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# Comparison of Text Analysis Programs for Identification of Emotional Expression

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LOMA LINDA UNIVERSITY
School of Behavioral Health
in conjunction with the
Faculty of Graduate Studies

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Comparison of Text Analysis Programs for Identification of
Emotional Expression

by

Michelle McDonnell

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A Thesis submitted in partial satisfaction of
the requirements for the degree
Doctor of Philosophy in Clinical Psychology

_____

December 2015

Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a thesis for the degree Doctor of Philosophy.

 

_____, Chairperson
Jason E. Owen, Associate Professor of Psychology

 

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Kendal C. Boyd, Associate Professor of Psychology

 

_____
David A. Vermeersch, Professor of Psychology

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To my family and friends, your love and support through this long endeavor. I may not be the easiest person to deal with when under stress and pressure, but I would never have been able to complete this task without all of your love and support.

CONTENT

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# ABBREVIATIONS

LIWC 2001     Linguistic Inquiry and Word Count 2001

LIWC 2007     Linguistic Inquiry and Word Count 2007

ABSTRACT OF THE THESIS

Comparison of Text Analysis Programs for Identification of
Emotional Expression

by

Michelle McDonnell

Doctor of Philosophy, Graduate Program in Clinical Psychology
Loma Linda University, December 2015
Dr. Jason Owen, Chairperson


Studies have show that written emotional expression assists in the recovery and

alleviates the pain associated with traumatic experiences, cancer diagnoses, and chronic

illnesses. Written interventions have been developed to utilize this emotional coping

approach. Unfortunately, evaluation of participants and patients written text is time

consuming and subjective to the coder. Researchers have developed computational text

analysis programs in an attempt to find an alternative to human coders for text analysis.

The current study will utilize data from previous research performed by Owen et al.,

(2005) entitled *Randomized Pilot of a Self-Guided Internet Coping Group for Women*

*With Early Stage Breast Cancer,* as well as from research performed by Bantum and

Owen, (2009) entitled *Evaluating the Validity of Computerized Content Analysis*

*Programs for Identification of Emotional Expression in Cancer Narratives*. This present

study will evaluate the previously collected data to examine the validity between the

previously validated Linguistic Inquiry and Word Count 2001 and the Linguistic Inquiry

and Word Count 2007, which has been edited based on the downfalls of the previous

model. Results indicate that LIWC 2001 and LIWC 2007 have a high validity in their

ability to identify emotional expression; however, LIWC 2001 is superior in its precision

of emotional identification. When comparing the results of LIWC 2001 and LIWC 2007 with human coders, LIWC 2001 most accurately reflects the human coders in emotional identification.

**CHAPTER ONE**

**INTRODUCTION**

Emotions have been found to play a key role in psychological adjustment to stress associated with living with a chronic disease such as cancer (Brissette, Scheirer, & Carver, 2002; De Ridder, Geenen, Kuijer, & van Middendor, 2008; Farber, Mirsalimi, Williams, & McDaniel, 2003; Soriano LeBovidge, Lavigne, Donenberge, & Miller, 2003; Stanton et al., 2000). Individuals who acknowledge and express their emotions, rather than suppress them, tend to have improved adjustment to stressful situations and chronic stressors, including but not limited to, decreased depressive symptoms (Austenfeld & Stanton, 2004; Cordova et al., 2003; Farber, Mirsalimi, Williams, & McDaniel, 2003), improved health status and quality of life (Stanton et al., 2000), as well as a decrease in healthcare utilization (Rosenberg et al, 2002; Stanton et al., 2000). Breast cancer patients who engage in higher levels of emotional approach coping report decreased levels of distress, increased vigor, and improved health status (Stanton et al., 2000), as well as fewer medical appointments and physical symptoms typically associated with their cancer treatment (Stanton et al, 2002). Breast cancer patients who express more positive emotions also tend to report higher levels of quality of life over time (Stanton et al., 2000). Additionally, there is evidence to suggest that emotion-focused coping related to a cancer diagnosis may predict cancer progression and outcome such that those patients who express various emotions ranging from distress to fighting spirit experience lower levels of cancer progression (Gross, 1989). While positive emotional expression has been found to promote psychological adjustment, inhibiting the expression of negative

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emotions can lead to higher levels of anxiety and depressive symptoms (De Ridder et al.,

2008).

# CHAPTER TWO

# BACKGROUND

## The Role of Emotions in Coping with Stressors such as Chronic Illness

Emotional approach coping is described as efforts to actively process and express emotions that arise due to an external or internal demands that exceed the individual's resources (Austenfeld & Stanton, 2004). Folkman and Greer (2010) have articulated a stress-appraisal model of coping that defines the role that emotional approach coping plays in adjustment to a chronic disease. According to this theory, individuals are consistently evaluating their relationship with their surroundings, assessing the potential threat presented by the change, and considering their current resources to address a potential threat. Appraisal occurs when the individual perceives a potential harm, threat, or challenge in their immediate environment and evaluate (or appraise) the personal resources they have to bring to bear to deal with this potential threat. The outcome of the appraisal influences the methods the individuals use to cope with the distress, which include problem-focused or emotion-focused coping. Appraising the level of control in the situation typically determines the coping strategy used. For example, under conditions of high perceived control, the individual may be more likely to utilize problem-focused coping strategies, whereas emotion-focused coping may be more common under conditions of low perceived control. Whether or not these immediate coping strategies are successful in abating the potential threat can further determine the level of distress and emotion subsequently experienced. An unfavorable resolution or no resolution increases negative emotions, and favorable resolutions typically produce positive emotion and/or reductions in negative emotions. Whether or not an individual continues with the

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coping style chosen is dependent on positive outcomes, the justification of their positive outcomes, and understanding of the failure in their methods of coping with the stressor. Meaning-based coping allows the individual to reassess their goals based on the situation and establish more reasonable goals for them to attempt to accomplish.

Gross and John (2003) proposed an influential model of emotional regulation, wherein the emotion actually begins with the evaluation of an emotional cue, which depending upon how the individual attends to those cues trigger a set of responses involving experiential, behavioral, and physiological systems. Once the response tendencies have begun to form they can be modified using antecendent- or response-focused strategies of emotional regulation.. Emotional regulation is described as the attempts an individual makes to influence the emotions they experience, when they are experienced, and how they are experienced (Gross, Richards, & John, 2006). John and Gross (2004) defined this reappraisal process, which is inherent to antecedent-focused strategies, as changing the way an individual thinks about the emotion-eliciting event, specifically, they are altering the way this item influences their emotions and ultimately the outward representation of those emotions. Some individuals, however, do not reappraise their situation but rather participate in active emotional suppression, inherent to response-focused strategies, to change the way they respond behaviorally and emotionally to the event, meaning they hide their behavioral response despite the fact they are currently experiencing those emotions (John & Gross, 2004). For those participants who consistently practiced reappraisal showed fewer symptoms of depression and they were more satisfied with their lives (Gross & John, 2003). The theoretical framework that has been provided by Gross and John, while beneficial to

understanding the effects of emotional expression and suppression, does have its limits. This theory has been tested and applied, for the most part, to young adults, which limits its generalizability to the older adult population, specifically those living with chronic health conditions. Those experiencing chronic health conditions, likely perceived as a threat or stressor, are likely to participate in specific coping strategies; therefore it is necessary to evaluate the strategies they are likely to utilize.

Emotion-based coping strategies have been evaluated across a wide variety of physical and mental health conditions. Elderly patients with suicidal thoughts who also suppress emotions are at greater risk to act on their ideations (Cukrowicz, Ekblad, Cheavens, Rosenthal, & Lynch, 2008). Quartana, Bounds, Yoon, Goodin and Burns (2010) found that pain levels were increased when a painful experimental stimulus followed a situation wherein the participant practiced anger suppression compared to those who were asked to freely express their anger. For individuals who experience stress due to a traumatic experience, emotional expression has been linked with improved health (Pennebaker, 1993; Smyth, 1998). Additionally, emotional expression in patients who have experienced trauma facilitates cognitive processes to conceptualize the trauma (Smyth, 1998). HIV/AIDS patients that participated in successful emotional coping showed decreased levels in EBV-VCA antibody titers one month after the study, suggesting that these patients experience a decreased risk for infection (Esterling et al., 1994).

The role of emotions in coping specifically with cancer has also received a great deal of attention in the literature (Cordova et al., 2003; Giese-Davis, Conrad, Nouriani, & Spiegel, 2008; Hoyt, Stanton, Irwin, & Thomas, 2013; Gross, 1989; Owen, Giese-Davis,

Cordova, Kronenweter, Golant, & Spiegel, 2006; Rosenberg et al., 2002; Stanton et al., 2000). In cancer patients and survivors, emotional expression has been linked with numerous benefits. Studies evaluating breast cancer have established similar results, revealing that women who participated in emotional expression following breast cancer treatment have decreased levels of distress (Owen, et al., 2006; Stanton et al., 2000), as well as improvements in quality of life, health status, and levels of energy (Stanton et al., 2000). Stanton et al., (2000) evaluated breast cancer patients' experience with cancer, their ability to generate plans to achieve goals, the receptivity of their social network towards their cancer experience, and also measured patients' quality of life, emotional approach coping, mood states, and health status at two time points. This study evaluated these constructs when patients completed their primary cancer treatment program and then again three months later. This study was unique in its ability to prospectively evaluate whether emotionally-expressive coping impacted psychological functioning across time. Stanton et al. (2000) found that those who participated in emotional expression following their primary cancer treatment reported improved quality of life and decreased levels of distress.  In a similar study conducted among men with prostate cancer, Rosenberg et al. (2002) asked patients to complete a four day writing task wherein they wrote specifically about their cancer experiences. Patients who used higher levels of emotional expression reported improvement in levels of physical symptoms and reduced use of medications across time (Rosenberg et al., 2002). Some studies have also suggested that higher levels of emotional expression maybe be linked with slower onset and progression of cancer (Gross, 1989).

Alternatively, some patients may cope with their diagnosis by engaging in active emotional suppression, wherein individuals consciously inhibit their own emotional expressive behavior when they experience an emotionally arousing event (Valentiner, Hood, & Hawkins, 2006). To explore the hypothesis that increased emotional suppression would be related to distress level experienced by cancer patients, Owen et al. (2006) asked 71 cancer patients to provide a written narrative of their cancer experience and to complete a questionnaire that evaluated their emotional suppression, mood disturbance, and emotional self-efficacy. Cancer narratives were evaluated for emotional expression using the Linguistic Inquiry Word Count (2001). Results indicated that individuals with higher levels of self-reported suppression also reported higher levels of mood disturbance. Furthermore, the relationship between suppression and mood disturbance was intensified in those participants who used more cognitive processing to describe their experiences with their cancer diagnosis. A number of other studies have reported that higher levels of emotional suppression are associated with more severe health related problems, such as increased side effects from cancer treatment (Giese-Davis et al, 2008; Hoyt et al., 2013; Owen et al., 2006). In men diagnosed with cancer, lower levels of emotional expression have been associated with increased negative affect, decreased self-efficacy, as well as more severe problems with sexual and bowel functions (Hoyt et al., 2013). Schlatter and Cameron (2010) evaluated the effects of emotional suppression on mood states, coping methods, and symptomatic side effects of breast cancer patients receiving Adriamycin/doxorubicin, cyclophosphamide/Cytoxan (AC) Chemotherapy. Participants were instructed to complete a questionnaire including the measures of symptoms, mood, and coping appraisals in addition to the self-report diary each day they

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received chemotherapy during their 84-day treatment. Results indicated that the tendency to participate in emotional suppression was predictive of more negative mood states, appraisals of poor coping, and symptomatic side effects experienced during chemotherapy treatments.  An additional study evaluating breast cancer explored the influence of emotional approach coping on blood pressure.  Women who engaged in greater emotional suppression exhibited higher diastolic blood pressure, which is a key factor in allostatic load and overall disease progression (Giese-Davis et al., 2008). In another study regarding cancer patients, lower levels of emotional suppression were associated with lower mood disturbance (Cordova et al., 2003).  Finally, in a study of breast cancer patients, greater emotional suppression was associated with more severe levels of anxiety and depression (Iwamitsu et al., 2005).  Taken together, these studies suggest that emotional suppression has been associated with detrimental health concerns, such as increased negative affect, poorer mental health (e.g., anxiety, depression), decreased physical health, and increased perceived side effects due to treatment.

Many studies have identified salutatory effects of emotional expression and adverse impacts of emotional suppression. However, it is worth noting that these associations are far from universal, and there are several populations where emotional expression has been found to be harmful and emotional suppression found to be helpful. For example, Leff et al., (1987) found that for schizophrenic individuals of Indian descent, the act of emotional expression actually increases the chances of schizophrenic relapse. Kennedy-Moore and Watson (2001) reported that emotional expression of distress resulted in worse long term outcomes for trauma victims. The quality of the emotional expression also determines its positive or negative outcomes. When measuring

burnout rates for employees, those that participated in negative emotional expression were more inclined to burnout faster than those who participated in positive emotional expression (Zellars & Perrewe, 2001). Additionally, for employees expressing contradictory emotions the longer the length of emotional expression, the increased frequency of expression, and the intensity of expression all result in a stress-related reaction (Morris & Felhman, 1996). Other studies have suggested that emotional suppression may play a positive role dependent upon the situation. When employees are expected to maintain a specific emotional expression, despite their internal emotional status, they are more likely to report emotional exhaustion and dissatisfaction when the emotions are in opposition (Grandey, 2003). Additionally, contradictory emotional expression was a significant predictor of depersonalization and the act of distancing from others (Brotheridge & Grandey, 2002). These results suggest that emotional suppression would be equally or even less taxing on the individuals compared to contradictory emotional expression. A longitudinal study established that participants who were flexible in alternating between emotional suppression and expression evidenced less distress two years after they experienced a trauma (Bonanno, Papa, Lalande, Westphal, & Coifman, 2004). Patients diagnosed with major depressive disorder who were instructed to actively suppress negative emotions were capable of doing so, implying that this method may be applied to the daily life of depressed individuals (Joorman, Hertel, & Gotlib, 2005). Applying this method of suppression to the lives of depressed patients may be able to prevent the automatic tendency to recall negative thoughts and feelings.

**Issues in the Measurement of Emotional Expression**

Emotional expression is a complex process, both for those expressing the emotions and those interpreting the emotion. Researchers have identified facial expression, body posture, voice, self-report, neurological imaging, and expressive writing as distinct methods for measuring emotional expression. Paul Ekman has identified six categories of universally identified expressions: happiness, sadness, anger, fear, surprise, and disgust (Ekman, 1970), and body posture, bodily actions, and voice are used to display these emotions (Ekman, 1993). The expression of emotion, whether completed through facial expression, body posture, bodily actions, or voice, communicates an individual's intention for specific social interactions and situations in which they engage (Oatley & Jenkins, 1992). Humans are exquisitely adapted to identify emotions expressed by others. The occipital and temporal lobes quickly identify emotion, while other structures such as the amygdala begin to process that emotion (Adolphs, 2002). Additionally, the amygdala is implicated in visual processing of emotional communication. When individuals are presented with an emotional image, the activity and the amount of communication between the amygdala and visual cortex increases (Vuilleumier, 2005). Blood and Zatorre (2001) identified psychophysiological activity, including increased heart rate, respiration depth, and dopaminergic activity in the nucleus accumbens and ventral tegmental area, which is linked with the experience of listening to emotional music. While Paul Ekman's theories regarding emotional expression are widely accepted, they are unable to explain or define emotions expressed through written text.

Emotions can also be expressed and identified using self-report methodologies or through fixed-response standardized data collection. Emotional self-report allows individuals to report their emotions while expressing their knowledge of the situation (Robinson & Clore, 2002a). This free response of emotional expression allows the individual to provide their expert knowledge regarding their own internal state. The types of self-report practiced also assists in the retrieval of either episodic or semantic emotions, specifically long time frame self-reports illicit semantic emotions, while short time frame self-reports illicit episodic emotions (Robinson & Clore, 2002b). The limitations apparent in self-reports lay in the lack of objectivity in the methodology. The process of quantifying self-report responses forces researchers to place the responses in predetermined emotional categories, which may not properly reflect the emotions that the individual was attempting to convey (Scherer, 2005). The alternative methods of measuring emotional expression are fixed-response standardized questionnaires (Scherer, 2005). These provide the individual with several response alternatives that best match the various types of emotional expression. Scherer (2005) identified some serious disadvantages that are relevant in standardized data collection, such that the responses may prime the participants to select an emotion they may have otherwise not selected. An additional problem includes the lack of emotional representation in the scale where a participant may desire to respond with an emotional category that is not presently provided for them. Researchers have attempted to avoid the limitations apparent in self-report and standardized data collection by allowing individuals to participate in free response measurement of emotional feeling (Scherer, 2005). This method allows the participants to respond with freely chosen labels. This provides researchers with the

potential to objectively measure the responses, while the participant is capable of expressing their emotional state. Unfortunately, this method also contains limitations when comparing controlled versus experimental groups (Scherer, 2005). With the number of limitations present in measuring emotional expression, there is a strong argument that could be made for identifying emotion through text analysis programs, which have established an objective way of measuring self-report measures.

Recent studies have provided evidence that emotions can also be effectively identified in written text (Baddeley, Daniel, & Pennebaker, 2011; Ludwig et al., 2013; Peden & Carroll, 2008; Stirman & Pennebaker, 2001). Written emotions have been identified as significantly different from characteristically nonemotional writing, such as academic tasks  (Peden & Carroll, 2008) and more importantly, they can be correctly identified by readers (Ludwig et al., 2013). Furthermore, studies have shown that intense emotional states, such as suicidal ideation, can be accurately identified in written text (Baddeley, Daniel, & Pennebaker, 2011; Stirman & Pennebaker, 2001). The writings of individuals who had successfully committed suicide actually predicted the progressive inclination to end their lives (Stirman & Pennebaker, 2001; Baddeley, Daniel, & Pennebaker, 2011). A majority of these writings were processed by the Linguistic Inquiry Word Count (LIWC), a computational text analysis program, which indicated that those who committed suicide had an increased presence of first person singular self-references and negative emotional expression as they approached their successful suicide attempts (Stirman & Pennebaker, 2001; Baddeley, Daniel, & Pennebaker, 2011). While these studies on suicidal ideations were evaluated using LIWC, the most common method for evaluating emotions in writing text is through human coders (Bhatia, Verma, & Murty,

2006; Chochinoc, Wilson, Enns, & Lander, 1998). While qualitative analysis provides the most complete method for characterizing text-based communications (Kidd, 2002) the cost, time consumption, and subjectivity of the human coders make these methods prohibitively difficult for many applications. Pennebaker and Fancis (1999) have enlisted human coders to evaluate the accuracy of text analysis program. When provided with extensive amounts of human coding, text analysis programs, such as LIWC, can be used to evaluate the consistency between the coding procedures.

**Written Emotional Expression and Psychological Adjustment to Illness**

Using textual analysis programs may offer insight into the mechanisms of action that allow writing-based interventions to be useful in the assistance of in a number of populations, including trauma victims (Hoyt & Yeater, 2011; Parker, Stewart, & Gantt, 2006; Sloan & Marx, 2004), as well as those with chronic illnesses, including cancer (Broderick, Junghaenel, & Schwartz, 2005; Lieberman & Goldstein, 2006; Zabowski, Herzer, Barrett, Milligan, & Beckam, 2011). One hypothesized mechanism of action for these types of writing-based interventions is emotional expression. Research using writing-based interventions that encourage patients to express their emotions have shown promising results for improving psychological and physical well-being (Broderick et al., 2005; Hoyt & Yeater, 2011; Parker et al., 2006; Sloan & Marx, 2004). Undergraduate students assigned to the expressive writing condition showed a reduction in psychological and physical symptoms up to two months after completion of the writing task (Sloan & Marx, 2004). Additionally, undergraduate students with high traits of negative emotion showed a significant decrease in distress and posttraumatic stress symptoms when they

completed the expressive writing task when compared to those with low negative emotion traits (Hoyt & Yeater, 2011). Fibromyalgia patients experienced improvements in psychological well-being, fatigue, and pain levels when they participated in expressive writing about a traumatic experience (Broderick et al., 2005). Finally, writing interventions have shown to reduce depression for children who witnessed domestic violence (Parker et al., 2006).

While many studies have established the potential benefits of expressive writing, a number of others have found no effects of expressive writing on psychological or health outcomes. Walker, Nail, and Croyle (1999) reported that breast cancer patients did not experience improved mood or a decrease in intrusive cancer thoughts after being asked to complete a single dose or three-dose emotional expression task. Similarly, Low et al. (2010) reported that breast cancer survivors with average social support did not experience a decrease in psychological distress or physical health symptoms after writing about cancer related emotions. In another study, breast cancer patients who wrote about negative emotions experienced higher levels of anxiety and depression than did those who expressed positive emotions (Smith, Anderson-Hanley, Langrock, & Compas, 2005). The type of emotion expressed may also play a role in adjustment. Lieberman and Goldstein (2006), in a study of breast cancer patients, reported that those who expressed higher levels of fear and anxiety also experienced worse quality of life, but those who expressed anger reported higher quality of life and lower depression. For patients diagnosed with metastatic renal cell carcinoma, there was no significant difference in between those who participated in non-emotion writings and emotional writings in regards to levels of distress or mood disturbance (De Moor et al., 2002).

When participants were instructed to write about and simultaneously analyze about defeats they experienced in their lives they experienced reduced personal growth, general health, and physical health (Lyubomirsky, Sousa, & Dickerhoof, 2006). Smyth (1998) conducted a meta-analysis including 13 studies on written emotional expression and determined that participants experienced greater distress during the writing task, likely due to activating the negative or traumatic memory. Fortunately, at least one month post-writing produced superior health outcomes in physical health, psychological well-being, physiological functioning, and general function. It is unfortunate that participants experience an increased level of distress during writing tasks, however it is anticipated that they will receive long-term gains that exceed the initial distress.

**Need for Tools to Measure Emotional Expression in Text**

These studies show that research has produced conflicting findings regarding the efficacy of expressive writing. However, with the rise of SMS-based communications and social-networking applications, text-based communications have become a dominant means of social interaction. Mirroring these societal changes, psychological interventions and therapies are increasingly using text as a medium for treatment. Additionally, for research and therapy that is conducted outside of the office, a typical modem of communication lies on the exchange of text, such as emails, text messages, and facebook. Due to the plethora of text data available for evaluation, there is a clear need for tools that can accurately extract psychologically meaningful data from the text. The creation of a text analysis program that can accurately and objectively evaluate psychological data from text may clarify the conflicts that currently plague the literature

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of written emotional expression in psychological adjustment to chronic illness. Valid

measurement may allow researchers to identify how the specific forms of expression (e.g.

negative emotions, fear, anxiety, and positive emotions), or how formations of questions

intended to encourage expression influence the outcomes of psychological adjustment.

The utilization of valid measurements also allow for proper identifications of the

emotions being expressed. This would prevent researchers from subjectively, and

potentially inaccurately, labeling the emotional expression presented. This has the

potential to erase the possibility for separate research groups to label the same emotional

expression (e.g., fear) as two different emotions (e.g., anxiety or distress). A valid

measure will hopefully eliminate some of the conflicting data in psychological

adjustment to chronic illness caused by simple terminology differences.

While researchers have been able to use written interventions to assist in patients'

recoveries, the evaluation of written text is a time consuming and subjective process

(Pennebaker & Fancis, 1999). Computational text analysis programs may be able to

provide a more objective method to code the content found in written text, specifically

quantifying the amount of emotional expression (or other psychologically-relevant

constructs) in the text (Pennebaker & Francis, 1999). The goal of computational text

analyses programs is to establish a coding system that is efficient and accurate for

identifying emotions (and other psychologically-relevant constructs) expressed in text.

Computer programs have been found to do a reasonably good job in identifying emotions

in written text. However, because human coding has been regarded as the gold standard,

establishing the validity of a text analysis program requires that it be compared to that

standard. Bantum and Owen (2009) evaluated the validity of LIWC 2001 and established

that it had good sensitivity and specificity for identifying emotion. LIWC 2001 was evaluated for sensitivity, described as the proportion of total emotions words identified by raters as being characteristic of emotional expression that were correctly detected by the program. LIWC 2001 was also identified as having good specificity, which measured the proportion of non-emotional words accurately identified by LIWC as not having emotionally expressive content. Additionally, the positive and negative predictive values of LIWC 2001 were evaluated. The positive predictive value, the probability that a word identified by LIWC 2001 as being characteristic of emotional expression was previously established as emotional expression by the raters, was low. A low positive predictive value means that a large portion of words identified by LIWC 2001 as being indicative of emotional expression were not considered by human raters to be an occurrence of emotional expression. In other words, the program had a large proportion of false positive identification in regards to emotional expression. The negative predictive value, meaning the probability that a word not identified as emotion by the program was in agreement with the raters decision that the word was not associated with emotional expression, ranked very highly for LIWC 2001. These results indicate that LIWC 2001 has a high accuracy for identifying true negatives in regards to emotional expression, Despite the significant ratings in sensitivity, specificity, positive predictive values, and negative predictive values, LIWC 2001 has some limitations in regards to emotional identification. When evaluating the sensitivity in LIWC 2001 it was able to identify emotional expression. However, it did not perform well when identifying the subcategories of positive feelings, anger, and sadness, meaning that it had difficulty correctly placing a negatively or positively identified emotion word into its proper specified category.

Comparisons between LIWC 2001 and human coders indicated high correlations for overall emotion categories and all subcategories except the category of optimism ($r = .07$; $p > .05$). While analyzing the specifics of LIWC 2001, Bantum and Owen (2009) also evaluated the emotional identification in the Psychiatric Content Analysis and Diagnosis (PCAD), which analyzes text taking the context of the message into consideration. Results indicated that LIWC 2001 was a significantly better at emotional identification in all emotional categories compared to PCAD. Taking into consideration the limitations present in LIWC 2001, it is presently the most superior method for text analysis when compared to its competitors.

LIWC2007 was developed specifically to address a number of key limitations in LIWC2001, such as a limited dictionary, uncommonly used word categories, and a lack of function words (e.g., conjunctions, adverbs, quantifiers, auxiliary verbs, and impersonal pronouns). The creators of LIWC 2007, removed the following word categories found in LIWC 2001 because they suffered from poor base rates: optimism, positive feelings, communication verbs, metaphysical, sleeping, grooming, and school. The new dictionary for LIWC 2007 was altered to provide more accurate word categories by omitting those categories with insufficient validity and adding a number of categories to represent function words, as well as including previously experimental categories into the program (e.g., swear words, nonfluencies, and fillers). Additionally, researchers increased the dictionary count from 2,300 words and word stems to 4,500 words and word stems so that it may better represent emotional expression and other key psychological constructs. In addition, the dimensions of LIWC 2007 were slightly altered, now comprising linguistic processes, psychological processes, personal concerns,

and spoken categories. Specifically in regards to emotion words, there was an increase in the size of the dictionary, as well as the removal of the categories of Optimism and Positive Feelings. These two categories were removed from LIWC 2007 due to the consistent lack of utilization in testing samples. The decisions made by the authors to remove the categories of positive feelings and optimism was supported by independent research conducted by Bantum and Owen (2009). It was found that LIWC 2001 had low sensitivity when it attempted to identify positive feelings. In regards to optimism, it was found that there was no correlation between LIWC 2001 and rater codes, meaning the two were not identifying the same words as containing optimism. A lack of sensitivity for positive feelings and a low correlation for optimism indicated that LIWC 2001 was not accurately measuring these categories in regards to emotional expression and a removal of these categories was a proper decision.

The functioning of LIWC 2007 is the same as LIWC 2001 in that the program identifies individual words as being representative (or not) of specific psychological categories, including emotions. LIWC 2007 uses the same methodology as LIWC2001, but the dictionary has been modified to address some of the limitations noted above. The authors believed they had made significant changes to the categories and dictionary in LIWC 2001 that there would be an increase in the validity and reliability found in LIWC 2007. Pennebaker et al., (2007) determined that this computational text analysis program had significant levels of validity and reliability by instructing four judges to identify key psychological constructs, including emotional expression and other categories corresponding to the LIWC dictionary, in the writings of college freshman. To establish the reliability of LIWC a binary method was used to convert the usage of each individual

word within the text data into either a 0 (not used) or a 1 (used one or more time). The discrepancy found when conducting a binary method is that it has the potential to overestimate the reliability based on the length of the text. Conversely, it has the potential to underestimate the reliability based on the length variability of the base rates of word usage within a given category. In order to establish validity for LIWC a Pearson correlational analysis was conducted on the judges' results and the LIWC output to identify the level of agreement. It was established that there were adequate correlations between the judges and LIWC 2007 in positive emotions ($r = .41$), negative emotions ($r = .31$), Anxiety ($r = .38$), and anger ($r = .22$). It must be noted that the rater correlation for sadness was very low ($r = .07$). While the results indicated that LIWC 2007 has some evidence for external validity, alternate methods for testing validity, such as participant self-reports of emotional levels or analysis of specificity and sensitivity, may have provided different results compared to the correlational analysis between judges ratings and emotional categories. The lack of participant feedback regarding emotional expression requires the researchers to extrapolate on the intended emotion. More stringent validity measures can look to compare the relationship between the program, the judges, and the self-report measures of the participants. Alternatively, measures of validity can be improved by conducting more a more intensive analysis on the specificity and sensitivity of the test. This analyzes the specific implications behind the relationship established in a correlation analysis. A review of sensitivity and specificity allow researchers to identify the ways the program may inaccurately identify emotional words, fail to identify emotional words, or fail to properly categorized identified emotional

words. Beyond the validity research performed by Pennebaker et al., (2007), no further research has been conducted to establish the validity of the LIWC 2007.

A similar method of establishing validity was used for the development of LIWC 2001 (Pennebaker et al., 2001). During the formation of LIWC 2001, judges evaluated the passages provided by subjects and rated the essays on the emotional, cognitive, content, and composition dimensions according to the LIWC dictionary scales. The results of the judge's ratings and LIWC output were analyzed using a Pearson correlation and indicated that LIWC had good external validity. Very little work regarding the psychometric properties had been conducted outside of the research completed by the creators of LIWC 2001. Bantum and Owen (2009) was one of they very few studies to evaluate the psychometric properties of LIWC 2001. Rather than simply conducting a correlation between a small number of judges and LIWC 2001, Bantum and Owen evaluated the sensitivity, specificity, positive predictive value, and negative predictive value resulting from a LIWC 2001 analysis. This in depth psychometric evaluation revealed the weaknesses in the simplicity of the Pennebaker et al., validation process. The results of this study established that a number of emotional categories that were successfully validated through a Pearson correlation were not applicable when a more comprehensive validation methodology was conducted. Just as in LIWC 2001, the evaluation of the validity for LIWC 2007 was based on the results of a Pearson correlation. Similarly, no outside research group has explored the validity of LIWC 2007. Independent replication of the research must be conducted to empirically support data in all forms of research (Chambless & Hollond, 1998; Weisz & Hawley, 1998). The validation of LIWC 2007 has yet to be empirically supported by independent research

labs, therefore the validity cannot be fully embraced by other researchers as a highly valid scale. Considering the weaknesses that were revealed to exist in the previous Pennebaker validation, research must be conducted to establish if the changes made to LIWC 2007 significantly improves the text analysis program.

**Aims and Hypotheses**

Pennebaker, Chung, Ireland, Gonzalez, and Booth (2007) reevaluated the program and began to make alterations to create a better performing program, resulting in LIWC 2007. The purpose of this present study was to replicate the results of Bantum and Owen (2009) using the LIWC 2007 update and characterize potential improvements in the accuracy of detecting emotional expression in written text by comparing LIWC2001 with LIWC2007. Just as with LIWC 2001, there has been very little additional research conducted to establish the validity of LIWC 2007.

The first aim of this study was to evaluate the correlation between LIWC 2001 and LIWC 2007 results for emotion categories. Conducting this analysis will reveal the degree of association between these two programs.

The second aim of this study will be to evaluate the sensitivity, specificity, positive predictive value, and negative predictive value for LIWC 2007 to evaluate its accuracy in emotional identification.

The third aim was to compare these validity tests with those observed in previous research evaluating LIWC 2001 validity conducted by Bantum and Owen, 2009. It is hypothesized that LIWC 2007 is an improvement in emotional identification compared to LIWC 2001.

# CHAPTER THREE

# MATERIALS AND METHOD

## Participants

The participants in the initial study were recruited from a hematology/oncology outpatient clinic at a large medical center in the southeastern United States. This original study included 49 women with Stage 1 or Stage 2 breast cancer. Participants were not excluded from participating based on the time elapsed since their diagnosis or medical treatment. The women participated in a randomized 12-week clinical trial of an Internet based support group. Additional information regarding the sample has been previously reported (Owen et al., 2005). An additional 14 participants, women with Stage 3 or Stage 4 breast cancer, were collected and included in these analyses (Bantum & Owen, 2009). The additional set of women were included using a non-randomized pilot of an online intervention. The textual data for 63 participants was analyzed for this particular study. The participants had a mean age of 49.8 years old (SD = 11.0), the majority was college educated ($M$ = 15.4 years; SD = 2.4), and they were largely of Caucasian descent (93%).

## Procedures

The initial portion of the study included the 49 women diagnosed with Stage 1 and Stage 2 breast cancer. Of the original 49 women, some were given immediate access to the online support group ($n$ = 30) and those placed on a wait list ($n$ = 19). Over time those placed on the waitlist were gradually given access to the online support group. There were an additional 13 women diagnosed with Stage 3 and Stage 4 breast cancer who were enrolled in a nonrandomized intervention at a later time. All participants

completed a baseline assessment once they agreed to participate in the study, prior to being given access to the online support group. Once the participants were given access to the online support group they were encouraged to communicate with one another through a discussion board regarding general topics and a series of interactive coping-skills training. The textual data was stored in individual data file for each participant. Further information regarding the experimental procedures for these participants has been previously reported (Owen et al., 2005; Bantum & Owen, 2009). This current study utilized the data previously evaluated for the validation of LIWC 2001 to control for confounding variables that may be present when using an entirely new data set.

### *Rater Coding of Emotional Expression*

This particular study will utilize human-coded ratings of emotion generated in a previous analysis of these linguistic data (Bantum and Owen, 2009). To briefly describe how these codes were generated, Bantum and Owen, (2009) had a well defined set of rater coding rules for the human coders to follow. The first step required that the blinded coders identify the word as containing emotional expression. If the coders had classified that emotional expression was present in the word, then the word was placed into the best fitting category. The coding rules contained eight potential categories: "positive feelings," "optimism," "anxiety," "anger," "sadness," "other positive emotion," "other negative emotion," or "not emotion." Raters read each text folder and classified each word specifically identified by the LIWC 2001 dictionary in addition to screening for any other emotional expression words that PERL had failed to identify. It must be noted that the specific categorization of emotional words by the LIWC 2001 dictionary was not

made known to the human coders to prevent the results from influencing their responses. Any discrepancies found between coders were discussed among the researchers, in so far as explaining the reasoning behind the coding selection of each coder and reaching a general consensus. The interrater reliability between the two trained coders was very good ($\kappa = .80$). Two additional raters were trained on the coding process and then reviewed 33% of the text. The interrater reliability was evaluated between the two additional raters and was established to have substantial reliability ($\kappa = .69$).

## Measures

### *Linguistic Inquiry and Word Count 2001*

All of the text for each participant on this website was analyzed ($n = 63$). LIWC 2001 is a computational text analysis method that examines each written item on a word-by-word basis. LIWC compares each word in the text data sample to a dictionary of emotion words (Overall affect, positive emotion, and negative emotion) to determine whether the specific word from the data set matches any of the words or word fragments found in the LIWC library. If a word has been established to contain emotional expression, the program iterates a count of all emotion words identified in that particular emotion dictionary (e.g., positive emotion). This methodology creates a word count based on the number of words provided in the text sample that corresponded to the words contained in the LIWC emotion dictionaries for overall emotion, positive emotion, and negative emotion. LIWC uses the results of the word count to establish a percentage of total words in the text to contain emotion words or a specific type of emotion.  LIWC has been successfully translated into six languages, including Spanish, German, and Dutch.

Pennebaker et al., (2001) developed this measure by having judges evaluate roughly 2,000 words and selecting their coding categories. LIWC 2001 evaluates each word and when it identifies a word as being emotional it then designates the word as positive or negative. After the word has been identified as positive or negative it is then placed into a specific category such as, positive feelings or optimism in the positive category, and sadness, anger, or anxiety in the negative category. In some instances, words are identified as emotional, categorized as positive or negative, but further categorization does not take place. Additional circumstances actually places individual words into multiple subcategories.

*Linguistic Inquiry and Word Count 2007*

Each participant's text information will also be analyzed using LIWC 2007 (*n* = 63; Pennebaker, et al., 2007). LIWC 2007 has a similar structure to that of LIWC 2001 in that it is a computational text analysis program that evaluates each item on a word-by-word basis. Furthermore, LIWC 2007 also provides a percentage of total words that are represented by emotion. LIWC 2007 has not been translated into Spanish and German.

**Data Preparation**

Each time the individuals participated in the online support group their textual data was saved in their specific file. The files were then combined into one excel folder per participant so that each word was considered a subject. Additionally, the text files from the human rater coding of emotional expression was created to include only the words identified as emotional by the coders and LIWC 2001. The final outcome of this

document was all emotional words with the categorical ratings of each individual human coder, their agreed upon outcome, and the LIWC 2001 rating. For this particular study the complete textual data file was merged with the emotional data file for each participant. The merged documents were evaluated in its entirety to ensure there was not an error in the merged document. Finally, each instance of emotion was counted as one point, and frequency of a given emotion was divided by total words for that participant, resulting in a percentage of a given emotion for each participant. This was true for LIWC 2001 and LIWC 2007.

<div align="center">

**Data Analytic Plan**

</div>

This study contains a total of 165,754 words consisting of 278 single spaced, 12-point font pages. Each word is considered a single variable. An analysis of power was conducted using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) and indicated that with an effect size of 0.5, alpha level of .01, and the sample size of 165,754 that this current level of power is 1.00. This well exceeds the criteria for obtain power of 0.80 at an alpha level of .05. To evaluate the validity of LIWC 2007 in comparison with LIWC 2001, the Perl program will process all textual information. The Perl Program was developed to replicate the LIWC scoring procedure, which compares each individual word in a give text sample to each of the separate emotion libraries. The key difference between the Perl program and the LIWC programs is that rather than providing a total percentage of emotion words contained in the textual data, Perl provides a word count. The deciding factor in this decision was based upon the potential for a percentage of total words to underestimate emotional expression. Conducting a word count rather than a

percentage will remove the potential confounding factors associated with the length of the textual data provided. The first aim of this study was to evaluate the correlational values between LIWC 2001 and LIWC 2007 in regards to emotional identification. The second aim of this study was to assess the accuracy of LIWC 2007 for detection of emotional expression using tests of specificity, sensitivity, positive predictive value, and negative predictive value. The third aim was to evaluate the differences between LIWC 2001 and LIWC 2007 for emotional identification. It is predicted that LIWC 2007 will have significantly improved in levels of sensitivity and positive predictive value and remain the same in levels of specificity and negative predictive value in regards to identification of emotional expression compared to its predecessor.

# CHAPTER FOUR

## RESULT

There were three primary aims of the study. The first was to evaluate the overlap between LIWC 2001 and LIWC 2007 in regards to emotional identification. The second aim was to evaluate the accuracy of LIWC 2007 for the detection of emotional expression. The third aim was to evaluate whether LIWC 2007 exhibits better identification of emotion compared to LIWC 2001. To accomplish these aims, we evaluated previously analyzed and human coded text data collected from a research website. The entire transcript available for analysis consisted of 165,754 words (278 pages of single-space text, 12-point font). Further information regarding the experimental procedures for these participants has been previously reported (Owen et al., 2005; Bantum & Owen, 2009). On average LIWC 2001 identified 1.6% (SD = .125) of total words as negative emotion and 3.2% (SD = .175) of total words as positive emotion. Alternatively, LIWC 2007 identified 1.9% (SD = .137) of total words as negative emotions and 4.1% (SD = .198) of total words as positive emotion. For the more specific categories of negative emotion the average LIWC 2001 codes were as follows: anxiety = 0.5%, anger = 0.2%, and sadness = 0.3%. Specific categories of negative emotion, as coded by LIWC 2007, were as follows: anxiety = 0.6%, anger = 0.2%, sadness = 0.4%. Comparatively, human raters identified 0.9% (SD = .094) of total words as negative emotion and 0.9% (SD = .096) of total words as positive emotions. Specifically in regards to negative emotion the average human codes were as follows: anxiety = 0.3%, anger = 0.1%, and sadness = 0.2%.

## Relationship between LIWC 2001 and LIWC 2007 Coding Methods

To assess the relationship between coding methods, we calculated Pearson product-correlations to compare LIWC 2001 codes with LIWC 2007 codes (see Table 1). Across each emotion category, LIWC 2001 and LIWC 2007 were significantly positively correlated (all $p$'s < .001). The strongest correlations were found for sadness ($r = .931$, $p < .001$) and negative emotion ($r = .906$, $p < .001$). These results indicate that the coding methods between LIWC 2001 and LIWC 2007 are highly related.

**Table 1.** LIWC 2001 and LIWC 2007 Correlation Values Between Emotional Categories.

|  | 2007 Emotional Expression | 2007 Positive Emotion | 2007 Negative Emotion | 2007 Anxiety | 2007 Anger | 2007 Sadness |
|---|---|---|---|---|---|---|
| 2001 Emotional Expression | .863** | .685* | .511** | .314** | .189** | .262** |
| 2001 Positive Emotion | .695** | .855** | -.025** | -.014** | -.008** | -.011** |
| 2001 Negative Emotion | .500** | -.025** | .906** | .556** | .334** | .463** |
| 2001 Anxiety | .265** | -.014** | .482** | .847** | -.003 | .023** |
| 2001 Anger | .182** | -.010** | .331** | .043** | .858** | -.003 |
| 2001 Sadness | .230** | -.012** | .419** | .020** | -.003 | .931** |

** $p < .001$

To assess the differences between LIWC 2001 and LIWC 2007 in regards to accuracy of emotional identification, we calculated tests of proportions. We calculated the sensitivity, specificity, positive predictive value, and negative predictive value to identify the proportion of words that were similarly identified by human coders for both LIWC 2001 and LIWC 2007. Subsequently, we utilized the overall proportions for each emotional category and conducted the test of proportions using the total number of emotion words identified by human coders for each emotional category as the reference group. To control for the issues of power, we calculated a Bonferroni correction for the p-

value to provide a more stringent criteria for meeting sensitivity.

*Sensitivity*

Sensitivity captured the proportion of total emotion words identified by human raters as being representative of emotional expression that were also captured by either LIWC 2001 or LIWC 2007. Sensitivity for overall emotional expression was good for both LIWC 2001 (.858) and LIWC 2007 (.896). LIWC 2001 sensitivity was good for positive emotion (.873), negative emotion (.822), and anxiety (.862), however it did not perform as well in the subcategories of anger (.663) and sadness (.699). LIWC 2007 sensitivity produced similar results in that it was good for positive emotion (.913), negative emotion (.814), and anxiety (.892), however it did not perform as well in anger (.679) and sadness (.718). Sensitivity was significantly higher for LIWC 2007 in the categories of overall emotional expression and positive emotions (see Table 2). There were no differences between LIWC 2001 and LIWC 2007 for negative emotions, anxiety, anger, or sadness.

*Specificity*

Specificity measured the proportion of nonemotional words that were accurately coded by LIWC 2001 or LIWC 2007 as not being indicative of emotion. Specificity for LIWC 2001 and LIWC 2007 was exceptional in all emotion categories. There were no differences for overall emotional expression, positive emotions, negative emotions, anxiety, anger, or sadness between LIWC 2001 and LIWC 2007 (see Table 2).

**Table 2**. LIWC 2001 and LIWC 2007 Sensitivity and Specificity With 95% Confidence Intervals (CI; N = 63).

| Type of Emotion | 2001 Sensitivity (95% CI) | 2007 Sensitivity (95% CI) | P-value | 2001 Specificity (95% CI) | 2007 Specificity (95% CI) | P-value |
|---|---|---|---|---|---|---|
| Emotional Expression | .858 (.845-.871) | .896 (.884-.906) | <.0001* | .967 (.966-.968) | .955 (.954-.956) | .016 |
| Total positive emotion | .873 (.855-.889) | .913 (.898-.927) | .0003* | .976 (.975-.977) | .967 (.966-.968) | .134 |
| Total negative emotion | .822 (.803-.839) | .814 (.793-.834) | .575 | .990 (.990-.991) | .987 (.987-.988) | .446 |
| Anxiety | .862 (.829-.888) | .892 (.863-.916) | .128 | .998 (.998-.999) | .997 (.996-.997) | .739 |
| Anger | .663 (.591-.729) | .679 (.607-.744) | .740 | .998 (.998-.999) | .998 (.998-.999) | 1.00 |
| Sadness | .699 (.645-.748) | .718 (.664-.766) | .598 | .997 (.997-.998) | .997 (.997-.997) | 1.00 |

*p value corrected after Bonferroni's $p < .0021$ ($p = $ alpha/N)

### *Positive Predictive Value*

Positive predictive value measured the probability that a word identified by LIWC 2001 and LIWC 2007 as being representative of emotional expression was in agreement with human rater coding of emotional expression. For LIWC 2001, only 32% of words that were classified as any type of emotion were in agreement with human raters (i.e., 68% of words identified by LIWC 2001 as indicators of emotional expression were not thought by human raters to be indicative of emotional expression). LIWC 2001 had positive predictive value for all emotional categories than LIWC 2007, and was significantly higher for overall emotion (32%), positive emotion (25%), overall negative emotion (49%), anxiety (64%), anger (36%), and sadness (39%). For LIWC 2007, only 27% of words that were classified as any type of emotion were in agreement with human coders (i.e., 73% of words identified by LIWC 2007 as indicators of emotional

expression were not thought by human raters to be indicative of emotional expression). Precision performance for LIWC 2007 is listed as follows: positive emotions (21%), overall negative emotions (37%), anxiety (47%), anger (32%), and sadness (35%). LIWC 2001 had the following positive predictive values: total emotion (.326), positive emotion (.256), negative emotion (.498), anxiety (.640), anger (.357) and sadness (.699). LIWC 2007 produced the following positive predictive values: total emotion (.268), positive emotion (.207), negative emotion (.377), anxiety (.477), anger (.317), and sadness (.351). LIWC 2001's positive predictive value was significantly better than LIWC 2007 in total emotion, positive emotion, negative emotion, and anxiety (see Table 3).

### *Negative Predictive Value*

Negative predictive values measured the probability that a word not identified as emotion by LIWC 2001 and LIWC 2007 agreed with raters' judgment that the word was not associated with emotional expression. Both LIWC 2001 and LIWC 2007 have excellent negative predictive value across all emotion categories. Negative predictive values for LIWC 2001 and LIWC 2007 ranged from .997 for total emotional expression to .999 for anxiety, anger, and sadness. There was no significant difference between LIWC 2001 and LIWC 2007 in regards to negative predictive value (see Table 3).

**Table 3.** LIWC 2001 and LIWC 2007 Positive and Negative Predictive Value With 95% Confidence Intervals and Tests of Proportion p-values (CI; N = 63).

| Type of Emotion | 2001 PPV (95% CI) | 2007 PPV (95% CI) | P-value | 2001 NPV (95% CI) | 2007 NPV (95% CI) | P-value |
|---|---|---|---|---|---|---|
| Emotional Expression | .326 (.315-.336) | .268 (.259-.277) | <.0001* | .997 (.997-.997) | .997 (.997-.998) | 1.00 |
| Total positive emotion | .256 (.244-.268) | .207 (.197-.217) | .001* | .998 (.998-.998) | .999 (.999-.999) | .475 |
| Total negative emotion | .498 (.479-.516) | .377 (.361-.395) | <.0001* | .998 (.998-.998) | .998 (.998-.998) | 1.00 |
| Anxiety | .640 (.605-.675) | .477 (.446-.508) | <.0001* | .999 (.999-.999) | .999 (.999-.999) | 1.00 |
| Anger | .357 (.307-.409) | .317 (.273-.366) | .410 | .999 (.999-.999) | .999 (.999-.999) | 1.00 |
| Sadness | .389 (.349-.431) | .351 (.315-.389) | .320 | .999 (.999-.999) | .999 (.999-.999) | 1.00 |

*p value corrected after Bonferroni's $p < .0021$ ($p$ = alpha/N)

### *F-Score*

The F-score statistic measured the accuracy of LIWC 2001 and LIWC 2007 by considering both the precision and recall of each program. To control for the issues of power, we calculated a Bonferroni correction for the p-value to provide a more stringent criteria for meeting sensitivity. The results of the f-score were compared using a test of difference and revealed that LIWC 2001 was significantly superior in its evaluation of total emotional expression, positive emotion, and anxiety in comparison to LIWC 2007.

**Table 4.** LIWC 2001 and LIWC 2007 F-Score Values.

|  |  | Total Affect | Positive Emotion | Negative Emotion | Anxiety | Anger | Sadness |
|---|---|---|---|---|---|---|---|
| LIWC 2001 | Precision | .326 | .256 | .437 | .640 | .357 | .389 |
|  | Recall | .858 | .873 | .784 | .862 | .663 | .699 |
|  | F-Score | .472 | .396 | .561 | .735 | .464 | .499 |
| LIWC 2007 | Precision | .268 | .207 | .378 | .477 | .317 | .351 |
|  | Recall | .896 | .913 | .814 | .892 | .679 | .718 |
|  | F-Score | .413 | .337 | .516 | .622 | .433 | .472 |
| Difference P-Value |  | <.0001* | .0007* | .014 | <.0001* | .542 | .497 |

*p value corrected after Bonferroni's $p < .0083$ ($p =$ alpha/N)

# CHAPTER FIVE

## DISCUSSION

Our hypothesis that LIWC 2007 would be more sensitive to emotional expression than LIWC 2001 was not supported. LIWC 2007 was able to increase the previously established strength of LIWC 2001 in the identification of overall emotional expression and positive emotions. However, LIWC 2007 exacerbates the existing weakness of LIWC 2001 in that many of the words it identifies as emotion are not labeled as emotional by human raters. In regards to identification of nonemotional words, there was no improvement by LIWC 2007. Both LIWC 2001 and LIWC 2007 were excellent with respect to identification of nonemotional words. In other words, this research indicates that while LIWC 2007 had higher levels of emotional identification, more words were also inaccurately classified as emotion. Therefore, while both LIWC 2001 and LIWC 2007 measure a number of domains other than emotional expression, our findings suggest that both LIWC 2001 and LIWC 2007 have excellent sensitivity for detecting emotional expression, but LIWC 2001 is superior with respect to positive predictive value- the words it identifies as representing emotion are more likely than LIWC 2007 to be in agreement with human raters.

Pennebaker et al. (2007) made a number of alterations to LIWC 2007 based on the previously established weaknesses of LIWC 2001. For instance, they increased the dictionary size and removed the subcategories of optimism and positive feelings. Despite these changes, LIWC 2001 remains superior with respect to positive predictive value. The alterations to LIWC 2007 resulted in improvements in sensitivity. However, these changes did not improve LIWC 2001's previously established flaws. It seems likely that

the improvement in overall emotional identification as well as the increase in false positive error that occurs in LIWC 2007 is due to the alterations that have occurred to the LIWC 2007 dictionary. There were a number of words defined as emotional in the LIWC 2007 dictionary that were previously categorized as non-emotional (e.g., confident, champ, resolve). In addition to a reclassification of preexisting words, LIWC 2007 added additional emotional words that were not originally included in the LIWC 2001 dictionary (e.g., grace, jaded, joke, openness, rancid) and removed emotional words that were in the LIWC 2001 dictionary (e.g., sensitive). Finally, the LIWC 2007 dictionary classified the roots of words as emotional (e.g., stammer) that may be perceived as nonemotional by human coders in an extended form (e.g., stammered, stammering). The alterations to the LIWC 2007 dictionary may have resulted in the increased emotional identification but decrease in the precision of the identification.

The sensitivity levels for both LIWC 2001 and LIWC 2007 indicate strength in regards to identification of emotional content, such that both were highly sensitive to the identification of emotional expression. However, the positive predictive value was fairly poor for both LIWC 2001 and LIWC 2007. LIWC 2001 produced a significantly superior performance in regards to positive predictive value than LIWC 2007. Evaluation of the F-score, which evaluates both the positive predictive value and sensitivity, revealed that LIWC 2001 was superior to LIWC 2007 in emotional identification of overall affect, positive emotions, and anxiety. The remaining categories were not significantly different, indicating that LIWC 2001 and LIWC 2007 performed similarly in their identification of those emotion categories (e.g., negative emotion, anger, sadness). These results indicate that LIWC 2001 is more inclined to accurately identify emotion in accordance to human

rater when compared to LIWC 2007. Considering human coders are the gold standard in emotional identification, and LIWC 2001 provides results most similar to that of human coders, LIWC 2001 is superior to LIWC 2007.

LIWC 2001 may present as superior in its emotional identification over LIWC 2007, yet the accuracy in its performance is highly dependent upon the population being evaluated. Positive predictive value is dependent upon the prevalence in the population, meaning it can vary based on the sample utilized while sensitivity may stay the same despite what population is being evaluated (Altman & Bland, 1994). More specifically, cancer patients have been found to express more emotion than the health population (Linden, Vodermaier, Mackenzie, & Greig, 2012), meaning the prevalence of expressed emotion is higher for the sample utilized in this study than that of the general population. Considering prevalence rates or emotional expression in the cancer population, LIWC 2001 and LIWC 2007 are likely to produce poorer positive predictive values if being utilized with the emotional expression of a nonclinical population. LIWC 2001 and LIWC 2007 currently have a high rate of false positives, which may increase when evaluating a less emotional population or decrease when evaluating a more emotionally expressive population. Ultimately, the LIWC programs would benefit from further validation utilizing alternative populations with varying levels of emotional expression.

Pennebaker and his associates may have produced improvements in emotional identification in textual data had they utilized a more definitive validation process than simple correlation analyses. A correlation analysis describes the strengths of a relationship between variables but does not provide information regarding what components influence that relationship. Conducting analyses such as a test of proportions

allows users to see the weaknesses and strengths of that the relationship and what factors contribute to the strengths of that relationship. It may have been more beneficial for them to review text data obtained from their sample population along the LIWC results to ensure that the classification identified what emotions they intended to express with their written emotional expression. Emotions are multifaceted, making them much more difficult to accurately identify when simplified down to one modality. Based on the limitations involved in evaluating a single modality of emotion, obtaining a peer review on their validation procedures would have bolstered their utilization of their validation process.

It must be noted that there are some limitations to this study. The narratives utilized in this study were obtained from women diagnosed with breast cancer. Research has indicated that women cancer patients express more emotion than male counterparts (Linden, Vodermaier, Mackenzie, & Greig, 2012). Additionally, cancer patients are more inclined to endorse affective disorders, such as anxiety, which may impact their emotional expression (Mitchell, Ferguson, Gill, Paul, & Symonds, 2013). Additionally, based on the specific circumstances these women faced (e.g., cancer diagnosis, treatment, and outcomes) this may have limited the range of emotions that may have been discussed compared to a healthy population. Based on the population utilized, results may be limited to cancer survivors rather than the general population. Finally, there were very few emotions evaluated (e.g., overall affect, positive emotions, negative emotions, anger, anxiety, and sadness), which does not reflect the full range of emotions experienced. This limited range of emotions measured may not accurately reflect emotions expressed (e.g.,

frustration, excitement, fear). Taking those things into consideration, this may limit the generalizability of this research to a healthy population.

While human coders are the gold standard for emotional identification in text data, due to the time and cost associated with evaluating such large volumes of data human coders are not always reasonable. Based on the importance of positive predictive value in addition to sensitivity, LIWC 2001 is superior to LIWC 2007 and is the suggested modality for analysis of text data. Positive predictive value is highly dependent upon the prevalence of emotion in the specific population, such that the more emotion presented in a population the more accurate the analysis will likely be. Considering the high prevalence of emotion in a cancer population, and that LIWC 2001 performed significantly better than LIWC 2007, this indicates that for a population with much less emotional expression LIWC 2007 will still perform significantly poorer than LIWC 2001. LIWC 2001 seems to have a good validity in emotional identification and presents as a viable tool for identification of emotion in text-data, which is important in the increasingly digital world.

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