AUTOMATIC AND EFFORTFUL FACIAL EXPRESSION MIMICRY

AND DYSPHORIC MOOD

BY

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Abstract

Clinical depression has been widely associated with difficulty building and maintaining healthy social relationships (e.g., Lewinsohn, Mischel, Chaplin, & Barton, 1980; Libet & Lewinsohn, 1973; Segrin, 2000). Although many factors contribute to the development of positive social relationships, successful mimicry of others' facial expressions plays a key role in developing rapport and intimacy with others (Izard, 1989; Keltner & Haidt, 1999, Manstead, 1991), and multiple studies have noted important deficits for adults and children with depression in the ability to accurately mimic positive facial expressions (e.g., Lautzenhiser, 2003; Sloan, Bradley, Dimoulas, & Lang, 2002; Wexler, Levenson, Warrenburg, & Price, 1993). To date, published data has noted clear deficits in automatic facial expression mimicry in this population but has not examined *effortful* mimicry. The current study aimed to fill this gap in the literature by examining both automatic and effortful facial expression mimicry in individuals reporting dysphoria, a mild form of clinical depression. One hundred thirty-six participants were shown a series of happy, sad, and neutral faces, while electromyography (EMG) recorded automatic muscle response in the corrugator supercilii, zygomaticus major, and orbicularis oculi facial muscles. To assess effortful mimicry, participants were shown the series of images again with explicit instruction to mimic the faces appearing on the screen, while EMG again recorded effortful muscle responses. Associations between dysphoria and automatic and effortful facial expression mimicry were examined. Additionally, change in positive and negative emotions throughout the study, associations between facial expression mimicry and self-reported social functioning, and recognition of images presented in the study were also examined. Results indicated that high dysphoric mood was associated with deficits in automatic and effortful mimicry of happy, sad, and neutral facial expressions. Inaccurate automatic and effortful mimicry of faces was also associated with lower self-reported social support and greater loneliness. Results are discussed in light of current efforts to improve depressive symptoms via social skills training.

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Table of Contents

Automatic and Effortful Facial Expression Mimicry and Dysphoric Mood

Clinical depression remains a significant world health concern, with 11% of people in low or middle-income countries and up to 15% of people in high-income countries likely to develop the disorder at some point in their lifetime (Bromet et al., 2011). Although much research is currently focusing on understanding and treating clinical depression, additional research is needed to better understand how to prevent clinical depression from occurring in populations at high risk for developing the disorder. The presence of dysphoria, a mood state characterized by subclinical depressive symptoms, including symptoms of both depression and anxiety (Ingram & Hamilton, 1999), indicates high risk for future development of clinical depression (e.g., Cuijpers & Smit, 2004; Eaton, Badawi, & Melton, 1995). Although dysphoria is less severe than clinical depression, it is certainly evidenced by more complicated symptomatology than a typical sad mood state and can frequently lead to problematic functioning physically, emotionally, and interpersonally, just as clinical depression does (Ingram & Hamilton, 1999). Furthermore, at any given time, a significantly greater number of people suffer from this milder form of depression than suffer from clinical depression itself (e.g., Ingram & Hamilton, 1999).

A wealth of research has revealed that depressed and dysphoric individuals exhibit negative patterns of thinking and have difficulty functioning socially, which have each been shown to be associated with the cause, continuation, and resolution of depression (e.g., Lewinsohn, 1974). In light of this, the two most predominant theories explaining possible cause of and treatment for depression include cognitive and interpersonal variables that promote and maintain depressive symptoms (e.g., Beck, 1967; Coyne, 1976; Lewinsohn, 1974). Although these theories have traditionally examined depression from varying angles, researchers are attempting to merge these theories in an effort to better understand the complexity of depression and dysphoria (e.g., Bistricky, Ingram, & Atchley, 201; Gotlib & Hammen, 1992). One clear area of research ripe for the synthesis of cognitive and interpersonal theories is the examination of how dysphoric individuals process and mimic facial expressions, one of the most central, important non-verbal cues for social interaction (Ekman & Oster, 1979). Research from the interpersonal perspective has shown processing of facial expression to be important for healthy social functioning and emotion regulation (e.g., Cozolino, 2002), and previous work from cognitive perspectives has suggested that depressed and dysphoric individuals view, interpret, and remember human facial expressions in a manner that contributes to the continuation of depressed mood and thought processes (Bistricky, Ingram, & Atchley, 2011). The current study draws from both cognitive and interpersonal theories of depression to examine whether dysphoric mood is associated with automatic and effortful mimicry of others' facial expressions. Before the current project is discussed, a review of pertinent literature is presented, including a formal definition of dysphoria as it is operationalized in the current study and discussion of literature related to facial expression, mimicry, and social functioning in the context of dysphoric mood.

Defining Dysphoria

Several terms (i.e., subclinical depression, dysphoria, negative affective state) have been used throughout psychological literature to describe a population of individuals with mild depressive symptoms who do not meet full DSM-IV criteria for clinical depression (Ingram & Hamilton, 1999). Unlike clinical depression, which is characterized by a reliable set of clearly outlined symptoms, subclinical depressive states lack clear definitions, with most simply characterized as affective states resembling that of clinical depression but in milder form and causing less impairment. The current study specifically examined dysphoric mood as the presence of a self-reported negative mood state, which plays a major role in the experience and diagnosis of clinical depression and has been shown to be associated with genetic vulnerability for the development of clinical depression (e.g., Wichers et al., 2007).

The term dysphoric mood is often used to indicate a negative affective experience involving more than transient emotions. There has long been a temporal distinction between mood, a mental state lasting for a period of at least hours or days, and emotion, a brief feeling lasting a period of only seconds or minutes (e.g., Davidson et al., 1994). Short-lasting emotions are accompanied by expected autonomic changes that prepare individuals for action and are associated with fairly consistent physical expressions, particularly facial expressions (Levenson, Ekman, & Friesen, 1990); alternatively, mood is not necessarily accompanied by a distinct set of physical expressions or emotions but rather, can include a variety of emotional states within it and can influence and change cognition (Davidson et al., 1994). For example, individuals with dysphoric or depressed mood describe experiencing a variety of emotions, including sadness, anxiety, and anger, and can more readily cognitively access sad than happy memories (Ingram & Hamilton, 1999; Teasdale & Fogarty, 1979).

Negative affective experience is typically measured by having individuals report the degree to which they experience a set of negative adjectives over the course of various time periods. There are a variety of scales available to measure negative affective experience, including the Profile of Mood States (POMS; Usala & Hertzog, 1989); Positive and Negative Affect Schedule (PANAS; Watson, Clark, and Tellegen, 1988); and scales based on circumplex models of emotion (e.g., Larsen & Diener, 1992), which emphasize consideration of both valence and arousal of emotions. Each scale uses a slightly different set of words to represent positive and negative affective experience and was derived from varying theories of emotion. However, the words used are generally more similar than different across scales. Throughout all scales, negative mood is typically characterized by a set of reported affective experiences (e.g., fearful, sluggish, depressed, tired, nervous, tense, unhappy, angry) lasting for at least several hours or days, whereas negative emotions are characterized by a set of reported emotional experiences in a particular moment (Davidson et al., 1994). Thus, dysphoria can be present as a mood state or set of emotions in a given moment, which can be distinguished during measurement by asking individuals to report how they are feeling "right now" (negative emotion) or how they have felt in general "throughout the past week" (negative mood).

Facial Expression of Emotions

Although longer lasting moods are not generally associated with specific facial muscle movements or facial expressions, various emotions have been distinguished by instinctive and universal facial expressions for over a century (e.g., Darwin, 1872; Ekman, 1992). Ekman (1992) outlined seven basic emotional expressions found across the world (i.e., expressions of happiness, sadness, anger, disgust, fear, contempt and surprise). Furthermore, evolutionarily, facial expressions developed as social communicators long before language did (Wilson, 1999), making them one of the oldest forms of interpersonal communication and among the most important nonverbal cues for social functioning (Ekman & Oster, 1979). Modern research confirms that human facial expressions do successfully serve as indicators of emotional experience, conveying emotion and eliciting emotions in others (Ruys & Stapel, 2008). However, research throughout the past century has suggested that facial expressions are not always the result of emotional experience but that musculature changes in the face might be the cause of emotional change as well.

William James (1890) suggested over a century ago that physical change in the body (e.g., the muscles and circulatory system) could impact emotional experience. Similarly, Tomkins (1962) suggested that facial muscle movement is an important part of constructing emotional experience. Agreeing with Tomkins (1962), Tourangeau and Ellsworth (1979) labeled this concept, that facial muscle activation could influence emotional experience in a causal way, the "facial feedback hypothesis (FFH)." Thus, ample evidence has been found to suggest that both processing others' facial expressions and producing one's own expression in response, i.e., "mimicking" others, play important roles in the emotional experience and exchange between individuals in a social setting. Additionally, facial expression mimicry can occur both automatically and effortfully. Automatic mimicry occurs subconsciously and rapidly, typically occurring within 1,000 ms after viewing a facial expression, whereas effortful mimicry involves a slower, conscious effort to replicate another's facial expression (Beall, Moody, McIntosh, Hepburn, & Reed, 2008; McIntosh, Reichmann-Decker, Winkielman, & Wilbarger, 2006).

Measuring Facial Expression

Before mimicry occurs socially, the human eye must perceive a particular facial expression from another person, and most people have little difficulty perceiving clear facial muscular changes accompanying positive and negative facial expressions (Bassili, 1978). Thus, one of the most common valid and reliable systems used to identify and categorize facial expressions is the Facial Action Coding System (FACS; Ekman & Friesen, 1978), an anatomical coding system that uses trained human raters to classify facial expressions based on distinct facial muscle movements known to be associated with particular expressions. For example, positive facial expression (i.e., smiling) is associated with activity in the zygomaticus major muscle in the cheek. Additionally, a genuine "Duchenne" smile, named after its founder (Duchenne, 1862/1990; Ekman & Friesen, 1982), employs the zygomaticus major as well as the orbicularis oculi muscle around the eye, which produces the classic wrinkle around the corner of the eye commonly observed during genuine display of positive facial expressions. Sad facial expressions (i.e., frowning) typically involve activation in the corrugator supercilii muscle above the eyebrows, which produces the characteristic furrowed brow seen in sad and certain other negative facial expressions. Using FACS, trained observers can identify genuine facial expressions via activation in these expected muscle groups. However, the FACS system is somewhat limited to static images of facial expressions, as it is difficult to accurately code muscle activation during live observation.

Although the FACS system is widely used and effective in identifying clear, static facial muscle activity, it is less effective at detecting minute facial muscle activity, particularly during live observation. Because of this, electromyography (EMG) is frequently utilized to detect fine and subtle muscle movements associated with facial expressions occurring in real time (see Tassinary & Cacioppo, 2000). EMG data are collected by placing surface electrodes on the skin above various muscle regions (e.g., the zygomaticus major or orbicularis oculi region) with wires attached to an amplifier in order to detect electrical activity traveling across muscle fibers (Tassinary & Cacioppo, 2000). EMG does not measure direct tension or movement of one particular muscle; rather, it detects electrical activity moving across a particular muscle region, which may be the result of movement in more than one specific muscle in the face. Although EMG does not detect specific muscle tension, it has been shown to be a valid and reliable indicator of muscle activity associated with positive and negative facial expression and of emotional experience in general (e.g., Cacioppo, Petty, Losch, & Kim, 2008; Winkielman & Cacioppo, 2001). Furthermore, EMG has been widely used to identify minor muscle movement indicative of small changes in facial expressions, which are often unobservable with the human eye but are associated with automatic mimicry of others' positive and negative facial expressions

(Dimberg 1982; 1990; Lanzetta & Englis, 1989). It has also been tied to clinical conditions, revealing facial expression differences between individuals with and without psychiatric disorders (Berenbaum & Nisenson, 1997). Finally, studies have shown that FACS coding typically matches average EMG data collected, which indicates that both are measuring the same muscular activation but from different vantage points (Tassinary & Cacioppo, 2000).

Facial Expression and Dysphoria

Research on cognitive processing of clear, unambiguous as well as minute, ambiguous facial expressions has revealed differences in the way individuals process negative (e.g., angry, sad) versus positive (i.e., smiling) faces, with negative faces perceived quickly, through automatic parallel processing and positive, happy faces perceived less quickly, via serial, effortful processing (White, 1995). Furthermore, research has shown that not all positive expressions are "equal." For example, Duchenne (1862/1990) first distinguished a genuine smile from a non-genuine smile by activity in the orbicularis oculi muscle surrounding the eye, and Ekman (2001) has identified over 50 different types of smiles based on varying activation throughout the face. Regardless of type of smile, positive facial expression has been shown to be associated with physical and mental health and well-being. For example, individuals without psychological disorders smile more than individuals with psychological disorders (Abel & Hester, 2002), and more smiling occurs when individuals with depression have completed treatment than when first admitted to inpatient treatment (Berenbaum & Nisenson, 1997; Krause, Steimer, Sanger-Alt, & Wanger, 1989; Matsumoto, 1987). Smiling has even been associated with longevity (Harker & Keltner, 2001) and has been shown to speed cardiovascular recovery from brief stressors (Kraft & Pressman, 2012). Finally, and most importantly, research has shown that *effortfully* producing a smile activates the same brain regions involved with positive emotion as *automatically* smiling in response to a happy stimulus does (Ekman & Davidson, 1993).

Although the brain region responsible for producing a smile may be the same for dysphoric and nondysphoric individuals, those with depression and dysphoria have typically shown clear differences in the way in which they cognitively process others' expressions compared with nondepressed or dysphoric individuals (Hartlage, Alloy, Vasquez, & Dykman, 1993). Primarily, dysphoric individuals show deficiency in the ability to process effortfully but not automatically (Hartlage et al. 1993). This explains in part why dysphoric individuals are better at processing sad faces, which are processed automatically by all people, and have a deficiency in processing happy faces, which are processed effortfully.

Ample evidence has been found for this deficiency. For example, dysphoric and depressed individuals recall sad facial expressions better than happy or neutral facial expressions (e.g., Gollan et al., 2008; Gur et al., 1992; Leppanen et al., 2004; Surguladze et al., 2004); dysphoric individuals have been shown to shift attention away from happy to neutral faces when presented together (Bradley, Mogg, Falla, & Hamilton, 1998; Bradley, Mogg, & Millar, 2000); and although previous research has shown no difference in recognition of clear, unambiguous happy or sad faces between dysphoric and nondysphoric individuals (Segrin, 2001), it has revealed poorer recognition of mildly happy or neutral faces in dysphoric individuals (e.g., Gollan et al., 2008; Gur et al., 1992; Leppanen, Milders, Bell, Terriere, & Hietanen, 2004; Raes, Hermans, & Williams, 2006; Surguladze et al., 2004). Furthermore, although nondysphoric individuals generally rate neutral faces as more positive than they actually are, dysphoric individuals have a tendency to rate neutral faces as more negative than they actually are (e.g., Gollan et al., 2008; Gur et al., 1992; Leppanen et al., 2004; Surguladze et al., 2004). Finally, Van

Baaren et al. (2008) examined participants in an fMRI scanner by asking them to recall a happy or sad experience while simultaneously showing them pictures of happy and sad facial expressions. Results indicated that viewing facial expressions incongruent with their emotional memory led to activation in brain areas responsible for processing conflicting and unexpected responses from the environment and areas responsible for perceiving oneself as distant from social others. This incongruence between cognition and emotional experience as well as deficits shown in positive facial expression processing could be important factors contributing to the onset and maintenance of depressive symptoms.

Role of Cognitive and Interpersonal Theories in Facial Expression Processing Deficits

Cognitive models suggest that negative cognition drives the etiology and maintenance of clinical depression, such that negative mood and thought processes work together to make depressive information, in the form of words and images, more prominent and available for dysphoric and depressed individuals (Beck, 1967; Bistricky et al., 2011) and similarly, make positive information less available (e.g., Clark, Beck, & Stewart, 1990; Clark & Watson, 1991). Depression and dysphoria have also been conceptualized as the inability to inhibit processing of sad or negative affect (e.g., Goeleven, De Raedt, Baert, & Koster, 2006; Joormann, 2004). These deficiencies in processing positive expressions in dysphoric individuals can lead to a bias in perceiving negative facial expression, which can serve to maintain a depressive view of one's social environment (Bistricky et al., 2011). Furthermore, direct eye contact with another face, which most studies examining facial expression use, has been linked to "automatic self-referent processing (i.e., 'he is looking at me')" and "self-relative-to-other processing (e.g., 'is his response to me unfavorable?'), where depressed and dysphoric individuals may evaluate themselves negatively in response to negative facial feedback from others (Bistricky et al., 2011,

p. 999).

Alternatively, interpersonal theories of depression propose that deficits in social functioning (e.g., poor eye contact and conflict resolution) serve to make social interaction a negative experience for depressed and dysphoric individuals, typically leading to depressed individuals withdrawing from social interaction or overburdening a small social network of individuals with whom they feel comfortable (Bistricky et al., 2011; Joiner & Coyne, 1999; Lewinsohn, 1974). Studies have also shown important links between both social isolation and loneliness and significant increases in symptoms of depression (e.g., Cacioppo, Hawkley, & Thisted, 2010; Palinkas & Browner, 1995; Rockwell, Hodgson, Beljan, & Winget, 1976), suggesting that isolation, whether due to lack of opportunity for socialization or poor social skills leading to nonrewarding social interactions, contributes to the development and continuation of depressive symptoms. In light of these associations, it can be argued that the relationship between poor social interactions and depression is bidirectional, with poor social interactions contributing to depressive symptoms in addition to depressive symptoms leading to a higher likelihood of engaging in poor social interactions.

Although poor social skills and negative social interactions can certainly contribute to the continuation of depression (e.g., Bistricky et al., 2011), not all individuals lacking social skills develop depressive symptoms. However, individuals with depressive symptoms consistently report being dissatisfied with social relationships (e.g., Pearson, Watkins, Kuyken, & Mullan, 2010; Tao, & Li, 2003; Whisman, 2001), which indicates that depression does have a critical impact on social functioning. Taking both cognitive and interpersonal theories into perspective, Bistricky et al. (2011) have argued that it is likely that depression leads to problems with social functioning due to a) cognitive biases toward the negative, leading to the inability to correctly identify others' facial expressions and affective experience; b) the inability to adequately pay attention to positive facial expressions of others; and c) the tendency to take others' facial expressions more personally and find others' facial expressions threatening or aversive. Furthermore, depression not only affects how individuals process and interpret others' facial expressions and nonverbal cues but also impairs effective communication of their own emotional experience (Harper & Sandberg, 2009). All these may lead to social experiences being more punishing than rewarding and act as reinforcement for withdrawing socially.

Furthermore, decoding and correctly processing facial expression is an indicator of social competence and popularity (Leppanen & Hietanen, 2001), and is important in building healthy, successful relationships and bolstering intimacy (e.g., Elfenbein & Ambady, 2002; Marsh, Kozak, & Ambady, 2007; Montagne, Kessels, Frigerio, deHaan, & Perrett, 2005). Properly encoding and designing a message is also an important aspect of successful communication (Finset & Piccolo, 2011). Thus, depressed and dysphoric individuals' deficiencies in social functioning may be directly related to their deficiencies in processing positive emotional expressions during interactions and failing to respond appropriately both verbally and nonverbally in social interactions (e.g., Bistricky et al., 2011; Harper & Sandberg, 2009; Leppanen & Hietanen, 2001; Swenson, Rose, Vittinghoff, Stewart, & Schillinger, 2008).

Consistent with both cognitive and interpersonal theories' conclusions about the role of facial expression processing deficiency in maintaining depressive symptoms, studies have found higher facial muscle activity, measured by electromyography (see Fridlund & Cacioppo, 1986), before treatment for depression to be associated with better treatment outcomes (Greden, Price, Genero, Feinberg, & Levine, 1984). Similarly, paralyzing the corrugator muscles, which are associated with frowning, with botulinum toxin has been shown to be effective in reducing symptoms of depression up to six weeks post-treatment (Wollmer et al., 2012).

Mimicry and Dysphoria

Mimicry of specific facial expressions, such as frowning or smiling, in addition to mimicry of other nonverbal behaviors (e.g., posture), plays a central role in effective social communication (Chartrand & Bargh, 1999). The presence of facial mimicry in humans has been well established in the literature (e.g., Chartrand & Bargh, 1999; Zajonc et al., 1987; Meltzoff & Moore, 1977; Termine & Izard, 1988, Dimberg, Thunberg, & Elmehed, 2000; Dimberg, 1982; & Vaughan & Lanzetta, 1980). In fact, automatic mimicry of others' facial expressions can be seen as early as a few days after birth, with infants mimicking happy and sad faces of their caregivers (Field, Woodson, Greenberg, & Cohen, 1982). Similarly, when babies open their mouths, mothers typically respond by opening their own mouths too (O'Toole & Dubin, 1968). Perhaps the most convincing evidence for the automaticity of facial mimicry is Dimberg et al.'s (2000) finding that even when facial expressions were presented on a computer screen so fast that participants could not consciously identify the expression, their facial muscle movement, as measured by EMG, moved in expected directions associated with the images presented (i.e., zygomaticus major activity was elevated when happy expressions were shown and corrugator supercilii activity was elevated when sad expressions were shown).

Nonverbal mimicry in general, especially facial mimicry, can be both automatic and effortful, and it serves numerous important social functions, including enhancement of communication, building rapport and empathy in relationships, and increasing prosocial behavior (Chartrand & van Baaren, 2009; Kraut & Johnston, 1979; VanBaaren et al., 2004). Studies have shown that automatic mimicry is nonconscious and occurs as a way of affiliating with others (Lakin et al., 2003). For example, Brass et al. (2001) found that watching another person move a finger was associated with automatically moving that same finger and inhibited effortful movement of other fingers. Neurologically, researchers have linked mimicry with the discovery of mirror neurons in humans, which fire both when seeing someone else perform an action and when performing that action oneself (see Hurley & Chater, 2005). In macaque monkeys, Gallese, Fadiga, Fogassi, and Rizzolatti (1996) found that the same mirror neurons were activated when they grabbed a peanut and when other monkeys grabbed a peanut. This discovery of mirror neurons suggests that humans and higher order animals are hard-wired for mimicry.

Cognitively, theories of embodied cognition (Barsalou, Niedenthal, Barbey, & Ruppert, 2003; Niedenthal, 2007) and emotional contagion (e.g., Blairy, Herrera & Hess, 1999) state that a) mimicking others helps us recognize their affective experience, thus increasing our empathy for them, and b) by sharing facial expressions, we share affective experience. This is supported by research on nonverbal mimicry between psychotherapists and clients showing that the extent to which the therapist and client "match" postures by the end of the session predicts greater rapport (Charney, 1966; Maurer & Tindall, 1983). Similar results on the connection between nonverbal mimicry and rapport have also been found between students and teachers (LaFrance & Broadbent, 1976). The only caveat to this consistent finding is that mimicry from a member of one's out-group or a socially stigmatized person (i.e., an obese person or a person with a facial scar) has been found to lead to *less* rapport (Likowski et al., 2008; Johnston, 2002).

Several studies have found that dysphoric children and adults do not automatically mimic positive facial expressions as well as nondysphoric individuals (Lautzenhiser, 2003; Sloan, Bradley, Dimoulas, & Lang, 2002; Wexler, Levenson, Warrenburg, & Price, 1993). These studies examining automatic mimicry generally present a series of faces with different emotional expressions to participants for a short period of time (ranging from 4-12 seconds) with basic instructions to simply view the images while participants are hooked up to electromyography (EMG) to measure facial muscle activity in response to the images. These studies typically do not specifically mention their intention to study facial expression mimicry; rather, they leave instructions vague or utilize a cover story to allow participants to respond to the images as naturally as possible, without demand characteristics present from research assistants.

Using EMG, Lautzenhiser (2003) found that depressed children smiled significantly less than nondepressed children in response to positive emotion-inducing images and frowned significantly more than the non-depressed children in response to neutral images. However, no significant differences were found between depressed and nondepressed children in facial response to negative emotion-inducing images. Overall, Lautzenhiser (2003) reported that depressed children showed frowns in response to three image types – negative, positive, and neutral.

Similarly, Sloan et al. (2002) also found that although dysphoric and non-dysphoric individuals did not differ in automatic facial mimicry of sad faces, they did differ in automatic mimicry of happy faces, with non-dysphoric individuals showing expected zygomaticus major (cheek muscle) activity and dysphoric individuals not only not showing expected zygomaticus major activity but showing unexpected corrugator activity (furrowing of the brow). Wexler et al. (1993) found that although dysphoric and non-dysphoric individuals performed equally well on tasks of facial expression recognition, dysphoric individuals did not show expected changes in facial muscle activity in sad or positive automatic mimicry. Finally, Moody et al. (2007) found that when shown scary pictures before facial expressions, individuals did not automatically mimic as well, indicating that automatic mimicry involves rapid facial muscle movement and emotional experience and can change based on a person's mood state.

Mimicry, Dysphoria and Social Functioning

Deficits in the ability to cognitively process and behaviorally mimic positive facial expressions could be a key reason why depressed and dysphoric individuals have marked difficulty building and maintaining healthy interpersonal relationships (see Bistricky et al., 2011). Because facial expression and experience of emotions serve important social functions, including helping us communicate with others, facilitate social interaction, and start, maintain, and end relationships (Izard, 1989; Keltner & Haidt, 1999, Manstead, 1991), accurately processing others' facial expressions and producing one's own expression in response (i.e., "mimicking" others) is essential for healthy social exchanges between people. Failing to appropriately mimic others' facial expressions has been associated with poor quality of social interactions, which in turn can lead to depletion of mental resources, reduced self-control, and difficulty monitoring and regulating one's actions (Dalton, Chartrand, & Finkel, 2008).

Research has shown that dysphoric and depressed individuals not only display deficiencies recognizing and expressing emotion via facial expression but also that these individuals lack social skills in general, perceive themselves as socially incompetent, and can easily become socially isolated (e.g., Lewinsohn, Mischel, Chaplin, & Barton, 1980; Libet & Lewinsohn, 1973; Segrin, 2000). More specifically, research has shown that individuals with depression and dysphoria take longer to respond to others' verbal cues, are more likely to express dysphoric feelings in conversation, engage in less eye contact, and engage in less nonverbal mimicry overall, including not only facial expression mimicry but also mimicry of posture and gestures (see Segrin, 2000). These deficits are further evidenced by research showing social skills training, which often includes modeling effective nonverbal behavior (i.e., facial expression, posture), to be helpful for individuals with depression (e.g., Brown & Lewinsohn, 1984; Segrin, 2000).

In terms of social functioning, several studies have shown significant sex differences in facial expression mimicry in dysphoric and non-dysphoric individuals, with women showing greater muscle activation than men (e.g., Buck et al., 1974; Ekman, Friesen, & Ellsworth 1972; Wallbott & Scherer, 1991). Thus, sex was measured in the current study and considered as a control variable throughout analyses.

Importance of the Current Study

Clear deficits in automatic facial expression mimicry have been shown in individuals with depression and dysphoric mood (Lautzenhiser, 2003; Sloan et al., 2002; Wexler et al., 1993) as well as many other disorders, including autism (McIntosh et al., 2006), schizophrenia (Penn & Combs, 2000; Varcin et al., 2010; Wolf et al., 2006), and bulimia nervosa (Kuhnpast et al., 2012). However, little research has examined whether dysphoric mood is also associated with deficits in effortful mimicry of facial expressions. McIntosh et al. (2006) did find distinct deficits in both automatic *and* effortful facial mimicry in autistic individuals, but to our knowledge no study to date has been published examining differences in both automatic and effortful facial expression mimicry in dysphoric individuals, making the current study one of the first to examine effortful facial expression mimicry in this population. Given that it has been estimated that millions of people will experience dysphoria at some period in their lives (Ingram & Hamilton, 1999), the results from the current study could potentially benefit a large range of individuals in the general population. By providing a more complete understanding of how individuals with depressive symptoms mimic faces automatically and effortfully, individuals with dysphoria as well as their friends, family members, and treatment providers will be better prepared to seek and utilize successful methods for improving non-verbal communication and alleviating depressive symptoms.

More comprehensive knowledge of facial expression mimicry and dysphoria will also significantly contribute to understanding how dysphoric mood develops and persists. Additionally, it could shed light on a potentially critical pathway connecting dysphoria and poor social functioning, including difficulty developing and successfully maintaining friendships and romantic relationships, problems working successfully with peers, and trouble communicating needs and desires effectively. Because social support and social relationships play a large role in life satisfaction, deficits in facial expression mimicry and social functioning could also highly influence overall quality of life for individuals with dysphoric mood as well as longevity of depressive symptomatology (e.g., Levitt, Clark, Rotton, & Finley, 1987).

Finally, understanding potential deficits for dysphoric individuals in automatic and effortful mimicry could greatly inform identification and clinical diagnosis of subclinical depression by drawing attention to this important non-verbal domain of functioning that may operate differently for individuals with depressive symptoms. It may also better inform clinical treatments for subclinical depression, particularly social skills training and behavioral activation strategies that emphasize interpersonal activity and are often included in evidence-based treatments for depression (Segrin, 2000; Soucy Chartier & Provencher, 2013).

The Current Study

Although previous literature has examined automatic facial expression mimicry in individuals with depression and dysphoric mood (e.g., Lautzenhiser, 2003; Sloan, Bradley, Dimoulas, & Lang, 2002; Wexler, Levenson, Warrenburg, & Price, 1993), no previous study has examined both automatic and effortful mimicry and dysphoric mood. Because the ability to effectively mimic others' facial expressions has important implications for social functioning, it is essential to understand whether dysphoric mood is associated with deficiencies in not only automatic mimicry, as previous research has suggested (e.g., Lautzenhiser, 2003; Sloan et al., 2002; Wexler et al., 1993), but also in effortful mimicry.

Purpose

This study examined: a) whether dysphoric mood is associated with poor automatic mimicry of others' facial expressions, b) whether dysphoric mood is associated with poor effortful mimicry of others' facial expressions, c) whether dysphoric mood is associated with reported emotion changes following exposure to happy, sad, and neutral facial expressions, d) whether degree of facial muscle activation change from baseline during automatic mimicry is associated with baseline measures of social support, loneliness, and social competence, e) whether degree of facial muscle activation change from baseline during effortful mimicry is associated with measures of social support, loneliness, and social competence, and f) whether dysphoric mood is associated with poor facial expression recognition.

Hypotheses include the following: a) consistent with previous literature reporting processing and mimicry deficits of positive facial expression for individuals with depressive symptoms (e.g., Hartlage et al. 1993; Lautzenhiser, 2003; Sloan, Bradley, Dimoulas, & Lang, 2002; Wexler, Levenson, Warrenburg, & Price, 1993), dysphoric mood will be associated with decreased ability to both automatically and effortfully mimic positive facial expressions but will not be significantly associated with the ability to mimic neutral or negative facial expressions; b) dysphoric mood will be associated with change in negative emotional experience throughout the study (i.e., reported increases in negative emotions following the appearance of negative facial stimuli) but not in positive emotional experience, due to hypothesized deficits in correct muscle activation of positive facial expression, which could significantly alter the impact of facial feedback on emotion change (Tourangeau and Ellsworth, 1979), c) greater correct/accurate facial muscle activation change from baseline during both automatic and effortful mimicry will be associated with higher scores on measures of social support and social competence and lower self-reported loneliness, and d) dysphoric mood will be associated with poor recognition of facial expressions presented throughout the study.

Method

Participants

One hundred thirty-six college students were recruited through the University of Kansas psychology department's online recruitment system. Basic information was provided to potential volunteers on this website (e.g., time, duration of study, and number of credits towards KU's research participation requirement reimbursed). See Table 1 for a complete summary of sample characteristics.

Table 1
Sample Characteristics

Variable		n	%	Range	M(SD)
Sex					
	Female	89	65.4		
	Male	45	33.1		
	No data	2	1.5		
Race					
	Caucasian	104	76.5		
	African American	8	5.9		
	Native American	2	1.5		
	Asian/Pacific Islander	8	5.9		
	Hispanic/Latino	7	5.1		
	Other	4	2.9		
	No data	3	2.2		
Current Psychological Disorder					
	None	127	93.4		
	ADHD	1	.7		
	Anxiety	3	2.2		
	Depression	2	1.5		
	Bipolar	1	.7		
	Other	2	1.5		
Beck Depression Inventory Scores				0-46	7.7(8.0)
Baseline Negative Emotion				.1-2.9	1.2(.7)

Inclusion criteria. Only fluent English speakers were eligible for participation, as it would have been difficult for non-English speakers to accurately complete all questionnaires for this study. Similarly, all participants with facial muscular disorders or injury were excluded to ensure that all participants were physically capable of mimicking the facial expressions presented in the study. Nine participants reported currently being diagnosed with a psychological disorder, with three reporting an anxiety disorder, two reporting clinical depression, one reporting attention deficit/hyperactivity disorder, one reporting bipolar disorder, and the remaining two choosing not to complete this item. Six of these nine participants reported taking medication for a psychological disorder. All individuals reporting a psychological disorder were carefully examined to ensure that their responses did not inappropriately skew scores on dependent variables of interest.

Measures

Screening measure. Individual "Yes/No" items were used to screen for English fluency and facial muscle disorder, and if participants marked "yes," they were excluded. Participants were also be asked to state whether or not they have been diagnosed with a psychological disorder, and if so, which disorder and whether they currently carry the diagnosis.

Demographic covariates. Basic demographic data, including age, sex, and race were collected at baseline and used as covariates throughout analyses when significantly associated with dependent variables of interest.

Potential depression. The Beck Depression Inventory – Second Edition (BDI-II; Beck, Steer, & Brown, 1996) is a 21-item self-report questionnaire designed to assess dysphoric mood and symptoms of depression outlined in the Diagnostic and Statistical Manual of Mental Disorders Fourth Edition (DSM-IV-TR; 1994). Each item assesses the existence and severity of a different symptom on a scale from 0 to 3, with 3 being the most severe. Symptoms assessed include: Sadness, Pessimism, Past failure, Loss of pleasure, Guilty feelings, Punishment feelings, Self-dislike, Self-criticalness, Crying, Agitation, Loss of interest, Indecisiveness, Worthlessness, Loss of energy, Changes in sleeping pattern, Irritability, Changes in appetite, Concentration difficulty, Tiredness or fatigue, and Loss of interest in sex. BDI-II scores range from 0 to 63, with scores between 13 and 19 indicative of dysphoric mood, and scores between 20 and 63 indicative of likely depression (Dozois, Dobson, & Ahneberg, 1998). Reliability (α = .91) and validity of the BDI – II have been established (e.g., Dozois et al., 1998).

Positive and negative affective experience, including dysphoric mood. Both positive and negative emotion (NE and PE) (i.e., feelings present "right now") and mood (trait NM and PM) (i.e., feelings present "during the past week") were measured at baseline, and the presence of emotions continued to be measured throughout the study after each block of images by using a brief 24-item version of the Profile of Mood States (POMS) based on a factor analysis of original POMS items (Usala & Hertzog, 1989; McNair, Lorr, & Droppleman, 1971). The scale ranged from 0 to 4 for each item, asking participants how they felt "now," with 0 indicating that the item was not at all accurate in describing how the participant felt at that moment, and 4 indicating that the item was extremely accurate in describing how the participant felt. Negative emotions and mood were measured based on five categories of subscales: Fatigue (including sluggish, tired, and sleepy); Depression (including unhappy, depressed, and sad); Fear (including fearful, frightened, and afraid); Anxiety (including on edge, nervous, and tense); and Hostility (including hostile, angry, and resentful). Due to primary interest in dysphoria, the current analyses will focus specifically on Depression subscale scores in addition to the overall negative emotion score. Positive emotions and mood were measured using three categories of subscales: vigor (including full of pep, energetic, and lively); well being (including happy, pleased, and cheerful); and calm (including at ease, calm and relaxed). Reliability (α ranging between .66 -.95) and validity of various short forms of the POMS has been established (e.g., McNair, Lorr, & Droppleman, 1971; Grove & Prapavessis, 1992).

Social support. The Interpersonal Support Evaluation List – 12 (ISEL-12; Cohen, Memelstein, Kamarck, & Hoberman, 1985) is a 12-item self-report scale measuring perceived availability of social support. Individuals are asked to respond on a scale from 0 (Definitely False) to 3 (Definitely True) whether statements describing availability of varying types of social support (appraisal, belonging, self-esteem, and tangible) are true for their life experience. Sample items include, "If I were sick, I could easily find someone to help me with me daily chores" and "When I need suggestions on how to deal with a personal problem, I know someone I can turn to." Reliability (α = .77) and validity of the ISEL have been established (Cohen & Hoberman, 1983).

Loneliness. UCLA Loneliness Scale – 8 (Hays & DiMatteo, 1987) is an 8-item self-report questionnaire measuring feelings of loneliness or social isolation. Individuals indicate the degree to which they have experienced a series of statements on a scale from 1 (Never felt this way) to 4 (Often felt this way). Example items include, "I lack companionship" and "There is no one I can turn to." Internal consistency reliability (α = .84) and validity have been well established (Hays & DiMatteo, 1987).

Social competence. The Short form of the Texas Social Behavior Inventory: Form B (TSBI; Helmreich & Stapp, 1974) is a 16-item self-report questionnaire measuring social competence. Individuals were asked to respond on a scale from 0 (Not at all characteristic of me) to 4 (Very characteristic of me) whether the series of statements accurately describes them. Example items include, "I would describe myself as socially unskilled" and "I frequently find it difficult to defend my point of view when confronted with the opinions of others." The full version of the TSBI has been shown to be reliable (α = .88; Helmreich & Stapp, 1974).

Facial expression recognition. One question was included at the end of the study asking participants to identify which faces they saw throughout the study. Eighteen total faces were chosen for the recognition task, including six faces that had appeared throughout the study with the same facial expression they had appeared with, six faces that had appeared in the study with a *different* facial expression than they had appeared with, and six expressions that had appeared in the study on a *different face* than the faces that had appeared in the study. Multiple correct and incorrect face and expression combinations were chosen to assess conjunction errors (i.e., choosing the correct face but with the wrong expression or the correct expression but with the wrong face), one of the most common errors typically found in recognition memory tasks (see Jones & Atchley, 2002).

Recording apparatus. Facial muscle movement was measured continuously throughout the study using electromyography (EMG; see Tassinary & Cacioppo, 2000). EMG was obtained from seven electrodes placed on the face using a MindWare BioNex EMG amplifier. One electrode was placed on the forehead as a ground electrode, and pairs of electrodes were placed approximately 1.25cm apart on the corrugator supercilii (Corr) muscle above the eyebrow (typically utilized in sad facial expressions), zygomaticus major (Zygo) muscle in the check (typically utilized to produce a smile), and the orbicularis oculi (Obic) muscle around the eye (typically utilized to produce a genuine smile). Data acquisition and recording of EMG was carried out using a MindWare BioLab 3.0 acquisition system. The signals were filtered with a low pass of 200 Hz and a high pass of 20 Hz and were sampled at 1000 Hz.

Procedure

Overview. The present study examined mimicry of facial muscle activation, both automatically and effortfully, in response to a series of photographs of different individuals displaying happy, sad, and neutral facial expressions. Expressions were presented in 10-image blocks, with all images from the same emotional expression shown together (i.e., 10 happy, then 10 sad, then 10 neutral images; See McIntosh et al., 2006). Order of images was randomized by block (i.e., some participants saw 10 happy, 10 sad, then 10 neutral, while others saw 10 neutral, 10 happy, then 10 sad). All possible combinations of block randomization (i.e., happy, sad, neutral; happy, neutral, sad; neutral, happy, sad; neutral, sad, happy; sad, happy, neutral; and sad, neutral, happy) were used to ensure randomization of all image sets across participants. Facial muscle activation was recorded using electromyography at baseline and throughout the study.

Experimental stimuli. Images of happy, sad, and neutral facial expressions were selected from the Karolinska Directed Emotional Faces (KDEF) system, a validated system of images containing 35 adult Caucasian females and 35 adult Caucasian males with various facial expressions (Lundqvist, Flykt, & Ohman, 1998). Caucasian faces were chosen for this study primarily because few standardized image sets with racially diverse images are currently available, and among those that are available, picture quality was substantially lower. Thus, the current study utilized five different male images and five different female images portraying each facial expression (sad, happy, and neutral) from the KDEF image set. All individuals appearing in the images were wearing a plain gray t-shirt and are free of makeup to ensure as much standardization as possible. All images were selected from the 20 most validated KDEF images from each emotional expression category of interest and the 20 most validated individuals appearing in pictures across emotion categories (Goeleven, De Raedt, Leyman, & Verschuere, 2008). Furthermore, images were tested and selected by team of 12 trained research assistants who unanimously agreed that the final set of images displayed the appropriate emotion they were intended to.

Experimental procedure. Participants came in for one two-hour session and were asked to provide informed consent before participating. At the beginning of the session, all participants were asked to complete an additional screening questionnaire that assessed for English language fluency and facial muscular disorders. If answers to the screening questions lead to ineligibility at this point, participants were thanked for their participation, debriefed, and given one credit towards their total research participation hours required by the KU psychology department. Eligible participants continued to have seven electrodes placed on the left side of the face (see Fridlund & Cacioppo, 1986) to measure facial muscle movement in the Corr muscle in the forehead (typically activated when expressing sadness), the Zygo muscle in the cheek (typically activated when expressing a smile), and the Obic muscle around the eye (typically activated when expressing a genuine smile). See Appendix A, Figure 1 for actual electrode placement. All sites for electrode placement were cleaned first with an alcohol swab and second with a gentle exfoliant in order to reduce impedance of electrode sites to less than 10 ohms. Participants then sat in front of a computer monitor where they were asked to complete self-report measures (i.e., questionnaires collecting demographics and general health information and assessing current positive and negative emotions, dysphoric mood, social support, loneliness, and social competence) online via Qualtrics survey software.

Once participants had completed baseline questionnaires, they were asked to sit quietly for a five-minute baseline period. During the course of the baseline period and for the rest of the study, measures of facial muscle activity were gathered. After the baseline measurement, Participants were asked to view a series of images with individuals expressing a neutral face, a sad face, and a happy face. They were instructed to simply "watch the pictures as they appear on the screen" in order to assess automatic muscle movement in reaction to the stimuli. All three 10-image sets were presented with rest periods between each set, and order of the sets was randomized across participants. All images were presented for 12 seconds, and another 12-second intertrial interval (ITI) appeared between images, with instructions to "watch the pictures as they appear on the screen" appearing on the computer monitor in front of the participant during the ITI period. Between each 10-image set, participants were immediately given questions that assessed emotions experienced, and a brief distracter task, which asked participants to memorize a 6-item grocery list and answer a brief question about whether a particular item was on the list. This was completed to ensure that emotion change does not carry over from one condition block to the next. Rest periods lasted five minutes and facial muscle activity continued to be assessed during this time. After this initial viewing of each 10-image set of facial expressions, individuals were shown the images again in the same order by set that they were presented initially. However, this time, they were also asked to purposefully mimic the facial expressions while these effortful facial muscle changes are measured. Again, participants were immediately asked to report emotions experienced after each 10-image set of facial expressions and engaged in the brief distracter task (memorizing a grocery list). After all 30 images had been viewed twice and both automatic and effortful mimicry assessed, participants were debriefed regarding the study goals and granted four credits towards the KU psychology department's required research participation hours. See Appendix A, Figure 2 for a summary of the complete study procedure.

Analytical procedure. Prior to analyses, all EMG data were cleaned by identifying and removing spontaneous movement not associated with genuine mimicry (i.e., sneezing, coughing, or yawning) throughout all data collected. Bivariate correlations were conducted between all dependent variables of interest and the age, sex, race of participants. Variables significantly associated with dependent variables of interest were controlled for throughout analyses by adding them to multiple regression models. Specific variables controlled for are listed throughout the presentation of results. Throughout analyses, dysphoric mood was assessed through the use of multiple measures, including the following: a) scores on negative affect scales of the 24-item version of the Profile of Mood States (POMS) (Usala & Hertzog, 1989) measured twice, as NE and NM; b) scores on the Beck Depression Inventory; and c) scores on the depression subscale of the POMS, measured twice, as depressed emotion (DE) and as depressed mood (DM), since this is the subscale of greatest relevance to the current study.

First, paired samples t-tests were used to determine a) whether expected changes in facial muscle activation were seen from baseline to the presentation of each image set. Next, multiple regression was used to answer the following: Is there is an association between dysphoric mood (assessed via multiple measures) and b) The ability to automatically mimic others' facial expressions? c) The ability to effortfully mimic others' facial expressions? d) Change in emotions experienced following the presentation of each emotional image set? Additionally, e) Is greater correct facial muscle activation change from baseline during automatic and/or effortful mimicry associated with greater social support and social competence and less loneliness across all participants (and vice versa for incorrect or no activation)? And f) Is dysphoric mood associated with poor recognition of images presented throughout the study?

Furthermore, because the sample as a whole presented as very low in dysphoric mood at baseline (i.e., Baseline Negative Mood: $M = 1.17$; Baseline BDI: $M = 7.69$), all significant regression results throughout analyses were also examined using Univariate Analysis of Variance (ANOVA), comparing individuals in the bottom tertile to individuals in the top tertile of dependent variable scores in order to better understand differences in functioning between the least and most dysphoric individuals in the sample. See Table 6 in Appendix B for a summary of mean baseline scores of dysphoric mood across measures for individuals in the lower and upper tertile. ANOVA analyses and graphs will be used as supplementary information alongside continuous analyses to see whether differences are found primarily between those most dysphoric and those reporting very low or no dysphoric mood.

Preliminary Analyses

Because nine individuals in the current sample reported the diagnosis of a psychological disorder (See Table 1 for summary of reported disorders), ANOVA was used to examine differences between those with and without a psychological disorder. Of these nine individuals, only two indicated a current diagnosis of clinical depression. Results revealed significantly greater Beck Depression Inventory scores for those with a psychological disorder ($M = 16.56$) than without ($M = 7.06$), $F(1,133) = 12.81$, $p < .01$ as well as higher baseline negative mood scores for those with a psychological disorder ($M = 1.76$) than without ($M = 1.13$), $F(1, 133) = 7.46$, $p < .01$. Individuals reporting a psychological disorder were not excluded from analyses, as this subset theoretically represents an important part of the continuum of dysphoric mood of interest in the current set of analyses (i.e., the high end of dysphoria).

Results

A) Are Expected Changes Seen in Facial Muscle Activation from Baseline to Image Presentation?

In order to assess whether participants showed expected changes in facial muscle activation in response to each image-set, paired samples *t*-tests were used to determine whether average facial muscle activation at baseline was significantly different from average facial muscle activation in the four-second period following the presentation of each image in each set. See Table 2 for a summary of all results. Following the presentation of happy facial expressions, greater Zygo and Obic activity was expected. Following the presentation of sad facial expressions, greater Corr activity was expected. No change in muscle activation from baseline was expected following the presentation of neutral facial expressions.

Automatic mimicry: Change in facial muscle activation from baseline to image presentation. As expected, significant differences were found in Zygo and Obic muscle activation before and after the presentation of happy images, with greater Zygo activation following the images than at baseline and greater Obic activation following the images than at baseline. Also as expected, significant differences were found in Corr muscle activation before and after the presentation of sad images, with greater Corr activation following the images than at baseline.

Table 2
Differences between Average Baseline Facial Muscle Activation and Average Activation 4 Seconds Post-Image Presentation in Response to Happy, Sad, and Neutral Faces

Variable		Mean	t	Sig (2-tailed)
Automatic Happy				
Corr	Baseline	.51	-2.40	*p* <.05
	Post-Image	.56		
Obic	Baseline	.24	-5.59	*p* <.01
	Post-Image	.36		
Zygo	Baseline	.15	-3.41	*p* <.01
	Post-Image	.22		
Automatic Sad				
Corr	Baseline	.51	-4.11	*p* <.01
	Post-Image	.62		
Obic	Baseline	.28	-3.47	*p* <.01
	Post-Image	.35		
Zygo	Baseline	.17	-1.32	NS
	Post-Image	.19		
Automatic Neutral				
Corr	Baseline	.51	-5.31	*p* <.01
	Post-Image	.61		
Obic	Baseline	.23	-2.37	*p* <.05
	Post-Image	.27		
Zygo	Baseline	.15	-1.29	NS
	Post-Image	.17		
Effortful Happy				
Corr	Baseline	.52	4.44	*p* <.01
	Post-Image	.41		
Obic	Baseline	.26	-21.62	*p* <.01
	Post-Image	.89		
Zygo	Baseline	.17	-19.70	*p* <.01
	Post-Image	.86		
Effortful Sad				
Corr	Baseline	.52	-17.25	*p* <.01
	Post-Image	1.08		
Obic	Baseline	.25	-11.04	*p* <.01
	Post-Image	.52		
Zygo	Baseline	.18	-6.59	*p* <.01
	Post-Image	.29		
Effortful Neutral				
Corr	Baseline	.51	-4.12	*p* <.01
	Post-Image	.62		
Obic	Baseline	.22	-5.96	*p* <.01
	Post-Image	.33		
Zygo	Baseline	.17	-3.68	*p* <.01
	Post-Image	.23		

Note. Corr = Corrugator Supercilii; Obic = Orbicularis Oculi; Zygo = Zygomaticus Major.

Effortful mimicry: Change in facial muscle activation from baseline to image presentation. As expected, significant differences were found in Zygo and Obic muscle activation before and after the presentation of happy images, with greater Zygo activation following the images than at baseline and greater Obic activation following the images than at baseline. Also as expected, significant differences were found in Corr muscle activation before and after the presentation of sad images, with greater Corr activation following the images than at baseline.

B & C) Is there an Association between Dysphoric Mood and the Ability to Automatically and Effortfully Mimic Others' Facial Expressions?

In order to assess whether dysphoric mood was associated with the ability to automatically and effortfully mimic others' facial expressions, change scores were calculated for each individual image by subtracting the mean facial muscle activation of the four seconds preceding the presentation of an image from the four seconds immediately following the presentation of each image (see Wexler et al., 1993). Change scores for each image presentation were averaged together per block of facial expressions in order to obtain an average change in facial muscle activity for both automatic and effortful mimicry following sad, happy, and neutral faces separately. Then, multiple regression was used, with calculated change scores for automatic and effortful mimicry for each muscle group following each facial expression group (happy, sad, and neutral) serving as dependent variables and dysphoric mood (assessed with multiple measures) as the independent variable. Age was significantly associated with NE and was controlled for throughout all analyses involving NE by adding it to the regression model. See Table 3 for a complete summary of regression analyses of all muscle groups.

Additionally, all significant and marginal regression results only were also examined using Univariate Analysis of Variance (ANOVA), comparing individuals in the bottom tertile to individuals in the top tertile of dysphoric mood scores, to better explore differences between those reporting the lowest and highest levels of dysphoria. Please see Appendix B for graphs of all ANOVA results. Across analyses, greater Zygo and Obic activity was expected following the presentation of happy facial expressions; greater Corr activity was expected following the presentation of sad facial expressions; and no change in muscle activation from baseline was expected following the presentation of neutral facial expressions.

Table 3
Standardized *ß* values from Significant and Marginal Regression Analyses Examining the Relationship between Dysphoria and Facial Mimicry

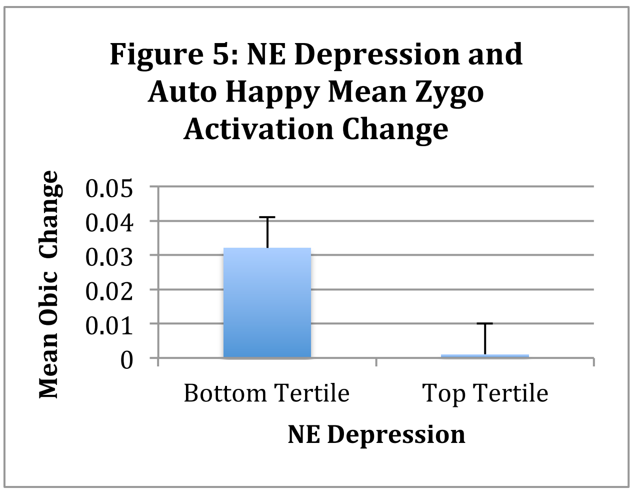
Variable	NM	NE	BDI	NM Depression	NE Depression
Automatic Happy					
Corr	NS	NS	NS	NS	NS
Obic	NS	NS	NS	NS	NS
Zygo	NS	-.16†	NS	NS	-.20*
Automatic Neutral					
Corr	NS	NS	NS	NS	NS
Obic	NS	NS	NS	NS	NS
Zygo	NS	NS	NS	NS	NS
Automatic Sad					
Corr	NS	NS	NS	NS	NS
Obic	NS	NS	NS	NS	NS
Zygo	NS	NS	NS	NS	NS
Effortful Happy					
Corr	NS	NS	NS	NS	NS
Obic	NS	-.20*	NS	-.19*	-.18*
Zygo	NS	NS	-.19*	NS	-.17†
Effortful Neutral					
Corr	NS	NS	NS	NS	NS
Obic	.18†	NS	NS	NS	NS
Zygo	NS	NS	NS	NS	NS
Effortful Sad					
Corr	NS	NS	NS	NS	NS
Obic	NS	NS	NS	NS	NS
Zygo	.16†	NS	.16†	.19*	.22*

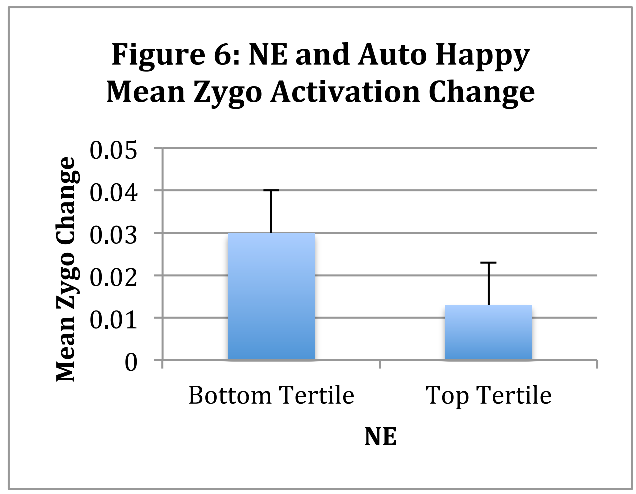
Note. Corr = Corrugator Supercilii; Obic = Orbicularis Oculi; Zygo = Zygomaticus Major. Age was controlled for throughout analyses based on associations with relevant outcomes. $^{**}p < .01$; $^{*}p < .05$; $^{\dagger}p \leq .10$.

Automatic mimicry of happy facial expressions.

Regression analyses. A significant relationship was found between high scores on the NE depression subscale and less change in Zygo muscle activation following happy facial expressions (ß = -.20, $p < .05$, $R^2 = .04$, $F(1, 122) = 4.99$, $p < .05$). Additionally, high NE was marginally associated with less change in Zygo muscle activation in automatic response to happy facial expressions (ß = -.16, $p < .10$; $R^2 = .03$, $F(1, 124) = 3.37$, $p < .10$).

ANOVA analyses. A significant difference was found between individuals in the bottom tertile ($M = .032$) and individuals in the top tertile ($M = .001$) of scores on the NE depression subscale when examining change in Zygo muscle activation following happy facial expression exposure, $F(1, 115) = 4.20$, $p < .05$, where individuals in the top tertile showed on average no change in Zygo activity (See Figure 5). When examining individuals in the top and bottom tertile of NE, there was no significant difference between groups in Zygo muscle activation change, although mean activation scores for the bottom tertile ($M = .030$) and top tertile ($M = .013$) were in the expected direction for happy facial expression exposure, with those reporting less NE showing more Zygo activation (See Figure 6).





Automatic mimicry of neutral facial expressions. As expected, no significant associations were found between automatic change in muscle activation following the presentation of neutral facial expressions and dysphoric mood.

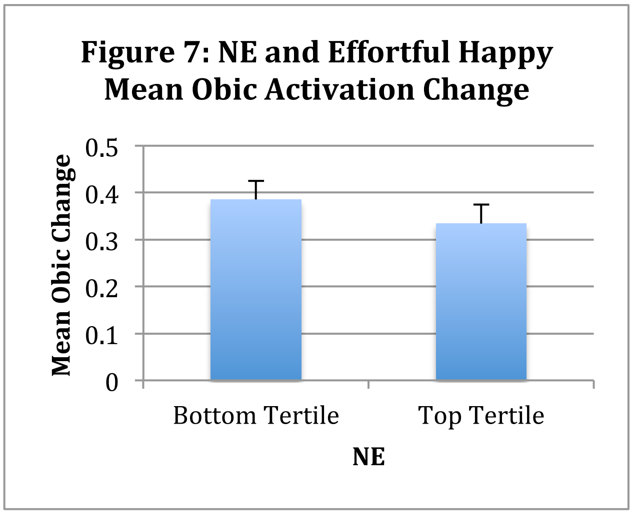
Automatic mimicry of sad facial expressions. Also as expected, no significant associations were found between automatic change in muscle activation following the presentation of sad facial expressions and dysphoric mood.

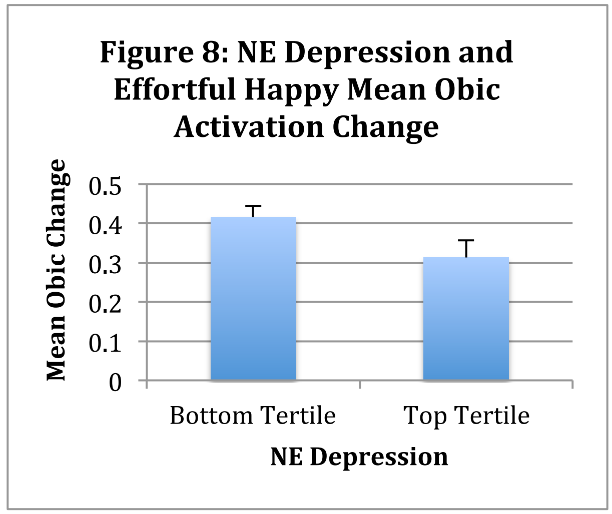
Effortful mimicry of happy facial expressions.

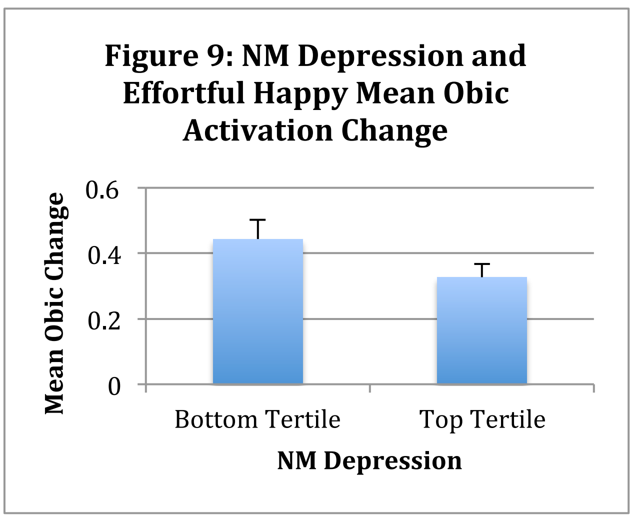
Regression analyses. Several significant and marginal associations were found between effortful change in Obic and Zygo muscle activation following the presentation of happy facial expressions and multiple measures of dysphoric mood. Greater change in Obic activation was significantly associated with less NE, controlling for age, (ß = -.20, $p < .05$, $R^2 = .08$, $F(2, 122) = 5.00$, $p < .01$); lower scores on the NM depression subscale (ß = -.19, $p < .05$ $R^2 = .04$, $F(1, 123) = 4.38$, $p < .05$); and lower scores on the NE depression subscale (ß = -.18, $p < .05$, $R^2 = .03$, $F(1, 122) = 3.96$, $p < .05$). Greater change in Zygo activation was significantly associated with fewer depressive symptoms measured by the Beck Depression Inventory (ß = -.19, $p < .05$, $R^2 = .04$, $F(1, 123) = 4.59$, $p < .05$); and marginally associated with lower scores on the NE depression subscale (ß = -.17, $p < .10$, $R^2 = .03$, $F(1, 122) = 3.41$, $p < .10$).

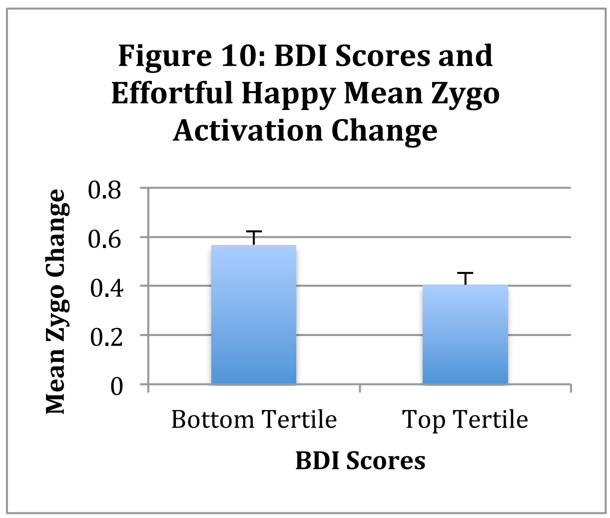
ANOVA analyses. No significant difference in Obic change was found between those in the bottom tertile ($M = .385$) and top tertile ($M = .334$) of NE scores in response to happy facial expressions, although means were in the expected direction, with individuals reporting low NE showing more Obic activation (See Figure 7). A marginal difference was found in Obic activation change between individuals in the bottom tertile ($M = .416$) and top tertile ($M = .313$) of NE depression subscale scores, $F(1,113) = 3.91$, $p < .10$, again with individuals reporting lower dysphoric mood showing greater change in Obic activation following the presentation of happy facial expressions (See Figure 8). No significant difference in Obic activation was found between individuals in the bottom tertile ($M = .443$) and top tertile ($M = .327$) of NM depression subscale scores, although mean values were also in the expected direction (See Figure 9). Significant differences in Zygo change were found between those in the bottom tertile ($M = .567$) and top tertile ($M = .405$) of Beck Depression Inventory scores, $F(1,77) = 4.97$, $p < .05$ (See

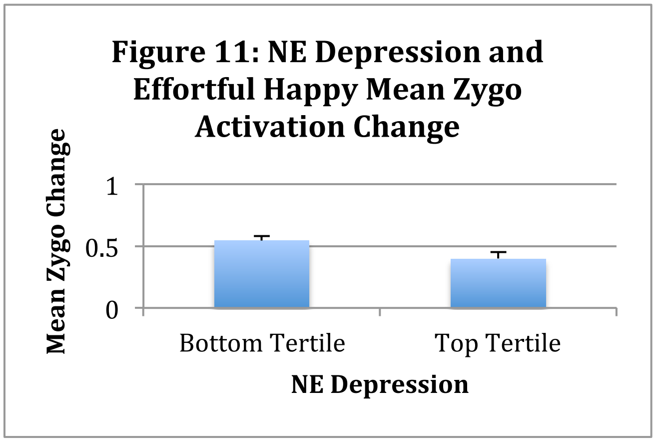
Figure 10), as well as those in the bottom tertile (M = .543) and top tertile (M = .397) of NE depressed affect scores, $F(1,113) = 4.72$, $p < .05$ (See Figure 11).







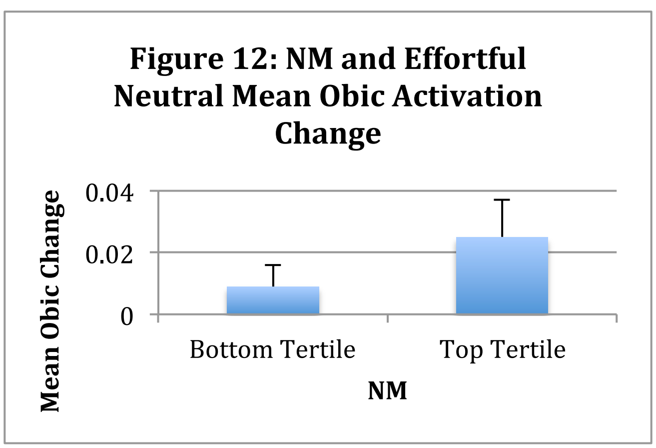




Effortful mimicry of neutral facial expressions.

Regression analyses. Although no specific associations between facial muscle activation and dysphoric mood were hypothesized following mimicry of neutral facial expressions, greater change in Obic activity was marginally associated with greater NM (ß = .18, $p < .10$, $R^2 = .03$, $F(1, 121) = 3.79$, $p < .10$), indicating that those higher in dysphoric mood were incorrectly activating muscles around their eyes.

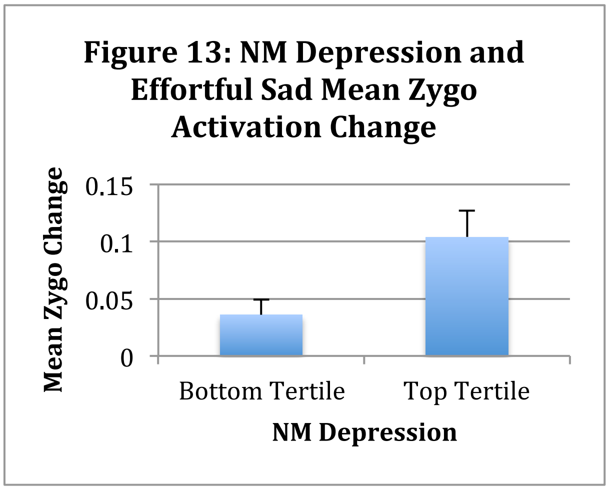
ANOVA analyses. No significant difference in Obic activity was found between those in the bottom tertile ($M = .009$) and top tertile ($M = .025$) of NM (See Figure 12).

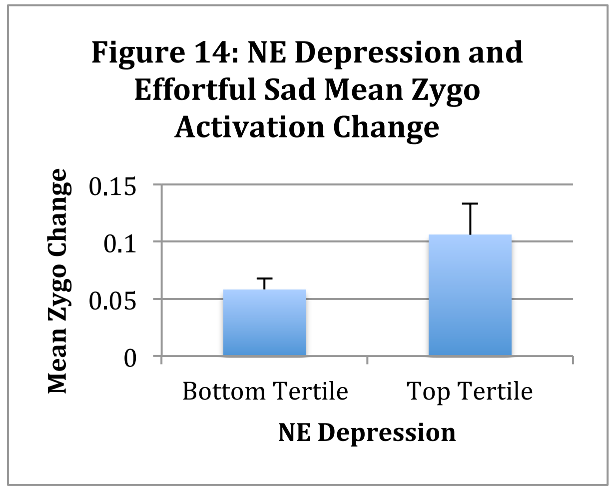


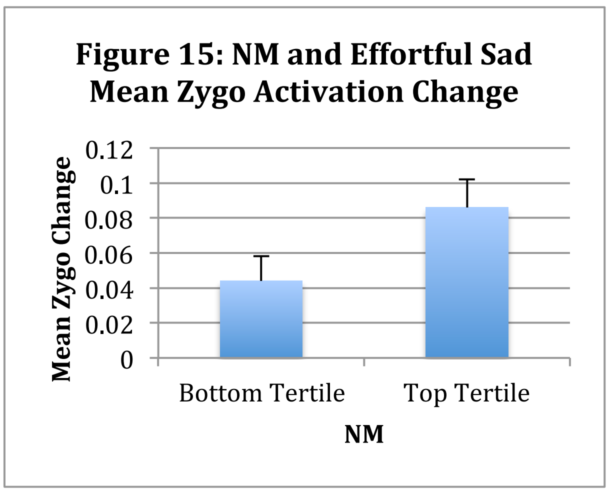
Effortful mimicry of sad facial expressions.

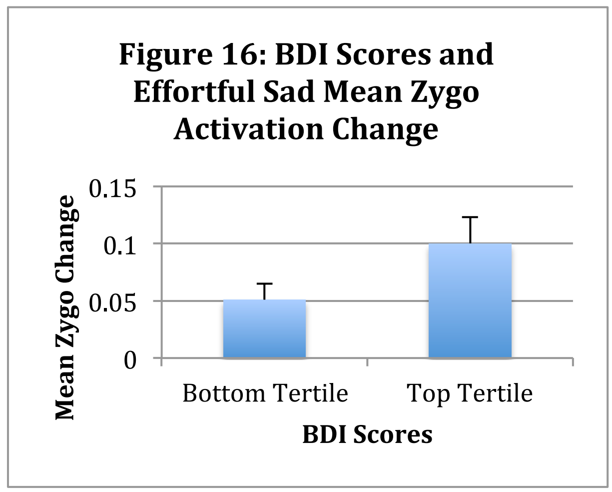
Regression analyses. Although no change in Zygo activity was hypothesized following mimicry of sad facial expressions, greater effortful change in Zygo activity following the presentation of sad facial expressions was found to be associated with multiple measures of dysphoric mood, including higher scores on the NM depression subscale (ß = .19, $p < .05$, $R^2 = .04$, $F(1, 124) = 4.53$, $p < .05$); higher scores on the NE depression subscale (ß = .22, $p < .05$, $R^2 = .05$, $F(1, 123) = 6.15$, $p < .05$); higher NM (ß = .16, $p < .10$, $R^2 = .03$, $F(1, 124) = 3.29$, $p < .10$); and symptoms of depression measured by the Beck Depression Inventory (ß = .16, $p < .10$, $R^2 = .02$, $F(1, 124) = 3.05$, $p < .10$). This indicates that individuals higher in measures of dysphoric mood were activating the *incorrect* facial muscle group, the Zygo muscle in the cheek, which is not necessary to correctly mimic a sad facial expression.

ANOVA analyses. Significant differences in Zygo change were found between those in the bottom tertile ($M = .036$) and top tertile ($M = .104$) of NM depression subscale scores, $F(1, 77) = 5.88$, $p < .05$ (See Figure 13); and those in the bottom tertile ($M = .058$) and top tertile ($M = .106$) of NE depression subscale scores, $F(1, 114) = 4.23$, $p < .05$ (See Figure 14), with individuals reporting higher dysphoric mood showing greater activation in the Zygo muscle, which is incorrect for sad facial expression mimicry. A marginal difference in Zygo change was found between those in the bottom tertile ($M = .044$) and top tertile ($M = .086$) of NM, $F(1, 84) = 3.91$, $p < .10$ (See Figure 15), and no significant difference in Zygo change was found between those in the bottom tertile ($M = .051$) and top tertile ($M = .100$) of Beck Depression Inventory scores (See Figure 16), although corresponding means were in the expected direction.









D) Is there an Association between Dysphoric Mood and Change in Emotions Experienced Following the Presentation of Sad, Happy, and Neutral Facial Expressions?

In order to assess whether dysphoric mood is associated with change in emotional experience following the presentation of each emotional image set, change scores for the PE well-being subscale (WB = happy, pleased, cheerful) and the NE depression subscale (DE = unhappy, depressed, sad) were calculated from baseline NE to each emotion questionnaire given throughout the five rest periods of the study, and multiple regression was utilized, with emotion change scores from baseline to each rest period serving as dependent variables and dysphoric mood as the independent variable. Mean emotion scores were examined at baseline and each rest period before analyses were completed to ensure that potential boredom as the study went on did not lead to a linear decline in WB and increase in DE. See Figures 17 and 18 below for graphs of mean emotion change throughout the study. Although small, gradual decreases in both WB and DE were seen across the study, suggesting that individuals reported lower levels of both WB and DE over time as the study progressed.

Associations between multiple measures of dysphoric mood and change in both WB and DE following the presentation of images were generally significant across all analyses, with just a few marginal and non-significant results. See Table 4 for complete results of regression analyses. Additionally, all significant and marginal regression results were also examined using Univariate Analysis of Variance (ANOVA), comparing individuals in the bottom tertile to individuals in the top tertile of dysphoric mood scores. See Appendix B, Tables 5 and 6 for the means and directions of all ANOVA results. One important note is that all emotion change results must be interpreted with caution, as a floor effect may be partially responsible for these findings. Individuals in the upper tertile of dysphoric mood reported very low baseline levels of WB (*M* = 1.20 across dysphoric mood measures) compared with individuals in the lower tertile (*M* = 2.27 across measures of dysphoric mood), and individuals in the bottom tertile reported almost no DE across measures (*M* = .05) compared with those in the upper tertile (*M* = 1.20).

Figure 17: Positive Emotion Well-Being Subscale Scores from Baseline to Study Completion

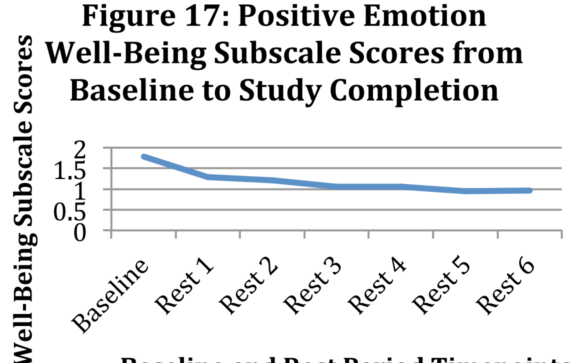


Figure 18: Negative Emotion Depression Subscale Scores from Baseline to Study Completion

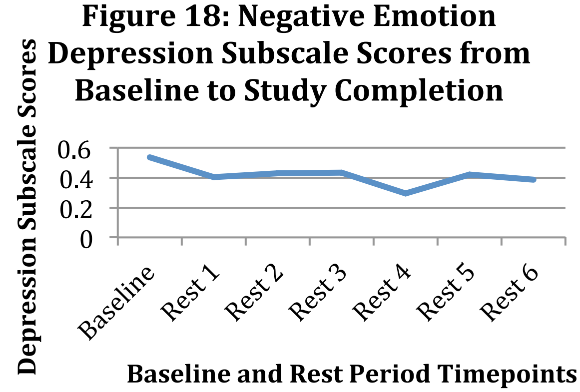


Table 4

Standardized *ß* values from Regression Analyses Examining the Relationship between Baseline Dysphoria and Change in PE Well-being Subscale Scores (WB) and NE Depression Subscale Scores (DE) Following Facial Mimicry

Variable	NM	NE	BDI	NM Depression	NE Depression
Automatic Happy					
DE Change	-.38**	-.61**	-.34**	-.40**	-.71**
WB Change	.24**	.18*	.23**	.19*	.17†
Automatic Neutral					
DE Change	-.32**	-.42**	-.33**	-.37**	-.51**
WB Change	.23**	.20*	.21*	.23**	.22*
Automatic Sad					
DE Change	-.17†	-.33	-.22**	-.24*	-.46*
WB Change	.26**	.29**	.17*	.25**	.29**
Effortful Happy					
DE Change	-.40**	-.52**	-.45**	-.41**	-.67**
WB Change	.25**	.17†	.29**	.22*	.19*
Effortful Neutral					
DE Change	-.39**	-.45**	-.38**	-.42**	-.60**
WB Change	.28**	.26**	.29*	.29*	.26*
Effortful Sad					
DE Change	-.28**	-.37**	-.31**	-.33**	-.52**
WB Change	.27**	.19*	.26**	.29**	.23*

Note. WB = Positive Emotion Well-being Subscale Scores ; DE = Negative Emotion Depression Subscale Scores NM = Baseline Negative Mood; NE = Baseline Negative Emotion; BDI = Beck Depression Inventory; NM Depression = Depression Subscale of Negative Mood Measure; NE Depression = Depression Subscale of Negative Emotion Measure. **$p < .01$; *$p < .05$; †$p \leq .10$.

Affect change following automatic mimicry.

Automatic happy. Following the automatic mimicry of positive facial expressions, high scores on all measures of dysphoric mood were significantly associated with decreases in WB and increases in DE (See Table 4). More specifically, ANOVA results (See Figure 19) revealed that although both individuals in the lower and upper tertile of all dysphoric mood variables reported a decrease in WB, individuals in the upper tertile of all dysphoric mood variables reported *less* of a decrease in WB, which occurred across the study naturally (See Figure 17). However, examination of baseline WB scores for both groups suggests a likely floor effect preventing individuals in the lower tertiles of NE from reporting a true incremental change in well-being due to very low initial baseline scores of well-being across measures of dysphoric mood at baseline for the lower tertile.

When examining DE separately, individuals in the lower tertile of all dysphoric mood variables reported increases in DE upon viewing happy faces, whereas individuals in the higher tertile of dysphoric mood reported decreases in DE (See Figure 20). However, a similar floor effect may have affected these results, with individuals in the lower tertile reporting almost no baseline DE scores to begin with.

Figure 19: NE and Change in WB Following Automatic Mimicry of Happy Facial Expressions

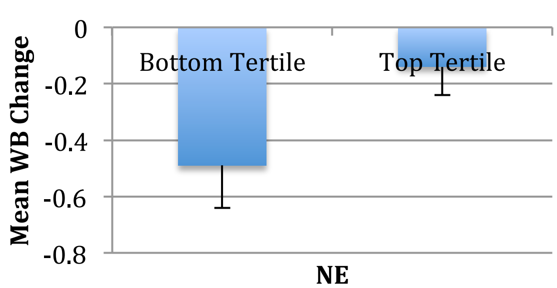
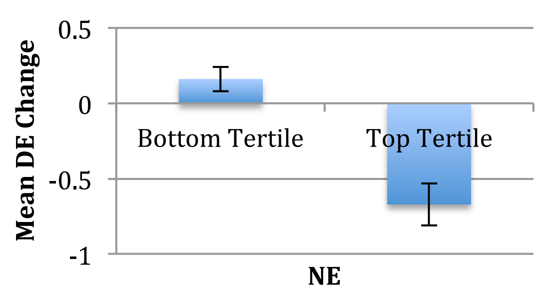


Figure 20: NE and Change in DE Following Automatic Mimicry of Happy Facial Expressions



Automatic sad. Following the automatic mimicry of sad facial expressions, scores on all measures of dysphoric mood were significantly associated changes in both WB and DE (See Table 4). ANOVA results indicated that individuals in both the lower and upper tertile of all measures of dysphoric mood displayed a decrease in WB; however individuals in the lower tertile of all dysphoric mood measures consistently displayed a greater decrease in WB than individuals in the upper tertile after viewing sad faces (See Figure 21). Again, it is possible that a floor effect may be partially responsible for these results, given very low starting mean WB scores reported by those in the lower tertile of NE.

Furthermore, when examining DE change separately, ANOVA results indicated that individuals in the lower tertile of dysphoric mood reported increases in DE, whereas individuals in the upper tertile reported decreases (See Figure 22). This suggests that individuals higher in baseline dysphoric mood might experience significantly different shifts in DE than individuals lower in dysphoric mood in response to the presentation and mimicry of negative facial expressions.

Figure 21: NE and Change in WB Following Automatic Mimicry of Sad Facial Expressions

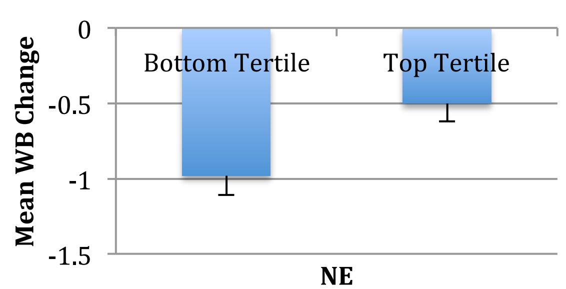
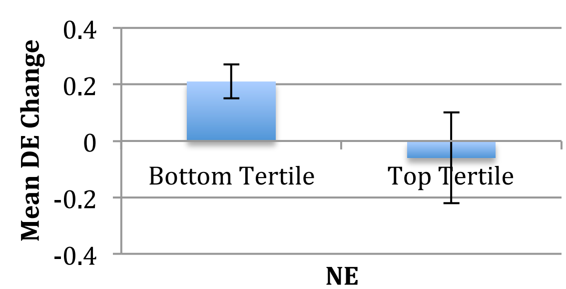


Figure 22: NE and Change in DE Following Automatic Mimicry of Sad Facial Expressions



Automatic neutral. Following the automatic mimicry of neutral facial expressions, all measures of dysphoric mood were again significantly associated with changes in both WB and DE (See Table 4). ANOVA results indicated that individuals in both the lower and upper tertile of all measures of dysphoric mood displayed a decrease in WB; however individuals in the lower tertile of all dysphoric mood measures consistently displayed a greater decrease in WB than individuals in the upper tertile (See Figure 23). When examining DE change separately, ANOVA results indicated that individuals in the lower tertile of dysphoric mood reported increases in DE, whereas individuals in the upper tertile reported decreases (See Figure 24). This suggests that individuals higher in baseline dysphoric mood experience significantly different shifts in DE (in opposite directions) than individuals lower in dysphoric mood in response to the presentation and mimicry of neutral facial expressions.

Figure 23: NE and Change in WB Following Automatic Mimicry of Neutral Facial Expressions

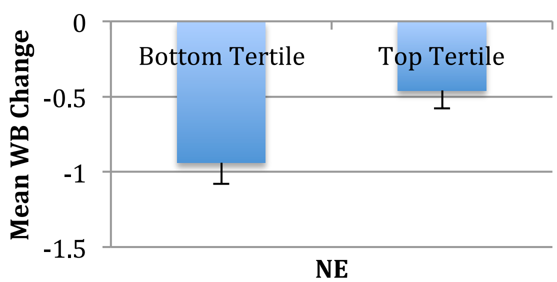
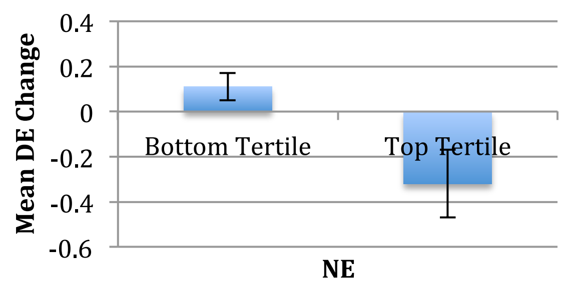


Figure 24: NE and Change in DE Following Automatic Mimicry of Neutral Facial Expressions



Affect change following effortful mimicry.

Effortful happy. Following the effortful mimicry of positive facial expressions, high scores on all measures of dysphoric mood were significantly associated with decreases in WB and increases in DE (See Table 4). More specifically, ANOVA results revealed that although both individuals in the lower and upper tertile of all dysphoric mood variables reported a decrease in WB, individuals in the upper tertile of all dysphoric mood variables reported *less* of a decrease in WB (See Figure 25). However, examination of baseline well-being scores for both groups suggests a likely floor effect may have prevented individuals in the lower tertile from reporting a true incremental change in WB due to very low initial baseline scores of WB across measures of dysphoric mood at baseline.

When examining DE separately, individuals in the lower tertile of all dysphoric mood variables reported very small increases on average in DE, whereas individuals in the higher tertile of dysphoric mood reported decreases in DE (See Figure 26). However, a similar floor effect may have affected these results, with individuals in the lower tertile reporting very low baseline DE scores.

Figure 25: NE and Change in WB Following Effortful Mimicry of Happy Facial Expressions

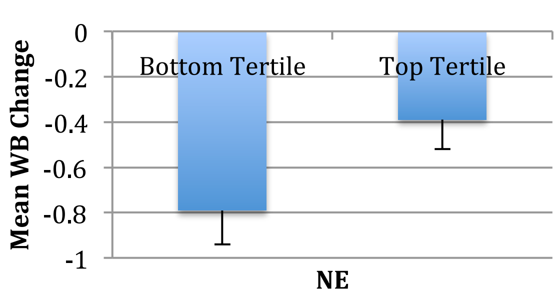
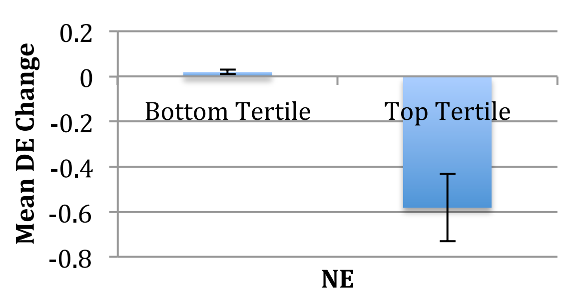


Figure 26: NE and Change in DE Following Effortful Mimicry of Happy Facial Expressions



Effortful sad. Following the effortful mimicry of sad facial expressions, all measures of dysphoric mood were significantly associated with changes in both WB and DE (See Table 4). ANOVA results indicated that individuals in both the lower and upper tertile of all measures of dysphoric mood displayed a decrease in WB; however individuals in the lower tertile of all dysphoric mood measures consistently displayed a greater decrease in WB than individuals in the upper tertile (See Figure 27). Furthermore, when examining DE change separately, ANOVA results indicated that individuals in the lower tertile of dysphoric mood reported small increases in DE, whereas individuals in the upper tertile reported decreases (See Figure 28). This suggests that individuals higher in baseline dysphoric mood experience significantly different shifts in DE than individuals lower in dysphoric mood in response to the presentation and mimicry of negative facial expressions.

Figure 27: NE and Change in WB Following Effortful Mimicry of Sad Facial Expressions

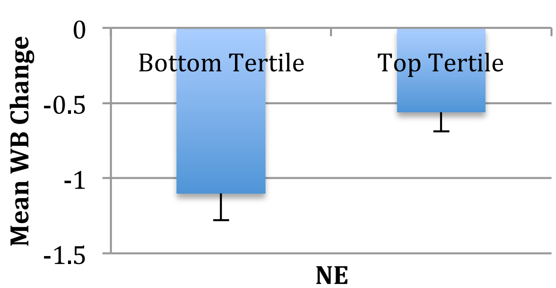
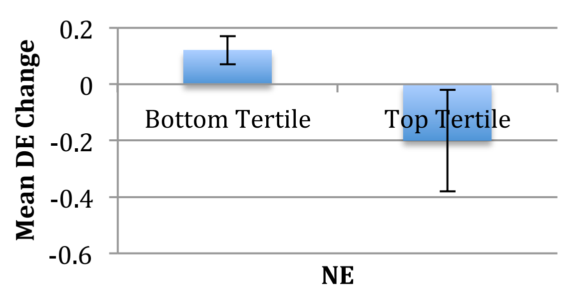


Figure 28: NE and Change in DE Following Effortful Mimicry of Sad Facial Expressions



__Effortful neutral.__ Following the effortful mimicry of neutral facial expressions, all measures of dysphoric mood were again significantly associated with changes in both WB and DE (See Table 4). ANOVA results indicated that individuals in both the lower and upper tertile of all measures of dysphoric mood displayed a decrease in WB; however individuals in the lower tertile of all dysphoric mood measures consistently displayed a greater decrease in WB than individuals in the upper tertile (See Figure 29). When examining DE change separately, ANOVA results indicated that individuals in the lower tertile of dysphoric mood reported increases in DE, whereas individuals in the upper tertile reported decreases (See Figure 30). This suggests that individuals higher in baseline dysphoric mood experience significantly different shifts in DE than individuals lower in dysphoric mood in response to the presentation and mimicry of neutral facial expressions.

Figure 29: NE and Change in WB Following Effortful Mimicry of Neutral Facial Expressions

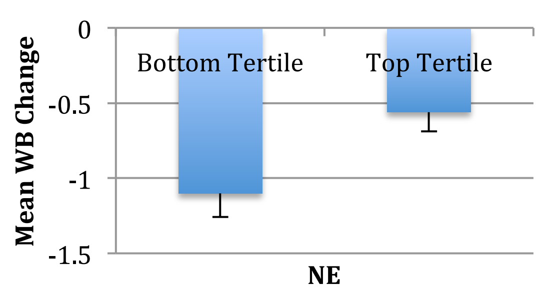
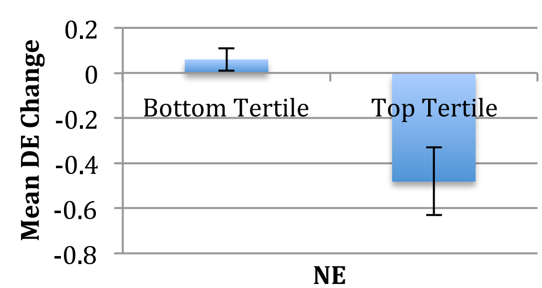


Figure 30: NE and Change in DE Following Effortful Mimicry of Neutral Facial Expressions



E) Is there an Association Between Facial Muscle Activation Change from Baseline to Automatic and Effortful Facial Expression Mimicry and Social Functioning?

In order to assess whether greater change in facial muscle activation from baseline during automatic and/or effortful mimicry is associated with social support, loneliness, and social competence, multiple regression was used, with facial muscle activation change scores regressed onto each of these social variables. Age was significantly associated with loneliness and was controlled for throughout all analyses involving loneliness by adding it to the regression model. Several significant associations were found between change in muscle activation and measures of self-reported social support and loneliness. No significant associations were found between change in muscle activation and social competence. See Table 7 for the results of these analyses. Additionally, all significant regression results were also examined using Univariate Analysis of Variance (ANOVA), comparing individuals in the bottom tertile to individuals in the top tertile of social functioning scores. In general, activating the correct muscle group (i.e., Zygo and Obic muscles following the presentation of happy facial expressions; Corr muscle following the presentation of sad facial expressions; and no change in any muscles following the presentation of neutral facial expressions) was hypothesized to be associated with better social functioning.

Table 7
Standardized *ß* values from Regression Analyses Examining the Relationship between Dysphoria and Self-reported Social Support and Loneliness

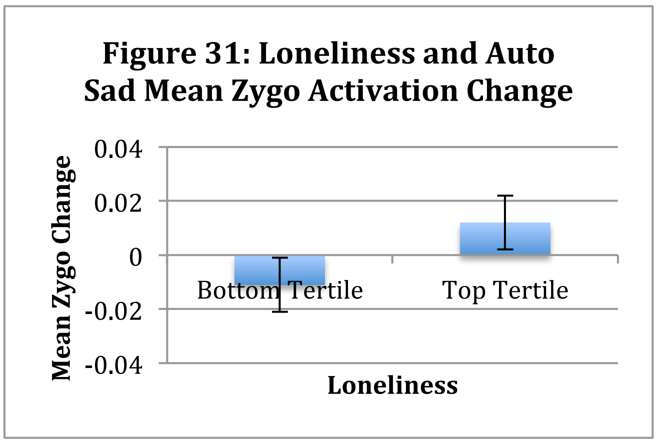
Variable	Social Support	Loneliness
Automatic Happy		
Corr	NS	NS
Obic	NS	NS
Zygo	NS	NS
Automatic Neutral		
Corr	NS	NS
Obic	NS	NS
Zygo	NS	NS
Automatic Sad		
Corr	NS	NS
Obic	NS	NS
Zygo	NS	.17*
Effortful Happy		
Corr	NS	NS
Obic	NS	-.15*
Zygo	NS	-.15*
Effortful Neutral		
Corr	NS	NS
Obic	NS	NS
Zygo	NS	NS
Effortful Sad		
Corr	.21*	-.17*
Obic	NS	NS
Zygo	**-.17†**	.21*

Note. Corr = Corrugator Supercilii; Obic = Orbicularis Oculi; Zygo = Zygomaticus Major**.** Age was controlled for throughout loneliness analyses based on association with loneliness scores. $^{**}p < .01$; $^{*}p < .05$; $^{†}p \leq .10$.

Facial muscle change with automatic mimicry and social functioning.

Regression results. Controlling for age, greater automatic change in Zygo activation following the presentation of sad facial expressions was significantly associated with self-reported loneliness ($ß = .17$, $p < .10$, $R^2 = .07$, $F(2, 125) = 4.35$, $p < .05$), which indicates that automatically activating the incorrect muscle group following the presentation of sad facial expressions is associated with increased loneliness.

ANOVA results. No significant difference in Zygo activation change following the presentation of sad facial expressions was found between those in the bottom tertile (*M* = -.011) and top tertile (*M* = .012) of loneliness scores, although corresponding means were in the expected direction, with individuals reporting lower dysphoric mood showing a decrease in Zygo activation and individuals reporting higher dysphoric mood showing an increase (See Figure 31).



Facial muscle change with effortful mimicry and social functioning.

Regression results. Following the presentation of happy facial expressions, significant associations, controlling for age, were found between greater self-reported loneliness and less Obic activation change (ß = -.15, $p < .05$, $R^2 = .05$, $F(2, 122) = 3.43$, $p < .05$), and less Zygo activation change (ß = -.15, $p < .05$, $R^2 = .06$, $F(2, 122) = 3.51$, $p < .05$), which suggests that less activity in the correct muscle groups following the presentation of happy facial expressions is associated with greater loneliness. Following the presentation of sad facial expressions, a significant association was found between higher self-reported social support and greater Corr activation change (ß = .21, $p < .05$, $R^2 = .04$, $F(1, 124) = 5.60$, $p < .05$), and a marginal association was found between higher self-reported social support and less Zygo activation change (ß = -.17, $p < .10$, $R^2 = .03$, $F(1, 124) = 3.81$, $p < .10$), which again suggests that activating the correct muscle groups associated with the presentation of sad facial expressions is associated with more perceived social support. Significant associations were also found, controlling for age, in response to the presentation of sad facial expressions between greater self-reported loneliness and less Corr activation change (ß = -.17, $p < .05$, $R^2 = .07$, $F(2, 123) = 4.62$, $p < .05$), as well as more Zygo activation change (ß = .21, $p < .05$, $R^2 = .08$, $F(2, 123) = 5.51$, $p < .01$), again providing supporting evidence for the association between incorrect muscle activation and greater self-reported loneliness.

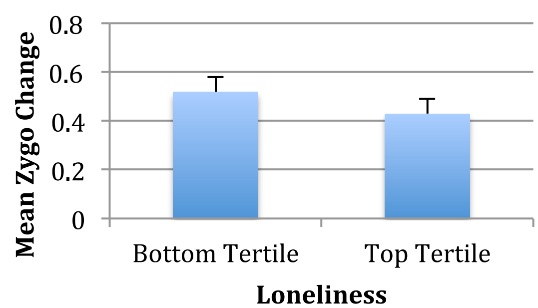
ANOVA results. No significant difference in Obic activation change following the presentation of happy facial expressions was found between those in the bottom tertile (M = .414) and top tertile (M = .338) of loneliness scores, although corresponding means are in the expected direction, with individuals reporting lower dysphoric mood also showing higher Obic activation following the presentation of happy facial expressions (See Figure 32). Similarly, no significant difference in Zygo activation change following the presentation of happy facial expressions was found between those in the bottom tertile (M = .519) and top tertile (M = .429) of loneliness scores, although corresponding means were also in the expected direction (See Figure 33).

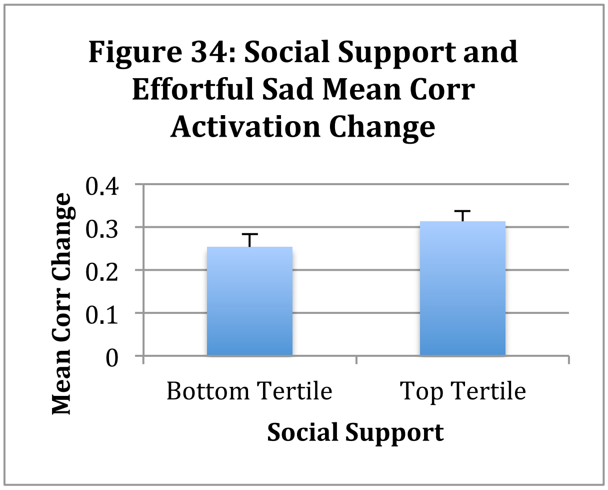
Following the presentation of sad facial expressions, no significant difference in Corr activation change was found between those in the bottom tertile (M = .253) and top tertile (M = .313) of social support scores, although means are in the expected direction with individuals reporting greater social support also showing greater Corr activation change in response to sad facial expressions (See Figure 34). A significant difference in Zygo activation change following the presentation of sad facial expressions was found between those in the bottom tertile (M = .114) and top tertile (M = .051) of social support scores, $F(1, 85) = 5.22$, $p < .05$, with individuals reporting lower social support also showing greater activation of the wrong muscle group, the Zygo muscle, following the presentation of sad facial expressions (See Figure 35). Similarly, a significant difference in Zygo activation change following the presentation of sad facial expressions was found between those in the bottom tertile (M = .058) and top tertile (M = .118) of loneliness scores, $F(1, 81) = 4.51$, $p < .05$, with individuals reporting greater loneliness also showing greater activation of the wrong muscle group, the Zygo muscle, following the presentation of sad facial expressions (See Figure 36).

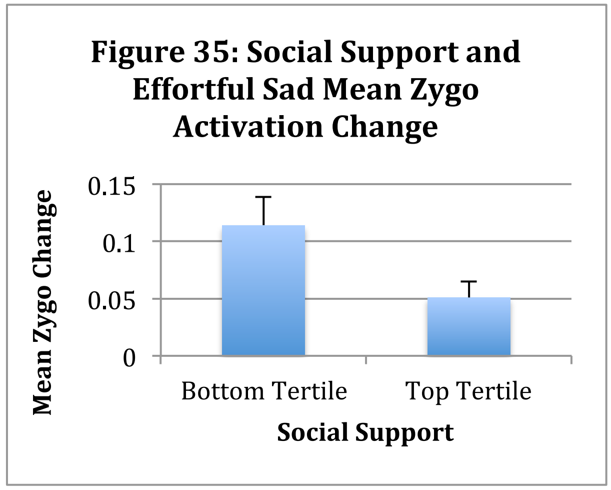
No significant difference in Corr activation change following the presentation of sad facial expressions was found between those in the bottom tertile (M = .297) and top tertile (M = .243) of loneliness scores, although corresponding means were in the expected direction, with individuals reporting lower loneliness also showing greater change in Corr activation following the presentation of sad facial expressions (See Figure 37).

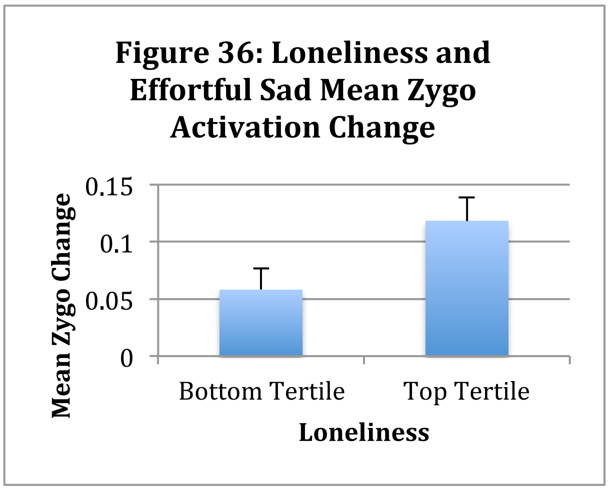
Figure 32: Loneliness and Effortful Happy Mean Obic Activation Change

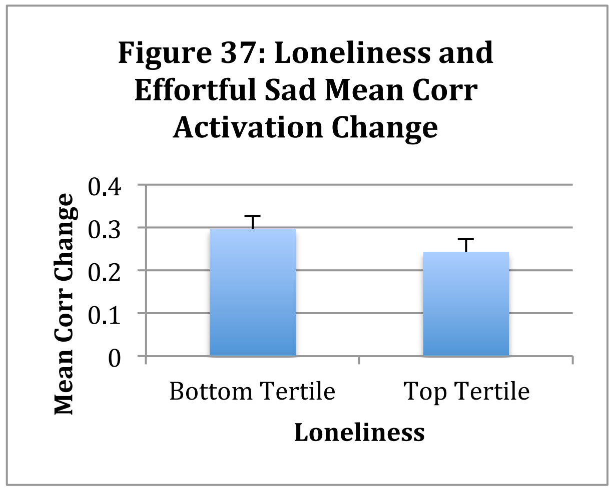
Figure 33: Loneliness and Effortful Happy Mean Zygomaticus Activation Change











F) Is Dysphoric Mood Associated with Recognition of Images Presented throughout the Study?

To assess whether dysphoric mood is associated with recognition of images presented throughout the study, multiple regression was used, with mood regressed onto a total recognition score, which was calculated as a ratio of the total number of correct images identified divided by the total number of incorrect images identified. Furthermore, dysphoric mood was also regressed on to a number of recognition variables accounting for conjunction errors via the series of varied faces used in the recognition task, including the percentage of correct positive and negative facial expressions identified, and the percentage of images misidentified that were in the categories examining faces that had appeared in the study but with an alternate facial expression and facial expressions that had appeared in the study but with an alternate face. See Table 8 for a summary of the percentage of correct and incorrect positive and negative images recognized. The sample as a whole scored very high on the recognition task, with an average of 85.12% correct images identified. No significant results were found throughout regression analyses, suggesting that dysphoric mood was not associated with facial expression recognition. Additionally, differences between upper and lower tertiles for each measure of dysphoric mood were examined using ANOVA. All results remained insignificant with the exception of one significant difference found between individuals in the lower (M = 92%) and upper (M = 82%) tertiles of trait depressive affect in the percentage of correct images identified total, $F(1, 49) = 5.67$, $p < .05$. This single significant finding is in the hypothesized direction, with individuals reporting higher trait depressive affect performing more poorly on the facial recognition task. However, results must be interpreted with caution, as the recognition task was added into the study at its mid-point, with only 75 of the 136 participants total completing these items at the end of the study.

Table 8

Mean, Range, and Standard Deviation for percentage scores (% OF ANSWERS CORRECT) on the Facial Expression Recognition Task

Variable	Range	Mean	SD
Percent of Correct Images Identified			
Total	1 – 100	85.12	18.64
Positive Expressions	0 – 100	90.04	23.09
Negative Expressions	0 – 100	83.35	27.63

Discussion

The current study examined the association between dysphoric mood and automatic and effortful facial expression mimicry in a sample of college students. Although multiple published studies have reported deficits in automatic facial expression mimicry for individuals with depression and dysphoria (Lautzenhiser, 2003; Sloan et al., 2002; Wexler et al., 1993), this is the first study to examine *effortful* facial expression mimicry in individuals experiencing dysphoric mood. Overall, results support previous literature by verifying a significant association between increased dysphoric mood and less change in facial muscle activation during automatic mimicry of positive facial expressions. More importantly, these results add to previous literature by confirming a significant and important association between increased dysphoric mood and less change in facial muscle activation during *effortful* mimicry of happy facial expressions. Additionally, current results show that individuals reporting high levels of dysphoria also have impaired effortful mimicry of sad facial expressions, with activation of incorrect muscle groups (i.e., the Zygo muscle) present during effortful mimicry of sad facial expressions.

General results examining dysphoric mood and facial expression mimicry confirmed the central hypothesis that dysphoric mood and emotions are associated with decreased ability to both automatically and effortfully mimic positive facial expressions. Although this association was not found across all measures of dysphoric mood, it was found between greater dysphoric affect, measured by both a negative state emotion scale and more specifically, the depression subscale of the negative emotion scale, and less change in automatic Zygo activity following the presentation of happy facial expressions. Associations were also found between dysphoric mood and less facial muscle activation in both the Zygo and Obic muscles during effortful mimicry of happy facial expressions. Specifically, higher scores on the Beck Depression Inventory were associated with less change in Zygo activity following the presentation of happy facial expressions, and higher dysphoric mood, measured by the negative emotion scale as well as the depression subscales of both the negative emotion and negative mood scales, was significantly associated with less change in Obic activity. In fact, individuals in the top tertile of negative emotion depression subscale scores showed virtually no change on Obic activity ($M = .001$) during effortful mimicry of happy faces. This lack of activity supports previous research suggesting that activation of both the Zygo and Obic muscles during happy facial expression, termed the “Duchenne Smile” is difficult to effortfully master without genuinely felt positive emotion present (Duchenne, 1862/1990; Frank & Ekman, 1993). However, individuals in the lower tertile of dysphoric mood scores were able to express clear activation in both the Zygo and Obic muscles during effortful mimicry of happy facial expressions, which indicates that individuals high in dysphoric mood do show impairment in facial reactivity to positive facial expressions, both automatically and effortfully, when compared with non-dysphoric individuals.

Additionally, contrary to the initial hypothesis that no significant association would be found between dysphoric mood and mimicry of neutral or negative facial expressions, current results confirmed that individuals high in dysphoric mood do display differences in effortful mimicry of sad facial expressions, with greater Zygo activation change, which is not typically seen during sad facial expression, present for individuals reporting higher dysphoric mood. Previous literature has shown similar deficits in automatic mimicry of positive facial expressions, with greater Corr activation, which is typically not associated with happy facial expressions, found in depressed individuals (Sloan et al., 2002); however, activation of incorrect muscle groups following mimicry of sad facial expressions has not been seen.

Higher dysphoric mood was also marginally associated with greater Obic activity during effortful mimicry of neutral faces. Because no significant change was expected during mimicry of neutral expressions, this suggests that dysphoric individuals may have had more difficulty accurately perceiving or interpreting the neutral image on the screen and may have been attempting to mimic muscle movement that was not present in the images. This is consistent with previous research showing that depressed individuals perceive neutral images to be more negative than they actually are (e.g., Gollan et al., 2008; Gur et al., 1992; Leppanen et al., 2004; Surguladze et al., 2004) and indicates a global problem with effortful mimicry in dysphoric individuals. Depressed individuals have also been shown to take significantly longer to recognize a neutral facial expression as emotionally neutral than non-depressed individuals, which indicates that there may be fundamental perception errors associated with depression before mimicry occurs (Leppanen et al., 2004).

Abnormal functioning throughout neural pathways linked to perception of negative emotions has also been identified in depressed individuals, with decreased activation during viewing of sad and angry facial expressions found in the dorsolateral prefrontal cortex, inferior orbitofrontal cortex, and medial orbitofrontal cortex, areas associated with processing of emotion-related stimuli (Lee et al., 2008). Future studies should continue to examine irregularities in neural pathways linked to processing of emotional information for individuals with dysphoria and depression, as effective mimicry depends on accurate visual perception facial expressions.

These deficits seen in effortful mimicry of facial expressions for individuals reporting high dysphoric mood have profound implications for clinical treatments for individuals with mild to moderate depression as well as future research on this population. To date, social skills training (SST), which often includes instruction and coaching related to effective non-verbal communication, has been widely employed in conjunction with other therapies to treat symptoms of depression and enhance social functioning in this population (see Segrin, 2000). Although SST has generally been found to be an effective adjunctive treatment for many individuals with depression (Segrin, 2000), the current results suggest that basic awareness and instruction in facial expression mimicry may not alone be effective in helping depressed individuals accurately mimic facial expressions. Additionally, it has been well documented that individuals with depression process facial expressions differently than non-depressed individuals, showing deficiencies in the ability to process expressions effortfully, which particularly affects cognitive processing of positive facial expressions (Hartlage et al. 1993). Results of the current study suggest that this processing deficiency may also be present in those with subclinical levels of depressive symptoms and that simply asking dysphoric individuals to purposefully mimic a happy facial expression is not enough instruction to lead to successful mimicry. Future studies should seek to test whether a more explicit SST module, with instruction about the specific muscle groups involved on happy facial expression (i.e., the Obic and Zygo muscles) could lead to more accurate effortful mimicry of positive facial expression.

Alternatively, it is possible that deficiencies in automatic and effortful mimicry seen in those with dysphoria and depression may be due to more than processing error or misperception. Previous research using functional magnetic resonance imaging (fMRI) has examined individuals with and without experimentally induced tryptophan depletion, which lowers brain serotonin levels in a manner similar to depletions seen in those with depressive symptoms, and has concluded that significant differences exist between these groups in the areas of the brain responsible for processing emotion and happy facial expressions, although no significant difference were seen in the processing of sad facial expressions (Daly et al., 2010).

Furthermore, fMRI research has also examined activity in the somatosensory cortices, areas heavily involved in emotional mimicry, in individuals with attachment avoidance, or the tendency to withdraw from social relationships, and has identified marked differences in activity of the primary somatosensory cortex between individuals with and without attachment avoidance in response to the viewing of negative facial expressions, with individuals in the attachment avoidance group showing less responsiveness in this region (Suslow et al., 2009). Currently, little is known about the exact brain regions responsible for the mimicry of emotional expressions. Future studies should continue to use fMRI to more accurately identify brain regions responsible for facial expression identification and mimicry as well as the neural pathways responsible for the connection between perception of facial expression and accurate motor output via muscle movement during mimicry to see if problems might exist in a sensorimotor pathway linking perception and action during mimicry.

Dysphoric mood was also expected to be associated with change in negative emotional experience throughout the study (i.e., reported increases in negative emotions following the appearance of negative facial stimuli) but not in positive emotional experience. However, despite deficits observed in positive facial expression mimicry, statistically significant associations were found between dysphoric mood and both change in emotions related to well-being (WB) and depression (DE) throughout the study. Particularly, decreases in WB were reported following both automatic and effortful mimicry of happy facial expressions, although when examining change in DE, individuals in the top tertile of dysphoric mood reported a decrease in depression, while individuals in the bottom tertile of dysphoric mood reported an increase. This suggests that although mimicry of positive facial expression did not necessarily increase WB, it may have had a differential impact on individuals reporting the highest baseline dysphoria, leading to less reporting of DE following mimicry of happy faces.

Following automatic and effortful mimicry of sad facial expressions, individuals in both the upper and lower tertile of dysphoric mood reported decreases in well-being; however, when examining emotions related to depression separately, those in the upper tertile of dysphoric mood generally reported a *decrease* in depression, whereas individuals in the lower tertile reported increases. This suggests that mimicry of sad facial expressions did have the hypothesized effect of increasing emotions related to depression but only for individuals reporting low baseline dysphoric mood. For individuals reporting higher baseline dysphoric mood, mimicry of sad facial expressions appeared to decrease these emotions. Although this decrease in DE was contrary to the initial hypothesis, it is actually consistent with the pattern of increased Zygo muscle movement observed in this group, which is more typically seen in positive facial expression. The facial feedback hypothesis (FFH) (Tourangeau and Ellsworth, 1979) states that the activation of muscles in the face contribute to change in emotional experience. According to the FFH, activation of the Zygo muscle would be associated with decreases in negative emotion. However, post hoc analyses did not show facial muscle activation to be a significant mediator of the associations between dysphoric mood and change in DE and WB following sad facial expressions, likely due to the brief period of time facial muscle activity was assessed.

Similar change in emotional experience following mimicry of sad faces was found following mimicry of neutral faces, with individuals in the upper and lower tertile of dysphoric mood reporting decreases in well-being but only those in the upper tertile of dysphoric mood reporting a decrease in DE while those in the lower tertile reported increases. This is again consistent with the FFH and the marginal association found between increased Obic activity and the presence of dysphoric mood. Because Obic activity is typically associated with positive facial expression (i.e., a genuine, "Duchenne," smile), activating this region may have contributed to the decrease in DE reported. However, post hoc analyses did not show facial muscle activation to be a significant mediator of the associations between dysphoric mood and change in DE and WB following neutral expressions.

Unfortunately, it is also likely that a floor effect may have affected participants' ability to accurately express change in WB and DE, with individuals high in dysphoria reporting very low (almost no) baseline levels of well-being, and individuals low in dysphoria reporting very low baseline levels of depression. Because of this, interpretation of these results must be made with caution. In order to better capture true change in emotion, future studies examining change in emotion across time with dysphoric populations should consider using scales with a broader Likert scale in addition to asking about emotion right before and after each picture series to re-establish more accurate baseline scores over time.

Because facial mimicry has been shown to be one of the most important nonverbal methods of communication (e.g., Izard, 1989; Keltner & Haidt, 1999, Manstead, 1991), it was hypothesized that greater facial muscle activation change from baseline during both automatic and effortful mimicry (i.e., correct muscle activation, more clear mimicry) would be associated with greater reported social support, less loneliness, and greater perceived social competence. Across mimicry conditions, a clear association was found between activation of the correct muscle group for the expression at hand and both greater social support and less loneliness. A significant relationship was found between activation of the incorrect Zygo muscle during both automatic and effortful mimicry of sad facial expressions and greater self-reported loneliness; however, no significant results were found between social variables and automatic mimicry of happy and neutral faces. The presence of Zygo activity during effortful mimicry of sad faces was also negatively associated with social support. The presence of Corr activity, which is appropriate during mimicry of sad facial expressions, was *positively* associated with social support and *negatively* associated with loneliness, which suggests that activation of the correct muscle group for the expression leads to better social functioning. This is also supported by results showing that greater Obic and Zygo activity during effortful happy facial expression, which is appropriate for the expression, was associated with decreased loneliness. Regarding perceived social competence, no significant associations were found with facial muscle activation during mimicry.

These results suggest that accurate facial mimicry does translate to healthy perceptions of social functioning outside of the laboratory. Unfortunately, research has shown that the relationship between depression and social functioning is often bi-directional, with depression leading to greater social withdrawal and less confidence in social ability, and alternatively, these same perceived or actual social difficulties leading to increased depression (e.g., Bistricky et al., 2011). However, these results also suggest that improving the accuracy of facial mimicry could contribute to the discontinuation of this cycle by leading to more effective and rewarding social experiences for individuals with dysphoria and depression. Future studies should examine whether more careful instruction in facial mimicry via social skills training could not only be effective in helping individuals with dysphoria and depression correctly mimic others' expressions but also improve overall communication skills and interpersonal effectiveness.

Finally, previous research has shown discrepancies between dysphoric and non-dysphoric individuals in the ability to recognize facial expressions, with dysphoric individuals better able to recall sad faces than neutral or happy (e.g., Gollan et al., 2008; Gur et al., 1992; Leppanen et al., 2004; Surguladze et al., 2004). However, no significant association was found between dysphoric mood and facial expression recognition across conditions in the current study. When examining differences between individuals in the upper and lower tertile of dysphoric mood, there was a significant difference the total number of correct faces identified, with those in the lower tertile identifying more (M = 92%) compared with individuals in the upper tertile (M = 82%); however there was no significant association found between dysphoric mood and number of conjunction errors, one of the most common errors made in recognition memory tasks (e.g., Jones & Atchley, 2002). This suggests that those lower in dysphoric mood were slightly better than those high in dysphoric mood with facial expression recognition memory overall; however, differences were not seen between happy, sad, and neutral expressions individually. These results should be interpreted with caution, however, as the recognition task for this study was added into the study after its start date. Thus, only 75 of the 136 total participants completed the task, including 19 participants (25%) scoring a 13 or higher on the BDI at baseline, which is indicative of mild to moderate depressive symptoms.

Aside from the recognition task having limited data, the current study has other limitations to consider. First, the sample overall was relatively healthy, with only 21% reporting high enough scores on the Beck Depression Inventory at baseline to warrant concern of subclinical depression, and only two individuals reported a current diagnosis of clinical depression. Although the purpose of the current work was to examine the presence of dysphoria in a generally recruited population, future studies should seek to examine the association between dysphoria and effortful facial expression mimicry in a sample with a wider severity range to better understand the level of dysphoric mood typically present when deficits in mimicry are seen. Because the current analyses focused on the entire spectrum of dysphoric mood, all individuals with psychological disorders were included. However, consistent significant results differentiating individuals in the upper and lower tertiles of dysphoric mood throughout analyses indicates that deficits in facial expression mimicry and social functioning are primarily seen in the most dysphoric individuals. Thus, post hoc analyses were conducted, controlling for individuals who reported a current or past diagnosis of clinical depression, in order to determine whether removing those in the most severe segment of the sample altered results.

When controlling for current or past diagnosis of depression, associations between dysphoric mood and less activation of the Zygo and Obic muscles during both automatic and effortful positive facial expression remained significant or marginal, indicating that deficits in positive facial expression mimicry are seen in those reporting dysphoric mood, regardless of the presence of clinical depression. The association between dysphoric mood and increased Zygo activity during effortful mimicry of sad facial expressions remained significant with dysphoric mood measured by the depression subscale of the negative emotion scale. Other measures of dysphoria were not significantly associated with effortful mimicry of sad facial expressions when controlling for presence of clinical depression, which indicates that individuals at the most severe levels of dysphoria were likely driving this finding. Similarly, when controlling for current or past diagnosis of depression, significant associations remained between greater correct muscle activation (Corr) during sad facial expression and higher reported social support and lower loneliness. However, all other associations between facial muscle activation and social functioning became marginal or non-significant, which indicates that the most dysphoric individuals were driving these findings as well. Because the current results support deficits in mimicry and poor social functioning occurring especially in those individuals reporting the most dysphoria, future studies should also examine effortful mimicry in individuals diagnosed with clinical depression, particularly since this is the population likely to receive SST or other interventions designed to improve interpersonal communication and effectiveness.

In addition to a low number of participants in the sample reporting high levels of dysphoria, it was also clear that the questionnaire chosen to examine change in positive and negative emotions across the study was likely influenced by a floor effect in responding. Future studies should consider using a questionnaire with a wider Likert scale to allow for more movement in responding across time. Additionally, scales chosen to assess associations between facial mimicry and social functioning were somewhat limited, with only perceived social support, loneliness, and social competence assessed. Because social interactions involve a complex array of skills and perceptions, future studies should consider examining a wider range of social functioning, including individual perception of social skills, particularly the ability to maintain successful relationships, as well as measures assessing satisfaction with friendships, working relationships, and romantic relationships. Data from outside sources (e.g., co-workers, partners, friends) would also be helpful in narrowing areas of social functioning most affected by deficits in facial expression mimicry, which may ultimately help refine an SST program to be most effective for this population. Finally, although images of facial expressions are widely used throughout research protocols, they are still one-step removed from in-person social interaction. Future research should consider examining facial EMG data during live interpersonal interaction to assess whether more genuine mimicry occurs naturalistically than seen in a laboratory setting with images.

Despite limitations of the current work, results have contributed to filling an important gap in the literature by examining the association between dysphoric mood and effortful facial expression mimicry. To date, no published studies have examined whether deficits in effortful mimicry are seen in this population, and current results suggest that deficits previously seen in automatic mimicry do carry over to effortful mimicry for individuals reporting a high degree of dysphoric mood. Observed deficits in both automatic and effortful mimicry pose the need for the field to continue to answer a number of questions about how this might be occurring and what we can do to assist individuals with dysphoria and depression to mimic more accurately. Future research should more carefully examine this population to see if more specific instructions as part of a SST module might lead to successful effortful mimicry of facial expressions. In light of deficits in effortful mimicry found in the current study, future studies should also carefully examine neural pathways that might be responsible for deficits in effortful mimicry. Understanding whether deficits in effortful mimicry have been noted primarily due to lack of specificity in the training instructions prior to mimicry or whether potential underlying problems exist with sensory and motor processing in the brain remains key in designing treatments to improve automatic and effortful facial expression mimicry in this population.

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APPENDIX A: Electrode Placement and Study Procedure

Figure 1: Facial Electrode Placement

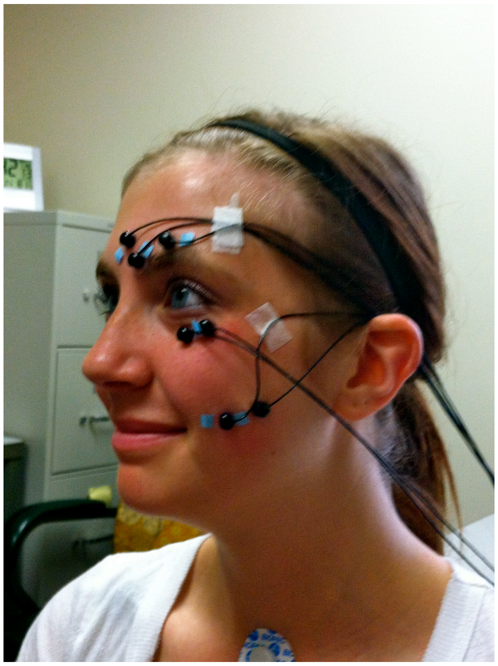
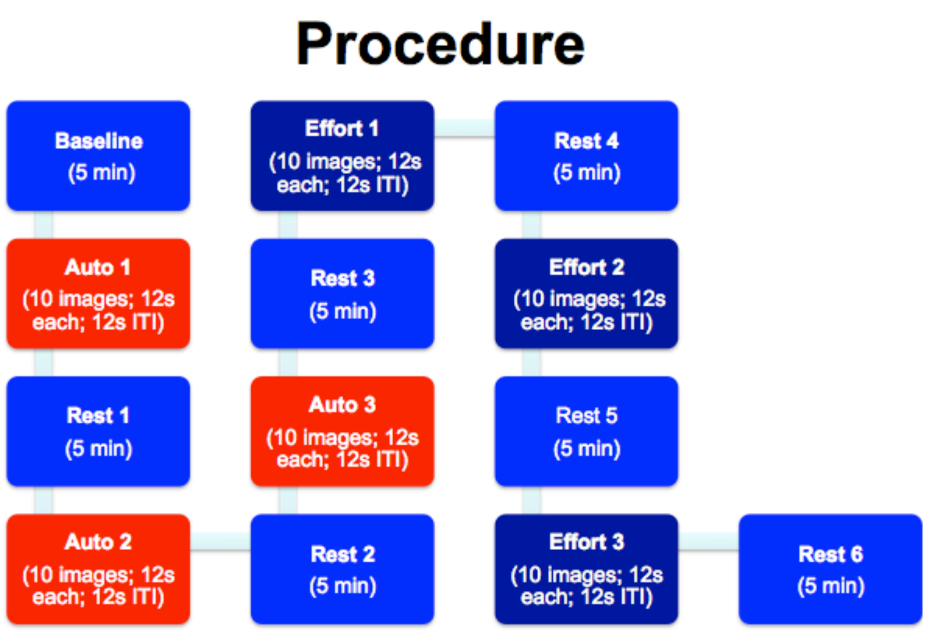


Figure 2: Study Procedure



APPENDIX B: Dysphoric Mood Change in WB and DE in Response to Facial Expressions

Table 5
Differences between Change in Positive Emotion Well-being Subscale Scores (WB) in Response to Happy, Sad, and Neutral Faces and Dysphoric Mood

Variable	Tertile	Mean	Std. Err	F	Sig (2-tailed)
Baseline Well-Being					
NM	Bottom	2.28	.87	$F(1,87) = 36.18$	$p < .01$
	Top	1.22	.77		
NE	Bottom	2.28	.15	$F(1,83) = 35.53$	$p < .01$
	Top	1.19	.11		
BDI	Bottom	2.37	.13	$F(1,82) = 42.27$	$p < .01$
	Top	1.23	.11		
NM Depression	Bottom	2.35	.14	$F(1,82) = 46.16$	$p < .01$
	Top	1.17	.11		
NE Depression	Bottom	2.08	.10	$F(1,121) = 29.34$	$p < .01$
	Top	1.21	.12		
Automatic Happy Change					
NM	Bottom	-.52	.12	$F(1,85) = 7.49$	$p < .01$
	Top	-.09	.10		
NE	Bottom	-.49	.15	$F(1,81) = 3.65$	$p < .10$
	Top	-.14	.10		
BDI	Bottom	-.53	.15	$F(1,79) = 4.97$	$p < .05$
	Top	-.14	.10		
NM Depression	Bottom	-.40	.13	$F(1,79) = 2.52$	*NS*
	Top	-.15	.10		
NE Depression	Bottom	-.46	.10	$F(1,117) = 1.8$	*NS*
	Top	-.25	.12		
Automatic Sad Change					
NM	Bottom	-.97	.11	$F(1,85) = 11.22$	$p < .01$
	Top	-.47	.12		
NE	Bottom	-.98	.13	$F(1,80) = 7.34$	$p < .01$
	Top	-.50	.12		
BDI	Bottom	-.84	.13	$F(1,79) = 1.29$	*NS*
	Top	-.64	.11		
NM Depression	Bottom	-.93	.12	$F(1,79) = 4.66$	$p < .05$
	Top	-.60	.10		
NE Depression	Bottom	-.88	.09	$F(1,117) = 4.13$	$p < .05$
	Top	-.57	.14		
Automatic Neutral Change					
NM	Bottom	-.90	.11	$F(1,85) = 9.59$	$p < .01$
	Top	-.43	.10		
NE	Bottom	-.94	.14	$F(1,79) = 6.96$	$p < .05$
	Top	-.46	.12		
BDI	Bottom	-.82	.16	$F(1,80) = 3.52$	$p < .10$
	Top	-.48	.10		
NM Depression	Bottom	-.80	.12	$F(1,79) = 5.33$	$p < .05$
	Top	-.45	.09		
NE Depression	Bottom	-.78	.09	$F(1,117) = 2.99$	$p < .10$
	Top	-.50	.13		
Effortful Happy Change					
NM	Bottom	-.74	.12	$F(1,82) = 10.53$	$p < .01$
	Top	-.24	.10		

NE	Bottom	-.79	.15	$F(1, 76) = 4.26$	$p < .05$
	Top	-.39	.13		
BDI	Bottom	-.95	.17	$F(1,77) = 14.08$	$p < .01$
	Top	-.23	.10		
NM Depression	Bottom	-.68	.14	$F(1,75) = 6.71$	$p < .05$
	Top	-.25	.10		
NE Depression	Bottom	-.68	.10	$F(1,112) = 2.52$	*NS*
	Top	-.39	.14		
Effortful Sad Change					
NM	Bottom	-1.20	.14	$F(1,83) = 13.65$	$p < .01$
	Top	-.54	.11		
NE	Bottom	-1.14	.18	$F(1,76) = 3.91$	$p < .10$
	Top	-.70	.13		
BDI	Bottom	-1.23	.16	$F(1,77) = 7.10$	$p < .01$
	Top	-.71	.11		
NM Depression	Bottom	-1.22	.15	$F(1,75) = 10.64$	$p < .01$
	Top	-.63	.11		
NE Depression	Bottom	-1.07	.12	$F(1,112) = 3.63$	$p < .10$
	Top	-.70	.14		
Effortful Neutral Change					
NM	Bottom	-1.00	.14	$F(1,82) = 9.68$	$p < .01$
	Top	-.43	.11		
NE	Bottom	-1.10	.16	$F(1,74) = 6.86$	$p < .05$
	Top	-.56	.13		
BDI	Bottom	-1.14	.17	$F(1,77) = 8.64$	$p < .01$
	Top	-.54	.18		
NM Depression	Bottom	-1.02	.15	$F(1,74) = 8.17$	$p < .01$
	Top	-.51	.11		
NE Depression	Bottom	-.95	.11	$F(1,111) = 3.02$	$p < .10$
	Top	-.63	.14		

Note. WB = Positive Emotion Well-being Subscale Scores ; NM = Baseline Negative Mood; NE = Baseline Negative Emotion; BDI = Beck Depression Inventory; NM Depression = Depression Subscale of Negative Mood Measure; NE Depression = Depression Subscale of Negative Emotion Measure. Age, sex, and ethnicity were controlled for throughout analyses based on associations with relevant outcomes.

Table 6
Differences between Change in Negative Emotion Depression Subscale (DE) Scores in Response to Happy, Sad, and Neutral Faces and Dysphoric Mood

Variable	Tertile	Mean	Std. Err	F	Sig (2-tailed)
Baseline Depressed Affect					
NM	Bottom	.04	.02	$F(1,87) = 44.62$	$p < .01$
	Top	1.20	.17		
NE	Bottom	.00	.00	$F(1,83) = 57.84$	$p < .01$
	Top	1.36	.17		
BDI	Bottom	.07	.04	$F(1,82) = 32.13$	$p < .01$
	Top	1.13	.17		
NM Depression	Bottom	.14	.07	$F(1,82) = 29.73$	$p < .01$
	Top	1.20	.17		
NE Depression	Bottom	.00	.00	$F(1,121) = 227.38$	$p < .01$
	Top	1.61	.15		
Automatic Happy Change					
NM	Bottom	.02	.04	$F(1,85) = 11.96$	$p < .01$
	Top	-.49	.14		
NE	Bottom	.16	.08	$F(1,80) = 25.61$	$p < .01$
	Top	-.67	.14		
BDI	Bottom	.01	.07	$F(1,79) = 8.32$	$p < .01$
	Top	-.46	.14		
NM Depression	Bottom	-.04	.04	$F(1,79) = 8.82$	$p < .01$
	Top	-.49	.14		
NE Depression	Bottom	.11	.04	$F(1,117) = 74.58$	$p < .01$
	Top	-.85	.13		
Automatic Sad Change					
NM	Bottom	.12	.06	$F(1,85) = 2.09$	*NS*
	Top	-.08	.13		
NE	Bottom	.21	.06	$F(1,80) = 2.29$	*NS*
	Top	-.06	.16		
BDI	Bottom	.17	.10	$F(1,79) = 2.86$	$p < .10$
	Top	-.11	.12		
NM Depression	Bottom	.19	.06	$F(1,79) = 3.89$	$p < .10$
	Top	-.09	.12		
NE Depression	Bottom	.22	.04	$F(1,117) = 25.99$	$p < .01$
	Top	-.38	.14		
Automatic Neutral Change					
NM	Bottom	.08	.06	$F(1,85) = 8.83$	$p < .01$
	Top	-.35	.13		
NE	Bottom	.11	.06	$F(1,79) = 6.99$	$p < .05$
	Top	-.32	.15		
BDI	Bottom	.02	.07	$F(1,80) = 4.27$	$p < .05$
	Top	-.30	.13		
NM Depression	Bottom	.12	.08	$F(1,79) = 8.65$	$p < .01$
	Top	-.35	.13		
NE Depression	Bottom	.13	.04	$F(1,117) = 30.54$	$p < .01$
	Top	-.52	.15		
Effortful Happy Change					
NM	Bottom	.00	.04	$F(1,82) = 16.42$	$p < .01$
	Top	-.56	.14		
NE	Bottom	.02	.01	$F(1,76) = 14.84$	$p < .01$
	Top	-.58	.15		

BDI	Bottom	.05	.07	$F(1,77) = 15.75$	$p < .01$
	Top	-.57	.13		
NM Depression	Bottom	-.05	.06	$F(1,75) = 10.45$	$p < .01$
	Top	-.56	.14		
NE Depression	Bottom	.08	.03	$F(1,112) = 120.01$	$p < .01$
	Top	-.93	.12		
Effortful Sad Change					
NM	Bottom	.16	.07	$F(1,82) = 8.50$	$p < .01$
	Top	-.33	.15		
NE	Bottom	.12	.05	$F(1,75) = 2.93$	$p < .10$
	Top	-.20	.18		
BDI	Bottom	.16	.11	$F(1,77) = 4.52$	$p < .05$
	Top	-.25	.16		
NM Depression	Bottom	.16	.08	$F(1,75) = 4.86$	$p < .05$
	Top	-.27	.17		
NE Depression	Bottom	.22	.05	$F(1,111) = 41.16$	$p < .01$
	Top	-.60	.15		
Effortful Neutral Change					
NM	Bottom	.10	.07	$F(1,81) = 10.61$	$p < .01$
	Top	-.42	.14		
NE	Bottom	.06	.05	$F(1,73) = 11.09$	$p < .01$
	Top	-.48	.15		
BDI	Bottom	.13	.08	$F(1,77) = 11.20$	$p < .01$
	Top	-.43	.14		
NM Depression	Bottom	.09	.08	$F(1,74) = 10.42$	$p < .01$
	Top	-.47	.15		
NE Depression	Bottom	.10	.04	$F(1,110) = 36.44$	$p < .01$
	Top	-.63	.15		

Note. DE = Negative Emotion Depression Subscale Scores; NM = Baseline Negative Mood; NE = Baseline Negative Emotion; BDI = Beck Depression Inventory; NM Depression = Depression Subscale of Negative Mood Measure; NE Depression = Depression Subscale of Negative Emotion Measure. Age, sex, and ethnicity were controlled for throughout analyses based on associations with relevant outcomes.