidence suggests alexithymia is associated with intact physiological correlates of emotion (e.g., Bausch et al., 2001; Constantinou, et al., 2014; Eastabrook et al., 2013; Pollatos et al., 2008; Roedema & Simons, 1999) and inaccurate reporting about internal experiences (e.g., Constantinou et al., 2014; Stone and Nielson, 2001; Franz et al., 2003; Pollatos et al., 2011; Vanman et al., 1998).

Alexithymia was associated with faster response times to questions about emotional intensity. This finding is inconsistent with work showing faster response time to emotional questions is associated with greater emotional clarity (Lischetzke et al., 2005; Lischetzke et al., 2011), a construct thought to overlap with the alexithymia (Taylor, 2004). However, the stimuli used in the present study where relatively complex and intense compared to Lischetzke et al. (2005) and Lischetzke et al. (2011), and may reflect reduced dialecticism of experiences that entailed greater mixed affect. Research shows that when answering questions following the presentation of ambiguous stimuli, response time slows (Hock & Krohne, 2004; Hock, Krohne, & Kaiser, 1996; Lischetzke et al., 2005). Thus, if alexithymia entails reduced complexity of emotional experience, it would follow that response time would be faster compared to a normative population in response to the same stimuli. In fact, alexithymia was associated with reduced negative dialecticism in the current study. Because dialecticism of emotional experiences is adaptive, faster response time among those with heightened alexithymia may indicate a problematic lack of dialectical thinking, or lack of awareness of mixed emotional states. Similarly, faster response times in the present study could reflect reduced contemplation about emotional states prior to responding.

Emotional Complexity

Total alexithymia score was associated with reduced negative granularity, reflecting reduced tendency to differentiate between negative emotion states. This finding adds credence to the long-held theory that those with elevated alexithymia experience states of "undifferentiated negative affect" (e.g., Lane, 1997). Emotional granularity is associated with increased frequency and success of employing emotion regulation strategies in response to negative affect (e.g., Barret et al., 2001). In order to cope effectively in situations that elicit negative affect, one must be capable of identifying the specific emotion state that needs addressing (Kashdan et al., 2015). For example, effective strategies for reducing "anger" are different from strategies utilized to reduce "sadness."

Deficits in emotion granularity may help explain why alexithymia is associated with reduced use of effective coping strategies (e.g., Fukunishi & Rahe 1995; Moriguchi et al., 2007; Parker et al. 1998; Swart et al., 2009; Vingerhoets, van den Berg, Kortekaas, van Heck, & Croon, 1993). In the absence of emotional awareness, those with elevated alexithymia may not have the necessary information to differentiate affective states. Because poor regulation of negative affect leads to poor health outcomes (see Desteno et al., 2013 for review), reduced negative granularity may also help explain why alexithymia is associated with many medical comorbidities (e.g., Tominaga, Choi, Nagoshi, & Fukui, 2013).

Alexithymia was also associated with reduced negative dialecticism, or endorsing the experience of negative affective states following a positive emotion induction. This finding is particularly impressive as the videos selected for use in the current study were selected to elicit intense prototypical emotional states, and thus not designed to elicit mexed emotion. A core component of dialectical behavioral therapy (Linehan, 1993), dialecticism has clear implications for mental health, by enhancing emotion regulation and distress tolerance, among other benefits (e.g., Lynch, Chapman, Rosenthal, Kuo, & Linehan, 2006). It is adaptive to recognize negative affect during a primarily positive emotional state; for example, if you come home in good spirits after a great day at work and find your partner has had a terrible day, it benefits both parties if you can empathize by attuning to your partner's negative affective experiences in conjunction with your overall positive affective state. Accordingly, dialecticism may promote empathizing with others.

There was no relationship between positive dialecticism and alexithymia in the current study, however this effect may be understated as the task design was better suited to tap into negative dialecticism. In fact, positive dialecticism was associated with reduced likelihood of selecting the target emotion, suggesting that as assessed in the current study, elevated positive dialecticism did not promote normative emotional processing. The positive films presented in this paradigm are inherently more ambiguous than those used to induce negative affect. For example, one of two amusement inductions depicts Robin William's performing standup comedy. All data collection was conducted shortly after William's unfortunate death in August 2014, so it is not surprising that 28% of participants endorsed sadness as a secondary emotion. The same clip has references to drug use and drunk driving, which may explain why 15% of participants endorsed "disgust" as a secondary emotion.

Similarly, the second amusement-inducing clip, from *When Harry Met Sally,* depicts a scene in which the actress Meg Ryan demonstrates her ability to fake an orgasm in a crowded restaurant; thus, it is not surprising that 45% of participants endorsed "embarrassment" as a secondary emotion. Consequently, a degree of dialecticism may be normative for positive emotion inductions in this study, whereas greater endorsement of positive emotions in negative film clips (e.g., apartheid scene in *Cry Freedom*) does not represent adaptive emotional processing. Future studies should continue investigating the role of positive dialecticism in alexithymia, as well as its negative consequences, using ambiguous stimuli. The current paradigm could easily be adapted to investigate this possibility in the future, by replacing Gross and Levenson's (1995) film clips with more ambiguous inductions.

The current study suggests alexithymia is associated with intact ability to differentiate between positive affective states. There were also no differences between positive emotional differentiation in alexithymia. It may be that greater deficits are observed in complexity of the experience of negative emotions because of the tendency for those with elevated alexithymia to avoid or suppress negative affect (Páez et al., 1999; Panayiotou et al., 2014; Parker et al., 1998; Swart et al., 2009) which may interfere with the development of effective conceptual knowledge of these experiences. Interestingly, positive granularity was not correlated with any performance variables in the current study, suggest that in general, it may entail underpinnings distinct from negative granularity. In either case, findings are promising as they reveal intact granularity in alexithymia; it may be that negative granularity and dialecticism can be enhanced through intervention, which may reduce its problematic behavioral correlates.

Subscale Analysis

Performance variables differentially predicted TAS-20 subscales; each subscale was predicted by a distinct pattern of performance variables. These disparate findings underscore important theoretical differences between components of alexithymia and speak to the importance of considering subscales independently, rather than assessing TAS-20 only in its composite score. Subjective arousal best predicted DDF; those with elevated DDF scores reported reduced arousal overall. DIF was best predicted by faster secondary intensity RT and at the trend level, reduced negative granularity. EOT was best predicted by reduced negative dialecticism and increased target composite (selecting "no emotion" and "confusion" as primary emotions).

Predictive models explained the most variance in EOT scores (15%). A preference for externally oriented thinking may relate to a higher than average threshold for recognizing the correlates of an emotional experience, resulting in generation of "no emotion" or "confusion" as primary emotional state. Similarly, it may limit recognition of negative emotions experienced during primarily positive affective states (e.g., "sadness" when watching Robin William's standup comedy). Reduced subjective arousal in DDF may result in reduced awareness of interoceptive correlates of emotional experiences. DIF was best predicted by reduced negative granularity and faster response time for reporting secondary intensity. The ability to "identify feelings" may involve clearly and discretely identifying emotional states; faster response time may indicate reduced complexity of emotional experiences while reduced negative granularity indicates diffuse versus specific experience of negative affect. Future studies should carefully parse behavioral findings as they relate to specific TAS-20 subscales. Doing so may illuminate inconsistencies in the field and promote generation of clearer themes in alexithymia.

Secondary Emotion Words

Exploratory analysis of specific secondary emotion words was employed to identify superfluous emotion word variables to potentially be deleted in future iterations, increasing task efficiency. This analysis conveys that the following emotions do not have value for predicting TAS-20 subscales: anger, calm, confusion, contempt, contentment, enthusiasm, happiness, inspiration, jittery, pride. Future iterations of this task may consider removing these words to increase efficiency. The word "pity" carried significant variance in its intensity ratings and RT ratings in both DIF and EOT subscales. Inclusion of this word was the result of piloting this study. It is not a part of PANAS (Watson et al., 1988) nor the original Gross and Levenson (1995) battery; thus, it may be considered in the future as a relevant in alexithymia studies.

Patterns revealed in this analysis validate several additional task findings. In predicting EOT, intensity of only words following positive emotion inductions carry predictive weight. Of these words, all are negative, validating the finding that the EOT subscale is associated with reduced negative dialecticism. No intensity ratings of secondary emotions predict the DDF subscale, and only two (amusement following positive induction, pity following negative induction) predict DIF.

Secondary intensity response times following positive and negative inductions predict DIF, consistent with the previous finding that overall response time in secondary emotion condition best predicts the DIF subscale. Response times to specific items contribute significant variance across other subscales and emotion inductions, highlighting its potential future use as an implicit measure of emotion processing in alexithymia.

Post-Experiment Measures

Finally, alexithymia was associated with experiencing the task as more challenging (driven by DIF and DDF) and less enjoyable (driven by EOT). These ratings speak to the subjective challenge of reflecting on emotional states in those who struggle to identify and describe their internal experiences, and the preference of those with externally-oriented cognitive styles to avoid thinking about emotional experiences.

Limitations

Providing emotion labels was an important first step for this line of work; however, doing so inevitably confers study limitations. Evidence suggests reports of emotional experience are more likely to be biased by external information rather than interoceptive cues in individuals with alexithymia (Peasley-Miklus, 2015), which might explain the discrepancy between physiology and subjective report in alexithymia (e.g., Stone and Nielson, 2001; Franz, et al., 2003; Pollatos et al., 2001; Vanman et al., 1998). Emotion labels provide contextual cues that may serve to normalize subjective report, increasing the chance of responding based on knowledge of an emotion category rather that one's experience of an emotion.

It might also be the case that providing labels has a restorative effect on deficits in emotion processing, as evidenced in facial emotion recognition work (Nook et al., 2015). Providing labels in the current study might have facilitated access to internal emotional states, which might explain why there weren't greater deficits in selecting the target emotion as primary. This possibility presents interesting avenues of future research that have the potential to enhance intervention in those with elevated alexithymia. Future studies could easily adapt the current paradigm to address this question, by replacing emotion labels with prompts for free response.

In either case, results of the present study would likely differ if participants were prompted to identify emotional states using free response. Similarly, results should be considered in light of the nature of laboratory-based designs, which are more likely to tap into *capacity* for emotion processing versus the *tendency* to do so, a distinction that Torrisi and colleagues (Torrisi, Lieberman, Bookheimer, & Altshuler, 2013) highlight in their work on affect labeling. In the absence of ecological validity assessment, it is impossible to know the extent to which the process of emotion labeling is employed in every day emotional processing. Similarly, emotional granularity is traditionally measured using experience sampling methods (e.g., Tugade et al., 2004); such methodology is essential for understanding how deficits in granularity manifest in daily life. Experience sampling methods are an important next step in parsing this difference in alexithymia.

This study would have benefited from consideration of depressive symptoms, known to affect levels of alexithymia; though participants were screened for psychopathology, it is likely that sub-clinical depressive symptoms were present in this population. The current study also did not collect a baseline measure of response time, important for interpreting response latency results (Fazio, 1990).

The current study sought to understand alexithymia as it is normally distributed in the population, instead of comparing groups with high and low alexithymia. Understanding how alexithymia affects emotional processing in a normal population is important; however, the latter approach would likely reveal more significant performance deficits. Thus, these findings should be replicated in groups with significantly high levels of alexithymia, as well as psychopathology populations marked by heightened alexithymia (e.g., autism spectrum disorders, schizophrenia).

Conclusions

The current study presents a novel laboratory-based paradigm that can be utilized in the future to investigate follow-up research questions generated in this study. Results highlight abnormalities in a number of emotional processing domains, including several that have been minimally studied in this field. Consistent with theory that alexithymia is associated with impoverished emotion concepts (Kashdan et al.,2015; Lindquist & Barrett, 2008), alexithymia was associated with reduced tendency to select intended emotional experiences as primary. This is particularly interesting considering inductions in the current study were relatively intense, discrete, and accompanied by a number of contextual cues. In daily life, relevant emotional experiences are rarely this prototypical; thus, it follows that conceptualization of emotional states are more problematic in daily emotional processing, and their individual and interpersonal consequences magnified.

Consistent with accounts that alexithymia is associated with states of undifferentiated negative affect (Lane et al., 1997), the construct was associated with reduced negative granularity and reduced negative dialecticism in the current study. Faster RTs in response to questions about emotional intensity might also reflect reduced dialecticism. Interestingly, alexithymia was associated with neither positive granularity nor positive dialecticism. These hopeful results suggest the possibility of intact capacity for emotional complexity in this population that may be trained to improve health outcomes.

Currently, minimal research has investigated the role of granularity, dialecticism, and other measures of emotional complexity in alexithymia. Reich et al. (2013) argue that emotional complexity comprises multiple aspects of emotional experience, which should be studied in tandem (Boden et al., 2013). Results of the current study highlight the necessity of continued investigation of these constructs in the field, demonstrating that their predictive value surpasses other commonly utilized measures, such as emotional intensity.

Future research is needed to continue identifying problematic elements of emotional processing in alexithymia, as well as their behavioral consequences. The current study points to ways in which alexithymia might lead to problematic mental and physical health outcomes: reduced emotional awareness may hinder development or utilization of conceptual emotional knowledge, which may prohibit effective emotion differentiation, limiting tailored options for emotion regulation. The task presented in this study can be utilized as is or adapted to continue investigating these possibilities further in laboratory-based settings.

CHAPTER III

Experiment 2: Investigating the Relationship Between Alexithymia and Interoceptive Accuracy and Examining the Benefits of a Brief Mindfulness Meditation

Aims

1) Assess the relationship between alexithymia and measures of interoceptive awareness.
2) Test the benefit of a brief mindfulness meditation for improving interoceptive awareness and deficits in emotional processing identified in experiment one.
3) Examine the relationship between interoceptive awareness, alexithymia, and meditation on measures of emotional processing.

Methods

Participants

78 undergraduates were recruited and received course credit for their participation. As in the previous study, exclusion criteria were a past or current diagnosis of depression, anxiety, or substance use disorder. Because of equipment failure, two participants were excluded. Of the 76 remaining participants, 66% were women. The average age was 19.70 (SD = 0.95). Participants were randomly assigned to a meditation or a control group (see below for details). There were no group differences in gender ($\chi^2(1) = .06$, $p = .81$) or age ($t(72) = .229$, $p = .82$). 54% of participants identified as Caucasian, 16% African American or African; 15% Asian or Asian American 3% Hispanic, and 10% “Multiracial” or “other.” There were no group differences between racial background ($\chi^2(6) = 10.42$, $p = .11$).

Materials

Apparatus. In addition to equipment used in experiment one, a Polar H7 Bluetooth Smart Heart Rate Sensor was utilized to measure heart rate. The sensor is attached to a strap that wraps around the chest, below the pectoral line. To facilitate connection, the back of the strap was wet with a moist cotton ball prior to donning. Heart rate data was transmitted using Bluetooth technology to a 4th generation iPad using the Polar Beat App for iPad.

Questionnaires. As in experiment 1, Participants completed the Toronto Alexithymia Scale (TAS-20; Bagby, et al., 1994). Chronbach's alpha was 0.64 in this sample. Throughout the experiment, the reported arousal and intensity ratings using a 1-9 Likert scale. Participants also completed a brief demographics questionnaire, which in addition to age, gender and race, asked for height and weight to calculate body mass index (BMI).

Audio stimuli. Participants listened to a ten-minute audio recording prior to beginning the experimental portion of the study. Participants assigned to the meditation group listened to a recording guiding them through a body scan mediation, in which participants were instructed to mindfully attend to their breath and specific parts of their body. Participants in the control group listened to a passage from a natural history text book. Recordings were generated and validated by Cropley, Ussher & Charitou (2007).

Design and Procedure

After written informed consent was obtained, participants completed a demographic form and questionnaire battery. Using a random number generator, they were randomly assigned to group (meditation or control) and run order. As in the previous study, there were two counterbalanced run orders in which positive and negative emotion eliciting videos were evenly distributed.

Procedure. Participants were provided verbal and visual instructions for applying the heart rate monitor, after which they had the opportunity to ask questions and decline to participate in this portion of the experiment. If willing, the experimenter left the room while the participant applied the monitor. Heart rate was monitored before and after the experimental portion, so for efficiency, participants wore it throughout testing.

Heartbeat tracking task. Schandry's (1981) heartbeat tracking paradigm was employed after completing questionnaires. A baseline measure was collected after completing questionnaires and a follow-up measure collected after emotion induction task. Participants were instructed to sit with eyes closed and hands on the table with palms face up to prevent utilizing pulse detection as a proxy for heartbeat. They were instructed: "Count the number of times you think your heart beats." They first completed a 30s practice trial and had the opportunity to ask questions. Next, they completed 25s, 35s and 45s trials. After each trial, they were asked "how many times did your heart beat." After completing all four trials, they were asked to rate confidence in their estimation as well as perceived difficulty on 1-10 scales (1 = "not at all confident"/"extremely easy"; 10 = "completely confident"/"extremely difficult").

Interoceptive accuracy was calculated as average percent accuracy of all three heart beat counting trials. Because interoceptive sensitivity is inversely related to body fat (Rouse, Jones & Jones, 1988) and in line with formal recommendations for analyzing interoceptive accuracy data detailed in Kleckner et al. (Kleckner, Wormwood, Simmons, Barrett, & Quigley, 2015), BMI was entered as a covariate in all interoception analyses.

Emotion induction task. After completing the first heartbeat detection task, participants completed a practice trial of the emotion induction task as in experiment one. Afterwards, they completed the task exactly as it described in experiment one.

Data Analytic Approach

Missing and outlying data. Similar to experiment one, technical errors resulted in some missing data. In this case, 0.001% of performance data was missing. One participant was missing data from one disgust trial. As before, data from the existing disgust trial were imputed to calculate overall aggregate variables. Data in the present study was also affected by RT outliers. As before, outliers were defined as data points 6 SDs greater than the mean, and were winsorized. A total of 0.004% of response time variables were adjusted in the control condition and 0.003% in the meditation condition. All variables met assumptions of linear regression (Tabachnick & Fidell, 2007).

Three participants were missing heart rate data: one participant declined to participate in this portion, and two participants were missing data due to equipment problems. Two additional participants missed follow-up heartbeat detection measures due to time constraints.

Results

Descriptive Statistics

Alexithymia*.* Means, standard deviations, and *t* values for group differences in TAS-20 are depicted in Table 10. A one-way ANOVA was employed to compare TAS-20 scores from experiment one, the control condition and meditation condition in experiment two. There were no significant differences between total score ($F(2, 181) = .40$, $p = 0.67$) or any subscales (*ps* > 0.27). There was no significant difference between TAS-20 total scores in males compared to females.

	Control	Meditation	*t*
DDF	11.76(3.73)	12.00(3.58)	-0.28
DIF	14.76(3.69)	15.08(4.93)	-0.32
EOT	18.08(4.69)	17.45(3.55)	0.66
Total	44.61(9.53)	44.53(9.31)	0.04

Table 10. Descriptive information and tests of group differences for TAS-20 scores in meditation and control groups.

Measures of interoception. Means and standard deviations for interoception variables are presented in Table 11, as well as their change scores from baseline to follow-up. There were no baseline differences between control and meditation group. There were also no gender or BMI differences. From baseline to follow-up, the only group difference was a reduction in confidence in the meditation group ($t(38) = 2.10$, $p < .05$). Follow-up analyses revealed this was only true for those who had low baseline interoceptive accuracy ($t(25) = 2.40$, $p < .05$). Interoceptive accuracy was correlated with perceived difficulty ($r = -0.36$, $p < .01$). Difficulty and confidence ratings were also correlated ($r = -0.35$, $p < .01$). Interoceptive accuracy and confidence were not correlated.

	Control			Meditation		
BMI	22.87 (2.75)			22.26 (3.47)		
	Pre	Post	Δ	Pre	Post	Δ
Heart rate	76.07(12.54)	69.19(8.97)	6.64	76.94(10.85)	71.71(10.68)	6.48
% Accuracy	0.69 (0.17)	0.75(0.15)	0.06	0.72 (0.18)	0.80 (0.15)	0.08
Confidence	5.56 (1.90)	5.97 (1.67)	0.41	6.18 (2.04)	5.89 (1.99)	-0.29
Difficulty	6.08 (1.86)	5.62 (1.90)	-0.46	5.44(2.00)	5.16 (1.92)	-0.28

Table 11. Means and standard deviations for interoceptive variables in control and meditation conditions. *Note:* Δ refers to change in score from baseline to post measures; *t* scores represent group differences in change between control and meditation group; BMI refers to body mass index.

Relationship Between Alexithymia and Interoception at Baseline

Interoceptive accuracy. Based on visual inspection of scatterplots depicting the relationship between baseline interoceptive accuracy and TAS-20 total score, the quadratic relationships between TAS-20 total and each subscale was tested using hierarchical linear regression. An example of the quadratic relationship observed is depicted in Figure 6.

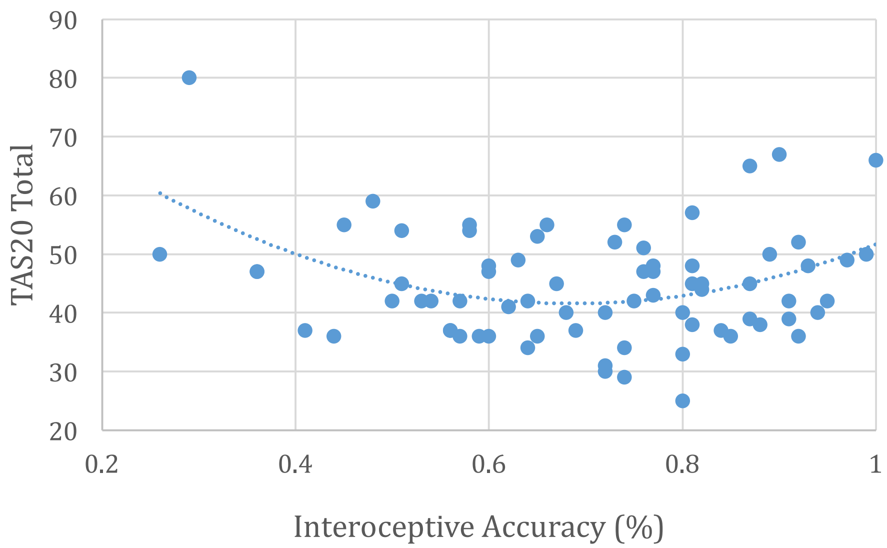

Figure 6. Quadratic relationship between TAS-20 and interoceptive awareness.

BMI was entered as the first step of the model. BMI alone significantly predicted DIF score (F (1,68) = 4.78, R^2 = .07, p < .05). Alone, it predicted no other subscale. The linear term was entered as the second step of the model, and the quadratic term entered as the third. For all models, the quadratic term best captured the relationship, as it significantly increased R^2 from its linear term. Interoceptive accuracy predicted TAS-20 total score (F (1,66) = 10.98, R^2 = .16, p < .01), and in order of significance, EOT (F (1,68) = 7.82, R^2 = .12,

$p < .01$), DDF (F (1,68) = 7.18, R^2 = .13, $p < .01$) and DIF (F (1,68) = 4.27, R^2 = .13, $p < .05$).

Summary depicted in Table 12.

	Step 1		Step2		Step3	
	B (SD)	β	B (SD)	β	B (SD)	β
TAS-20						
BMI	-0.38 (.35)	-0.13	-0.35 (0.36)	-0.12	-0.29 (0.34)	-0.10
HBD			-3.85 (6.50)	-0.07	-132.18 (39.20)	-2.48**
HBD^2					96.56 (29.13)	2.44**
R^2		0.02		0.02		0.16
F for ΔR^2		1.16		0.35		10.98**
Model F		1.16		0.75		4.24**
DDF						
BMI	-0.18 (.14)	-0.15	-0.16 (0.14)	-0.14	-0.14 (.13)	-1.04
HBD			-2.23 (2.51)	-0.11	-43.26 (15.50)	-2.79**
HBD^2					96.562 (29.14)	2.68**
R^2		0.02		0.04		0.13
F for ΔR^2		1.16		0.79		7.18**
Model F		1.16		1.21		3.27**
DIF						
BMI	-0.36 (.16)	-0.26	-0.34 (0.16)	-0.24	-0.32 (.16)	-0.23
HBD			-2.42 (3.01)	-0.10	-41.15 (18.97)	-1.63*
HBD^2					96.562 (29.14)	2.68*
R^2		0.07		0.08		0.13
F for ΔR^2		4.78*		0.65		4.27*
Model F		4.78*		2.70†		
EOT						
BMI	-0.15 (.16)	-0.12	-0.15 (0.16)	-0.11	-0.17 (.15)	-0.13
HBD			-0.80 (2.86)	-0.03	-47.77 (17.58)	-2.72**
HBD^2					36.55 (13.07)	2.80**
R^2		0.01		0.02		0.12
F for ΔR^2		0.96		0.08		7.82**
Model F		0.96		0.51		2.98*

Table 12. Hierarchical multiple regression testing the quadratic relationship between TAS-20 and interocpetive accuracy. *Note:* BMI refers to body mass index. HBD indicates interocpetive accuracy. Alone, HBD refers to the linear term. HBD^2 refers to the quadratic term. *$p < .05$; **$p < .01$.

Interoceptive awareness. The relationship between measures of confidence in heart beat estimation and perceived task difficulty were also assessed for linear and quadratic relationships.

Baseline measures of confidence quadratically predicted TAS-20 total (F (1,68) = 2.83, R^2 = .12, p < .05), with a significant increase from the linear term (F(1,62) = 4.10, ΔR^2 = .06, p < .05). *Post-hoc* analyses revealed this was only true for the DIF scale. In the first step of this model, BMI significantly predicted DIF (ΔF (1,64) = 4.73, R^2 = .07, p < .05). Adding the linear term was also significant (F (1,63) = 3.70, R^2 = .11, p < .05) and added significantly the step one (ΔF(1,63) = 2.56, ΔR^2 = .06, p < .05). Adding the quadratic term was significant (F (1,62) = 4.57, R^2 = .18, p < .05), adding significantly to step two (ΔF(1,62) = 5.76, ΔR^2 = .08, p < .05). When confidence and accuracy quadratic terms were entered into a multiple regression equation, the predictive value of confidence terms became nonsignificant (ps > .82), suggesting that interoceptive accuracy better captures variance in the DIF subscale.

Relationship Between Alexithymia and Interoception at Follow-Up

Interoceptive accuracy. At follow-up, neither linear nor quadratic interoceptive accuracy terms predicted TAS-20 or any of its subscales, with or without group assignment entered as a covariate. *Post hoc* analyses were performed to better understand why the significant relationship between TAS-20 and post-interoceptive accuracy became non-significant. To account for the finding that alexithymia was associated with either increased or decreased heartbeat detection accuracy, four groups were created by splitting alexithymia and baseline interoceptive accuracy scores at their means to form alexithymia/interoception (A/I) group assignments: 1) low alexithymia and low baseline interoceptive accuracy (LA/LI); 2) low alexithymia and high baseline interoceptive accuracy (LA/HI); 3) high alexithymia and low baseline interoceptive accuracy (HA/LI); and, 4) high alexithymia and high baseline interoceptive accuracy (HA/HI). There were no significant group differences in matched variables (e.g., TAS-20 in LA/LI and LA/HI).

Two ANOVA analyses were conducted to determine whether A/I group assignment had an effect on interoceptive accuracy change from baseline to follow-up. A/I group assignment had a significant effect on interoceptive accuracy change in the control group ($F(33, 3) = 3.38$, $p < .05$) and meditation group ($F(36, 3) = 4.49$, $p < .01$). Four paired sample t-tests revealed no significant differences between change scores in each four A/I group assignments in meditation versus control conditions, so subsequent analysis reflects data collapsed across group. After data was collapsed, there were no significant differences between interoceptive accuracy and TAS-20 total scores in matched groups.

Follow-up t-tests were conducted to assess patterns of differences (Figure 7). There was no significant differences in interoceptive accuracy change in those with low alexithymia, regardless of baseline interoceptive accuracy ($t(36) = 0.64$, $p = .53$). In other words, participants with low alexithymia show similar improvement in interoceptive accuracy over the course of the experiment, even if their initial interoceptive accuracy was relatively high.

Those with high alexithymia and low interoceptive accuracy (HA/LI) at baseline show improvement in interoceptive accuracy that exceeds the three other A/I groups: LA/LI group ($t(16) = -2.80$, $p < .05$), the LA/HI group ($t(22) = -2.65$, $p < .05$) and the HA/HI group ($t(19) = -2.21$, $p < .01$).

Unlike all other interoception/TAS-20 groups, participants who initially had high alexithymia and high interoceptive accuracy at baseline not only showed no improvement in interoceptive accuracy over time, they showed a decline in accuracy. In this group, change scores were significantly smaller than all other groups (compared to LA/LI, $t(35) = 2.94$, $p < .001$; compared to LA/HI: $t(37) = -2.50$, $p < .05$).

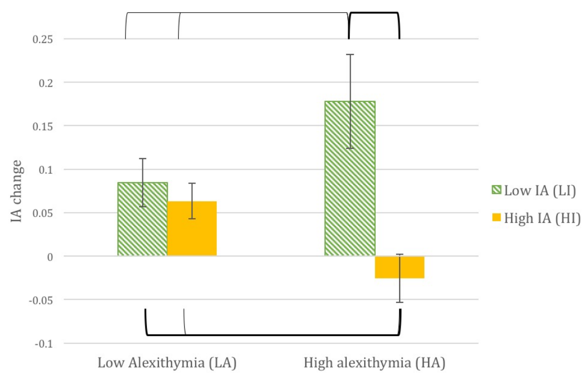

Figure 7. Group differences in interoceptive accuracy (IA) change based on high and low TAS-20 and high and low baseline IA. Bolded lines indicate group differences with $p < .01$; solid lines depict $p < .05$.

Interoceptive awareness*.* Similar methods were used to asses whether follow-up measures of confidence and perceived difficulty predicted TAS-20, with group entered in the first step of the regression analysis along with BMI. Neither post measures of confidence nor perceived difficulty significantly predicted TAS-20 total.

Task Performance

Overall differences in alexithymia*.* In the control group, TAS-20 total was associated with positive dialecticism ($\rho = 0.33$, $p < .05$). In the meditation group, TAS-20 total was associated with increased secondary intensity ($\rho = 0.37$, $p < .05$), increased total secondary emotions endorsed ($\rho = 0.57$, $p < .001$), and with reduced negative granularity ($\rho = 0.35$, $p < .05$).

Comparison to experiment one. Compared to experiment one, the control group in experiment two showed reduced target composite (i.e., reduced frequency of endorsing "no emotion" and "confusion" as primary) at the trend level ($t(144) = -1.94$, $p < .10$). Surprisingly, the control group was associated with reduced negative ($t(144) = 3.40$, $p < .01$) and positive granularity ($t(144) = 5.98$, $p < .001$) compared to experiment one. *T*-tests between other performance variables are depicted in Appendix E.

Using Fisher's z transformations, the correlations between TAS-20 and task variables were compared between data in experiment one and the control condition in experiment two (Meng, Rosenthal & Rubin, 1992). Two significant differences emerged: the correlation between primary intensity RT and TAS-20 was significantly different between the two studies (z = -2.34, $p < .05$), as well as target emotion RT and TAS-20 at the trend level (z = -2.34, $p < .10$).

To better understand these differences in primary intensity RT and target emotion RT, participants were divided into high and low TAS-20 using a mean split, and compared across experiment. For those with high alexithymia, there was a statistical trend for increasing RT variables from experiment one to the control condition of experiment two (for primary intensity RT, $t(67) = 1.88$, $p < .10$; for selecting target emotion RT, $t(67) = 1.81$, $p < .10$). For those with low alexithymia, RT remained the same from experiment one to experiment two.

Overall group differences. First, repeated measures ANOVAS tested the interaction effect of emotion category by group assignment on performance variables. There were no significant interactions; thus, performance variables remained collapsed across emotion categories.

To determine the effect of meditation condition on performance, main effect of group was assessed for overall performance variables, including: target emotion, intensity of primary and secondary emotions, subjective arousal, negative and positive granularity, number of secondary words endorsed, dialecticism, and RT variables. TAS-20 and interoceptive accuracy were split at their means, and entered into the model to test for main effects and interactions. Because of the introduction of interoceptive accuracy, BMI was entered as a covariate. All relationships reported remained significant when gender was entered as a covariate. There was a statistical trend for main effect of TAS-20 on primary intensity ($F(1, 61) = 3.23$, $p < .10$); regardless of group, alexithymia was associated with reduced intensity overall.

Target emotion*.* Compared to experiment one, there was no difference in likelihood of selecting target emotions as primary in those with low and high alexithymia. For selecting target emotion, there was a significant interaction of group by interoceptive accuracy ($F(1,61) = 4.73$, $p < .05$). In the control group, those with low interoceptive accuracy were significantly less likely to select the target emotion compared to those with high interoceptive accuracy ($t(34) = -2.50$, $p < .05$). This difference was not significant in the meditation condition, suggesting meditation was effective in improving normative emotional experiences among those with low interoceptive accuracy.

There was a significant interaction of TAS-20 by interoceptive accuracy ($F(1,61) = 5.00$, $p < .05$), by which those with high alexithymia and low interoceptive accuracy showed significantly lower percentage of selecting the target emotion compared to those with low interoceptive accuracy and low alexithymia ($t(34) = -2.53$, $p < .05$). These interactions are visually depicted in Figure 8.

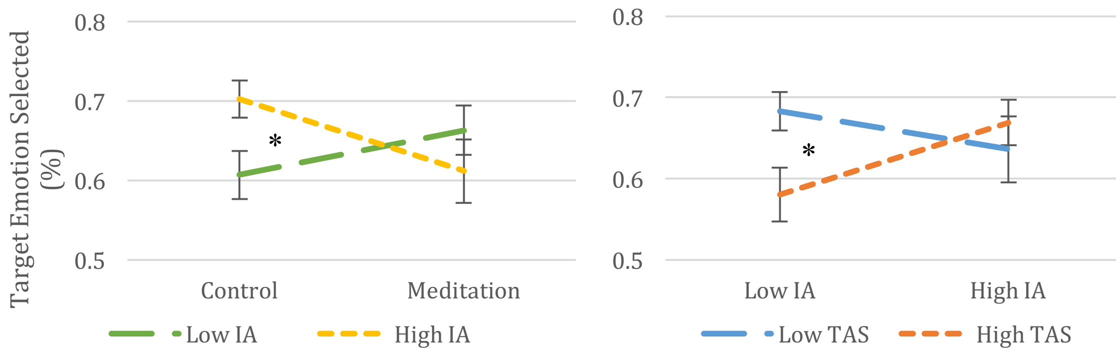

Table 8. Depicts significant interactions related to selecting target emotion; group by interoceptive accuracy and interoceptive accuracy by TAS-20. *Note*. IA refers to baseline interoceptive accuracy. *$p < .05$

Response time variables. There were no main effects of TAS-20 or group on any RT variable; however, for all primary emotion RT variables, there were TAS-20 by group interaction. This interaction was significant for primary intensity RT ($F(1,61) = 5.11$, $p < .05$), subjective arousal RT ($F(1,61) = 10.75$, $p < .01$) and a statistical trend for selecting target emotion RT ($F(1, 61) = 3.58$, $p < .10$). There was also a significant effect of gender of target emotion RT ($F(1,61) = 8.39$, $p < .01$) by which males have slower RTs for identifying primary emotion (mean = 10.44, sd = 3.05) compared to females (mean = 8.33, sd = 2.60), similar to study one.

Follow-up *t*-tests were conducted to assess patterns of differences in primary RT variables between low and high alexithymia in control and meditation groups. For all interaction effects, there was a pattern of slower RT in the control condition among those with high TAS-20 compared to low TAS-20. For all RT variables, TAS-20 was associated with a reduction in RT in the meditation condition. In the control group, high alexithymia was associated with slower primary intensity RT compared to those with low alexithymia ($t(36) = -1.76$, $p < .10$). There was no difference between the two in the meditation condition. At the trend level, high alexithymia was also associated with slower RT to questions about subjective arousal in the control condition ($t(36) = -1.89$, $p < .10$), and faster RT in the meditation condition ($t(36) = 2.01$, $p < .10$). Group differences in RT are depicted visually in Figure 9.

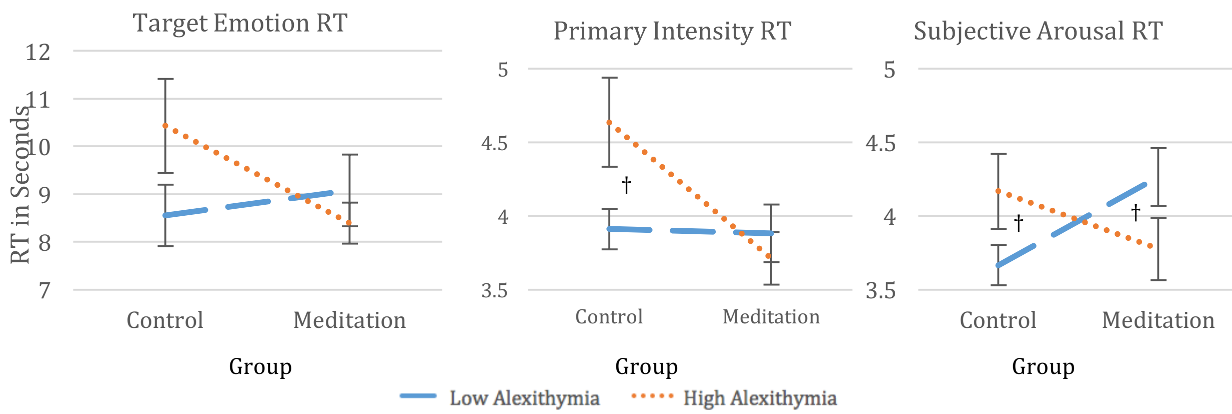

Figure 9. Group by alexithymia interaction on primary RT variables. *Note*. Bars indicate standard error; † $p < .10$ for t-tests between high and low alexithymia.

Similar to primary emotion RT variables, there was an interaction effect of group by TAS-20 total on secondary intensity RT ($F(1, 61) = 4.25$, $p < .05$), by which high alexithymia was associated with a pattern of slower RT in the control condition compared to those with low alexithymia, and compared to the meditation condition. In addition, there was a significant main effect of interoceptive accuracy on secondary intensity RT. ($F(1, 61) = 4.21$, $p < .05$), in which high interoceptive accuracy (mean = 1.42s, SD = 0.39) was associated with slower RT compared to low interoceptive accuracy (mean = 1.59s, SD = 0.36); however, this relationship became nonsignificant when entering total secondary emotions as a covariate ($p = .49$).

Total secondary words. For total emotion words endorsed, there was a main effect of group ($F(1, 61) = 4.00$, $p <.05$) and TAS-20 ($F(1, 61) = 4.06$, $p < .05$). TAS-20 and the meditation condition were associated with endorsing a greater number of secondary emotion words. There was a statistical trend for group by interoceptive accuracy on total secondary emotions ($F(1, 61) = 3.43$, $p < .10$), in which low interoceptive accuracy was associated with selecting fewer secondary emotion words (mean = 9.12, sd = 3.64) compared to high interoceptive accuracy (mean = 11.27, sd = 2.33; $t(34) = -2.11$, $p < .05$) in the control group only.

Granularity. There was no main effect of group ($F(1, 61) = 0.13$, $p = .73$) or alexithymia ($F(1, 61) = 0.23$, $p = .63$) on negative granularity; however, the interaction between the two was significant ($F(1, 61) = 4.07$, $p < .05$. Follow-up *t*-tests revealed that in the control group, those with high alexithymia have greater negative granularity at the trend level ($t(36) = -1.76$, $p < .10$) compared to those with low alexithymia. In the meditation group, high alexithymia is associated with lower negative granularity at the trend level ($t(36) = 1.69$, $p < .10$) compared to those with low alexithymia. Results are depicted visually in figure 10.

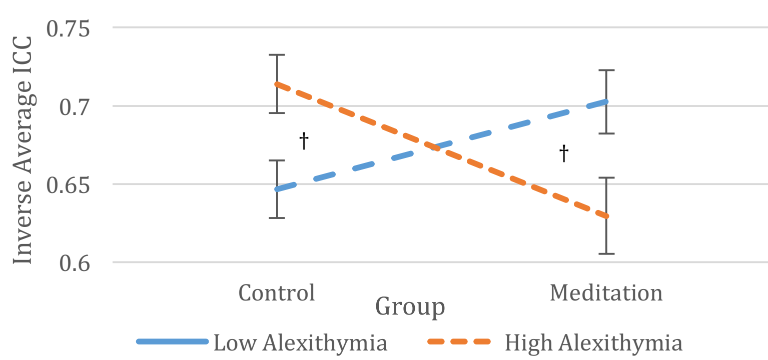

Figure 10. Group by alexithymia interaction on negative granularity. *Note.* ICC refers to intraclass correlation. $^{\dagger}p < .10$.

There were no significant main effects of group, TAS-20, or interoceptive accuracy on positive granularity; however, there was a statistical trend for a three-way interaction

($F(1, 61) = 3.64$, $p < .10$), depicted in Figure 11. In the control group, those with high TAS-20 and low interoceptive accuracy were associated with lower positive granularity compared to those with high TAS-20 and high interoceptive accuracy at the trend level ($t(14) = 1.94$, $p < .10$).

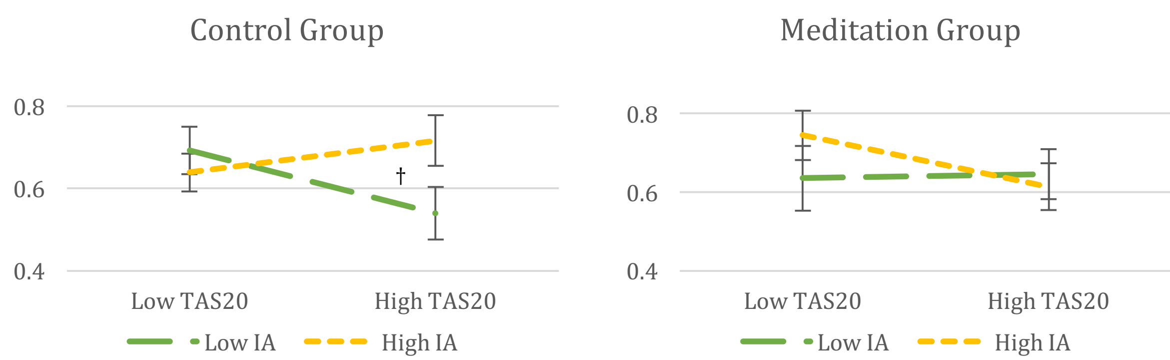

Figure 11. Three-way interaction of group by TAS-20 by interoceptive accuracy on positive granularity. *Note.* Bars indicate standard error; † $p < .10$ for *t*-tests between high and low alexithymia. IA refers to baseline interoceptive accuracy.

Dialecticism. For positive dialecticism, there was a statistical trend for main effect of TAS-20 ($F(1, 61) = 3.32$, $p <.10$). TAS-20 was associated with increased positive dialecticism overall. Positive dialecticism was also influenced by a statistical trend for TAS-20 by interoceptive accuracy interaction ($F(1, 61) = 4.00$, $p <.10$). Among those with low interoceptive accuracy, those with high TAS-20 showed greater positive dialecticism compared to those with low TAS-20 ($t(30) = 2.19$, $p < .05$). There was no difference among those with high interoceptive accuracy.

TAS-20 Subscales and Task Performance

Spearman correlations were conducted to consider unique contributions of each TAS-20 subscale and to facilitate comparison with study one. A summary of these analyses is presented in Table 13. In the control condition, DDF was associated with slower RT for selecting target emotion and providing primary intensity ratings. EOT was associated with reduced primary and secondary intensity, as well as reduced subjective arousal. There were no correlations between DIF and primary performance variables in the control condition. In the meditation condition, DDF and DIF were associated with increased secondary intensity, and correspondingly, increased total secondary emotions endorsed.

	Control			Meditation		
	DDF	DIF	EOT	DDF	DIF	EOT
Target Emotion	-0.20	-0.19	-0.23	-0.21	-0.07	0.16
Target Composite	-0.05	-0.18	0.16	0.16	0.18	0.12
Primary Intensity	-0.21	0.04	-0.40*	-0.08	-0.03	-0.16
Subjective Arousal	-0.09	0.12	-0.39*	-0.06	-0.15	-0.11
Secondary Intensity	-0.14	-0.03	-0.28†	0.33*	0.39*	0.02
Total Secondary Emotions	-0.05	0.13	-0.25	0.46**	0.52***	0.22
Target Emotion RT	0.49**	0.21	-0.04	0.33*	-0.03	0.02
Primary Intensity RT	0.33*	0.15	-0.04	0.11	-0.17	-0.02
Subjective Arousal RT	0.25	0.12	0.14	-0.10	-0.20	-0.04
Secondary Intensity RT	0.25	0.17	-0.09	0.18	0.03	-0.11

Table 13. Spearman correlations between performance variables and TAS-20 subscales for control and meditation conditions. *Note.* †$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$.

Follow-up analyses were conducted to understand the increase in total emotions endorsed in the meditation condition. DDF was correlated with increased endorsements of positive words following positive emotion inductions ($\rho = 0.41$, $p < .05$) and positive words ($\rho = 0.35$, $p < .05$) and negative words ($\rho = 0.41$, $p < .05$) following negative emotion inductions. DIF was significantly correlated with increased negative words endorsed in negative categories ($\rho = 0.42$, $p < .01$). At the trend level, it was associated with greater endorsements of positive words in positive categories ($\rho = 0.28$, $p < .10$) and in negative categories ($\rho = 0.30$, $p < .10$). Neither were significantly correlated with negative words endorsed in positive categories, highlighting that increased total secondary emotions contains a relative lack of negative dialecticism.

Spearman correlations were also conducted to examine the relationship between measures of emotional complexity and TAS-20. In the control group, TAS-20 was associated with increased positive dialecticism ($\rho = 0.33$, $p < .05$). In the meditation group, TAS-20 was associated with reduced negative dialecticism ($\rho = 0.35$, $p < .05$). Relationship between measures of emotional complexity and TAS-20 subscales are depicted in Table 14.

	Control			Meditation		
	DDF	DIF	EOT	DDF	DIF	EOT
Negative Granularity	0.17	0.08	0.12	-0.30†	-0.37*	-0.17
Positive Granularity	-0.05	-0.09	-0.15	-0.16	-0.13	-0.11
Negative Dialecticism	0.11	0.11	0.05	-0.16	0.09	-0.23
Positive Dialecticism	0.39*	0.22	-0.04	0.02	-0.09	-0.15

Table 14. Spearman correlations between emotional complexity and TAS-20 subscales for control and meditation conditions. $*p < .05$.

To better understand the significant correlation between positive dialecticism and DDF, spearman correlations were employed to assess the relationship between DDF score and endorsements of the ten positive emotion words following negative induction (i.e., amusement, calm, contentment, enthusiasm, excitement, happiness, inspiration, interest, pride, relief) in the control group. There was a significant relationship between DDF and “amusement” ($\rho = 0.32$, $p < .05$) and at the trend level, “relief” ($\rho = 0.28$, $p < .10$).

*Prediction Models***.** Prediction models developed in experiment one were tested on the control condition in experiment two. First, *t*-tests were conducted to test differences in these two sets of data to assess similarity, presented in Appendix E. Compared to experiment one, the control group in experience two was associated with reduced target composite, suggesting fewer endorsements of "no emotion" and "confusion" at the trend level ($t(144) = -1.94$, $p < .10$). The control group was also associated with reduced negative ($t(144) = -3.40$, $p < .001$) and positive ($t(144) = -5.98$, $p < .001$) granularity compared to experiment one. The predictive models generated in experiment one, in which DDF was best predicted by subjective arousal, DIF by secondary RT and negative granularity and EOT by dialecticism and target composite, were not significant for the control or meditation condition in the current study.

Post-experiment questions. In the control condition, TAS-20 total score was associated with perceiving the task as less enjoyable ($\rho = 0.37$, $p < .05$) and at the trend level, more challenging ($\rho = -0.32$, $p < .10$). In the meditation group, TAS-20 total score was associated with perceiving the task as more challenging ($\rho = -0.36$, $p < .05$). Correlations with specific subscales are presented in Table 15.

	Control			Meditation		
	DDF	DIF	EOT	DDF	DIF	EOT
Enjoyable	-0.28†	-0.20	-0.39*	-0.14	-0.05	-0.13
Challenging	0.32†	0.30†	0.19	0.36*	0.26	0.23

Table 15. Post-experiment questions about task enjoyment and challenge. *Note.* †*p* < .10; **p* < .05.

Discussion

Experiment two reveals interesting relationships between alexithymia and measures of interoceptive awareness: the two are quadratically related, with relatively low and relatively high interoceptive accuracy predicting heightened alexithymia. Compared to the predictive models generated in experiment one, these models consistently predicted variance in each TAS-20 subscale, and to a greater extent. Alexithymia and interoceptive awareness affect performance in conjunction, and differently following meditation or control task. Predictive models from experiment one did not replicate in this study; it may be that relatively short and simple interventions, such as asking individuals to attend to their heart beat or providing a period of relaxation, normalize aspects of emotional processing in alexithymia. Overall, mindfulness meditation was successful in improving some aspects of performance among those with elevated alexithymia, including response time and positive granularity, though other deficits remained.

Interoception

Replicating previous results (Herbert et al., 2011), interoceptive accuracy at baseline significantly predicts TAS-20. In the current sample, TAS-20 total and all subscales were quadratically related to interoceptive accuracy; thus, alexithymia was associated with either relatively low or high interoceptive accuracy at baseline. Importantly, interoceptive accuracy predicted all three subscales of alexithymia, unlike other measures of performance in the current study. This pattern supports theories that abnormalities in interoceptive awareness are a core feature of alexithymia.

These findings contribute significantly to debate in the alexithymia literature regarding the role of interoception. Some argue that alexithymia is in fact, at its core, a deficit in interoceptive awareness, preventing the formulation of subjective feelings states (e.g., Bird et al., 2010; Herbert & Pollatos, 2012; Silani et al., 2008). Others argue alexithymia is associated with hyperfocus on interoceptive signals, leading to somatic symptom disorders and other medical conditions (Taylor et al., 1997; Lumley et al., 2007).

Current findings suggest the presence of two subgroups of alexithymia: one group marked by low interoceptive accuracy at baseline, and the other with heightened accuracy. The two opposing accounts of how interoception and alexithymia relate may account for these differing subtypes. Low accuracy may limit awareness of somatosensory correlates of an emotional experience, preventing the development of conscious subjective emotional states (Critchley et al., 2004) which may contribute to alexithymia and its problematic correlates (Herbert & Pollatos, 2012). Alternatively, heightened interoceptive accuracy may promote over-amplification of physiological sensations, distracting from their emotional relevance. For example, an individual might interpret the physiological components of emotional experience as signs of physical illness (Taylor & Bagby, 2004; Panayiotuo et al., 2015; e.g., attribute "butterflies in my stomach" to stomach ache). This may subvert normal range awareness of that emotion, limiting appropriate subsequent action. The latter case may characterize somatization disorders, which are associated with heightened sensitivity to visceral cues, as well as elevated alexithymia (Taylor et al., 1997; Katz et al., 2009).

Those with low interoceptive accuracy and high alexithymia at baseline showed significantly greater improvement in interoceptive accuracy than all other groups, regardless of meditation or control group assignment; thus, this subgroup is capable of being trained to pay more attention to internal stimuli. Panayiotou et al. (2015) argue that problematic correlates of alexithymia (e.g., somatization, depression) emerge from a learned tendency to avoid interoceptive cues and subjective experiences that accompany negative affect; they show that avoidance mediates the relationship between alexithymia and various clinical populations. The subset of individuals with heightened alexithymia and low interoceptive accuracy might possess the capacity to attend to internal stimuli but a reduced tendency, or even avoidance, to do so, resulting in low baseline interoceptive accuracy observed in the current study. This may contribute to atypical subjective experiences of emotion states. This group may particularly benefit from interventions designed to increase awareness of bodily states.

In the current study, this group was associated with greater atypical patterns of emotional processing compared to those with high alexithymia and high interoceptive accuracy. Specifically, this subgroup was relatively less likely to select the target emotion as primary and demonstrated reduced positive granularity as well as increased positive dialecticism (which as explained later, may be problematic). Similar deficits were not observed among individuals with heightened alexithymia and good interoceptive accuracy, suggesting high interoceptive accuracy may preserve aspects of emotional processing in those with heightened alexithymia.

In addition to improvements in interoceptive accuracy, those with high alexithymia and low interoceptive accuracy also show improvement in positive granularity in response to meditation. This subgroup may particularly benefit from body-focused interventions, that increase attention to internal stimuli. Individuals with high alexithymia and high interoceptive accuracy on the other hand, may not benefit from such interventions; they already have high baseline interoceptive accuracy, and are resistant to improvement in interoceptive accuracy over time, in contrast to their high interoceptive accuracy counterparts with low alexithymia. High baseline accuracy, as well as resistance to improvement, may reflect a baseline tendency to hyper-focus on internal sensations.

These individuals were not associated with the same patterns of abnormal emotional processing evident in those with high alexithymia and low interoceptive accuracy. This group may more likely be associated with problematic patterns of thinking about physiological sensations, such as somatosensory amplification (Karlsson et al., 2008) or catastrophic thinking about physiological cues, to the detriment of their physical health. Future research should investigate whether this profile characterizes individuals with heightened alexithymia and somatic symptoms disorders. If so, they may benefit most from cognitive strategies designed to reduce maladaptive appraisals of interoceptive signals (e.g., Gaylord et al. 2011; Garland et al., 2012).

Differences in Experiment One and Experiment Two

It was expected that the control condition in experiment two would show results similar to experiment one; however, that was not the case. The predictive patterns generated in experiment one did not predict alexithymia subscales in the control condition in experiment two. Overall patterns of relationships between performance and alexithymia also differed. In the control condition, TAS-20 total score was only associated with increased positive dialecticism. Compared to experiment one, there were significant differences in response time variables; in experiment two, alexithymia was associated with slower response time.

Though the emotion task was the same in experiment two, other experimental parameters could have influenced performance. Supporting this possibility is the finding that both groups showed comparable increases in interoceptive accuracy over the course of the study. Compared to experiment one, participants in the control group showed reduced selection of “no emotion” and “confusion” as primary, suggesting parameters of experiment two may have improved awareness of emotional cues, facilitating access to conceptual information about emotional states.

Various factors could have influenced performance in experiment two. Participants were instructed to attend to and evaluate their heartbeat for about three minutes prior to completing the emotions task during the heartbeat detection trial. Asking participants to count their heartbeats may have prompted greater awareness of internal states. Constantinou et al. (2014) present participants with emotional imagery scripts and instruct them to engage in either shallow (i.e., focusing on visual aspects of the image) or deep emotional processing. In the deep emotional processing condition, participants were instructed to attend to other imagined experiences, including bodily changes. This relatively short and simple manipulation resulted in improvements in multiple emotional domains among those with heightened alexithymia; attention to heartbeat prior to completing the emotion induction task may have similarly normalized deficits in the current study. Participants in experiment two also wore a heart rate monitor around their chest through the duration of the task. This could have prompted ongoing awareness of internal states, particularly as simple self-referential stimuli, such as a mirror or personally relevant words, improve interoceptive accuracy (Ainley et al., 2012; Ainley et al., 2013).

The control condition in experiment two also differed from experiment one in its provision of a ten-minute control recording. In its original study, the control recording was described as "neutral, but relaxing" (Cropley et al., 2007). A brief period of relaxation can have benefits similar to mindfulness meditation (e.g., Jain et al., 2007) which could have influenced performance in the control group. Either through relaxation, increasing attention towards interoceptive stimuli, or a combination of the two, experimental parameters seem to have improved performance from experiment one among those with heightened alexithymia. These changes may be particularly salient to individuals who do not naturally attend to such signals (e.g., those with high alexithymia and low interoceptive accuracy at baseline).

Performance Variables in Control versus Meditation Group

In the control group, alexithymia was only associated with increased positive dialecticism, driven primarily by DDF. DDF was also associated with slower response times for target emotion and primary intensity. EOT was negatively correlated with subjective arousal and intensity. Patterns of responding differed in the meditation group, in which total alexithymia was associated with increased total secondary words, and correspondingly, increased secondary intensity. Notably, though alexithymia was associated with increased negative and positive words across positive and negative inductions (congruent and incongruent), it was not associated with increased negative words following a positive induction (i.e., negative dialecticism). Increased secondary words was driven by DDF and DDF, which were correspondingly associated with greater secondary intensity and reduced negative granularity. DDF was also associated with slower response times for questions about primary emotion. There were no associateions between EOT and performance variables in the meditation condition. Additional group differences in total alexithymia emerged when considering the interaction effect of high or low alexithymia as well as high or low interoceptive accuracy.

Primary intensity and arousal. Those with high alexithymia reported decreased primary intensity regardless of group or baseline interoceptive accuracy. In the control condition, this was especially true for EOT. EOT was also associated with reduced subjective arousal in the control condition. Reduced intensity and arousal is consistent with the notion that at baseline, an externally oriented cognitive style reduces awareness of autonomic correlates of emotional experiences. These were the only deficits associated with EOT in experiment two, which notably, were not present in the meditation condition.

Meditation may function to increase awareness of these aspects of emotional experiences, though some deficit remains.

There were no overall group findings for subjective arousal. Though decreased subjective arousal was the best predictor of DDF in experiment one, it was not correlated with DDF in the control or meditation condition in experiment two. Intervention-like qualities of the control condition may have been sufficient to increase awareness of autonomic signals among those with elevated DDF and DIF, normalizing report of subjective arousal.

This is consistent with the theory that at baseline, alexithymia is associated with reduced attention to interoceptive aspects of emotions (Panayiotou et al., 2015), and suggests attention towards such stimuli can be trained using simple interventions, especially for those with elevated DDF and DIF. Remaining deficits in intensity and arousal for EOT in the control condition (but not meditation condition) suggest EOT may require more intensive remediation to increase awareness, consistent with findings that EOT is more resistant to intervention than DDF and DIF (cf. Cameron et al., 2014).

Differences from experiment one to experiment two demonstrate how small changes in experimental design can alter subjective arousal, adding to a body of vast inconsistencies regarding this aspect of emotional processing in alexithymia (Bausch et al., 2001; Constantinou et al., 2014; Eastabrook et al., 2013; Friedlander et al., 1997; Infrasca, 1997; Peasley-Miklus et al., 2015; Pollatos et al., 2008; Roedema & Simons, 1999; Stone & Nielson 2001).

Target emotion. There was a significant decrease in target composite in experiment two. Although target composite was a primary predictor of EOT in experiment one, there were no correlations between target composite and TAS-20 or any of its subscales in the control or meditation condition in the current experiment. There were also no relationships between alexithymia and likelihood of selecting the target emotion overall in the current study, nor was there an effect of alexithymia on total average non-primary emotions endorsed overall. Experimental parameters in experiment two may have served to normalize performance. For example, the heartbeat detection task may have increased one's awareness of somatosensory correlates of emotional states, facilitating access to emotional concepts that were inaccessible in experiment two.

In fact, interoceptive accuracy did promote normative emotional labeling overall, especially for individuals with high alexithymia. Those with high alexithymia and high interoceptive accuracy show similar likelihood of selecting the target emotion as those with low alexithymia. With reduced awareness of both subjective and somatosensory correlates of emotion, those with high alexithymia and low interoceptive accuracy show reduced likelihood of selecting the target emotion. Intact awareness of internal cues *or* subjective cues may be sufficient to normalize selection of primary emotion among others. Importantly, mindfulness meditation appears to promote selection of the target emotion among those with low interoceptive awareness at baseline, suggesting awareness of internal cues can be trained and harnessed to normalize emotional processing.

Response time*.* In the control condition, alexithymia was generally associated with slower response timess to questions about emotional experiences in the control condition, particularly DDF. Compared to experiment one, those with elevated alexithymia showed a significant increase in response time, whereas those with low alexithymia remained the same. In the meditation condition, those with elevated alexithymia showed a decrease in response time similar to individuals with low alexithymia. Experimental parameters may have contributed to increased awareness of mixed-emotion or increased time spent contemplating emotional states, both of which might lead to increased response time.

In the control condition, faster response times among those with low alexithymia may reflect greater emotional clarity, as well as a "normative" degree of time spent contemplating evaluations given their respective ambiguity. In the absence of intervention-like features in experiment one, faster response times in alexithymia may reflect reduced experience of mixed-emotion and possibly, reduced time spent contemplating on subjective experiences (see experiment one discussion for additional interpretation). In the same way the control condition appears to have increased awareness of intensity and subjective arousal, it may also have increased awareness of mixed-emotional states or prompted additional contemplation of internal states. Supporting the possibility that the control condition increased awareness of mixed-emotion is the finding that alexithymia was associated with increased positive dialecticism.

Abnormal patterns of intensity and target emotion response times were not apparent in the meditation condition, in which high alexithymia was associated with a decrease in response time comparable to response times of those with low alexithymia. Meditation may be successful in improving emotional clarity and awareness of mixed-emotion is those with heighted alexithymia. Correspondingly, there were no relationships between TAS-20 subscales and dialecticism in the meditation condition. There were no positive relationships between interoceptive accuracy and response time for questions about subjective arousal or any other variable, suggesting response time should not be used as an index of interoceptive accuracy as it has been in the past (e.g., Silverstein et al., 2011).

Little research has assessed the relationship between response time and measures of alexithymia and related constructs, and existing data is mixed. More work is needed in this area to clarify the role of response time in the experience of emotions; for example, clarifying the (likely non-linear) relationship between response time and adaptive emotional processing. Such work would shed light on differences observed in the relationship between alexithymia and response time in experiment one and two, and how the differing tasks might have contributed to changes.

Emotional complexity*.* ***Granularity.* Though alexithymia was associated with reduced negative granularity in experiment one, there were no relationships between alexithymia and negative granularity in the control condition of experiment two. Experimental parameters may have normalized negative granularity in the control group, though deficits re-emerged following meditation, from which individuals with low alexithymia may derive greater benefit. Whereas meditation appears to improve negative granularity among those with low alexithymia, those with high alexithymia show a decrease from control to meditation condition. In experiment one, granularity was associated with reduced total secondary emotions endorsed. Though not significant in the current study, increased number of secondary words endorsed in the meditation condition may also reflect a trend towards reduced granularity. Mindfulness meditation, at least in the dose provided in the current study, may be ineffective for increasing granularity in individuals with heightened alexithymia.

The meditation condition *was* successful in improving positive granularity among individuals with high alexithymia and low interoceptive accuracy. This serves as additional evidence that mindfulness meditation may be ideally suited to alleviate deficits associated with reduced interoceptive accuracy. It highlights the importance of bodily awareness for promoting positive granularity, in contrast to negative granularity, which was not influenced by interoceptive accuracy. In experiment one, positive granularity was not associated with any performance measures, whereas negative granularity was correlated with many. Current results suggest interoceptive awareness is key in the experience of positive granularity, further supporting the possibility that different mechanisms are responsible for the generation of positive and negative granularity.

Dialecticism. Though negative dialecticism was an important predictor variable in experiment one, it was not related to TAS-20 in experiment two. Surprisingly, alexithymia was associated with greater positive dialecticism, particularly in the control group and among those with low interoceptive accuracy. Though the ability to recognize positive emotions in a state of negative affect is important, the current study depicted clips designed to induce intense, negative, and relatively discrete affective states (e.g., death scenes, interpersonal violence), not ideally suited to elicit positive dialecticism (see discussion of experiment one for further elaboration).

Given the nature of these videos, it is likely that increased dialecticism in the control condition is not adaptive. Consistently, positive dialecticism was associated with reduced likelihood of selecting the target emotion. In the current study, increased positive dialecticism was driven by increased endorsements of “relief” and “amusement” following negative emotion inductions. Increased endorsements of “amusement” could reflect simplistic emotional concepts following positive inducing clips (e.g., "films are amusing"). Increased endorsements of relief may reflect reduced distress tolerance of negative affective states. Future studies presenting more ambiguous stimuli is a critical next step in this field to further parse the role of dialecticism in alexithymia.

No significant relationships between alexithymia and negative dialecticism were observed in the current study, consistent with the notion that the intervention properties present in both conditions increased access to greater information about emotional states in those with heightened alexithymia, facilitating awareness of the experience of negative emotions following a positive emotion induction. Though notably, alexithymia was not associated with an increase in negative words following positive inductions compared to all other combination of positive and negative affective words and inductions. Nevertheless, negative dialecticism appears to have improved from experiment one, which in the current paradigm, is a better indicator of adaptive emotional processing compared to positive dialecticism.

Limitations

Limitations detailed in experiment one apply as well to experiment two. The provision of labels and emotion inductions selected to elicit relatively discrete and prototypical emotional experiences were essential first steps, though inherently limiting. Along the same lines, the current study provided ample contextual cues that could have facilitated access to emotional concepts and altered performance. Experience sampling methods are a critical next step in understanding how emotional experiences are altered in daily life, and to obtain more valid measures of emotional granularity. Depressive symptoms and baseline response time were also not collected in experiment two, and would have benefited interpretation of findings, particularly for response time variables.

Experiment two was limited by its sample size. Sample size was 30% smaller than experiment one, and even smaller when divided into control versus meditation group. This limits comparison of findings between experiment one and experiment two. Power was further reduced for ANOVA analyses that considered the role of baseline interoceptive accuracy in addition to group assignment and level of TAS-20 score.

Reliance on Schandry's (1981) heartbeat tracking task is a limitation. Heartbeat tracking tasks like Schandry's (1981) have been criticized for their methodological limitations (see Reed, Harver, & Katkin, 1990), particularly as participants can estimate their heartbeat in the absence of interoceptive signals. However, heartbeat tracking tasks are feasible and accessible, and remain the most common methods of assessing interoceptive accuracy (Kleckner et al., 2015). The current study attempted to tackle some limitations of this methodology by assessing confidence and difficulty ratings in addition to accuracy, and found that confidence predicts alexithymia as well as accuracy.

A clear limitation, as detailed throughout this discussion section, are the apparent intervention-like properties of the study, particularly within the control condition. Instructing participants to attend to their internal stimuli likely altered interoceptive awareness throughout the study, as well as the provision of an interoceptive cue – a heartrate monitor worn throughout the duration of the experiment. In the control condition, the control script had relaxation properties that might have had benefits similar to a brief mindfulness meditation script (Jain et al., 2007). Again, this makes it challenging to compare results of experiment one and two, as was the original goal.

The meditation script itself may have been limiting. Though selected because it was validated in another laboratory-based design (Coffey et al., 2007), it may not have been ideal. It was delivered in a dark room via headphones and was recorded in a British accent. Had the script been delivered in person (similar to classical mindfulness trainings; Kabat-Zinn, 1990), or had been individualized for the present study using a familiar accent, it may have had a stronger effect on performance. Many studies show improved interoceptive accuracy in response to mindfulness meditation (Farb, Segal, & Anderson, 2013; Hölzel et al., 2008; Lazar et al., 2005); however, these studies are done in long-term meditators, or in individuals following long-term mindfulness intervention. A ten-minute meditation almost certainly underestimates the potential benefits of a long-term intervention.

Conclusion

This experiment in the first is the literature to show different subtypes of individuals with elevated alexithymia based on interoceptive accuracy. Elevated alexithymia was characterized by either relatively high or relatively low interoceptive accuracy; those with high interoceptive accuracy showed fewer deficits in emotional processing overall, whereas those with low interoceptive accuracy gained more benefit from a mindfulness meditation. Those with low interoceptive accuracy at baseline showed a dramatic improvement in interoceptive accuracy from baseline to follow-up, suggesting attention towards internal stimuli can be trained in this population.

These findings provide a platform for future investigations of alexithymia. It is very likely that among those with heightened alexithymia, baseline interoceptive accuracy corresponds differentially to clinical profiles and responds differently to intervention. For example, those with elevated alexithymia and high interoceptive accuracy may be particularly prone to the development of somatic symptom disorders. Because this group has high interoceptive accuracy at baseline, they will likely benefit less from body-focused interventions.

Though deficits similar to those in experiment one did not emerge as hypothesized, it is promising that performance improved in a number of domains in the control group compared to experiment one. It suggests that with even simple manipulations, such as introduction of a relaxation period and prompting attention towards heartbeat, performance measures can be improved.

CHAPTER IV

General Discussion

Study one presents a novel laboratory-based design capable of measuring a variety of subjective, implicit and complex emotional processes. It brings diverse measurements to the forefront of understanding the alexithymia construct, many of which have been minimally studied in this field, including dialecticism, granularity and response time. This study can be easily adapted to address a number of follow-up research questions.

Study two speaks to the importance of interoceptive awareness for understanding deficits associated with alexithymia. Normative performance in a number of domains was preserved in individuals with heightened alexithymia and good interoceptive awareness. It may be that in the absence of subjective emotional awareness, interoceptive cues help fill in the gaps of one's emotional experience. Future studies should investigate if and how differing alexithymia/interoception profiles map on to various clinical populations. Alexithymia with heightened interoceptive accuracy may best characterize individuals with somatic symptom or other medical conditions.

Differing subtypes of alexithymia and interoception will likely respond differently to psychosocial interventions. In the current study, mindfulness meditation was successful in improving positive granularity and selection of the target emotion among those with low interoceptive awareness. This group may particularly benefit from body-focused interventions, such as mindfulness meditation, whereas those with high interoceptive accuracy may benefit from other interventions. Identifying clinical profiles of each subtype is critical for guiding future clinical recommendations.

Even in response to the control condition, alexithymia showed improvements in performance compared to experiment one. This finding highlights the malleability of emotional processing in alexithymia, and suggests that deficits can be improved with targeted interventions. Those with high alexithymia and low interoceptive accuracy at baseline showed dramatic improvement in interoceptive accuracy at follow-up, regardless of condition. Instructing participants to attend to their heartbeat, as well as providing a period of relaxation or meditation may increase awareness of somatosensory and subjective correlates of emotional experiences, normalizing selection of the target emotion and awareness of mixed-emotional states. Consequently, there was a significant reduction of endorsements of "no emotion" and "confusion" in experiment two, and among those with alexithymia, increased response time, which may reflect increased awareness of mixed emotional states. Correspondingly, there were no significant relationships between TAS-20 and negative dialecticism in experiment two, though this was an important predictor of EOT in experiment one.

The meditation condition was successful in reducing remaining deficits in subjective arousal and intensity in those with elevated EOT; in fact, there were no significant associations between task performance and the EOT subscale in the meditation condition. This is particularly important, as EOT shows greater resistance to psychological intervention (Cameron et al., 2014; Páez et al., 1999). Furthermore, EOT was not associated with reduced enjoyment of the meditation task, unlike experiment one and the control condition of experiment two, suggesting this particularly approach may not be aversive. With targeted intervention approaches, deficits associated with EOT may be remediated. Meditation was also successful in normalizing response time compared to the control condition in those with heightened alexithymia, reflecting increased emotional clarity (Lischetzke et al., 2005; 2011).

Though meditation may have improved awareness of emotional signals, such as subjective arousal and the presence of mixed emotions, it was not successful in improving negative granularity among those with heightened alexithymia. Whereas those with low alexithymia showed improvement in negative granularity from control group to meditation group, those with heightened alexithymia got worse. It is particularly important to parse the role of negative granularity in alexithymia, as it might represent a mechanism by which alexithymia relates to deficits in emotion regulation (or vice versa).

Negative granularity was particularly low in individuals with heightened DDF and DIF. As a more complex aspect of emotional experience, one that is cultivated over time (Carstensen et al., 2000; Widen & Russell, 2008), a short mindfulness meditation may not be sufficient to increase levels among those with heightened alexithymia. Importantly, there were no overall relationships between TAS-20 subscales and positive granularity in either experiment; this suggests a degree of granularity is intact, which may indicate potential for increasing negative granularity among those with heightened alexithymia. It is important future studies determine whether granularity in alexithymia is malleable and how to best target it through intervention.

The current study clearly demonstrates potential for improvement among atypical emotional experiences in alexithymia, even through very simple interventions. Though multiple reviews highlight the value of intervention for reducing alexithymia (Cameron et al., 2014; Pinna et al., 2015), they disclaim that in many cases, interventions are ineffective or less effective for those with heightened alexithymia, and that even when relative levels of alexithymia are reduced, psychopathological features may remain. Interventions may need to be carefully tailored to best address the needs of those with alexithymia. Morie et al. (2015) provide interesting evidence that under the right circumstances, alexithymia may enhance the properties of a psychosocial intervention.

Future Directions

The results of this study pave many avenues for future research. First, the present study should be validated without the manipulations present in experiment two. Future studies should replicate this task using free response design to elicit information about emotional experiences. Nook et al. (2015) show that providing emotion labels has a restorative effect on emotion recognition deficits in alexithymia. It would be interesting to see how the absence of labels affects performance in the current task, and whether the presence of labels has an intervention effect of increasing access to conceptual knowledge about one's own internal emotional experiences. Additionally, the absence of labels would provide a more ecologically valid perspective of emotion labeling in alexithymia.

Experience sampling methods should be employed to continue investigating these traits in alexithymia. Emotion granularity emerged as an important predictor variable in the current study, and may have important implications for understanding and intervening on emotion regulation deficits in this population. Experience sampling methods would allow more classical investigation of granularity in this population (Barrett et al., 2001; Tugade et al., 2004). Additionally, they would facilitate parsing the ability to engage in emotional awareness from tendency to do so in every day life in alexithymia, which is difficult to assess in a laboratory-based setting.

Future studies should also utilize more ambiguous stimuli, such as those employed in Lischetzke et al. (2005), and less intense stimuli. In particular, future studies would benefit from more ambiguous negative inductions, as videos employed in the current study are relatively discrete. More ambiguous and less intense emotional experiences are more reflective of daily life, would likely be more sensitive to group differences, and less likely to be influenced by external knowledge of emotional states. This would also allow better investigation of dialecticism in alexithymia.

As an important predictor of alexithymia, future studies should consider incorporating measures of interoceptive awareness. In particular, studies should consider what combination of alexithymia and interoceptive accuracy best characterize various clinical diagnoses, and test the hypothesis that high interoceptive awareness best characterizes somatic symptoms disorder.

Conclusions

The current study shows that at baseline, reduced subjective arousal, greater frequency of reporting experiencing “no emotion” or “confusion” following a relatively intense and prototypical emotion induction, and reduced aspects of negative granularity are most predictive of alexithymia. In addition, interoceptive accuracy has important implications for behavioral manifestations of alexithymia; intact interoceptive accuracy among those with heightened alexithymia may preserve aspects of subjective emotional experiences. Fortunately, interoceptive accuracy and some other deficits appear to change with the introduction of short and relatively simple interventions.

Future studies should continue investigating the parameters of these deficits in emotional experiences in alexithymia and how they manifest in various forms of physical and mental health disorders. The laboratory-based task presented in this study holds promise for continued investigation of multiple domains of emotional processing simultaneously. By better understanding emotional deficits in alexithymia, interventions can be carefully crafted to target specific deficits and improve function and the vast group of individuals impacted by alexithymia.

APPENDIX

Film Title	Brief description of scene	Target Emotion	Additional Emotions
When Harry Met Sally	Sally fakes orgasm in a crowded restaurant	Amusement	n/a
Robin Williams Live	Robin Williams does standup comedy	Amusement	n/a
My Bodyguard	Young man gets bullied	Anger	Disgust
Cry Freedom	Soldiers shoot children in Apartheid scene	Anger	n/a
Stock Beach Scene	Seagulls walk along beach	Contentment	Happiness
Stock Wave Scene	Waves crash in ocean	Contentment	n/a
Stock Amputation Scene	Arm being amputated	Disgust	n/a
Pink Flamingos	Woman eats her dog's feces	Disgust	n/a
Silence of the Lambs	Woman hides from serial killer	Fear	Tension, Interest
The Shining	Boy walks into ominous room	Fear	Tension, Interest
Bambi	Bambi's mother shot and killed	Sadness	n/a
The Champ	Boy watches hero die after a boxing match	Sadness	n/a
Sea of Love	Pigeons unexpectedly fly at man's face	Surprise	n/a
Capricorn One	Man's apartment unexpectedly raided	Surprise	n/a

Appendix A. Emotion inducing clips and formulation of "target emotion" variable. Gross and Levenson (1995) show videos occasionally elicit more than the "target" emotion reliably. In the current study, "target emotion" variable constitutes percentage of times the target emotion or additional emotions listed here were selected. For more details about the clips utilized, please reference Gross and Levenson (1995).

Gross and Levenson (1995) original emotions	
Amusement	Fear
Anger	Happiness
Arousal	Interest
Confusion	Pain
Contempt	Relief
Contentment	Sadness
Disgust	Surprise
Embarrassment	Tension
Additional emotion words adapted from PANAS (Watson et al., 1988)	
Distress	Irritated
Enthusiasm	Jittery
Excitement	Nervousness
Guilt	Pride
Hostility	Shame
Inspiration	Strength
Interest	Upset
Additional words from piloting	
Calm	Pity

Appendix B. Comprehensive list of secondary emotion words and their sources.

Variable Name	Scale	Description
Target emotion	percentage	Percentage of trials target emotions words are selected as primary
Primary intensity	Likert scale	Intensity of primary emotion on a 1-9 Likert scale (1=least; 9=most)
Subjective arousal	Likert scale	Subjective arousal following each film clip on a 1-9 Likert scale using SAM rating (1=least; 9=most)
Secondary intensity	Likert scale	Average intensity of secondary emotions on a 1-9 Likert scale (1=least; 9=most).
Target emotion RT	seconds	Average RT (latency between stimulus onset and participant response) for selecting primary emotion
Primary intensity RT	seconds	Average RT(latency between stimulus onset and participant response) for reporting primary intensity
Subjective arousal RT	seconds	Average RT (latency between stimulus onset and participant response) for reporting subjective arousal
Secondary intensity RT	seconds	Average RT (latency between stimulus onset and participant response) for providing secondary intensity
Target composite	frequency	Frequency of endorsing "no emotion" and "confusion" as target emotion
Negative granularity	r to z transform	Average ICC between intensity ratings of negative secondary emotions, transformed with Fisher *r* to z , and subtracted from one
Positive granularity	r to z transform	Average ICC between intensity ratings of positive secondary emotions, transformed with Fisher *r* to z, and subtracted from one
Total secondary words	frequency	Number of secondary emotions in which intensity >1 averaged across inductions
Positive Dialecticism	Log_{10} transformed ratio	Log_{10} transform of ratio of positive to negative words endorsed following a negative emotion induction
Negative Dialecticism	Log_{10} transformed ratio	Log_{10} transform of ratio of negative to positive words endorsed following a positive emotion induction
Interoceptive Accuracy	%	1 - 100*((actual heartrate - perceived heartrate)/(actual heartrate)))
Interoceptive Confidence	Likert scale	Rating of confident in heartbeat estimation (1 = lowest; 9 = highest)
Interoceptive Difficulty	Likert scale	Rating of difficulty of heartbeat detection task (1 = lowest; 9 = highest)
Body Mass Index (BMI)	ratio	weight (kg)/height $(m)^2$

Appendix C. Depicts an overview of primary task variables and how they were formed. *Note:* RT = response time; ICC = intraclass correlation. Aggregate variables listed here form basis for variables assessed in experiment one and experiment two.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1.Target Emotion													
2.Target Composite	-0.52***												
3.Primary Intensity	0.15	-0.13											
4.Target Arousal	0.12	-0.19*	0.43***										
5.Total Emotions Endorsed	0.12	-0.21*	0.35***	0.25**									
6.Secondary Intensity	0.05	-0.15	0.64***	0.33***	0.82***								
7.Target Emotion RT	0.01	-0.20*	0.12	0.02	-0.07	-0.01							
8.Primary Intensity RT	-0.06	-0.18†	-0.15	0.03	-0.12	-0.21*	0.55***						
9.Primary Arousal RT	0.00	-0.22*	0.00	-0.06	0.02	-0.04	0.42***	0.50***					
10.Secondary Emotion RT	0.07	-0.39***	0.23*	0.13	0.45***	0.36***	0.51***	0.53***	0.55***				
11.Negative Dialecticism	-0.05	-0.13	0.20†	0.24*	0.54***	0.47***	0.00	-0.15	0.03	0.30**			
12.Positive Dialecticism	-0.19†	-0.05	-0.01	0.00	0.26**	0.25**	0.09	0.04	0.14	0.36***			
13.Negative Granularity	0.24*	-0.21*	-0.12	0.00	-0.34***	-0.34***	-0.01	-0.09	-0.21*	-0.08	0.06	-0.02	
14.Positive Granularity	-0.13	-0.02	0.04	0.04	-0.15	-0.03	0.14	0.06	-0.03	0.09	0.14	0.08	.17†

Appendix D. Spearman correlations between all major task variables in experiment one. †p < .10; *p < .05; **p < .01; ***p < .001.

	Experiment 1		Experiment 2		
	Original	t^b	Control	t^c	Meditation
Target Emotion	0.66(0.14)	0.33	0.66(0.12)	0.80	0.63(0.16)
Target Composite	1.27(1.45)	-1.94 †	1.79(1.36)	1.00	1.50(1.16)
Primary Intensity	5.86(1.02)	0.62	5.74(1.16)	0.74	5.92(0.99)
Subjective Arousal	4.55(1.14)	-0.56	4.67(1.23)	1.08	4.37(1.18)
Target Emotion RT	8.83(2.71)	-0.94	9.34(3.23)	0.88	8.74(2.65)
Primary Intensity RT	4.01(1.34)	-0.60	4.17(1.47)	1.12	3.82(1.24)
Subjective Arousal RT	4.07(1.18)	0.83	3.88(1.29)	-0.34	3.98(1.17)
Secondary Intensity	2.06(0.54)	0.49	2.01(0.45)	-1.40	2.16(0.44)
Secondary Emotions	10.74(4.11)	1.36	9.75(2.65)	-1.93†	11.24(4.78)
Secondary Intensity RT	1.47(0.40)	-0.14	1.48(0.38)	-0.87	1.55(0.37)
Negative Granularity	0.76(0.10)	3.40**	0.69(0.11)	-0.36	0.68(0.12)
Positive Granularity	0.81(0.12)	5.98***	0.67(0.14)	0.12	0.68(0.17)
Negative Dialecticism[a]	0.35(0.15)	-0.58	0.39(0.19)	-1.03	0.39(0.19)
Positive Dialecticism[a]	0.65(0.65)	-1.13	0.73(0.77)	-0.01	1.12(1.34)

Appendix E. Depicts means and standard deviations for primary performance variables, as well as *t*-tests comparing the original data from experiment 1 with the control condition from experiment 2. *Note.* [a]*t*-tests reflects difference in $\log_{10}$ transformed scores; [b]Reflects *t*-tests between experiment one and control condition of experiment two, df = 144; [c]Reflects *t*-tests between control and meditation conditions in experiment two, df = 74

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