TIMING CHARACTERISTICS OF SMILES IN RELATION TO HISTORY AND SYMPTOMATOLOGY OF DEPRESSION

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Several studies have investigated the effects of depression on the intensity and frequency of facial displays. Comparatively little research has investigated dynamic aspects of facial displays, such as timing, in mood disorders. The aim of the study was to investigate the effects of the history and current symptomatology of mood disorders on the timing of smiles by measuring latency and related timing characteristics in the production of positive facial displays in response to stimuli intended to elicit positive emotion. Configurations of smiles (AU12) were measured using FACS (Ekman & Friesen, 1978) and Automated Facial Image Analysis (Tian, Kanade & Cohn, 2001). No differences were found relating to the timing characteristics of smiles in those with a history of unipolar or bipolar disorder, though men with a history of bipolar disorder were found to have shorter smile onsets than women with bipolar disorder. Consistent with previous literature, smiles of greater intensity were more frequently accompanied by contraction of the *Orbicularis Oculi* (AU6). Self reported symptoms of depression as measured by the Beck Depression Inventory (BDI) were positively correlated with dampening movements, which are thought to be efforts to inhibit or control the expression of positive emotion. This finding suggests that symptomatic subjects were attempting to down regulate their positive affect. Consistent with previous reports, results investigating the relationship between the maximum velocity and amplitude of smiles provide evidence for the automaticity of smiles.

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1. Introduction

Several studies have investigated the effects of depression on the intensity and frequency of facial displays (Berenbaum & Oltmanns, 1992; Ekman, Matsumoto, & Friesen, 1997; Gehricke, & Shapiro, 2000; Schwartz, Fair, Mandel, Salt, Mieske, & Klerman, 1976; Sloan, Bradley, Dimoulas, & Lang, 2002; Sloan, Strauss, Quirk, & Sajatovic, 1997; Sloan, Strauss, & Wisner, 2001). While such studies have investigated effects of depression on the intensity and frequency of facial displays, comparatively little research has investigated dynamic aspects of facial displays in depression such as timing (Schmidt & Cohn, 2001; Schmidt, Cohn, & Tian, 2003). It has been suggested that the timing of various aspects of non-verbal behavior are related to perceived warmth, similarity, and empathy during a social interaction (Jaffe, Beebe, Feldstein, Crown, & Jasnow, 2001; Schmidt, Cohn, & Tian, 2003). The timing of facial displays may be adversely affected in depression. The aim of the current study is to investigate the effects of depression on the timing of smiles by measuring latency and related parameters in the production of positive facial displays in response to stimuli intended to elicit positive emotions. The ability to communicate positive emotion is important to social interaction and appears to be a selective deficit in depression (Clark and Watson, 1991).

1.1. The Intensity and Frequency of Facial Displays in Depression

Studies investigating the intensity and frequency of facial displays in depressed individuals have generally shown a significantly diminished intensity and frequency of positive facial displays in depressed individuals in response to stimuli intended to elicit positive emotion.

Berenbaum & Oltmanns (1992) investigated the facial displays of 43 schizophrenic, 17 unipolar depressed individuals (as diagnosed by a psychiatrist), and 20 control subjects in response to slides intended to elicit positive emotion. Compared with control subjects, individuals with diagnosed schizophrenia and depression showed less frequent and intense facial displays in response to slides designed to be hedonically pleasant.

Similar results were found by Sloan et al. (2001). Their study included 20 female patients diagnosed with major depression and currently in a major depressive episode and 20 non-depressed females. They investigated the intensity and frequency of facial displays in response to slides intended to elicit positive emotion. They found a diminished frequency and intensity of positive facial displays in depressed women compared to non-depressed women in response to hedonically pleasant slides. As in Berenbaum and Oltmanns (1992), they found that the frequency and intensity of responses to hedonically unpleasant slides did not vary between groups.

Consistent results were also found in studies using facial electromyography (EMG). Sloan et al. (2002) investigated the facial displays of individuals with depressive symptomatology as assessed by self-report. In comparison with control subjects with low symptomatology, it was found that those rated highly in depressive symptomatology failed to show the expected increase in zygomatic activity in response to stimuli intended to elicit positive emotion. Both groups showed the expected increase in corrugator activity in response to stimuli intended to elicit negative emotion.

Schwartz et al. (1976) also investigated facial EMG in relation to depressive symptomatology as assessed by self-report. They found decreased zygomatic activity in response to stimuli intended to elicit positive emotion in those with depressive symptomatology compared to controls with no depressive symptomatology.

Another EMG study, conducted by Gehricke and Shapiro (2000) found evidence of adverse effects in depressed outpatients. This study investigated the facial display responses of 11 depressed individuals, as diagnosed by the Structured Clinical Interview for DSM-IV (SCID; First, et al., 1994) and the Beck Depression Inventory. Positive and negative as well as social and non-social imagery were used to elicit positive and negative emotion. Results revealed a reduction in facial muscle activity in the depressed subjects compared with non-depressed controls for both positive and negative stimuli.

Sloan, et al. (1997) investigated the facial displays of 24 male inpatients and outpatients diagnosed with major depression and currently in a major depressive episode and 23 non-depressed male comparison subjects in response to slides varying in hedonic content. Depressed subjects exhibited more negative expressions than non-depressed subjects to negative slides, though the two groups did not differ in facial display responses to positive slides. These results are not entirely consistent with other studies, as neither group displayed much affect in response to positive slides. A possible reason for this discrepancy is that participants included were all males, while the other investigations included either both males and females or just females. Males, who are generally regarded as less expressive than females, may have a reduced amount of affect in response to positive slides independent of depression.

In a study by Ekman, Matsumoto, and Friesen (1997), the frequency of positive and negative facial displays was investigated in the context of an interview. Their sample included 4 major depressive, 3 minor depressive, 2 bipolar (manic), and 2 schizophrenic (using DSM-III criteria) participants interviewed during admission and shortly after discharge. Participants with major depressive disorder showed more negative facial displays and less positive facial displays than those with minor depression. Participants with bipolar disorder (in the manic state) showed more positive facial displays and fewer negative facial displays than participants in both the major and minor depression group. These results must be interpreted with caution, as the sample sizes in each group were small. These results also cannot be directly compared to other studies measuring the frequency and intensity of facial displays because the interview context was not intended to explicitly elicit positive or negative emotion.

Overall, these studies show that facial displays of depressed individuals in response to stimuli intended to elicit positive emotion are less frequent and intense in comparison with those of non-depressed individuals. The findings are consistent in studies using various visual methods of analysis, such as the Facial Expression Coding System (FACES; Kring & Sloan, 1991) and the Facial Action Coding System (FACS Ekman & Friesen, 1978) as well as those using psychophysiological methods, such as facial EMG. The findings generalize to participants with current depressive symptomatology and subjects currently in a major depressive episode.

The one study showing inconsistent results is the study by Sloan et al. (1997). This study failed to find much positive emotion in either the depressed or non-depressed groups. There are two possible explanations: 1) the study only included male participants, who are generally regarded as less expressive than females, while the other studies used either a group of male and female participants, or only female participants 2) the study used slides to elicit positive emotion, which may not be as effective. One of the aims of the current study is to improve upon past research by investigating the effects of the history of both unipolar and bipolar disorder in both men and women on the timing and intensity of facial displays in response to stimuli intended to elicit positive emotion and to include a larger number of participants than in previous studies.

1.2. The Timing of Facial Displays as a Sign

A distinction can be made between *symptoms* (a phenomenon of physical or mental disorder or disturbance which leads to complaints on the part of the patient) and *signs* (objective evidence or physical manifestation of disease). Because signs, as opposed to symptoms, are an objective measure, it has been suggested that signs may be superior to symptoms in the discrimination of disorders (Parker, Hadzi-Pavlovic, Boyce, Wilhelm, Brodaty, Mitchell, Hicke & Eyers, 1990). Results from clinical and laboratory studies also suggest that signs occur very early in the course of affective disorders, before psychological symptoms are prominent and tend to persist even after obvious mood changes recede.

Several researchers, such as Jaffe, Beebe, Feldstein, and Crown (2001) and Schmidt and Cohn (2001) have argued that other aspects of nonverbal behavior may be important in the communication of individuals in addition to merely frequency and intensity. One of these aspects is the timing of facial displays. Other nonverbal aspects, such as sound-silence, or look-look away, may exchange important information regarding the perceived warmth, similarity, and empathy during a social interaction (Jaffe, Beebe, Feldstein, Crown, & Jasnow, 2001). In addition to the exchange of important information in social interactions, timing may provide an important signal in the differential diagnoses of unipolar and bipolar depression.

Clinical studies have shown that bipolar disorder is frequently misdiagnosed as unipolar major depressive disorder and consequently the appropriate treatment is not given (Ghaemi, Sachs, Chiou, Pandurangi, and Goodwin 1999; Ghaemi & Goodwin 2001). Results of the Pisa-Memphis Collaborative Study (University of Pisa, Italy, University of Tennessee, Memphis, USA) have indicated that approximately 30% of persons with a diagnosis of major depression in clinical settings might pertain to the bipolar spectrum (Cassano, Akiskal, & Musetti 1989; Cassano, Akiskal, & Savino 1992). These misdiagnoses may be due to clinicians ignoring subtle, but clinically meaningful signs and symptoms and/or the fact that the current nosology fails to include mild signs and symptoms that do not meet threshold criteria.

It has been argued that clinicians should pay particular attention to the endorsement of possible manic-hypomanic signs and symptoms, even when those manifestations are isolated or subthreshold. It is possible that these lifetime isolated signs, symptoms, and subthreshold phenomena could be associated with an increased risk of developing full-blown manic episodes (Cassano, Rucci, Frank, Fagiolini, Dell'Osso, Shear, & Kupfer, 2004). It was recently suggested that the accuracy of diagnoses of bipolar disorder could be improved through the introduction of a refined procedure for the detection and evaluation of a broader range of signs and symptoms relevant to mania (Cassano, Dell'Osso, Frank, Miniati, Fagiolini, Shear, Pini, and Maser 1999).

Many clinicians who are experienced in the evaluation of the full range of behavior in bipolar disorder argue that alternating mood episodes in bipolar disorder patients are rarely purely depressive or manic, but are more likely mixed. An example is that during severe depression, a bipolar patient may respond to something that they perceive as amusing with a cackling laugh (Cassano, et al. 1999). It is possible that a standardized procedure, such as the precise measurement of the intensity and timing of facial displays could improve identification of the variety of mixed and/or subthreshold bipolar states.

Any demonstration of distinguishing signs would be of considerable clinical value, as they would be helpful in determining treatment options in common clinical situations such as first-onset depression, an ambiguous past history of (hypo)mania, or the MDD patient with a family history of bipolar disorder (Mitchell, Wilhelm, Parker, Austin, Rutgers, and Mahli, 2001). One aim of the current study is to explore possible differences in the facial displays of individuals with unipolar and bipolar disorder. If significant differences are found it is possible that facial displays could be used to identify depressive individuals with a bipolar spectrum.

1.3. Studies of Timing in Unipolar Depression

Two lines of research suggest that timing may be impaired in depressed individuals: 1) paralinguistic research concerning switching and speech pause durations in affective contexts and 2) reaction time studies. Both lines of research have found that timing is adversely affected in depression. It is possible that the affects found in these studies may generalize to facial displays.

1.4. Paralinguistic Studies of Depression

The first line of research, paralinguistic research, has investigated latency of vocal responses in depressed individuals by focusing on two different types of durations while speaking: *switching pauses* and *speech pause times*. A third variable, *vocalization times*, has not been directly measured by these studies, but can be derived from measures of speech pause times. Switching pauses refer to the time duration between one person's action and another person's response and are defined as the duration of silence. Speech pause times refer to the duration of silence within a single individual's response while vocalization times refer to the duration of vocalizations within a single individual's response. Speech pause times and vocalization times are usually measured by having a participant count to ten and measuring the duration of silence (speech pause times) and non-silence (vocalization times).

Paralinguistic research investigating speech pause time has generally found an increase in pause times in depressed individuals as compared with non-depressed individuals (Breznitz, 1992; Nilsonne, 1988; Szabadi, Bradshaw, & Besson, 1976). Depressed individuals also have a larger percentage of speech pause times while currently symptomatic (Greden and Carroll, 1980; Kuny & Stassen, 1993; Nilsonne, 1987).

Switching pauses in relation to depression have been examined in studies of face-to-face interaction between depressed or symptomatic mothers and their infants. Mothers with depressive symptoms as measured by the Beck Depression Inventory (Beck, Steer, & Farbin, 1988) have been found to have longer and more variable switching pauses than non-symptomatic comparison mothers (Bettes, 1988). Zlochower and Cohn (1996), using Research Diagnostic Criteria to assess depression (Spitzer, Endicott, & Robins, 1978) also found that switching pauses of depressed mothers were longer and more variable.

These results for switching pauses are consistent with those for speech pause times. In both cases, depression or depressive symptoms were associated with longer and often more variable pauses.

These findings in the vocal domain lead to the hypothesis that similar effects may be found in the facial domain. The response of a facial display of one person to another has properties analogous to switching pauses: both responses involve a duration during which the responding individual must initiate the response, and a duration during which the responding individual must motorically complete the response. The present study will test the hypothesis that depression is associated with increased latency to respond to a social stimulus intended to elicit positive affect.

1.5. Reaction Time Studies of Depression

The second line of research, reaction time research, more explicitly explores increased response durations in depression. Several reaction time studies have demonstrated the independence of *response latency* and *action duration* components of reaction time by measuring separately the time necessary to initiate the response with the time required to carry out the motor activity to complete the response (Danev, DeWinter, & Wartna, 1971; Henry, 1961; Weiss, 1965; Welford, 1968). It has been shown that individual differences in latency and action duration are independent and have a correlation of approximately zero (Henry, 1961).

Results have been mixed in the measurement of simple reaction time tasks (reaction time tasks that require no cognitive effort) and complex reaction time tasks (reaction time tasks that require cognitive effort). Several studies investigating reaction time tasks have shown an increase in response latency and action duration (Cornell, Suarez & Berent, 1984; Rogers, Less, Smith, Trimble & Stern, 1987).

Cornell, et al. (1984) attempted to differentiate between components of behavior that might underlie latency in depression. They distinguished between these two components through systematic variation of response demands in a series of reaction time tasks. As diagnosed by comprehensive psychiatric evaluations, it was found that melancholic depressed patients, in comparison to non-melancholic depressed patients and controls, had an increased cognitive latency as indicated by an increased latency in the response to complex reaction time tasks.

In a similar study (Rogers et al., 1987), it was found that response latency in a digit symbol task was longer in both Parkinsonian and depressed patients (as diagnosed by RDC; Spitzer & Endicott, 1977) as compared with controls.

Byrne (1976) investigated response latency in neurotic and psychotic depressed patients (as diagnosed by RDC; Spitzer & Endicott, 1977) together with a non-depressed control group. The results showed an increase in response latency in the depressed group as compared with the control group, but only found increased response latency in the psychotic as compared to the neurotic depressed group. It was also found that response latency increased directly with depressive severity.

In a recent study, Lemelin & Baruch (1998) varied the level of attentional effort in various reaction time tasks in 30 depressed participants (with severity measured using the Hamilton Depression Rating Scale; HDRS; Hamilton, 1960), and found an increased response latency in the performance of reaction time tasks that require attentional effort, but found that this increased response latency did not generalize to reaction time tasks that do not require attentional effort.

1.6. Reaction Time Studies of Bipolar Disorder

Several studies have shown an increase in reaction time in individuals with bipolar disorder compared with healthy control subjects. Swann, Katz, Bowden, Berman and Stokes (1999) investigated various measures of psychomotor performance such as tapping speed, trail making, dot placement, and reaction time. Included patients were 78 healthy control subjects, 60 bipolar patients (10 currently in a manic episode, 8 currently in a mixed episode, and 42 currently in a depressive episode), and 80 unipolar patients. It was found that patients with unipolar and bipolar disorder were slower than controls in all four tests. Another finding was that the patients in the mixed states resembled manic, rather than depressed patients, and did not differ from controls. Although the majority of the patients in the bipolar group were currently in a depressive episode, these results suggest that timing may be affected in bipolar disorder depending on the phase of bipolar disorder, either primarily manic, or primarily depressed.

The effects of bipolar disorder on reaction times were also studied by Pfeiffer and Maltzman (1976). They compared 10 male and 26 female clinically diagnosed bipolar outpatients (as diagnosed by a staff psychiatrist), with and without lithium bicarbonate maintenance medication, in euthymic and depressed states with 9 female and 11 male control subjects. They found that bipolar patients were uniformly slower than controls across all treatment conditions with no group interactions.

Similar results were found in a study of attentional function in remitted bipolar disorder conducted by Wilder-Willis, Sax, Rosenberg, Fleck, Shear, and Strakowski (2001). In their study of 14 stable bipolar subjects (most recent episode manic) and 12 controls, it was found that patients with bipolar disorder demonstrated slower psychomotor processing as well as impairments in fine motor skills compared with controls (as assessed by the Degraded Stimulus Continuous Performance Test and the Digit Span Distractibility Test). It was also found that neither psychiatric symptom severity nor medication effects influenced performance on measures of fine motor skills or psychomotor processing speech in patients with bipolar disorder in a euthymic (i.e. neither depressed, manic or hypomanic) state.

Strauss, Novakovic, Tien, Bylsma, and Pearlson (1991) found that overall reaction times were slower in individuals with bipolar disorder and schizophrenia compared with controls. Their investigation compared individuals with bipolar disorder and schizophrenia with controls subjects, measuring reaction time with various forms of cues. Their sample included 10 schizophrenic patients (5 male, 5 female), 6 bipolar patients (3 male, 3 female), and 20 controls (9 male, 11 female). Both the schizophrenic patients and the bipolar patients were in states of remission.

A limitation to these reaction time studies is that the most common paradigm in these reaction time studies requires the participant to volitionally either press or release a key on a keyboard to initiate a response. This volitional motor action differs from the action of creating a spontaneous facial display for two primary reasons. The first reason involves the production of voluntary and involuntary motor actions. It has been suggested by Rinn (1984) that volitional movements of the face use different upper motor neuron pathways than those used for involuntary movements. Impulses for volitional movements emanate from the cortical motor strip and course to the facial nucleus through the pyramidal tract. Impulses for involuntary facial movements arise from a phylogenetically older motor system known as the extrapyramidal motor system, which involves mostly subcortical nuclei (Rinn, 1984). This fundamental difference may make the results from reaction time tasks specific only to voluntary movements.

The second reason involves affective state. The affective state during reaction time tasks is presumably neutral, as the induction of the response is simply to a command. The production of facial displays involves an affective state because the induction of the response is not to a command, but to a stimulus intended to elicit a positive or negative emotion. For this reason, the investigation of timing in facial displays is much more complex than the investigation of timing in simple and choice reaction time tasks.

The next step in this program of research is to investigate the influence of depression on the timing of facial behavior in response to an affective stimulus, to do so for both men and woman, and individuals with well-defined unipolar and bipolar course. The present goal is to elucidate the ways in that timing characteristics of smiles are affected in depression. This question has not been previously investigated.

Differences in the timing of facial displays may be manifested in individuals with unipolar or bipolar disorder by 1) an increased latency between the stimulus and the onset of the facial display, by 2) an increased duration between the onset of the facial display and the peak of the facial display, 3) an increased duration of the peak of the facial display, or by 4) an increased duration of the offset of the facial display. It is possible that variability in any of these 4 phases may have pronounced effects in communication.

The current study specifically investigated the immediate reaction, that which extends from the stimulus until the peak of the facial display. It has been found that the display onset provides the initial and most conspicuous change in appearance of the face, as perceived by human observers (Leonard, Voeller, & Kuldau, 1991). It has been suggested that observers have a propensity to respond very rapidly to facial displays, and that this rapid reaction is most likely in response to the onset of the display, rather than other phases of the display (Dimberg & Thunberg, 1998). Thus, one of the aims of the current study was to investigate the effects of unipolar and bipolar disorder on the first two of these phases.

The current study was designed to elicit facial displays in response to a positive social stimulus in individuals with bipolar and unipolar disorder, as well as non-depressed controls. The immediate response was investigated by looking at the *response latency* and the *onset duration* of the complete response independently. Response latency was operationalized as the duration from the eliciting event to the time of the first visible muscular movement of the facial display. Onset duration was operationalized as the duration from the time of the first observable muscular movement of the facial display until the time of the peak of the facial display.

The sample of the current study was chosen because in addition to including participants with a range of current depressive symptomatology, it includes a group of participants with Childhood-Onset Depression (unipolar depression diagnosed before the age of 14), a group with early-onset bipolar disorder (bipolar disorder diagnosed before the age of 17), and a group with late-onset bipolar disorder (bipolar disorder diagnosed after the age of 17). The inclusion of a group with current depressive symtomatology and groups with a varying history of depression enabled the study to examine history and type of disorder as well as current symptomatology in relation to the timing of the facial display. Timing included latency, intensity, onset duration, and velocity.

Because previous literature suggests sex differences in facial expressiveness, both men and women were included. Men are generally regarded as less expressive than women, and influence of depression and sex may combine to reduce latency, intensity and onset duration. It was hypothesized that women would respond more quickly (i.e., shorter latency) and more intensely.

It is possible that additional facial actions happening at the time of the smile may affect timing characteristics of the smile. Thus, the occurrences of Duchenne and non-Duchenne smiles as well as the occurrence of smile dampeners were also examined.

The current study also investigated the relationship between the velocity and the amplitude of facial displays. Previous work on automatic movements has shown a consistent and deterministic relationship between maximum velocity and amplitude in non-depressed individuals, which is known to be characteristic of automatic movements (Baloh, Sills, Kumley, & Honrubia, 1975; Zuber, Stark, & Cook, 1965; and more recently, Schmidt et al., 2003). The characteristic of a facial display reaching its peak in a systematic and uninterrupted manner implies that the production of a facial display is automatic and programmed. It was hypothesized that the relationship between the velocity and amplitude in the production of facial displays would be consistent and deterministic.

2. Method

2.1. Participants

Two-hundred and eighty-three participants were selected from a larger study investigating the longitudinal correlates and risk factors for childhood onset mood disorders. Participants were enrolled in this larger study if they had a history of childhood-onset depression (COD) or no history of psychiatric illness (controls). COD was operationally defined as a DSM-based psychiatric diagnosis of major depressive disorder by age 14 (COD-Unipolar) or bipolar spectrum disorder (COD-Bipolar) by age 17. Within the bipolar group, there were both early-onset (diagnosis of bipolar spectrum disorder before the age of 17) and late-onset (diagnosis of bipolar spectrum disorder after the age of 17) cases.

To be enrolled as a control, participants had to have history free of any major psychiatric disorder. All psychiatric assessments concerning history of psychiatric illness involved documentation from childhood as well as the use of semi-structured clinical interviews, such as the Structured Clinical Interview for DSM-IV (SCID) (First, et. al. 1994), which adheres closely to DSM-IV criteria (Antony & Barlow, 2002).

The present study reports on 149 young adult participants from this larger study. Participants were included in the study if they smiled while watching a specific 11 second segment of a film clip intended to elicit positive emotion and video recording of their facial behavior was analyzable. Specifically, if the participant smiled during the specified 10 second segment, the face was free of occlusion (e.g., hand in front of face), any out-of-plane head motion was small to moderate, and there were no technical problems. Technical problems included synchronization problems, lack of video, occlusions, tracking errors, and missing data. Excluded and included subjects did not differ by group, age, gender, race, or depressive symptoms as measured by the Beck Depression Inventory (all $p > .10$). (See Tables 1, 2, and 3).

Table 1 Percentage of participants who were excluded from the analyses because of either failure to smile or technical problems

Group	Number of Subjects Excluded	No Smile	Lack of synchronization	Technical Problems: No Video	Technical Problems: Occlusion	Tracking error	Missing data
Control	43	65%	12%	0%	7%	9%	7%
COD-Unipolar	55	60%	22%	2%	5%	9%	2%
COD-Bipolar	36	56%	17%	0%	0%	17%	11%
EOB	29	59%	17%	0%	0%	21%	3%
LOB	7	43%	14%	0%	0%	0%	43%

Table 2 Comparison of included and excluded subjects by sex, race, and group

Group	Included	Excluded
Control	60	43
% Male	28%	28%
%White	80%	63%
COD-Unipolar	62	55
% Male	24%	33%
% White	77%	78%
COD-Bipolar	27	36
% Male	33%	42%
% White	81%	78%

Table 3 Comparison of included and excluded subjects by Beck Depression Inventory scores

Group	Included Mean (SD)	Excluded Mean (SD)
Control	3.00 (4.21)	2.76 (3.45)
COD-Unipolar	13.85 (10.82)	14.05(10.05)
COD-Bipolar	13.41(11.47)	11.37(8.68)
EOB	11.70 (11.33)	11.23 (9.20)
LOB	18.29 (11.20)	12.00 (6.54)

Thus, the current sample (N=149) included 62 participants with a history of depression (childhood-onset depression, COD-Unipolar) (15 male, 47 female), 20 participants with a history of bipolar disorder with an early-onset (7 male, 13 female), 7 participants with a history of bipolar disorder with a late-onset (2 male, 5 female), and 60 controls (17 male, 43 female). Because the number of participants with late-onset bipolar disorder was small, late- and early-onset bipolar course were pooled in analyses of COD-Bipolar unless otherwise noted. (See table 4 for a distribution of sex by group.)

Table 4 Sex of Participants by Group

Group	N	Percent Male
Control	60	28.33
COD-Unipolar	62	24.19
COD-Bipolar	27	33.33

The mean age of control participants was 26.62 (SD = 5.35). The mean age of COD-Unipolar and COD-Bipolar participants was 24.24 (SD=3.78) and 25.22 (SD=3.81) respectively. In the control group, there were 48 Caucasian, 10 African-American, 1 Asian, and 1 multi-ethnic participant. In the COD-Unipolar group, there were 48 Caucasian, 9 African American, and 5 Hispanic or multi-ethnic participants. In the COD-Bipolar group, there were 22 Caucasian, 2 African American, and 3 multi-ethnic participants. Control, COD-Unipolar, and COD-Bipolar participants did not differ in sex or ethnic background ($p > .10$). Small but significant group differences in age showed that the control group was significantly younger than the COD-Unipolar group, $F(2,148) = 4.292$, $p = .015$.

2.2. Procedures

Depressive Symptoms. Current depressive symptomatology for each participant was ascertained prior to the film clip viewing by use of the Beck Depression Inventory (BDI) and the Follow-up Depression and Follow-up Anxiety rating scales (FAS/FDS) conducted on the same day that each participant was seen. The BDI has proven to be a reliable measure of the presence and severity of depressive symptomatology in both general populations and psychiatrically diagnosed patients (Beck et al., 1988). The FAS/FDS is a clinical interview based on the Interview Schedule for Children and Adolescents (ISCA) which measures symptoms of depression and anxiety (Sherrill and Kovacs, 2000).

Observations. Participants watched 7 film clips, each of which was intended to elicit a specific emotion with the exception of the first clip, which showed a train moving down a track and was intended as a neutral or baseline condition. The second film clip was from a comedy routine intended to elicit positive emotion. This clip was of the African American comedian/actor Chris Rock and was entitled “Chris Rock: Bring the Pain”. In this segment, the comedian discusses topics such as food, organ donation, and relationships. Because participant responses to this comedy clip are the focus of this report, the remaining film clips will not be described.

During the film clip viewing, participants were alone and seated in a comfortable chair. A 21-inch video monitor was positioned 6 feet and 10 inches in front of them at a height of 2 feet. An S-VHS camera was placed discretely below the monitor and behind a plexiglass barrier and thus partially hidden.

In addition to video-recording of the participant’s behavior, facial electromyography (EMG), heart rate, and respiration were measured. Only the video recordings were used in the current study. After each film-clip, participants rated each of 5 felt emotions (happy, sad, anger, disgust, and fear) on a 9-point Likert-type scale.

Video-recordings of the participants’ facial behavior was digitized for 11 s at 30 frames per second, which produced a set of 330 sequential, 640x480 pixel full color images for each participant. The 11 s segment digitized for each subject begins precisely 1 s before the punch line and ends 10 s after the punch line. Although the length of these digitized sequences does not allow for analysis of extremely long smiling actions, it does allow for the analysis of spontaneous smiles that are similar in length to the average 4 to 6 s reported for spontaneous smiles (Frank, Ekman, and Friesen, 1993).

Manual FACS coding. The Facial Action Coding System (FACS: Ekman & Friesen, 1978) is a comprehensive, anatomically based system for measuring all visually discernable facial movement. FACS describes all visually distinguishable facial activity on the basis of 44 unique action units (AU's), as well as several categories of head and eye positions and movements. Each AU has a nominal code. To become a certified FACS coder, one must complete a standardized exam and attain an agreement ratio of at least .70 with criteria. It has been shown that this reliability generalizes to research settings (Sayette, Cohn, Wertz, Perrot, & Parrot, 2001).

Manual FACS coding was done for the specified 11 second segment for activity of facial muscles affecting lip corner movement (zygomatic major) by the first author. The occurrences of Cheek raising (orbicularis oculi, AU6) and dampening movements (such as dimplers, AU14; lip corner depressors, AU 15; lower lip depressors, AU 16; and lip sucks, AU 28) were coded by the first-author and a second certified FACS coder. Reliability for AU 12 was not assessed, as previous research indicates high reliability (Ekman and Rosenberg, 1997). To determine reliability of coding for AU 6 and for dampeners, video of 20% of the participants was independently coded by a comparison coder and quantified using kappa, which corrects for chance agreement. Reliability for the coding of cheek raising (orbicularis oculi) was high: the kappa statistic was .940. Reliability of dampening movements was moderate: the kappa statistic was .561.

Automated Facial Image Analysis. Smiles in the digitized video were analyzed using Automated Facial Image Analysis (AFA) version 3 (Cohn & Kanade, In press; Cohn, Reed, Ambadar, Xiao, & Moriyama, 2004). AFA version 3 is a computerized system that concurrently tracks head and facial feature motion. The concurrent tracking of both head motion and facial feature motion allows us to measure the movement of facial feature points while controlling for head motion. Facial features are extracted in the image sequence and tracked using the Lucas-Kanade (1981) feature tracking algorithm.

The current report concerns the facial feature point located on the left lip corner of the mouth, which measures the activity of the zygomaticus major muscle. The initial (x,y) coordinate of the left lip corner in each participant's segment was designated as the origin point, (0,0), of which the displacement of the lip corner from this origin point on the stabilized image was recalculated for each frame as:

$$\Delta d = \sqrt{\Delta x^2 + \Delta y^2}$$

Displacement values were calculated for each frame of each participant's segment, forming a time series of lip corner positions. Although this calculation only gave a value for displacement and not direction, it was already known that the participant smiled during the segment, thus direction can be inferred. Results from the times series data were smoothed using the T4253H algorithm (SPSS Inc., Chicago IL, 1999) (See Figure 1 for an example of an automatically tracked smile and smoothed displacement values). Following Schmidt, Cohn, and Tian (2003), these smoothed values were then analyzed to determine the longest continuous increase in displacement and the longest continuous decrease in displacement which partition the facial display into pre-onset and onset phases described in the following section.

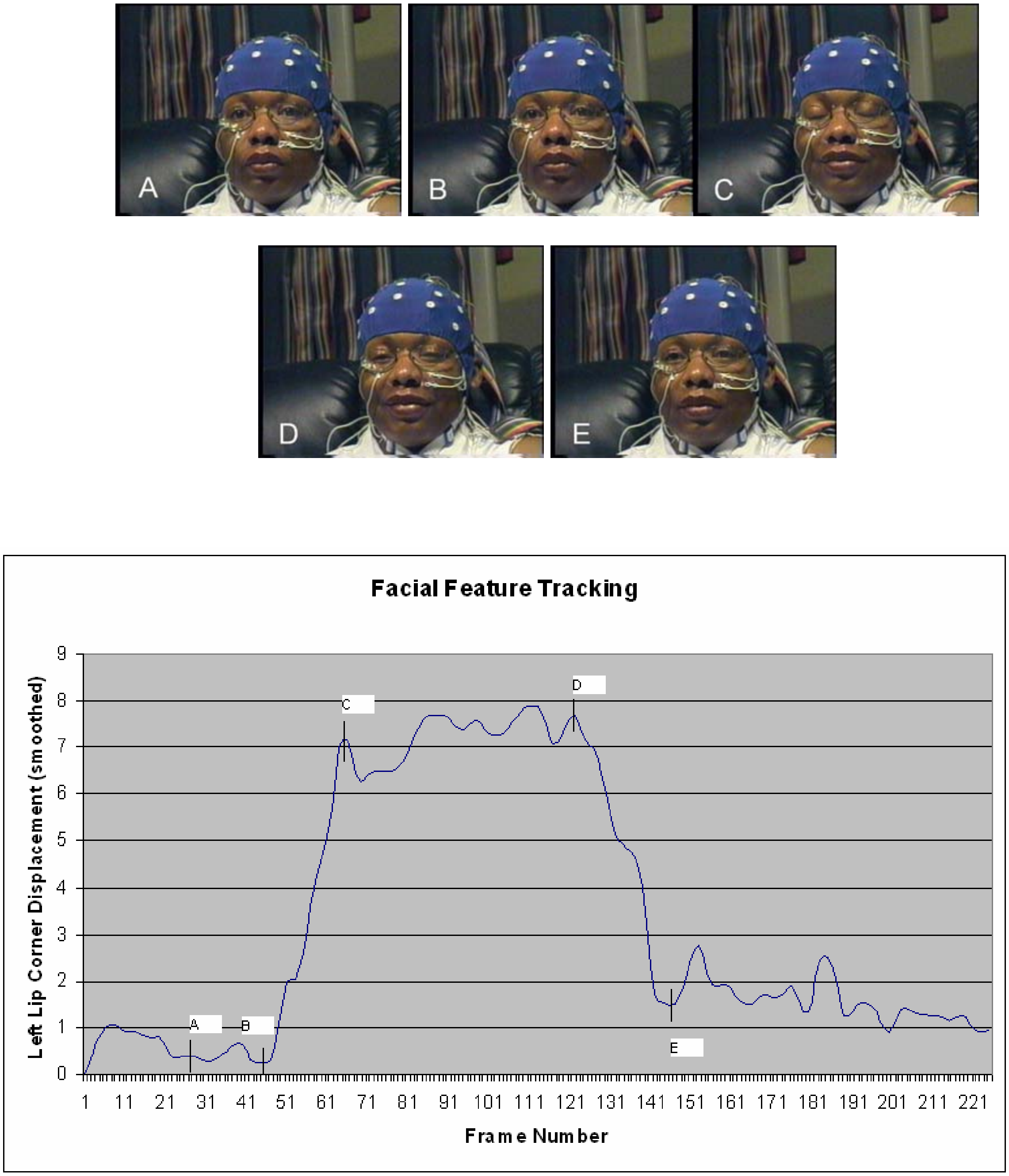
2.3. Phases of the Facial Display

Partitioning of the smile. The smile was partitioned into 4 separate phases from the resulting time series of lip corner positions. Five points partition these separate phases, as shown in

Figure 1. Point A represents the event that elicits the facial display (joke punch line). Point B represents the beginning of the longest continuous increase in lip corner displacement. Point C represents the end of the longest continuous increase in lip corner displacement. Point D represents the beginning of the longest continuous decrease in lip corner displacement. Point E represents the end of the longest continuous decrease in lip corner displacement.

The duration (on a time base of 30 frames per second) between points A and B represents the *latency* to the facial display, the phase in which it was predicted that depressed individuals manifest and increased latency compared to non-depressed individuals. The *intensity* of the facial display was defined as the point of maximum displacement of the left lip corner. The duration between points B and C represents the *onset duration* of the facial display, the phase in which it was hypothesized that depressed individuals would not manifest an increased latency compared to non-depressed individuals. The duration between points D and E represents the offset of the facial display.

Figure 1 Computerized facial feature tracking of lip corner movement during emotion eliciting film clip.



3. Results

3.1. Preliminary Results

Preliminary results focused on presence of AU 6, or Duchenne's marker, which is believed to differentiate felt from social smiles, and dampening movements, such as pressing the lips together (AU 24) or pulling down the lip corners (AU 15) during smiles. Additional analyses evaluated the relation among self-report and behavioral measures.

Presence of AU 6 and dampening movements. A logit analysis was done to determine whether the presence of AU6 varied by sex, group, or by a sex-group interaction. AU6 did not vary in terms of these factors (Likelihood Ratio (4) = 4.035, *p* = .776). AU6 also did not differ by BDI score, *F*(1, 147) = .444, *p* = .506.

Table 5 Distribution of Beck Depression Inventory Scores by Sex, Group, and Smile

Sex	Group	Duchenne		Non-Duchenne	
		N	Mean	N	Mean
Male					
	Control	8	2.50	9	1.44
	COD-Unipolar	7	7.86	8	13.38
	COD-Bipolar	3	9.33	6	11.33
Female					
	Control	20	2.65	23	4.09
	COD-Unipolar	25	12.56	22	17.41
	COD-Bipolar	11	16.82	6	12.33

Dampening actions were analyzed to test the relation between the occurrence of dampening actions with latency, intensity, onset duration, sex, BDI, self-report emotion following the film clip, and group. Thirty-eight out of 148 participants (25.5%) displayed dampening actions. There were no sex differences in the frequency of dampening actions χ^2 (1) = 1.129, p = .288. Dampening actions were unassociated with latency to smile, *F*(1, 147) = .151, *p* = .698, intensity of smiles, *F*(1, 147) = 1.204, *p* = .313, and onset duration of smiles, *F*(1,147), .047, *p* = .828.

Those participants without dampening actions reported significantly greater happiness following the film clip *F*(1, 142) = 7.156, *p* = .008 than those participants with dampening actions. Self-reported anger was marginally higher for those participants with dampening movements *F*(1,142) = 3.809, *p* = .053 although the ratings for both groups were very low.

There were no group differences concerning self-reported happiness scores. Mean scores for Control, COD-Unipolar, and COD-Bipolar groups were 5.96, 5.55, and 5.44, respectively, $F(2, 143) = 2.352$, $p = .099$.

Lower BDI scores were associated with dampening actions $F(1,147) = 9.671$, $p = .002$. There was also a trend for increased frequency of dampeners in the COD-Unipolar group relative to the COD-Bipolar group and controls χ^2 (2) = 5.76, $p = .056$.

Zero-order correlations among measures were examined using Pearson correlation coefficients. BDI score was negatively correlated with self-report happiness $r(144) = -.216$, $p = .009$ and positively correlated with self-report anger $r(144) = .305$, $p < .001$.

Relation between self-report measures and behavioral measures. Low but significant correlations were found concerning the relation between self-report and behavioral measures. Self-reported happiness significantly correlated with maximum intensity, $r(143) = .229$, $p = .003$, and onset duration, $r(144) = .250$, $p = .001$, but not with latency, $r(144) = -.132$, $p = .058$. Self-reported anger negatively correlated with maximum intensity, $r(143) = -.232$, $p = .003$.

Descriptive statistics for latency, intensity, and onset duration are presented in Table 6. Small but significant correlations were found between latency and onset duration, $r(149) = -.202$, $p = .013$ and maximum intensity and onset duration, $r(148) = .386$, $p < .001$, but not between maximum intensity and latency to smile.

Table 6 Descriptive Statistics for Latency, Onset Duration, and Maximum Intensity by Group and Sex

Group	Sex (N)	Latency (SD)	Intensity (SD)	Onset (SD)
Control	Male (17)	106.705 (71.522)	0.127 (.082)	19.882 (5.946)
	Female (43)	82.116 (61.560)	0.114 (.068)	19.883 (7.068)
COD-Unipolar	Male (15)	89.133 (68.865)	0.092 (.070)	19.466 (7.577)
	Female (47)	74.085 (58.461)	0.103 (.048)	18.914 (5.992)
COD-Bipolar	Male (9)	86.222 (49.613)	0.089 (.054)	13.222 (3.598)
	Female (18)	48.500 (12.401)	0.131 (.052)	18.888 (7.095)

Hypothesis Testing. Simultaneous multiple regression models were used to test hypotheses concerning the relation of smiles with current depressive symptomatology and history of depression. COD-status was dummy coded (Cohen and Cohen, 1983). Independent variables were sex, COD-Unipolar, COD-Bipolar, BDI, type of smile (presence/absence of AU6), and all possible two-way interactions. Although group differences in age were found, age was not included as in independent variable in the presented regression models (regression models including age were run, showing that age was not a significant variable). As previously noted, Early- and Late-Onset Bipolar groups were combined into one single COD-Bipolar group because the individual group sizes were not large enough to separately analyze.

Hypothesis 1A: Increased depressive symptomatology is associated with increased latency to smile. Although the overall model was significant, there were no significant main effects or interaction effects for any of the independent variables (see Table 7).

Table 7 Summary of Regression Analysis for Models Predicting Latency to Smile (N=148)

Variables	R2	Sig. F	B	SE B	β	*p*
Model	0.204	0.004				
Sex			-0.045	0.093	-0.073	0.626
History						
Unipolar			-0.057	0.126	-0.101	0.652
Bipolar			-0.099	0.140	-0.136	0.480
Symptomatology						
BDI			-0.006	0.01	-0.218	0.568
AU6			0.126	0.098	0.226	0.200
Interactions						
Sex by Unipolar			-0.021	0.127	-0.035	0.870
Sex by Bipolar			-0.174	0.151	-0.199	0.253
Sex by BDI			0.006	0.007	0.227	0.390
Sex by AU6			-0.175	0.101	-0.305	0.085
Unipolar by BDI			0.009	0.009	0.316	0.315
Unipolar by AU6			-0.130	0.112	-0.192	0.251
Bipolar by BDI			0.008	0.010	0.212	0.402
Bipolar by AU6			0.101	0.139	0.107	0.467
BDI by AU6			-0.007	0.006	-0.195	0.241

Hypothesis 1B: History of depression is associated with increased latency to smile. As in the variables concerning symptomatology, there were no significant main effects or interaction effects for any of the independent variables concerning history of depression (see Table 7).

Table 8 Summary of Regression Analysis for Models Predicting Maximum Intensity of Smile (N=148)

Variables	R2	Sig. F	B	SE B	β	*p*
Model	0.298	0.000				
Sex			-0.017	0.019	-0.123	0.382
History						
Unipolar			-0.019	0.026	-0.147	0.483
Bipolar			-0.002	0.029	-0.009	0.959
Symptomatology						
BDI			0.001	0.002	0.133	0.712
AU6			0.067	0.020	0.537	0.001
Interactions						
Sex by Unipolar			0.019	0.027	0.141	0.484
Sex by Bipolar			0.042	0.032	0.218	0.183
Sex by BDI			0.000	0.001	0.072	0.772
Sex by AU6			0.003	0.021	0.027	0.870
Unipolar by BDI			-0.002	0.002	-0.258	0.383
Unipolar by AU6			-0.015	0.023	-0.101	0.520
Bipolar by BDI			-0.002	0.002	-0.251	0.290
Bipolar by AU6			-0.035	0.029	-0.167	0.226
BDI by AU6			0.000	0.001	0.065	0.676

Hypothesis 2A: Increased depressive symptomatology is associated with less intense smiles. There was no main effect of BDI, suggesting that current depressive symptomatology was unrelated to the intensity of smiles. There was a main effect of type of smile, showing that Duchenne smiles were associated with more intense smiles (see Table 8).

Hypothesis 2B: History of depression is associated with less intense smiles. There were no significant main effects or interaction effects for any of the independent variables concerning history of depression (see Table 8).

Table 9 Summary of Regression Analysis for Models Predicting the Onset Duration of Smiles (N=148)

Variables	R2	Sig. F	B	SE B	β	*p*
Model	0.227	0.001				
Sex			-0.012	0.048	-0.036	0.806
History						
Unipolar			-0.056	0.065	-0.191	0.388
Bipolar			-0.152	0.072	-0.399	0.037
Symptomatology						
BDI			0.004	0.005	0.254	0.500
AU6			0.039	0.050	0.134	0.442
Interactions						
Sex by Unipolar			0.026	0.065	0.085	0.686
Sex by Bipolar			0.157	0.078	0.345	0.045
Sex by BDI			-0.004	0.004	-0.293	0.261
Sex by AU6			0.031	0.052	0.104	0.550
Unipolar by BDI			-0.002	0.005	-0.131	0.673
Unipolar by AU6			0.036	0.058	0.101	0.537
Bipolar by BDI			-0.003	0.005	-0.161	0.518
Bipolar by AU6			-0.056	0.071	-0.114	0.432
BDI by AU6			0.004	0.003	0.206	0.208

Relation between depressive symptomatology and onset duration. There were no significant main effects or interaction effects for any of the independent variables concerning current depressive symptomatology (see Table 9).

Relation between history of depression and onset duration. A main effect of COD-Bipolar was found which indicated that those participants in the COD-Bipolar group had shorter onset durations than those participants in the control and COD-Unipolar groups.

This unexpected finding of significant contributions of the bipolar group in the prediction of onset duration could be interpreted as the bipolar group having either faster or less intense smiles. To test this, a One-Way ANOVA was conducted to test for sex and group differences in intensity. Because no group differences were found, $F(5, 143) = 1.524$, $p = .186$, it can thus be concluded that participants in the bipolar group reach the peak of their facial displays, which are not significantly different in intensity, faster than other groups.

A bipolar by sex interaction effect was also found, showing that male bipolar participants had shorter onset durations than female bipolar participants. Thus, the main effect of the COD-Bipolar group on onset duration mentioned above cannot be interpreted. This sex interaction qualifies the main effect of bipolar disorder on onset durations mentioned above.

To further investigate this interaction, differences in intensity and maximum velocity between males and females within the bipolar group were additionally examined to test whether this was a result of either faster or less intense smiles. Significant intensity differences were found between males and females within the bipolar group $F(1, 26) = 6.915$, $p = .014$, showing that males had less intense smiles than females. Significant maximum velocity differences were also found between males and females within the bipolar group $F(1, 24) = 8.235$, $p = .009$, showing that males had lower maximum velocities than females. Thus, the results show that the bipolar depressed males have shorter onsets, less intensity, and lower maximum velocity than bipolar depressed females. Together, these findings suggest that although males within the bipolar group have shorter onset durations, their smiles cannot be characterized as more explosive than females within the bipolar group because males were shown to have smiles with less intensity and lower maximum velocities.

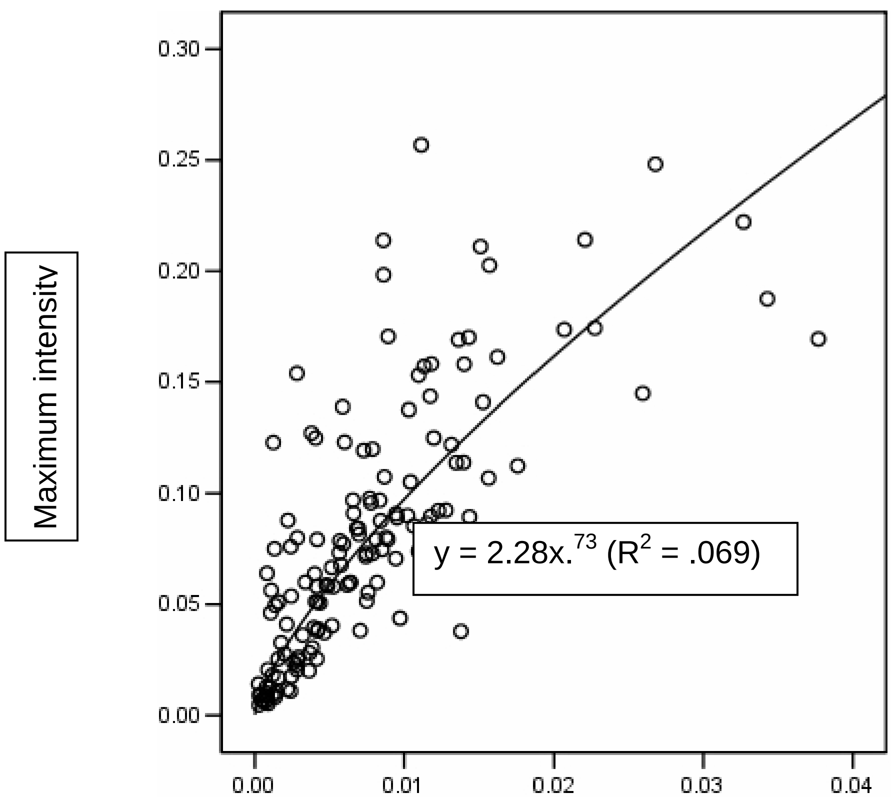
Hypothesis 3: Relation between intensity and velocity of smiles. An additional simultaneous regression analysis was conducted to test whether intensity significantly predicts velocity of lip corner movement during smiles. It was hypothesized that a deterministic relationship would be found between the intensity at the end of the onset of the smile (point c) and the maximum velocity of the onset of the smile as was found in Schmidt, Cohn and Tian (2003).

Schmidt, Cohn and Tian (2003) found that the relationship between the intensity and maximum velocity of the smile onsets was best fit by the power curve $y=50.5x^{1.4}$ ($R^2=.0.87$).

The current study (which used the same solitary participants as Schmidt, Cohn, and Tian (2003), but with a larger sample size) also found that the relationship between intensity and maximum velocity of smile onsets was best fit by a power curve, with the equation $y=2.82x^{.73}$ (R^2=.69).

In order to directly compare the results from Schmidt, Cohn, and Tian (2003), subjects included in the current study that were also included in the former study were excluded. A total of 31 participants were included in both studies. After the exclusion of these participants, the relationship between intensity and maximum velocity of smile onsets was best fit by a power curve, with the equation $y=3.39x^{.78}$ (R^2=.74). This supports the finding by Schmidt, Cohn, and Tian (2003) that smiles represent stereotyped, automatic movements. See Figure 2.

Figure 2 Relation between maximum velocity and intensity of smile onsets



4. Discussion

4.1. Depressive symptomatology and history of depression are not associated with latency

No association was found between current depressive symptomatology and latency to smile or between history of depression and latency to smile. This finding is not consistent with paralinguistic research studies concerning switching and speech pause times in affective contexts. While these studies have found increases in pause times in depressed individuals as well as longer and more variable switching pauses in mothers high in depressive symptomatology and mothers diagnosed with depression, results from the current study do not show the comparable increases of latency in facial behavior.

Table 10 Summary of Results

	Latency	Intensity	Onset Duration
Current Depressive Symptomatology	No significant findings	**AU6** - Duchenne smiles were more intense than Non-Duchenne smiles	No significant findings
History of Depression	No significant findings	No significant findings	**Bipolar** - Bipolar participants had shorter onset durations. **Sex by Bipolar** – Male bipolar participants had shorter onset durations

This inconsistency could be the result of the unique social situation presented in the current study. Paralinguistic research investigating speech pause times and switching pauses have all been conducted in a dyadic social situation in which there is bidirectional communication between two individuals. Although the current study also represents a social situation, the communication is only unidirectional. That is, the participants in the current study are influenced by, but cannot influence the pre-recorded film clip. Further research needs to investigate the timing characteristics of smiles in a dyadic social situation.

Results from the current study are not entirely consistent with reaction time studies. As previously mentioned, these differences could be present because reaction time studies involve the production of voluntary motor actions, while the current study involved the production of involuntary motor actions. Inconsistencies may also be present because reaction time studies involve a neutral affective state, while the current study investigates reactions in response to a film clip intended to elicit positive emotion.

4.2. Depressive symptomatology and history of depression are not associated intensity

Neither current depressive symptomatology nor history of depression was found to be related to intensity of smiles. This is inconsistent with previous research investigating the intensity and frequency of facial displays in depression. This inconsistency could simply be a result of the lack of moderately or severely depressed participants in the current study. Although current depressive symptomatology was ascertained, few participants had BDI scores above 19, which would be indicative of moderate to severe depressive symptomatology. It is also impossible to ascertain if those participants with a history of depression were currently in a depressive state or not. Likewise, it is impossible to ascertain what state the COD-Bipolar participants were in. Further research needs to focus on the timing characteristics of smiles in a sample in which current state is known.

4.3. History of bipolar disorder is associated with shorter onset durations

Another unexpected finding showed that those participants with a history of bipolar disorder had shorter onset durations than those participants in the control and COD-Unipolar groups. In interpreting this finding, it is important to note that there were no group differences in the intensity of smiles at the end of the smile onset. This suggests that individuals with a history of bipolar disorder reach the peak of their facial displays, which do not differ in intensity, faster than individuals without a history of bipolar disorder. An interpretation of this finding is that individuals with a history of bipolar disorder are more explosive in the production of smiles. This, along with the finding that those participants with a history of Bipolar disorder may have more intense smiles, is highly consistent with the suggestion that individuals pertaining to the bipolar spectrum respond to something perceived as amusing with a cackling laugh (Cassano et al., 1999).

This main effect cannot be interpreted, as it was also found that within the bipolar group, males had shorter onset durations than females. This sex interaction qualifies the main effect of bipolar disorder on onset durations mentioned above. Although this sex difference was not hypothesized, it is consistent with research in the bipolar literature stating that bipolar women have a course of predominantly depressive states while men have a course of predominantly manic states (Leibenluft, 1996). This finding is also consistent with findings from studies showing that the state of exuberance is far more common in bipolar boys and men than bipolar girls and women (Jamison, 2004).

The number of male participants with bipolar was only nine. Thus, it was possible that one or two of the male participants with a history of bipolar disorder accounted for the sex differences within the bipolar group. This was not the case. There were no outliers among men in the bipolar group. Eight of the nine males within the bipolar group had onset durations shorter than the mean of the females within the bipolar group. Thus, it seems conclusive that the males within the bipolar group did indeed have shorter onset durations than the females within the bipolar group.

To further investigate the finding of sex differences in onset duration within the bipolar group, sex differences in intensity and maximum velocity were additionally measured. It was found that the bipolar men had less intense smiles than the bipolar women. It was also found that the bipolar depressed men had lower maximum velocities than bipolar depressed women. So, although males within the bipolar group had shorter onsets than females within the bipolar group, males also had less intense smiles as well as lower smile velocities. These additional findings obscure the suggestion that males within the bipolar depressed group have faster and more explosive smile onsets than do females within the bipolar depressed group. It is possible that onset differences between males and females within the bipolar group could be due to differences in intensity. The finding that males within the bipolar group also have lower maximum velocities than females within the bipolar group gives further weight to the possibility that onset differences between males and females could be due to differences in intensity.

4.4. Consistent and deterministic relationship between intensity and velocity of smiles

An additional regression analysis was conducted to test the hypothesis that predicted a deterministic relationship between the maximum velocity and the amplitude of the facial display. The current study found a consistent and deterministic relationship between the intensity and maximum velocity of smiles. This finding is a successful replication of that of Schmidt and Cohn (2003). This gives further support to the suggestion that facial displays represent stereotyped, automatic movements, and generalize to social and solitary conditions.

Several differences must be noted when comparing these relations. Schmidt, Cohn and Tian (2003) measured movement of the right lip corner, whereas the current study examined movement of the left lip corner. It also must be noted that Schmidt, Cohn and Tian (2003) measured spontaneous smiles in both social and solitary conditions, whereas the present study only examined spontaneous smiles in a solitary context.

4.5. The effect of dampening actions on smiles

The investigation of dampening actions on smiles led to some expected and interesting findings. First, dampening actions were unrelated to latency, intensity, and onset duration. This finding is consistent with that of Schmidt, Cohn, and Tian (2003) who found that dampening actions occur after the onset phase.

High BDI scores were associated with a greater frequency of dampening actions. This suggest that those participants who were currently depressed felt the intended positive emotion while viewing the film clip (due to the initial smile onset), but dampened that felt emotion (or the expression of that felt emotion) during the smile.

The effect of dampening action on smiles within the current study is without a clear explanation. Dampening actions consisted of dimplers, AU14; lip corner depressors, AU 15; lower lip depressors, AU 16; and lip sucks, AU 28. There were no systematic group differences between the occurrences of any one specific dampening action. One possible explanation is that the participants who displayed dampening actions experienced two subsequent emotions: initial joy followed by disgust, anger or embarrassment in response to the film clip. This seems possible, as the presence of the initial smile suggests that a positive emotion was felt. Thus, it could be that a positive emotion was felt initially, only to be reduced or “dampened” after its onset. This interpretation is consistent with the appearance of the dampeners occurring after the onset of the smile and could represent a cognitive bias within the participant.

To further investigate this interpretation, self report measures were analyzed. Those participants without dampening actions reported significantly greater happiness following the film clip than those participants with dampening actions. There was also a trend for significantly greater anger reporting during the film clip for those participants with dampening actions than those participants without dampening actions, though the ratings for both groups were very low. Self report ratings of sadness, fear and disgust did not differ between those participants with dampening actions and those without. These self report ratings must be interpreted cautiously, as they represent ratings for the entire film clip rather than the specific 11 second segment analyzed.

4.6. Summary

Although none of the primary hypotheses were supported, the results of the current study represent the first evidence of the effects of bipolar disorder on the timing characteristics of smiles. Although future research must be conducted, these results show promise in the suggestion that differences in the timing of smiles may prove to be reliable signs of individuals suffering from mood disorders with and without sub-threshold symptomatology. As previously stated, any demonstration of distinguishing signs would be of considerable clinical value. These signs could be used in the discrimination between bipolar depression and unipolar depression, which would aid in determining treatment options in common clinical situations such as first-onset depression, an ambiguous past history of mania, or the MDD patient with a family history of bipolar disorder. Further research in this area could focus on the effects of bipolar spectrum disorders on the production of positive and negative facial displays. It is possible that timing characteristics of facial displays may be useful not only in the discrimination of unipolar and bipolar depression, but also in the placement of individuals along the bipolar spectrum.

There was not a significant difference in the frequency of smiles during the specified 11 second segment between those participants with a history of unipolar or bipolar disorder and controls. This is not entirely consistent with the literature comparing the frequency of positive facial displays in currently depressed individuals with non-depressed controls. This inconsistency could be present because not all those with a history of depression were currently depressed during the time of the investigation. This may be the case because, as previously noted, the included and excluded groups did not vary in terms of current depressive symptomatology.

Despite this inconsistency, it is not surprising to have found differences in the timing characteristics of smiles without having found differences in the frequency of smiles. Bettes (1998) found differences in the timing characteristics in motherese (variability of utterances, duration of pauses, and variability of pauses) without finding significant differences in the number of responses. Thus, it is stressed that when looking at the timing characteristics of emotional responses, the *quality* of the response is just as important as the *quantity* of responses. Results of the present study suggest that differences in the timing characteristics of facial displays are present when comparing individuals with current depressive symptomatology and with a history of depression. Further research needs to ascertain whether these differences in timing characteristics can be discerned by individuals. A perception study, in which the timing characteristics of facial displays are precisely manipulated, could yield such useful information.

4.7. Limitations

There are several important limitations to the present study. First, it is possible that this community sample does not include participants with a severity of depression great enough to induce latency in facial displays. In addition, the current study does not have data pertaining to which state the COD-Unipolar and COD-Bipolar participants were in during the time of the study. There were no questions or observational data pertaining to mania or hypomania. Though it is possible, it seems unlikely that a participant in a manic state could complete the protocol which involved remaining seated for several hours. Informal discussion with staff members also suggests none of the participants showed signs of mania or hypomania. Future research should examine the effects of state on facial behavior.

A second limitation of the present study is also a result of the sample. It is known that the mean onset age of bipolar disorder is 24 years. The present study included individuals in the COD-UNIPOLAR and control groups with an age range of 18-38. It is possible that some of the COD-UNIPOLAR subjects will go on to have an initial manic episode.

Third, the method of eliciting positive emotions and facial displays in the present study may also be considered a limitation. There are several advantages and disadvantages of using this comedy segment to elicit positive emotion. The use of film clips remains the preferred method of eliciting positive emotion in the present study because of two main advantages: 1) the film clip involves the monologue of a single comedian, which is a better analogue to a dyadic conversation than slide viewing or imagery, and 2) the film clip is standardized, so all participants will be exposed to exactly the same stimulus at precisely the same time. The latter is crucial, as it allowed for the precise measurement of duration for each participant that would not be possible in the context of an interview. Despite these advantages, results from the current study were not ultimately consistent with studies conducted in a social and dyadic context. Future research on the timing characteristics should focus on social contexts and influences.

The disadvantages of the current study are 1) studies investigating the intensity and frequency of facial displays used slides and imagery intended to elicit positive emotion, thus the results of the present study cannot be directly compared to those studies, 2) although the punch line of the joke has a discrete time point, there are other stimuli present in the video which could elicit positive emotion such as the nonverbal behavior of the comedian and the presence of audience laughter included in the audio, and 3) because the clip is a pre-recorded monologue, participants viewing the segment are not subject to display rules as in a true dyadic conversation. In addition, the present study only included self-report measures for the entire comedy segment rather than merely the 11 second segment used in the present study. This may have affected the validity of the self-report measures used in the present study, though there is no evidence that this is indeed the case.

The present study is also limited because it only investigates positive facial displays. While the number of subjects was large, the behavior sample was small in that only stimuli intended to elicit positive emotion were used. It is possible that there may be differences in timing in response to stimuli intended to elicit negative facial displays. Without the elicitation of negative facial displays as well as positive facial displays, it is unknown whether the results of the present study are specific only to positive facial displays or generalize to positive and negative facial displays.

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