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Associations between Alexithymia and Executive Function in Younger and Older Adults

Gennarina Diane Santorelli
University of Massachusetts Amherst

ASSOCIATIONS BETWEEN ALEXITHYMIA AND EXECUTIVE FUNCTION IN YOUNGER AND OLDER ADULTS

A Thesis Presented

by

GENNARINA D. SANTORELLI

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GENNARINA D. SANTORELLI

Approved as to style and content by:

Rebecca E. Ready, Chair

Elizabeth A. Harvey, Member

Rebecca M. C. Spencer, Member

Harold D. Grotevant, Department Chair

ABSTRACT

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GENNARINA D. SANTORELLI, B.S., FORDHAM UNIVERSITY

M.S., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Professor Rebecca E. Ready

The prevalence of alexithymia, a condition characterized by difficulties identifying and verbalizing one's emotions, increases across the lifespan, with older adults reporting greater alexithymic features than young and middle-aged adults. This late-life increase in alexithymia may be the product of age-related decline in prefrontal brain circuitry implicated in emotional awareness and executive processes, notably in the anterior cingulate cortex (ACC). There is a dearth of research on the link between executive function and alexithymia in healthy adults. This study determined associations between alexithymia and executive function in healthy younger and older adults. Higher alexithymia scores were predicted to be associated with poorer performance on measures of executive function, specifically one that taps into ACC function (i.e., verbal fluency). Sixty-five young adults and 44 older adults completed the 20-item Toronto Alexithymia Scale, three executive function tasks (Verbal Fluency, Design Fluency, and Trail Making), assessments of memory and verbal ability, and a self-report measure of depressive symptoms. Greater total alexithymia and difficulties describing feelings (a dimension of alexithymia) were associated with poorer verbal fluency, accounting for

age, gender, and depressive symptoms, in the full sample and in older adults, but not in young adults. Findings support the theoretical model that alexithymia is associated with age-related decline in frontal circuitry – possibly specific to declines in ACC functioning. Results provide insight into the possible origins of emotion self-awareness deficits in older adulthood.

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CHAPTER I

ALEXITHYMIA AND EXECUTIVE FUNCTION IN YOUNGER AND OLDER ADULTS

A. Introduction

Alexithymia is an emotion processing deficit characterized by the inability to identify and describe one's feelings and a tendency toward externally-oriented thinking (Lesser, 1981; Sifneos, 1972). Despite its high prevalence amongst those with psychiatric and medical illnesses, as well as its occurrence in the general population, little is known about the nature and etiology of alexithymia (Taylor, Bagby, & Parker, 1997). Recent epidemiological studies suggest that the prevalence of alexithymia increases across the lifespan, with older adults reporting greater alexithymic features than young and middle-aged adults (Lane, Sechrest, & Riedel, 1998; Mattila, Salminen, Nummi, & Joukamaa, 2006; Salminen, Saarijärvi, Äärelä, Toikka, & Kauhanen, 1999). The mechanisms underlying this change, however, are relatively unknown. One theory is that older adults may be falsely characterized as alexithymic due to improved emotion regulation strategies in older adulthood that cause them to be less affected by, or less likely to report, negative emotions (Reed & Carstensen, 2012). This decrease in reporting negative emotions may be mistaken for a deficit in the ability to identify and describe one's emotions. Stronger evidence, however, supports the theory that the late-life increase in alexithymia may be the product of age-related decline in prefrontal brain circuitry associated with emotion self-awareness, and thus may be associated with decline in cognitive abilities dependent on frontal regions, namely executive processing (Onor, Trevisiol, Spano, Aguglia, & Paradiso, 2010; Paradiso, Vaidya, McCormick, Jones, &

Robinson, 2008). Alexithymia in populations with prefrontal dysfunction (e.g., asymptomatic HIV, neurodegenerative disorders) is associated with deficits in executive function (Bogdanova, Díaz-Santos, & Cronin-Golomb, 2010; Sturm & Levenson, 2011); however, more research is needed on executive function in healthy adults with alexithymia to better understand the mechanisms underlying the link between aging and alexithymia.

B. Alexithymia: "No Words for Emotions"

The term *alexithymia*, derived from the Greek translation of "no words for emotions," describes a condition characterized by difficulties identifying and describing one's emotions, a lack of introspection (i.e., externally-oriented thinking), and difficulties distinguishing feelings from physical symptoms associated with emotional arousal (Lesser, 1981; Sifneos, 1972). Originally a syndrome associated with psychosomatic illness, alexithymia has since been investigated in multiple medical and psychological disorders, including eating disorders, anxiety disorders, depression, trauma, and neurodegenerative disorders, as well as in the general population (Berthoz, Consoli, Perez-Diaz, & Jouvent, 1999; Cochrane, Brewerton, Wilson, & Hodges, 1993; Fukunishi, Sasaki, & Chishima, 1996; Honkalampi & Hintikka, 2000; Mattila, Salminen, Nummi, & Joukamaa, 2006; Sifneos, 1972; Sturm & Levenson, 2011; Taylor, Bagby, & Parker, 1997). The prevalence of alexithymia in the general population is approximately 5 – 13%, with higher rates associated with older age, fewer years of education, lower socioeconomic status, and being male (Lane et al., 1998; Mattila et al., 2006; Salminen et al., 1999). Although alexithymia is often treated as a categorical construct (i.e., alexithymic versus non-alexithymic) in prevalence studies, it is more likely dimensional

in nature, with individuals falling on a continuum of alexithymic features (Salminen et al., 1999; Taylor et al., 1997).

The clinical presentation of alexithymia varies widely. Persons with this condition experience deficits in emotion self-awareness and often exhibit "a cognitive style that shows a preference for the external details of everyday life rather than thought content related to feelings, fantasies, and other aspects of a person's inner experience" (Bagby, Parker, & Taylor, 1994, p. 31). Individuals with alexithymia may express or report heightened emotional states (e.g., dysphoria, anger, rage), but frequently possess little understanding of how those feelings relate to higher level affects, cognitions, memories, and specific experiences (Taylor et al., 1997). This lack of insight appears to be indicative of a deficit in affect (or emotion) regulation, a process involving the integration of neurophysiological, motor-expressive, and cognitive-experiential domains in the experience and expression of emotion (Taylor et al., 1997). The theory of emotion dysregulation in alexithymia is supported by research that finds that individuals with alexithymia experience impairments in verbal and nonverbal recognition of emotional stimuli and cognitive processing of emotion information (Lane et al., 1996; Suslow & Junghanns, 2002).

Alexithymia is a multifaceted construct. Early work proposed a four-factor structure of alexithymia: (a) difficulty identify feelings and distinguishing feelings from bodily sensations (DIF), (b) difficulty describing feeling (DDF), (c) reduced daydreaming or constricted imaginal processes, and (d) stimulus-bound, externally-oriented thinking (EOT; Bagby, Taylor, & Ryan, 1986). Analyses of this structure, however, indicated that the daydreaming factor was theoretically incongruent with the alexithymia construct and

the other three factors (Bagby et al., 1994). In accordance with this finding, the 20-item Toronto Alexithymia Scale (TAS-20), the most extensively utilized alexithymia measure, was modified to reflect a three-factor structure: DIF, DDF, and EOT (Bagby et al., 1994). Although alexithymia is indeed a complex construct, associated with a number of features indicative of deficits in emotion self-awareness, the three-factor structure is widely accepted in the literature.

C. Alexithymia: State or Trait?

There is disagreement about the stability of alexithymia across the lifespan. Although some postulate that alexithymia is a stable personality trait that may increase an individual's risk for psychopathology, others have suggested that alexithymic features are more state-dependent and can change during one's lifetime, possibly depending on the course and resolution of psychiatric conditions (Fukunishi, Kikuchi, Wogan, & Takubo, 1997; Martínez-Sánchez, Ato-García, Córcoles Adam, Huedo Medina, & Selva España, 1998; Saarijärvi, Salminen, & Toikka, 2001). The research findings on this matter are equivocal. Martínez-Sánchez and colleagues (1998) found that, in a non-clinical sample of undergraduate students, alexithymia remained stable at a 17-week follow-up, despite changes in emotional distress. In clinical samples, there is differential stability of alexithymic features, suggesting that some characteristics of alexithymia may be state-dependent (Fukunishi et al., 1997; Saarijärvi et al., 20013). Studies on the stability of alexithymia in individuals with depressive and anxiety disorders have found that decreases in DIF and DDF were associated with decreases in depressed mood and anxiety; further, such alexithymic symptoms decreased following psychiatric treatment (Fukunishi et al., 1997; Saarijärvi et al., 20013). EOT, however, remained stable despite

declines in psychiatric symptomology and psychological distress (Fukunishi et al., 1997; Saarijärvi et al., 2001). Thus, the stability of alexithymia may be dependent on associated clinical features (e.g., anxiety, depression) and the resolution of those symptoms. Alternatively, alexithymia may have both trait-like and state-like qualities. Some researchers differentiate *primary alexithymia*, a stable personality characteristic that predisposes a person to develop psychosomatic illness or other mental disorders, from *secondary alexithymia*, which is believed to result from a primary medical illness, mental illness, or psychological trauma or stressor (Freyberger, 1977; Lesser, 1981). This distinction may account for the inconsistencies in the literature on the stability of alexithymia.

D. Alexithymia in Older Adulthood

Older adults report greater alexithymic features than young and middle-aged adults (Lane et al., 1998; Mattila et al., 2006; Salminen et al., 1999). A large epidemiological survey conducted in Finland determined the prevalence and distribution of alexithymia in a sample of 5,454 participants between the ages of 30 and 97 (Mattila et al., 2006). The prevalence of alexithymia increased with age; while only 4.7% of the youngest group in the sample (ages 30 – 44) were classified as alexithymic, 29.3% of the oldest group (age 85 and above) met criteria for the condition (i.e., obtained a score > 60 on the TAS-20). The high rate of alexithymia in the older adult population is alarming, particularly in light of the link between this condition and numerous psychiatric and medical disorders (Taylor et al., 1997). Such findings signal a need for further investigation of the alexithymia construct in older adults.

1. Mechanisms of Change in Alexithymia in Older Adulthood

The mechanisms underlying the increased rate of alexithymia in older adulthood are unknown. As previously mentioned, competing theories regarding this epidemiological trend in the geriatric population have been proposed. Two potential explanations that have garnered some attention include a theory of improved emotion regulation in older adulthood and a "deficit" view of alexithymia as the product of neuroanatomical decline (Onor et al., 2010; Paradiso et al., 2008; Reed & Carstensen, 2012; Sturm & Levenson, 2011). The possibility of cohort effects has also been proposed as reason for the seemingly late-life increase in alexithymia.

a. Improved Emotion Regulation in Older Adulthood

Somewhat paradoxically, older adults may be more likely than young and middle-aged adults to be inaccurately labeled as alexithymic due to age-related *improvements* in emotion regulation, which may resemble alexithymia, a *deficit* in emotion regulation (Onor et al., 2010). Healthy older adults devote more cognitive resources to actively down-regulate emotional responses to negative stimuli than their younger counterparts, and show an attentional bias for positive over negative information (Leclerc & Kensinger, 2011; Reed & Carstensen, 2012; Williams et al., 2006). This decrease in attending to, and perhaps reporting of, negative emotions may influence how one responds to the items on the TAS-20, the most widely used alexithymia scale, or other self-report measures of alexithymia (e.g., Bermond-Vorst Alexithymia Questionnaire) because a large portion of the items on these measures focus on negative emotions (e.g., sad, frightened, angry, distressed; Parker, Taylor, & Bagby, 2003; Vorst & Bermond, 2001). On scales of this type, improved emotion regulation strategies may be mistaken for a deficit in the ability to identify and describe one's emotions. Consequently, older

adults may be falsely characterized as alexithymic, driving this increased rate of alexithymia in late life.

b. Neurobiological Decline and Alexithymia

Recent findings on alexithymia in older adulthood more strongly coincide with a deficit theory of alexithymia in the aging population that links this condition with neuroanatomical decline (Onor et al., 2010). Late-life increase in alexithymia may be the product of age-related decline in prefrontal brain circuitry associated with emotion processing (Paradiso et al., 2008; Sturm & Levenson, 2011). This line of research stems from imaging studies that found reduced activation in the anterior cingulate cortex (ACC), a frontal brain region implicated in the awareness of one's own emotional experiences, in individuals with alexithymia compared to those without alexithymia (Kano et al., 2003; McRae, Reiman, Fort, Chen, & Lane, 2008; Wingbermühle, Theunissen, Verhoeven, Kessels, & Egger, 2012). The rostral-ventral, or "affective" subdivision, of the ACC is a component of an extensive emotion circuit, with connections to the amygdala, periaqueductal gray, nucleus accumbens, hypothalamus, anterior insula, hippocampus, and orbitofrontal cortex (Bush, Luu, & Posner, 2000, Devinsky, Morrell, & Vogt, 1995). This network, part of which makes up the rostral limbic system, is implicated in evaluating the salience of emotion information and regulating emotional responses (Bush, Luu, & Posner, 2000, Devinsky, Morrell, & Vogt, 1995). Decline in functioning of the ACC and associated networks is associated with aging (Pardo et al., 2007). Paradiso et al. (2008) investigated the relation between reduced ACC volume and alexithymia with respect to aging in a sample of 24 participants, aged 24 to 79 (M = 53.7, SD = 17.1), using magnetic resonance imaging. Older age was significantly associated

with higher total alexithymia scores and reduced ACC subregion volume. Total alexithymia score (as measured by the TAS-20), as well as EOT, were negatively correlated with right rostral sub-region volume in the ACC. The results suggest that an increase in the rate of alexithymia in late life may be related to a decline in brain circuitry associated with emotion, particularly the right rostral ACC and associated emotion circuitry. However, additional research in this area that controls for aging as a potential covariate needs to be conducted to rule out the possibility that alexithymia and neuroanatomical decline are unrelated and simply co-occur with age.

The frontal dysfunction patterns associated with alexithymia are also hallmarks of several age-related neurodegenerative diseases (Sturm & Levenson, 2011). Sturm and Levenson (2011) explored the overlap between alexithymia and frontotemporal neurodegenerative disorders in 25 patients who were early in their disease course and seven healthy controls. Total alexithymia scores were significantly greater in patients with neurodegenerative diseases (including those with frontotemporal dementia, semantic dementia, Alzheimer's disease, and corticobasal degeneration/progressive supranuclear palsy) than controls. The same pattern was found for each of the alexithymia subscales. Sturm and Levenson (2011) found that 80% of participants with neurodegenerative disorders scored in the alexithymic range (i.e., score of 61 or higher on the TAS-20), whereas no control participants scored within this range. Additionally, neuroimaging data indicated that gray matter volume in the right pregenual ACC was significantly associated with alexithymia total scores in the control group. (Participants with neurodegenerative disease were not included in brain imaging analyses.) These findings suggest that alexithymia may be a feature of neurodegenerative disorders, may occur

early in the course of the disease, and may be specifically associated with frontotemporal circuitry.

c. Cohort Effects

Some researchers have argued that higher rates of alexithymia in older versus younger adults may simply reflect cohort effects. Salminen et al. (1999) suggest that generation effects may explain differences between older adults and younger adults in their reporting of emotions. Older adults may have grown up in a cultural environment that placed less emphasis on emotional expression and instead stressed different ways of handling one's affective experiences. However, no research to the author's knowledge has explored this possibility. Prospective studies are necessary to confirm or rule out possible cohort effects.

2. Alexithymia and Executive Function

In support of the neurobiological deficit nature of alexithymia, cognitive impairment may occur concurrently with alexithymia as a result of disruption of frontal circuitry (Bogdanova et al., 2010; Paradiso et al., 2008). Specifically, the relationship between deficits in executive function and alexithymia has been studied because of the independent associations of these conditions with reduced ACC activity (Bogdanova et al., 2010; Onor et al., 2010). Executive function is a broad term referring to "a process used to effortfully guide behavior toward a goal, especially in nonroutine situations" (Banich, 2009, p. 89). Numerous executive abilities, including response monitoring, simultaneous processing when performing multiple tasks, and conflict resolution, have been found to be associated with ACC function (Banich, 2009; Carter, Botvinick, & Cohen, 1999; Dreher & Grafman, 2003; Posner, 1994). As previously discussed, reduced

ACC activation has been implicated in features of alexithymia, specifically emotion self-awareness deficits (McRae et al., 2008; Wingbermühle et al., 2012). Although the different subregions of the ACC are believed to play separate roles in emotion (rostral ACC) and cognitive (dorsal ACC) processes, research suggests that there is a great degree of interregional interaction in the processing of both cognitive and emotional information (Mohanty et al., 2007). The rostral and dorsal subdivisions have reciprocal projections with both the amygdalae, which are involved in the physiological and automatic behavioral responses to emotion, and the prefrontal cortex, which is involved in emotional "feeling" and reflection (Bermond, Voorst, & Moormann, 2006).

Deficits in executive abilities have been found in nonclinical samples of young adults with alexithymia (Koven & Thomas, 2010; Zhang et al., 2011). Zhang and colleagues (2011) found that high alexithymic individuals (those with a TAS-20 score above 59; M_{age} = 21.1, SD = .64) had a significantly greater reaction time on a conflict processing task (i.e., the Attention Network Test) than low alexithymic individuals (M_{age} = 21.1, SD = .163), indicating that high alexithymic participants took longer to resolve conflict than low alexithymic participants. The authors concluded that alexithymia may be associated with less efficient executive control (Zhang et al., 2011). Additionally, certain facets of alexithymia in young adults, specifically deficits in emotional clarity (i.e., the ability to identify and understand one's emotions), are associated with self-reported behavioral manifestations of executive dysfunction across numerous domains, including inhibition, set-shifting, emotional control, self-monitoring, task initiation, planning, and task monitoring (Koven & Thomas, 2010).

3. Alexithymia, Executive Function, and Aging

Despite evidence supporting the relationship between executive function and alexithymia in younger adults, as well as neuroimaging research linking alexithymia and reduced ACC activity, research on executive dysfunction and alexithymia in the older adult population is scant. The lack of research exploring this link reflects a major gap in the literature, especially given the progressive decline in executive processing and prefrontal activity that occurs in older adulthood (Hedden & Gabrieli, 2004). Frontal brain structures undergo the greatest age-related volumetric changes during adulthood when compared to other brain regions (Resnick, Pham, Kraut, Zonderman, & Davatzikos, 2003). Additionally, cognitive functions largely associated with frontal lobe structures, specifically executive processes, decline in older adulthood (Salthouse, Atkinson, & Berish, 2003). Preliminary investigations exploring associations between alexithymia and age-related cognitive decline have produced conflicting results. Paradiso and colleagues (2008) found that greater alexithymia (total score and all three subscale scores) was associated with poorer performance on the Controlled Oral Word Association Test (COWA), a measure of executive function, in a sample of older adults. Measures of general intelligence and verbal abilities were not significantly correlated with alexithymia. Onor and colleagues (2010) found that alexithymia scores (i.e., total score and all three subscales) were correlated with several measures of neurocognitive function, including those assessing verbal memory, visual memory, and nonverbal intelligence. However, due to lack of significant age-group differences on measures of executive function in Onor et al.'s (2010) broad age-range sample, the relation between executive function and alexithymia was not explored or reported. This lack of age-group differences in executive performance may be due to the exclusion of participants who

scored 0.5 or more standard deviations below standardized means (for age and education) on any of the administered cognitive tests, as well as those who scored less than perfect on the Mini Mental State Examination, Basic Activities of Daily Living, and Instrumental Activities of Daily Living in this study. These stringent exclusion criteria suggest that Onor et al.'s (2010) older adult sample likely represents a subset of high functioning older adults; thus, results may not reflect the average neurocognitive capabilities of older adults and how such cognitive functions correlate with alexithymia. Previous studies (e.g., Onor et al., 2010; Paradiso et al., 2008) have primarily focused on identifying associations between alexithymia and executive function in broad age-range samples, without controlling for aging as a potential covariate. Thus, it is difficult to determine if a true relationship exists between these variables or if they simply co-occur with age. However, preliminary data from these studies are intriguing and support the need for more work in the area of alexithymia and executive function in older adulthood.

E. Alexithymia and Public Health Concerns

Alexithymia in older adulthood is a clinically-relevant issue that requires greater attention. Older adults with alexithymia may be at greater risk for depression (Bamonti et al., 2010). Alexithymic features, including the inability to verbalize one's emotions, may partially explain the underreporting of depressive symptoms that frequently occurs in the older adult population. Underreporting of depressive symptoms due to alexithymia may contribute to the under-diagnosis of late-life depression, "constituting a significant public health problem" (Paradiso et al., 2008, p. 767). Furthermore, a positive relation between executive dysfunction and alexithymia may suggest an increased risk of emotion regulation difficulties in older adults with cognitive impairment, including those with

mild cognitive impairment (MCI). Thus, a clearer picture of the relation between alexithymia and cognitive functioning may inform new assessment strategies for late-life depression and emotion dysregulation in healthy older adults, as well as those with cognitive impairment.

CHAPTER II

THE CURRENT STUDY

The purpose of the current study was to address a significant gap in the literature on alexithymia and cognitive functioning in older adulthood by determining associations between alexithymia and executive function in younger and older adults. The specificity of these relationships was tested by also determining associations between alexithymia and other cognitive functions that may (e.g., memory) or may not (e.g., verbal ability) change with age. The inclusion of memory measures allowed us to ascertain if alexithymia is associated with a cognitive function tied to non-frontal brain regions that typically decline with age (e.g., networks within the temporal region) or specific to frontal circuitry. Since poorer verbal skills have been found to be associated with greater alexithymia (Lamberty & Holt, 1995), a measure of verbal ability (i.e., the American National Adult Reading Test) was also included. Additionally, some studies indicate that alexithymia is associated with decreased activation in right hemisphere structures (Paradiso et al., 2008; Spalletta et al., 2001) while others find that it is specific to dysfunction of left hemisphere structures (Lamberty & Holt, 1995). Thus, lateralized measures of executive ability (verbal fluency and design fluency) and memory (verbal memory and visual memory) were included to investigate the extent to which alexithymia is associated with lateralized functions.

A primary goal of this investigation was to contribute to our understanding of the late-life increase in alexithymia – that is, whether or not it is associated with age-related neurocognitive decline linked to frontal brain circuitry implicated in emotion self-awareness. Preliminary work in this area suggests that alexithymia is associated with

poorer cognitive functioning in older adults and deficits in executive functioning in individuals with prefrontal dysfunction (Bogdanova et al., 2010; Onor et al., 2010). Considering the role of the ACC and associated frontal brain circuitry in both executive processes and alexithymia, we predicted that executive function would be uniquely associated with alexithymia when accounting for age and non-frontally-mediated neurocognitive functions (e.g., memory and verbal abilities; Banich, 2009; Wingbermühle et al., 2012). It was hypothesized that higher alexithymia scores would be associated with poorer performance on a measure of executive function that taps into ACC function (i.e., verbal fluency) in both the younger and older adult groups, as well as the entire, broad age-range sample. The alternative explanation that changes in each of these variables co-occur as a result of the aging process was addressed by comparing the relationship between alexithymia and executive function in the younger adult sample and the older adult sample and statistically controlling for age in both groups. Differences between younger adults and older adults in alexithymia, the three alexithymia dimensions (i.e., DIF, DDF, and EOT), and measures of executive function were also determined. In accordance with epidemiological studies that indicate that the rate of alexithymia increases across the lifespan, we predicted that older adults would report significantly greater total alexithymia, DIF, DDF, and EOT than younger adults (Mattila et al., 2006).

A. Method

1. Participants

Sixty-five younger adults (aged 18 – 30; 46% female) and 44 older adults (aged 61 – 92; 73% female) participated in this study. In accordance with research that indicates a notable age-related increase in alexithymia even within the older adult

population (Mattila et al., 2006), we deliberately recruited 22 older adults between the ages of 60 and 74 and 22 over the age of 74 to ensure variability in age for our older adult sample. Participants were primarily from the Western Massachusetts area and were recruited through newspaper advertisements, the University of Massachusetts' Aging Database, local community senior centers, and the SONA System at the University of Massachusetts. Persons with cognitive impairment (evidenced by a score of 29 or less on the Telephone Interview for Cognitive Status – Modified [TICS-m]) were excluded.

2. Procedure

The data for this study were collected as part of a larger study investigating age group differences in the cognitive organization of emotion information (Principal Investigator: R. Ready, PhD). Following informed consent, a brief cognitive screening (i.e., TICS-m) was administered to participants to ensure that cognitive impairment was not present. Participants' cognitive functioning, including executive functioning, memory, and verbal abilities, was then assessed. Demographic information and self-report ratings of alexithymia and depression were also collected. All participants were provided a written debriefing form at the end of the testing session. Testing sessions lasted approximately two and a half hours. Participants were compensated $12 per hour, rounded up to the nearest half-hour, or 1 experimental extra credit for each half-hour of participation for students participating through SONA. This study was approved by the University of Massachusetts Amherst Institutional Review Board (IRB).

3. Measures

a. Alexithymia

Alexithymia was assessed using the Twenty-Item Toronto Alexithymia Scale

(TAS-20; Bagby et al., 1994; see Appendix). Items on the TAS-20 are rated on a Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Scores range from 20 to 100, with higher scores indicating greater alexithymia. Sample items include, "I am often confused about what emotion I am feeling" and "I find it hard to describe how I feel about people."

The items on the TAS-20 correspond to three distinct factors of alexithymia: Difficulty Identifying Feelings and Distinguishing them from Bodily Sensations of Emotion (DIF; Items 1, 3, 6, 7, 9, 13, and 14), Difficulty Describing Feelings (DDF; Items 2, 4, 11, 12, and 17), and Externally Oriented Thinking (EOT; Items 5, 8, 10, 15, 16, 18, 19, and 20; Bagby et al., 1994). In this study, TAS-20 total and subscale scores were included in analyses.

The TAS-20 has demonstrated adequate test-retest reliability ($r = .77$, $p < .01$, with a three week period between administrations) and internal consistency (Cronbach's $\alpha = .81$; Bagby et al., 1994). The internal consistencies of the TAS-20 in the full sample (Cronbach's $\alpha = .76$), younger adult sample (Cronbach's $\alpha = .77$), and older adult sample (Cronbach's $\alpha = .77$) in the current study were adequate and consistent with previous research. The TAS-20 exhibits construct validity via significant negative associations with related measures of psychological mindedness and emotion self-awareness, and is not significantly correlated with measures of unrelated constructs, including agreeableness, conscientiousness, and excitement seeking (Bagby et al., 1994). Additionally, confirmatory factor analyses support the TAS-20's three-factor structure of alexithymia (Bagby et al., 1994).

b. Executive Function

The Delis–Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001) Verbal Fluency, Design Fluency, and Trail Making Test, as well as an executive function composite variable (created by combining standardized scores from these three measures), were used to assess executive functions. The D-KEFS Verbal Fluency Test is an assessment of higher-level cognitive functions, including task initiation, simultaneous processing, systematic retrieval of responses, and speed of processing (Delis et al., 2001). In the "Letter Fluency" Condition, participants are asked to generate words that begin with a particular letter (*F*, *A*, and *S* in the Standard Form). In the "Category Fluency" Condition, participants are asked to generate words that belong to the same semantic category (*Animals* and *Boys' Names* in the Standard Form). Total number of correct words produced in the letter condition and the category condition were added to create a total Verbal Fluency score, which was used in analyses. The D-KEFS Verbal Fluency Test has demonstrated good test-retest reliability (Letter Fluency: r_{12} = .80; Category Fluency: r_{12} = .79) and has reasonable sensitivity in distinguishing those with focal frontal lesions from healthy controls (Baldo, Shimamura, Delis, Kramer, & Kaplan, 2001; Delis et al., 2001). Performance on similar verbal fluency tasks (e.g., COWA) is associated with activation of the ACC and was linked to alexithymia in previous research (Audenaert et al., 2000; Paradiso et al., 2008).

The D-KEFS Design Fluency subtest is an assessment of response inhibition, cognitive shifting (flexibility), and design fluency (Delis et al., 2001). In this task, participants are presented with rows of boxes containing dots and asked to draw a shape in each box, based on specific rules, in 60 seconds. There are three conditions: Condition

1 Filled Dots, Condition 2 Empty Dots Only, and Condition 3 Switching. Condition 3 Switching is the primary measure of executive processes in this task (Delis et al., 2001); thus total number of correct designs produced in Condition 3 was used to create a Design Fluency score, which was included in analyses. The D-KEFS Design Fluency Test has demonstrated moderate test-retest reliability (Condition 1: r_{12} = .58, Condition 2: r_{12} = .57, Condition 3: r_{12} = .32) and, like Verbal Fluency, has reasonable sensitivity in distinguishing those with focal frontal lesions from controls (Baldo et al., 2001). Design Fluency was included in the current study because it serves as a nonverbal analog of the Verbal Fluency subtest.

D-KEFS Trail Making is a visual-motor task primarily used to measure cognitive flexibility (Condition 4: Number-Letter Switching), with additional conditions used to assess visual scanning/attention (Condition 1: Visual Scanning), visual-motor function (Condition 2: Number Sequencing), verbal skills required for letter sequencing (Condition 3: Letter Sequencing), and motor speed (Condition 5: Motor Speed). In this test, participants are asked to scan or connect dots containing numbers and letters in a particular sequence within 150 seconds (240 seconds for Condition 4). Since Condition 4 is the primary measure of executive processes in this task, time to completion for Condition 4 was used to measure performance and included in analyses. Higher scores on this measure indicate poorer performance.

The D-KEFS Trail Making Test has demonstrated adequate test-retest reliability (Condition 1: r = .56; Condition 2: r = .59; Condition 3: r = .59; Condition 4: r = .38; Condition 5: r = .77; Delis et al., 2001). Condition 4 has also been shown to correlate with performance on the Wisconsin Card Sorting Test (r = -.49 for categories),

supporting its convergent validity (Delis et al., 2001). Performance on Trail Making Condition 4 is associated with activity in the dorsolateral prefrontal cortex and does not appear to be linked to ACC function (Stuss et al., 2001). Thus, this measure will be included to investigate differential associations of alexithymia with an executive function measure that taps into ACC function and one that does not.

Given the conceptual and neuroanatomical overlap amongst executive function domains, an executive function composite variable was included in analyses to capture global executive abilities (Kemper & McDowd, 2008). This variable was created by adding Verbal Fluency and Design Fluency z-scores, then subtracting Trail Making Condition 4 z-scores from these values. Higher scores on this variable indicate greater executive performance.

c. Memory

The Wechsler Memory Scale – Fourth Edition (WMS-IV; Wechsler, 2009) Visual Reproduction II and Logical Memory II subtests were used to assess visual and verbal memory (specifically delayed recall), respectively. Visual Reproduction II is an assessment of delayed recall of non-verbal visual stimuli. In this task, participants are asked to draw from memory five geometric designs that were presented to them 20 to 30 minutes prior. Raw scores range from zero to 43. The WMS-IV Visual Reproduction II has demonstrated adequate reliability, including high internal consistency (r = .97) and moderate test-retest reliability (corrected r = .64). In terms of its concurrent validity, WMS-IV Visual Reproduction correlates with the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) immediate and delayed memory scores (rs ranging from .48 to .61).

The WMS-IV Logical Memory II is an assessment of delayed recall of orally presented stories. Participants are asked to recall two stories that were presented to them orally 20 to 30 minutes prior. Raw scores range from zero to 50. The WMS-IV Logical Memory II has demonstrated adequate reliability, including high internal consistency (r = .85) and moderate test-retest reliability (r = .71). Research also supports the validity of the WMS-IV Logical Memory; it has been found to moderately correlate with short-delay and long-delay cued and free recall scores on the California Verbal Learning Test (CVLT; rs ranging from .40 to .53).

d. Estimated Verbal IQ

The American National Adult Reading Test (ANART) was used to estimate verbal intelligence (Gladsjo, Heaton, Palmer, Taylor, & Jeste, 1999; Schwartz & Saffran, 1987, cited in Grober, Sliwinski, & Korey, 1991). In this task, participants are presented with 50 words with irregular pronunciations and asked to read each word aloud. Number of ANART errors was entered into an equation developed by Gladsjo and colleagues (1999) to calculate each participant's estimated verbal IQ; this variable was used in analyses.

The ANART is the American modification of the National Adult Reading Test, which demonstrates strong test-retest reliability (r = .98) and high construct validity as a measure of verbal intelligence and general intelligence (g), with a factor loading of .85 on g (Crawford, Parker, Stewart, Besson, & Lacey, 1989; Crawford, Stewart, Cochrane, Parker, & Besson, 1989; Gladsjo et al., 1999).

e. Depression

The Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977)

was used to assess depressive symptoms in the sample. The CES-D Scale is a 20-item self-report measure of depressive symptomatology developed for use in community populations. Respondents rate how many times during the past week they have experienced a number of emotions or behaviors on the following scale: *rarely or none of the time (less than 1 day), some or a little of the time (1-2 days), occasionally or a moderate amount of time (3-4 days), most or all of the time (5-7 days)*. Scores range from zero to 60, with higher scores indicating greater depressive symptomatology. Sample items include, "I am bothered by things that usually don't bother me" and "I felt lonely."

Research indicates that the CES-D Scale demonstrates adequate reliability, including high internal consistency (r = .85 in the general population sample) and moderate test-retest reliability (all but one r ranged from .45 to .70; Radloff, 1977). The internal consistency of the CES-D in the full sample (Cronbach's α = .85), younger adult sample (Cronbach's α = .83), and older adult sample (Cronbach's α = .88) in the current study was high and consistent with other studies. In terms of convergent and divergent validity, the CES-D has been found to be positively correlated with other self-report scales designed to measure depression, including the Bradburn Negative Affect Scale, and was not significantly correlated with measures of unrelated constructs, such as aggression (Radloff, 1977). Depressive symptomatology was assessed in the current study because of its associations with alexithymia (Bamonti et al., 2010) and executive function (Fossati, Ergis, & Allilaire, 2002).

4. Data Analytic Plan

Descriptive statistics were examined and evaluated for normality and outliers. Preliminary analyses were conducted to assess correlations amongst measures of

executive function (predictor variables), alexithymia total score and subscale scores (outcome variables), and age, education, depressive symptoms, verbal memory, visual memory, and estimated verbal IQ (possible relevant covariates) to determine which variables to control in regression analyses. This series of analyses was conducted also to explore differential associations of alexithymia with a global executive function measure, executive function measures that specifically tap into ACC function (e.g., Verbal Fluency), and those that do not (e.g., Trail Making Test); differences in associations with right (i.e. Design Fluency) and left (i.e., Verbal Fluency) lateralized executive function measures were also explored. Since higher rates of alexithymia are found in males, a *t*-test was conducted to explore gender differences in alexithymia total score and subscale scores and to determine if gender should be controlled in regression analyses (Salminen et al., 1999). Additionally, a series of *t*-tests were conducted to determine if younger adults and older adults significantly differed on total alexithymia, DIF, DDF, EOT, executive function, and other cognitive measures.

Hierarchical linear regression analyses were then conducted to determine the unique contribution of executive function to alexithymia scores in the broad age-range sample, as well as separately in the younger adult group and the older adult group. Separate models were run for total TAS-20 score, DIF, DDF, and EOT. Four separate models were used to explore the predictive nature of the executive function composite variable, Verbal Fluency, Design Fluency, and Trail Making Condition 4.

Hierarchical regressions controlled for age and other relevant covariates determined to be significant in correlational analyses. For each executive function measure, all covariates were entered as a block in Step 1, and the executive function

measure was entered in Step 2. Incremental R^2 was used to determine if executive function explained significant additional variance in TAS-20 total score over and above covariates.

a. Power Analysis

Results of a power analysis for the regression models indicated that a sample of 52 was required to detect a large effect, with a power of .80 and alpha set at .05. A large effect for the relation between executive function and total alexithymia was found in Paradiso et al. (2008).

CHAPTER III

RESULTS

A. Descriptive Statistics

Participants were 44 older adults (OA) and 65 younger adults (YA; Table 1). In the full sample and the OA group, the majority of participants were female (57% in the full sample and 73% in the OA group). In the YA group, there were slightly more male participants than female participants (54% male). In the full sample, 74% of participants identified as White, 12% as Asian, 4% as Black, 3% as Latino/a, and 6% as other. In the YA group, 61% identified as White, 20% as Asian, 5% as Black, 5% as Latino/a, and 9% as other. There was less variability in the ethnic/racial composition of the OA group (93% White, 2% Black, 2% other, 3% missing). Chi-square tests indicated that gender and ethnic distributions significantly differed in the YA and OA groups: $\chi^2(1) = 7.55$, $p < .01$ for gender, and $\chi^2(1) = 16.80$, $p < .01$ for ethnicity. Half ($n = 22$) of the OA participants were between the ages of 60 and 74, and the rest were between the ages of 75 and 92.

All other variables were normally distributed except for Trails Condition 4 and CES-D, which were positively skewed. Logarithmic transformations were applied to these two variables, which resulted in normal distributions of both. Logarithmic transformed Trails Condition 4 and CES-D values were therefore used in all subsequent analyses.

A series of *t*-tests were conducted to determine differences between YA and OA on all study variables (Table 1). As expected, YA and OA significantly differed on all neuropsychological variables; YA performed better on all neuropsychological measures

except a measure of estimated verbal IQ. OA had a higher level of education than YA. OA and YA did not significantly differ on total alexithymia or alexithymia subscales. Gender differences were found for some alexithymia scores (Table 2); for all three samples, gender was controlled in primary analyses for alexithymia scales with significant gender differences.

Intercorrelations amongst study variables in the full sample (Table 3) and YA and OA samples (Table 4) were used to determine covariates for hierarchical regressions. Neurocognitive and demographic variables that were significantly associated with alexithymia, DIF, DDF, and EOT were controlled in their respective regression analyses. Age was controlled in all regression analyses.

Alexithymia subscales (DIF, DDF, and EOT) were significantly correlated but sufficiently distinct (correlations below .60) in the full sample (Tables 3), providing evidence that these variables should be treated separately in regression analyses. Further, significant moderate correlations between alexithymia and depressive symptoms in each of the samples (Tables 3 and 4) suggest that these variables are distinct constructs that share some overlap.

Correlations amongst study variables reveal different patterns of associations in the full sample, YA group, and OA group; in the full sample, EOT was significantly correlated with visual memory and design fluency, but these associations were not found in YA and OA. Significant correlations between EOT and verbal memory in the full sample and YA group were not found in the OA group. Further, verbal fluency was significantly correlated with both total alexithymia and DDF in both the full sample and OA group (Figures 1 and 2), but not in the YA group. Differential correlation patterns

amongst the full sample, OA, and YA supported the decision to run distinct regression models with different covariates for each sample.

B. Executive Function Measures as Predictors of Alexithymia in the Full Sample

Hierarchical linear regression analyses were conducted to determine if any of the three executive function measures (Verbal Fluency, Design Fluency, and Trails Condition 4) and/or an executive function composite score (comprised of the three measures) predicted alexithymia and subscale scores in the full sample, accounting for covariates determined to be significantly correlated with TAS-20 Total, DIF, DDF, and EOT. Prior to running these analyses, the data were evaluated for assumptions of multiple regression; results indicated homoscedasticity of residuals, independence of error, and an absence of outliers and multicollinearity. Four models were then run for each outcome variable (i.e., TAS-20 Total, DIF, DDF, and EOT); for each model, covariates were entered in a single block in step 1, and one of the four executive function measures was entered in step 2 (Table 5). As hypothesized, verbal fluency significantly predicted total alexithymia, controlling for age, sex, and depressive symptoms, such that poorer verbal fluency was associated with greater alexithymia, $R^2 = .19$, $F(1, 100) = 4.67$, $p = .03$. Similarly, verbal fluency significantly predicted DDF, controlling for age, sex, and depressive symptoms, such that poorer verbal fluency was associated with greater DDF, $R^2 = .19$, $F(1, 100) = 6.23$, $p = .01$. Design Fluency, Trails Condition 4, and the executive function composite score were not significant predictors of alexithymia, DIF, DDF, or EOT.

C. Executive Function Measures as Predictors of Alexithymia in YA

Similar hierarchical regression analyses were run with the YA sample. However, the covariates included in the models with YA differed; these analyses accounted for age and covariates determined to be significantly correlated with TAS-20 Total, DIF, DDF,

and EOT in the YA sample specifically (Table 4). Results indicated that none of the four executive function measures significantly predicted total alexithymia or alexithymia subscale scores.

D. Executive Function Measures as Predictors of Alexithymia in OA

The series of regression analyses conducted with the OA group (Table 6) were similar to those run with the full sample and YA; however, covariates in these models included age and variables found to be significantly correlated with total alexithymia and subscale scores in the OA sample (Table 4). Verbal fluency significantly predicted total alexithymia, controlling for age, sex, and depressive symptoms, such that poorer verbal fluency was associated with greater alexithymia, $R^2 = .33$, $F(1, 37) = 5.76$, $p = .02$. Similarly, verbal fluency significantly predicted DDF, controlling for age, such that poorer verbal fluency was associated with greater DDF, $R^2 = .23$, $F(1, 40) = 5.76$, $p = .01$.

CHAPTER IV

DISCUSSION

In light of research that suggests alexithymia may increase with age because of its potential links to cognitive decline, the present study aimed to determine associations between alexithymia and executive functions in younger and older adults. Greater total alexithymia and DDF were associated with poorer verbal fluency in the full sample and in older adults, even when accounting for age and depressive symptoms. This association was not found in the younger adult sample. Contrary to previous research, young adults and older adults in our sample did not significantly differ on their self-reported ratings of alexithymia.

A. Alexithymia and Executive Function in Older Adulthood

Our primary finding that alexithymia was significantly associated with verbal fluency in the full and OA samples is consistent with previous research, including imaging studies, identifying links between alexithymia, verbal fluency, and the ACC. The ACC is a brain region that has been implicated in the awareness of one's own emotional experiences – a skill that is lacking in individuals with alexithymia (Kano et al., 2003; McRae et al., 2008; Wingbermühle et al., 2012). Indeed, imaging studies have found reduced activation in the ACC in those with alexithymia compared to those without alexithymia (Kano et al., 2003; McRae et al., 2008; Wingbermühle et al., 2012). Verbal fluency, an executive function measure that assesses simultaneous processing and systematic retrieval of responses, has been found to be associated with ACC activation (Audenaert et al., 2000). The findings of the current study lend support to the theory that alexithymia may result in part from declines in prefrontal brain circuitry, specifically that

which involves the ACC.

This finding is particularly notable given that the other cognitive measures in the study, including those that assess verbal ability, verbal memory, visual memory, and domains of executive function that *do not* tap into ACC function, were not significantly associated with any of the alexithymia factors in regression analyses. Results thus support the specificity of the relationship between alexithymia and executive functions that are primarily linked to ACC circuitry (e.g., verbal fluency), and provide evidence against the argument that broad/general cognitive decline in older adulthood, rather than declines in a specific brain region or circuitry, may predict alexithymia. The specificity of this relationship is also consistent with evidence that poorer performance on a measure of verbal fluency, but not other measures of executive function (e.g., working memory, Stroop), predicts deficits in emotion regulation and emotional responding in older adults (Gyurak et al., 2009). Further, findings of this study are in line with evidence that alexithymia is primarily a verbal, left-hemispheric deficit (Lamberty & Holt, 1995); in the current study, design fluency – the nonverbal analog of verbal fluency – was not a significant predictor of alexithymia or any of the alexithymia factors.

An alternative explanation for the primary findings of this study is that *verbal skill*, not executive function, predicts alexithymia in older adults. Indeed, in addition to being a measure of task initiation and systematic retrieval of responses (aspects of executive function), verbal fluency is also a measure of verbal knowledge (Delis et al., 2001), and the relationship between verbal fluency and difficulty *describing* feelings in the current study suggests that verbal skills may play an important role in alexithymia. However, it is unlikely that verbal ability is driving this relationship; in the current study,

we did not find a significant relationship between any of the alexithymia factors and verbal ability (as measured by estimated verbal IQ).

This study builds upon previous work that explored associations between alexithymia and executive function in broad age-range samples, but did not account for age as a potential covariate (e.g., Onor et al., 2010; Paradiso et al., 2008). Without controlling for age, it is unclear if executive functions, specifically, predict alexithymia, or if changes in each of these variables simply co-occur as a result of the aging process. The current study addressed this issue by controlling for age, and other relevant variables (e.g., depression), in all analyses. Even when accounting for age, alexithymia was still a significant predictor of alexithymia and DDF in the current study.

A surprising finding was that verbal fluency *did not* predict alexithymia in the YA sample, despite significant associations between these constructs in the OA sample. This may be explained by differences in the variability of executive function performance in younger adults and older adults. Indeed, our YA sample was substantially more homogenous with regard to their executive function scores than our OA sample, particularly on the Verbal Fluency and Trail Making tasks. Further, imaging research indicates that frontal brain regions, compared to temporal and occipital regions, undergo the most substantial declines during older adulthood, even in healthy older adults (Resnick et al., 2003). Thus, individual differences in executive function skills, and possibly ACC activity, are likely much smaller in healthy younger adults than in healthy older adults. This, taken together with the current study's finding that older adults performed significantly worse than younger adults on executive function measures, suggests that executive function, particularly verbal fluency, may only be predictive of

alexithymia when there are more pronounced deficits in executive abilities, even if those impairments fall within the "normal" or "healthy" range of performance or activity, as they did in our OA sample. The lack of significant associations between executive functions and alexithymia in our YA group is not consistent with studies that have identified links between these variables in nonclinical YA samples (Koven & Thomas, 2010; Zhang et al., 2011). More work with younger adults with varying degrees of alexithymia and executive abilities is needed to address these inconsistencies.

The results of the current study indicate differential relationships between verbal fluency and the three alexithymia factors: DIF, DDF, and EOT. Despite high correlations between DIF and DDF in all three samples (as well as in previous research; see Kooiman et al., 2002), verbal fluency was only predictive of total alexithymia and DDF, suggesting that there is an important distinction between DIF and DDF. Parker and colleagues (1993) infer that the ability to communicate one's feelings to others (assessed by DDF) is largely dependent on one's ability to recognize his/her own emotions and distinguish them from bodily sensations of emotions (assessed by DIF); that is, one cannot discuss feelings that one cannot identify. This suggests that DDF may rely more heavily on the ability to concurrently process emotional experiences and determine appropriate verbal responses to those experiences than DIF, and would therefore be more strongly associated with an executive function measure that assesses simultaneous processing and systematic retrieval of verbal responses, such as verbal fluency. The lack of association between EOT and executive function in the current study is less surprising. Consistent with previous research (e.g., Kooiman et al., 2002), correlations between EOT and DIF/DDF were low in the full, YA, and OA samples in the current study. Indeed, the

literature indicates the EOT dimension of the TAS-20 is qualitatively distinct from the DIF/DDF dimensions; EOT has differential rates of stability than DIF and DDF, and has been found to possess low reliability in factor analytic studies of the alexithymia construct (Fukunishi et al., 1997; Kooiman et al., 2002; Saarijärvi et al., 2001).

B. Theories of Age-Related Changes in Alexithymia

The neurobiological decline theory of alexithymia, which contends that late-life increases in alexithymia may be the product of age-related decline in prefrontal brain circuitry, is somewhat supported by the findings of the current study, as previously discussed. Results of the current study do not support the opposing theory that postulates that reports of alexithymia increase in older adulthood due to age-related *improvements* in emotion regulation. This theory suggests that, as a result of improved emotion regulation strategies, older adults are less likely to attend to – and thus report – negative emotions and experiences; however, the significant positive correlation between alexithymia and self-reported depressive symptoms in the OA group suggests that this was not the case in our sample.

Contrary to findings from epidemiological studies (e.g., Mattila et al., 2006; Salminen et al., 1999), the current study did not find significant age differences in alexithymia. There are several possible explanations for the lack of age-group differences in alexithymia in this study. First, compared to the epidemiological studies that found differences in the prevalence of alexithymia between older adults and younger adults, the sample size from the current study was smaller and the average alexithymia rating was lower and had less variance (e.g., average alexithymia in the full sample of the current study = 39.42, *SD* = 8.97; average alexithymia in Salminen et al.'s [1999] sample =

46.00, *SD* = 11.60). Additionally, the YA and OA groups in the current study's sample were relatively homogenous in terms of their demographics, with the majority of participants being well-educated, White, and from the same geographic region. The lack of demographic diversity in the sample may contribute to our inability to find age group differences in alexithymia that were found in large population-based studies, which had more diverse samples (e.g., Salminen et al., 1999).

C. Limitations of the Current Study

As discussed, the severity of alexithymia in our sample of healthy younger and older adults was low. Further, a disproportionate percentage (approximately 73%) of older adult participants were female and the majority of participants were White and highly educated, limiting generalizability. These are noteworthy factors because higher rates of alexithymia are associated with fewer years of education and being male (Mattila et al., 2006; Salminen et al., 1999). Indeed, gender differences in alexithymia were found in the current study, with men reporting greater alexithymia than women.

The current study also was limited by the use of a single alexithymia measure. Although the TAS-20 is the most widely used measure of alexithymia, it is not without limitation. First, the TAS-20 has been criticized for the instability of its factor structure across studies with different populations, and the unreliability of the EOT dimension (Kooiman et al., 2002; Müller, Bühner, & Ellgring, 2003). Additionally, it has been argued that self-report measures of alexithymia, such as the TAS-20, may actually be assessing *insight* into one's difficulties identifying and describing one's emotions rather than the *ability* to identify and communicate emotions (Müller, Bühner, & Ellgring, 2004); Lane and colleagues (1996) contend that highly alexithymic individuals may not

be able to accurately evaluate their ability to identify and describe their emotions. Thus, future research investigating this construct should include several measures of alexithymia, including an observer-rated measure such as the Beth Israel Hospital Psychosomatic Questionnaire (Sifneos, 1973). Further, only a subset of executive function measures was used in this study; findings may have differed if other executive function measures (e.g., Wisconsin Card Sorting Task, Stroop task) that tap into different executive processes were included.

D. Implications and Future Directions

Despite these limitations, the results of the current study provide insight into the possible origins of emotion self-awareness deficits in older adulthood. Although evidence of age-related decline in the activity of frontal circuitry has appeared in the literature for many years, little research has explored the associations between frontally-mediated changes in *emotion self-awareness,* including alexithymia, and *neuropsychological* indicators of executive decline in older adults. The significant negative associations between alexithymia and verbal fluency in older adults in this study provide support for the theoretical model that alexithymia is associated with age-related degeneration of frontal circuitry – possibly specific to declines in the activity of ACC circuitry. Future research should utilize a longitudinal design and functional neuroimaging with young, middle-aged, and older adults to further examine this theoretical model.

Further, the negative association between executive function and alexithymia in older adults suggest an increased risk of emotion dysregulation in older adults with impairments in executive function due to neurological conditions that affect frontal subcortical circuitry. Although there are links between alexithymia and severe

neurodegenerative disorders (Sturm & Levenson, 2011), the primary finding of the current study that poorer executive function performance predicts alexithymia in older adults with no diagnosis of neurodegenerative disease supports the need for further investigation into the links between alexithymia, executive function, and frontal circuitry in older adults with *mild* cognitive deficits. Additionally, future research on alexithymia in young and middle-aged adults with executive dysfunction resulting from injury or illness that disrupts brain function (e.g., traumatic brain injury) may clarify the nature of the relationship between alexithymia, executive functioning, and frontal dysfunction when age-related decline is removed from the equation.

Table 1

Descriptive Statistics and Young Adult versus Older Adult t-Test Comparisons for All Study Variables

Variables	Full Sample $N = 109$ *M(SD)*	Younger Adults $n = 65$ *M(SD)*	Older Adults $n = 44$ *M(SD)*	YA vs. OA *t*
Demographics				
Age	41.61 (26.85)	20.12 (2.08)	73.36 (8.62)	--
Education	15.08 (2.98)	14.31 (2.23)	16.29 (3.58)	-3.18**
Alexithymia				
TAS-20 Total	39.42 (8.97)	39.36 (8.72)	39.49 (9.44)	-0.07
TAS-20 DIF	11.68 (4.35)	11.73 (3.82)	11.59 (5.07)	0.17
TAS-20 DDF	10.67 (3.79)	11.05 (3.71)	10.11 (3.87)	1.27
TAS-20 EOT	17.04 (4.18)	16.58 (4.26)	17.72 (4.03)	-1.39
Depressive Symptoms				
CES-D	10.24 (7.65)	11.30 (7.56)	8.65 (7.61)	2.56*
Executive Functions				
Verbal Fluency	83.00 (18.85)	86.78 (15.76)	77.37 (21.68)	2.45*
Design Fluency	8.94 (3.82)	10.54 (3.76)	6.60 (2.50)	6.50**
Trails Condition 4[a]	84.00 (44.62)	60.50 (16.65)	115.52 (50.73)	-7.82**
Memory				
LM Delayed Recall	24.21 (8.19)	25.98 (7.67)	21.59 (8.32)	2.83**
VR Delayed Recall	29.84 (10.89)	36.02 (6.03)	20.73 (10.05)	9.05**
Verbal Ability				
Estimated Verbal IQ	48.04 (3.57)	46.48 (2.82)	50.33 (3.34)	-6.50**

Note. TAS-20 = Toronto Alexithymia Scale-20 item; DIF = Difficulty Identifying Feelings; DDF = Difficulty Describing Feelings; EOT = Externally-Oriented Thinking; CES-D = Center of Epidemiological Studies – Depression Scale; LM Delayed Recall = Wechsler Memory Scale - Logical Memory Delayed Recall; VR Delayed Recall = Wechsler Memory Scale - Visual Reproduction Delayed Recall; YA = younger adult sample; OA = older adult sample.

[a] Higher scores on Trails Condition 4 indicate poorer performance.

* $p < .05$. ** $p < .01$.

Table 2

Gender Differences in Alexithymia, Difficulty Identifying Feelings (DIF), Difficulty Describing Feelings (DDF), and Externally Oriented Thinking (EOT) in the Full Sample, Younger Adult Group, and Older Adult Group

		Full Sample[a]			Younger Adults[b]			Older Adults[c]		
		M	*SD*	*t*	*M*	*SD*	*t*	*M*	*SD*	*t*
TAS-20 Total	Male	42.34	9.49	3.08**	41.26	8.95	1.93	45.50	10.69	2.78**
	Female	37.20	7.95		37.17	8.04		37.23	7.99	
DIF	Male	12.57	5.18	1.80	11.97	4.38	0.53	14.33	6.97	1.78
	Female	11.00	3.49		11.47	3.12		10.56	3.80	
DDF	Male	11.74	4.04	2.65**	11.71	3.54	1.59	11.83	5.42	1.43
	Female	9.85	3.40		10.27	3.81		9.47	2.96	
EOT	Male	18.02	4.49	2.18**	17.57	4.61	2.07*	19.33	4.03	1.67
	Female	16.27	3.80		15.43	3.54		17.10	3.91	

Note. TAS-20 = Toronto Alexithymia Scale-20 item; DIF = Difficulty Identifying Feelings; DDF = Difficulty Describing Feelings; EOT = Externally-Oriented Thinking.

[a] male $n = 47$, female $n = 62$; [b] male $n = 35$, female $n = 30$; [c] male $n = 12$, female $n = 32$.

* $p < .05$. ** $p < .01$.

Table 3

Intercorrelations amongst Study Variables in the Full Sample

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age	--												
2. Education	.27**	--											
3. TAS-20 Total	-.01	-.03	--										
4. TAS-20 DIF	-.05	-.06	.79**	--									
5. TAS-20 DDF	-.15	-.04	.81**	.59**	--								
6. TAS-20 EOT	.16	.02	.60**	.10	.21*	--							
7. CES-D	-.26**	-.15	.30**	.38**	.33**	-.03	--						
8. Verbal Fluency	-.26**	.02	-.21*	-.16	-.21*	-.10	-.05	--					
9. Design Fluency	-.55**	-.21*	-.07	-.01	.12	-.23*	.16	.37**	--				
10. Trails Condition 4[a]	.66**	.15	.07	.04	-.02	.12	-.18	-.49**	-.59**	--			
11. EF Composite	-.60**	-.14	-.06	.02	.03	-.16	.17	.76**	.81**	-.86**	--		
12. LM Delayed Recall	-.31**	-.04	-.10	.01	.10	-.32*	.25*	.31**	.30**	.33**	.37**	--	
13. VR Delayed Recall	-.72**	-.11	-.08	.00	.02	-.19*	.23*	.43**	.46**	.68**	.65**	.41**	--
14. Estimated Verbal IQ	.54**	.19	-.16	-.05	-.19	-.11	-.20*	-.05	-.14	.19	-.09	-.05	-.20*

Note. TAS-20 = Toronto Alexithymia Scale-20 item; DIF = Difficulty Identifying Feelings; DDF = Difficulty Describing Feelings; EOT = Externally-Oriented Thinking; CES-D = Center of Epidemiological Studies – Depression Scale; EF Composite = executive function composite score; LM Delayed Recall = Wechsler Memory Scale - Logical Memory Delayed Recall; VR Delayed Recall = Wechsler Memory Scale - Visual Reproduction Delayed Recall.

[a] Higher scores on Trails Condition 4 indicate poorer performance.

*$p < .05$. **$p < .01$.

Table 4

Intercorrelations amongst Study Variables in Young Adults (Above Diagonal) and Older Adults (Below Diagonal)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Age	--	.08	.11	-.01	.09	.15	.29*	-.06	-.25	.03	-.19	-.11	.10	.08
2. Education	-.34*	--	.12	.06	.02	.17	-.07	-.04	-.21	.09	-.17	-.06	.07	-.06
3. TAS-20 Total	-.14	-.16	--	.75**	.79**	.69**	.31*	-.14	-.11	-.02	-.06	-.14	-.06	-.15
4. TAS-20 DIF	-.20	-.12	.82**	--	.53**	.18	.32*	-.08	-.11	-.07	-.01	-.05	.02	-.06
5. TAS-20 DDF	-.24	-.02	.85**	.67**	--	.28*	.33**	-.14	.06	.09	-.06	.09	-.04	-.03
6. TAS-20 EOT	.16	-.22	.50**	.01	.17	--	.05	-.10	-.18	-.05	-.06	-.32*	-.10	-.23
7. CES-D	-.14	-.04	.32*	.46**	.29	-.06	--	-.05	.01	.05	-.02	.05	.07	-.05
8. Verbal Fluency	-.13	.23	-.31*	-.23	-.37*	-.05	-.17	--	.24	-.43**	.75**	.37**	.23	.15
9. Design Fluency	-.46**	.35	-.04	.10	.03	-.21	.02	.45**	--	-.33*	.76**	.13	.06	.13
10. Trails Condition 4[a]	.24	-.16	.20	.19	.09	-.21	.01	-.46**	-.54**	--	-.72**	.02	-.27*	-.01
11. EF Composite	-.37*	.25	-.16	-.06	-.12	-.17	-.02	.83**	.76**	-.82**	--	.21	.19	.07
12. LM Delayed Recall	-.35*	.15	-.06	.07	-.26	-.26	.33*	.16	.33*	-.42**	.34*	--	.30*	.18
13. VR Delayed Recall	-.39**	.23	-.15	-.03	-.12	-.18	.08	.46**	.34*	-.50**	.58**	.36*	--	.11
14. Estimated Verbal IQ	.15	.09	-.24	-.05	-.30	-.21	-.06	.60*	.30*	-.41**	.55**	.04	.41**	--

Note. TAS-20 = Toronto Alexithymia Scale-20 item; DIF = Difficulty Identifying Feelings; DDF = Difficulty Describing Feelings; EOT = Externally-Oriented Thinking; CES-D = Center of Epidemiological Studies – Depression Scale; EF Composite = executive function composite score; LM Delayed Recall = Wechsler Memory Scale - Logical Memory Delayed Recall; VR Delayed Recall = Wechsler Memory Scale - Visual Reproduction Delayed Recall.

[a] Higher scores on Trails Condition 4 indicate poorer performance.

*$p < .05$. **$p < .01$.

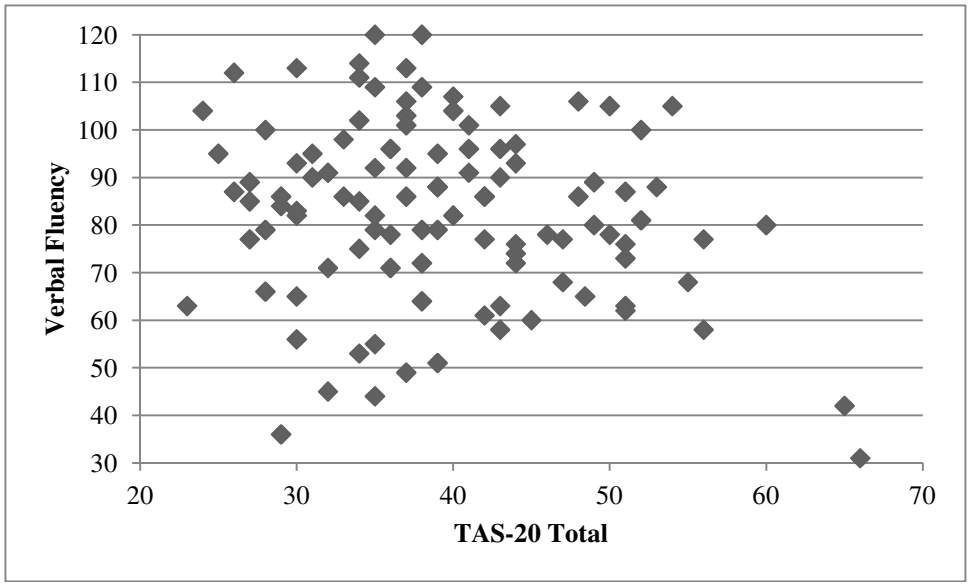

Figure 1. Scatterplot of the Correlation Between Total Alexithymia and Verbal Fluency in Older Adults

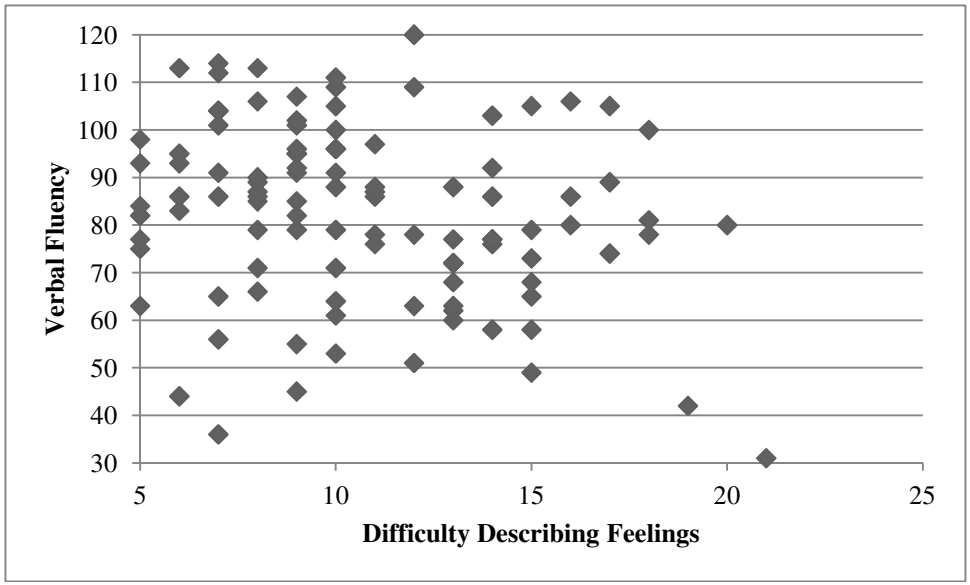

Figure 2. Scatterplot of the Correlation Between DDF and Verbal Fluency in Older Adults

Table 5

Hierarchical Regression Models Predicting Total Alexithymia, DIF, DDF, and EOT in the Full Sample

	Executive Function Measure											
	EF Composite			Verbal Fluency			Design Fluency			Trails Condition 4		
	β	R^2	ΔR^2	β	R^2	ΔR^2	β	R^2	ΔR^2	β	R^2	ΔR^2
TAS-20 Total												
Step 1												
Sex	-.26		--	-.26		--	-.22		--	-.29		--
CES-D	.22	.12	--	.25	.16	--	.25	.12	--	.26	.16	--
Age	.00		--	.06		--	.05		--	.02		--
Step 2												
EF measure	-.13	.13	.01	-.20	.19	.04*	-.08	.12	.01	.13	.01	.01
DIF												
Step 1												
CES-D	.36	.12	--	.39	.15	--	.36	.12	--	.41	.16	--
Age	.00		--	.03		--	.01		--	-.02		--
Step 2												
EF measure	-.05	.13	.00	-.14	.17	.02	-.06	.12	.00	.12	.16	.01
DDF												
Step 1												
Sex	-.17		--	-.18		--	-.15		--	-.20		--
CES-D	.22	.12	--	.25	.14	--	.24	.12	--	.26	.15	--
Age	-.16		--	-.11		--	-.04		--	-.13		--
Step 2												
EF measure	-.12	.13	.01	-.23	.19	.05*	.06	.12	.00	.13	.16	.01
EOT												
Step 1												
Sex	-.24		--	-.21		--	-.21		--	-.24		--
LM Delayed Recall	-.21	.14	--	-.23	.13	--	-.22	.14	--	-.22	.15	--
VR Delayed Recall	-.08		--	-.09		--	-.05		--	-.11		--

Age	.08		--	.07		--	.04		--	.10		--
Step 2												
EF measure	-.02	.14	.00	.01	.13	.00	-.13	.16	.01	-.05	.15	.00

Note. EF measure = For each outcome variable (TAS-20 total, DIF, DDF, and EOT), four separate models were run, each which included a single executive function measure (EF Composite, Verbal Fluency, Design Fluency, and Trails Condition 4).
TAS-20 = Toronto Alexithymia Scale-20 item; DIF = Difficulty Identifying Feelings; DDF = Difficulty Describing Feelings; EOT = Externally-Oriented Thinking; CES-D = Center of Epidemiological Studies – Depression Scale; LM Delayed Recall = Wechsler Memory Scale - Logical Memory Delayed Recall; VR Delayed Recall = Wechsler Memory Scale - Visual Reproduction Delayed Recall; EF Composite = executive function composite score.
$^{*}p < .05$.

Table 6

Hierarchical Regression Models Predicting Total Alexithymia, DIF, DDF, and EOT in Older Adults

	Executive Function Measure											
	EF Composite			Verbal Fluency			Design Fluency			Trails Condition 4		
	β	R^2	$R^2\Delta$	β	R^2	$R^2\Delta$	β	R^2	$R^2\Delta$	β	R^2	$R^2\Delta$
TAS-20 Total												
Step 1												
CES-D	.18		--	.19		--	.19		--	.25		--
Sex	-.32	.13	--	-.38	.22	--	-.31	.13	--	-.31	.22	--
Age	-.13		--	-.13		--	-.10		--	-.14		--
Step 2												
EF measure	-.26	.19	.06	-.34	.33	.11*	-.14	.15	.02	.20	.26	.04
DIF												
Step 1												
CES-D	.36	.14	--	.40	.22	--	.37	.14	--	.43	.22	--
Age	-.09		--	-.16		--	-.02		--	-.18		--
Step 2												
EF measure	-.09	.15	.01	-.20	.26	.04	.08	.14	.01	.22	.27	.04
DDF												
Step 1												
Age	-.26	.03	--	-.31	.06	--	-.20	.03	--	-.28	.06	--
Step 2												
EF measure	-.22	.07	.04	-.41	.23	.17*	-.06	.03	.00	.15	.08	.02
EOT												
Step 1												
Age	.09	.02	--	.14	.02	--	.06	.02	--	.12	.02	--
Step 2												
EF measure	-.14	.04	.02	-.03	.02	.00	-.18	.05	.03	.14	.04	.02

Note. EF measure = For each outcome variable (TAS-20 total, DIF, DDF, and EOT), four separate models were run, each which included a single executive function measure (EF Composite, Verbal Fluency, Design Fluency, and Trails Condition 4).
TAS-20 = Toronto Alexithymia Scale-20 item; DIF = Difficulty Identifying Feelings; DDF = Difficulty Describing Feelings; EOT = Externally-Oriented Thinking; CES-D = Center of Epidemiological Studies – Depression Scale; LM Delayed Recall = Wechsler Memory Scale - Logical Memory Delayed Recall; VR Delayed Recall = Wechsler Memory Scale - Visual Reproduction Delayed Recall; EF Composite = executive function composite score.
$^{*}p < .05$.

APPENDIX

TWENTY-ITEM TORONTO ALEXITHYMIA SCALE (TAS-20)

TAS-20 ID # _____ Date: _____

Instructions: Using the scale provided as a guide, indicate how much you agree or disagree with each of the following statements. Mark the appropriate rating next to the statement. Give only one answer for each statement.

	1= Strongly Disagree	2= Moderately Disagree	3= Neither Disagree or Agree	4= Moderately Agree	5=Strongly Agree
1. I am often confused about what emotion I am feeling.	1	2	3	4	5
2. It is difficult for me to find the right words for my feelings.	1	2	3	4	5
3. I have physical sensations that even doctors don't understand.	1	2	3	4	5
4. I am able to describe my feelings easily.	1	2	3	4	5
5. I prefer to analyze problems rather than just describe them.	1	2	3	4	5
6. When I am upset, I don't know if I am sad, frightened, or angry.	1	2	3	4	5
7. I am often puzzled by sensations in my body.	1	2	3	4	5
8. I prefer to just let things happen rather than to understand why they turned out that way.	1	2	3	4	5
9. I have feelings that I can't quite identify.	1	2	3	4	5
10. Being in touch with emotions is essential.	1	2	3	4	5
11. I find it hard to describe how I feel about people.	1	2	3	4	5
12. People tell me to describe my feelings more.	1	2	3	4	5
13. I don't know what's going on inside me.	1	2	3	4	5
14. I often don't know why I am angry.	1	2	3	4	5
15. I prefer talking to people about their daily activities rather than their feelings.	1	2	3	4	5

16. I prefer to watch “light” entertainment shows rather than psychological dramas. 1 2 3 4 5

17. It is difficult for me to reveal my innermost feelings, even to close friends. 1 2 3 4 5

18. I can feel close to someone, even in moments of silence. 1 2 3 4 5

19. I find examination of my feelings useful in solving personal problems. 1 2 3 4 5

20. Looking for hidden meanings in movies or plays distracts from their enjoyment. 1 2 3 4 5

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