Running Head: MOVEMENT DIFFERENCES IN FACIAL EXPRESSION

Movement Differences Between Deliberate and Spontaneous Facial Expressions: *Zygomaticus Major* Action in Smiling

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Abstract

Previous research suggests differences in lip movement between deliberate and spontaneous facial expressions. We investigated within participant differences between deliberately posed and spontaneously occurring smiles during a directed facial action task. Using automated facial image analysis, we quantified lip corner movement during periods of visible *Zygomaticus major* activity. Onset and offset speed, amplitude of movement, and offset duration were greater in deliberate smiles. In contrast to previous results, however, lip corner movement asymmetry was not greater in deliberate smiles. Observed characteristics of deliberate and spontaneous smiling may be related to differences in the typical context and purpose of the facial signal.

Key words: emotion expression, nonverbal communication, voluntary movement.

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The smile is one of the most frequent facial expressions and serves to communicate positive emotional states, as well as to serve social functions including greeting and appeasement (Keltner, 1995; Preuschoft, 1992; Schmidt & Cohn, 2001). Like many facial expressions, the smile can be produced either deliberately by voluntary movement of the *Zygomaticus major* muscles or spontaneously in response to social or emotional stimuli. The primary objective of this study was to determine whether deliberate and spontaneous smiles observed in the same individuals were significantly different in lip corner movement and in asymmetry of movement. The role of an additional facial movement, specifically *Orbicularis oculi* activity in these smiles was also addressed. Uncovering systematic differences in movement between deliberate and spontaneous expression has important implications for understanding pathological disruptions in facial movement, as well for understanding the biological basis underlying facial communication.

Spontaneous smiles of enjoyment have been found to have a number of distinctive timing and movement characteristics in general; as compared to deliberate smiles, spontaneous smiles tend to be shorter in total duration (from four and six seconds), slower in offset time (Hess & Kleck, 1997), and less asymmetric in lip corner movements (Hager & Ekman, 1997; Skinner & Mullen, 1991). The findings, obtained with perceptually based measures, have been supported in part by studies using more objective quantitative methods. Cohn and Schmidt (2004), for example, have found that deliberate smiles have faster onsets and are more asymmetric, with onset beginning earlier on one side of the face than on the other. A study of deliberately posed smiles vs. emotion-elicited smiles that compared observers' perceptions of happiness with electromyographic (EMG) recordings of the smiles found that temporal factors in the underlying muscle activity (EMG values) of the smiles discriminated between smiles that were deliberately posed and smiles that were elicited with happy emotions (Hess, Kappas, McHugo, Kleck, & Lanzetta, 1989). This study combines the measurement of temporal differences in smiling movements with the measurement of specific visible characteristics of intra-individual variation in smiling movements to determine which aspects of movement timing differentiate deliberate and spontaneous smiles.

Timing differences between deliberate and spontaneous smiles are important because they are likely to significantly affect social judgments of the person smiling. For example, asymmetry in smiling has been shown to relate to negative social judgments and lower ratings of trustworthiness in observers (Brown & Moore, 2002). In addition, Bugental (1986) found that women whose smiles offset rapidly were perceived as less genuine by observers. A study of temporally altered computer-generated smiles has shown that increasing the speed of onset decreases the perceived genuineness of smiles (Krumhuber & Kappas, 2005). These results may have been due to the similarity between timing characteristics of the artificially generated smiles to those of deliberately produced actual smiles. If smiles with faster onsets and offsets were perceived as less genuine, for example, it could be due to the fact that lip corner movement in these smiles was similar to that of deliberately produced smiles. These differences in smile characteristics are not only relevant for the study of social judgments in healthy individuals, but they are also relevant for understanding the pathology of spontaneous movement observed in individuals with Parkinson's disease and other facial movement disorders.

In addition to movement timing, smiles may also be characterized by additional action of other facial muscles, particularly *Orbicularis oculi* that produces wrinkles in the skin at the outer edge of the eye (Ekman, Davidson, & Friesen, 1990; Frank, Ekman, & Friesen, 1993). The presence of this additional muscle action may be associated with quantitative measures of lip corner movement (Frank et al., 1993). Smiles with *Orbicularis oculi* action were also longer on average than deliberate smiles lacking *Orbicularis oculi* from the same individuals. Furthermore, the presence of this action has come to be associated with smiles that are perceived as more genuine, with truly felt emotion. As a result, it has also been suggested that this movement is a characteristic of spontaneous smiles only and not deliberate smiles. However, there has also been the observation that intense deliberate smiles tend to be accompanied by the action of *Orbicularis oculi* (Ekman & Friesen, 1978). While the association between *Orbicularis oculi* and spontaneity of smiles awaits further and more rigorous research, we explored its association with variables describing movement of the lip corners, where this action existed in deliberate and spontaneous smiles. In this study, the effect of *Orbicularis oculi* activity on lip corner movement in spontaneous and deliberate smiles is discussed with reference to the unique aspects of this sample of smiles.

Given the importance of spontaneous smiles in influencing social impressions, we expected that movement in spontaneous smiles would not be characteristic of those produced deliberately. As in Frank et al. (1993), we expected that spontaneous smiles would have significantly slower onsets and offsets than deliberate smiles. Using more precise quantitative measurements of visible movement than have previously been available, we aimed to determine whether the duration, speed, and amplitude of lip corner movement in smiling differ in spontaneous and deliberate smiles of the same individuals. We also expected that the lip corner movement in deliberate smiles would be more asymmetric than that in spontaneous smiles, such that differences in the duration, maximum speed, and amplitude of left and right lip corner movement would be larger in deliberate than spontaneous smiles.

The presence of *Orbicularis oculi* activity in the smiles (both deliberate and spontaneous) that we analyzed was also considered as a possible influence on timing parameters (duration, maximum speed, amplitude of onset and offset, total duration of smile, and asymmetry of duration, maximum speed, and amplitude).

Method

Participants

Participants were 87 adult women whose videotaped data were available from the Cohn-Kanade AU-coded Facial Expression database (Kanade, Cohn, & Tian, 2000). The Cohn-Kanade image database is comprised of videotapes in which undergraduates were instructed to display facial expressions of basic emotions. Because the subset of women (n = 87) available for digital analysis at the time of this project was much larger than that of the men (n = 16), only data from women were chosen for analysis.

Materials

Deliberate and Spontaneous Smiles. The study began with the analysis of currently available videotaped deliberate joy expressions from a directed facial action task (Kanade et al., 2000). Participants were instructed to produce facial expressions of basic emotions including joy. They were instructed to bring their faces to a neutral position both before and after posing the expression.

Deliberate smiles were defined as facial expressions including *Zygomaticus major* activity (oblique raising of the lip corners) that commenced immediately (within one to two seconds) following the experimenter's instruction to produce an expression of joy. There were 87 participants who displayed deliberate smiles. Beginning with participants that had a deliberate smile, we then screened the video looking for instances of spontaneous smiles from the same individuals.

Spontaneous smiles used in this study were not a result of any specific elicitation procedure. At some points during the directed facial action task session, participants spontaneously smiled. In this study, spontaneous smiles were defined by *Zygomaticus major* activity occurring without specific instructions to smile or show joy. Presence or absence of a spontaneous smile was determined by a certified FACS coder, based on the occurrence of AU12 outside of the period in which participants were instructed to produce expressions of joy (smiles). Of 87 individuals with a deliberate smile, 64 also smiled spontaneously at some point during the procedure. Some participants spontaneously smiled on more than one occasion. To ensure a balanced representation of spontaneous smiles in our sample, we selected for each participant only the first spontaneous smile that had a relatively neutral onset with no facial actions related to the directed facial action task (as determined by a certified FACS coder) . This selection procedure resulted in 128 smiles, 64 each for deliberate and spontaneous smiles, from the 64 individuals (see Figure 1 for example smiles). These were the smiles included in the analyses.

A subset of five participants in the sample had a spontaneous smile onset, but did not have a visible spontaneous offset because of occlusion of the face near the end of the smile sequence. This resulted in the absence of offset data for these individuals. For this reason, data from these five participants were excluded from all analyses that required offset data.

Design and Procedure

All 128 smiles were subjected to both manual coding (using the Facial Action Coding System (FACS), Ekman, Friesen, & Hager, 2002) and automated facial image analysis (AFIA) as described below (Tian, Kanade, & Cohn, 2001).

Facial Action Coding. In FACS, each action unit is anatomically related to contraction of a primary facial muscle (Ekman & Friesen, 1978; Ekman et al., 2002). Facial action coding by two certified FACS coders aimed to determine the presence of *Zygomaticus major* activity (AU 12) and *Orbicularis oculi* activity (AU 6, movement of the skin at the lateral margin of the eye). Interrater reliability for these action units was high at 1.00 and .95 respectively for AU 12 and AU 6.

Automated facial movement analysis. Automated facial image analysis (AFIA) was performed on all smiles to objectively measure movement parameters. Figure 2 depicts the videotaped data as processed by the CMU/Pitt automated facial image analysis (AFIA) system. Once the sequence of digitized image frames were loaded into the system, the region of the face and location of individual facial features, pictured as x marks in Figure 2 were delineated in the initial frame. This step was performed automatically for the initial frontal image. Head motion parameters from subsequent video frames were then recovered automatically and these values were used to stabilize each face image in the sequence to a standard view. In this way, head motion did not confound measurement of change in facial features; movement of facial features due to head motion was effectively removed from the video sequence. Individual facial features were then tracked automatically by the program through successive frames. AFIA uses the Lucas-Kanade algorithm for optical flow to track this movement with sub-pixel accuracy (Lien, Kanade, Cohn, & Li, 2000; Tian et al., 2001). The changing location of these features over time was recorded and analyzed to quantify the dynamics of facial action (Cohn, Reed, Ambadar, Xiao, & Moriyama, 2004; Cohn, Xiao, Moriyama, Ambadar, & Kanade, 2003; Xiao, Kanade, & Cohn, 2003). Following Schmidt, Cohn, and Tian(2003), the extracted features (right and left lip corners) were represented as the mean displacement of the lip corner points, computed as $d = \sqrt{x^2 + y^2}$. These values of *d* were then standardized by dividing each value by the initial distance between the lip corners in the first frame of the videotape (mouth width), This procedure removed the effect of different mouth widths, allowing for comparison across participants. Data series were smoothed, and onsets and offsets identified quantitatively, as described below.

The periods of longest continuous increasing value of *d*, and subsequent longest continuous decrease in *d* were designated as onsets and offsets of the smile, respectively (see Figure 3). Duration of onset or offset was measured as the length of the onset or offset period in seconds. Maximum speed was measured as the maximum frame to frame difference in *d* occurring during the onset or offset period, and amplitude was measured as the total change in *d* from beginning to end of onset or offset.

Data reduction. We obtained measures of both left and right corner movement for each smile, which were used to calculate average lip corner movement values (mean duration, mean maximum speed, and mean amplitude) as well as movement asymmetry values. Asymmetry measures were calculated by taking the value of the difference of right and left lip corner values of duration, maximum speed, and amplitude for onsets and offsets, yielding six asymmetry measures for each smile.

After onsets and offsets were identified, we were able to determine the total duration of lip corner movement (total duration of the smile). The time between the first frame of the onset and the last frame of offset was measured for each lip corner and then total duration values for right and left lip corners were averaged to give a single total duration value for each smile.

Analysis. Separate repeated measures analyses of variance were used to investigate two main hypotheses: that deliberate smiles were different in onset and offset movement and that deliberate smiles were more asymmetric than spontaneous smiles during onset and offset respectively. The independent factor investigated was the classification of the smile as deliberate or spontaneous and the outcome measures were duration, speed, and amplitude of movement in the first hypothesis and asymmetry of duration, maximum speed, and amplitude in the second hypothesis. Analyses of movement (duration, maximum speed, and amplitude) and asymmetry of movement (asymmetry of duration, maximum speed, and amplitude) were performed separately for smile onset and smile offset, for a total of four repeated measures analyses. Analyses of movement were two-tailed, while analyses of asymmetry of movement were one-tailed, as previous reports suggested that deliberate expressions were more likely to be asymmetric.

The effects of *Orbicularis oculi* activity were explored in a number of ways. Chi-square analysis was used to determine whether there were differences in the proportion of smiles with *Orbicularis oculi* activity in deliberate and spontaneous expressions. ANOVA was used to investigate group differences in duration, maximum speed, amplitude, and asymmetry of duration, maximum speed, and amplitude between smiles with and without *Orbicularis oculi* activity (sample drawn from spontaneous smiles only, see below). We performed a t test (two tailed) to investigate differences in total duration between spontaneous smiles with and without *Orbicularis oculi* activity. In addition, we reported descriptive results of movement variables and performed repeated measures analyses testing the two main hypotheses on the subset of individuals who displayed *Orbicularis oculi* activity in both deliberate and spontaneous smiles. By analyzing data from only those participants (n = 39) that displayed *Orbicularis oculi* activity in both smiles, we aimed to determine whether results for the sample as a whole were associated with the presence/absence of *Orbicularis oculi* activity.

Results

Average values for lip movement, asymmetry, and total duration are reported in Table 1. Repeated measures analysis revealed significant effects of smile type (deliberate vs. spontaneous) in both smile onset ($F(1,61) = 113.1$, $p < .001$, $\eta_p^2 = .64$; $F(1,61) = 92.3$, $p < .001$, $\eta_p^2 = .59$ for maximum speed and amplitude, respectively) and offset ($F(1,61) = 6.1$, $p = .02$, $\eta_p^2 = .10$; $F(1,61) = 40.0$, $p < .001$, $\eta_p^2 = .39$; $F(1,61) = 38.3$, $p < .001$, $\eta_p^2 = .38$, for duration, maximum speed, and amplitude, respectively). Deliberate smile onsets were faster and larger in amplitude. Deliberate smile offsets were faster, larger in amplitude, and longer in duration. Neither onsets nor offsets of deliberate and spontaneous smiles differed in asymmetry of movement (asymmetry of duration, maximum speed, or amplitude).

Because amplitude differed between deliberate and spontaneous smiles, the differences we found in duration and maximum speed could be due to the amplitude difference between the two types of smile. To investigate this possibility we reran the repeated measure analysis of duration and maximum speed and included amplitude as a covariate. Similarly, reanalysis was done for asymmetry of movement.

For smile onset, the effect of type of smile on duration became significant, and the effect on maximum speed remained significant even after controlling for the effect of amplitude ($F(1,62) = 11.8$, $p = .001$, $\eta_p^2 = .16$ and $F(1,62) = 11.3$, $p = .001$, $\eta_p^2 = .15$, for duration and maximum speed respectively). For smile offset, the effect of type of smile on neither duration nor maximum speed remained significant ($F(1,62) = 3.55$, $p = .064$, $\eta_p^2 = .05$ and $F(1,62) = .19$, $p = .67$, $\eta_p^2 = .003$, for duration and maximum speed respectively). As in the original analysis, deliberate and spontaneous smile onsets and offsets did not differ in asymmetry of movement after the difference of amplitude was controlled for.

A subset of individuals in this sample ($n = 39$) showed activity of *Orbicularis oculi* (AU6) both in their deliberate and in their spontaneous smiles. Another 19 participants showed *Orbicularis oculi* activity in their deliberate, but not in their spontaneous smiles. An equal number of participants had either no *Orbicularis oculi* activity in either smile (n=3), or activity in spontaneous smile only (n=3). A chi-square analysis showed that differences in the proportion of smiles with *Orbicularis oculi* activity in deliberate and spontaneous expressions were not significant ($\chi^2(1,63)$=.72, p=.40).

Because there were so few deliberate smiles that lacked *Orbicularis oculi* activity, we did not analyze differences associated with this variable in the entire sample. Instead, analysis of the effect of *Orbicularis oculi* activity was performed only within the spontaneous smile group (n=64 spontaneous smiles). 42 participants had *Orbicularis oculi* activity in their spontaneous smiles and 22 did not. ANOVA was used to test differences in timing and asymmetry between spontaneous smiles with and without *Orbicularis oculi* activity using only those participants who had *Orbicularis oculi* activity in both types of smiles (n = 39; see Table 2). Using the Bonferroni correction for multiple tests, we set significance at $p < 0.008$. Under these criteria, spontaneous smiles with *Orbicularis oculi* activity had larger amplitude onsets ($F(1,63) = 16.5$, $p < .001$) and had faster and larger offsets ($F(1,63) = 23.3$, $p < .001$; $F(1,63) = 30.0$, $p < .001$). A t test showed that there were no differences in total duration of the smile (beginning of onset to end of offset) between spontaneous smiles with *Orbicularis oculi* activity and those without *Orbicularis oculi* activity ($t(63) = -1.26$, p =.21, two-tailed).

In light of the above effect of *Orbicularis oculi*, we explored the possibility that the differences between deliberate and spontaneous smiles observed in the larger sample may have been associated with the presence/absence of *Orbicularis oculi*. As noted above, a subset of participants had *Orbicularis oculi* activity in both their deliberate and spontaneous smiles (n = 39). Although *Orbicularis oculi* occurring with *Zygomaticus major* activity in smiling has been cited as an indicator of felt emotion (Ekman et al, 1990; Frank et al, 1993), its presence in these deliberate smiles is not totally unexpected because more intense movements of *Zygomaticus major* are known to be accompanied in many cases by *Orbicularis oculi* activity (Ekman & Friesen, 1978). Because of differences found in the spontaneous smiles comparison above, we performed the original repeated measures analyses of deliberate and spontaneous smiles using only those participants who had *Orbicularis oculi* activity in both types of smiles (n = 39). Results for this more limited sample were similar to the results obtained with the larger sample reported above. Taken together, the last two analyses on more limited samples suggest that the differences observed between deliberate and spontaneous smiles in the larger sample (N = 64) were not associated with the presence/absence of *Orbicularis oculi* activity (see Tables 1 and 2).

Discussion

The lip corners move differently in deliberate and spontaneous smiles, with differences most apparent in parameters such as maximum speed and amplitude rather than in the duration of lip corner movement. Timing differences between deliberate and spontaneous smiles occur in both onset and offset phases, with deliberate smiles moving faster and producing a larger amplitude lip corner movement. Especially for the onset period these differences occur in the absence of differences in duration, suggesting that deliberate smiles would produce a visibly different movement, rather than just an extended version of the same basic onset movement. Further analyses of maximum speed and duration between deliberate and spontaneous smiles controlling for difference of amplitude between the two types of smile showed that the contribution of amplitude difference is different for onset and offset of smiles. In the case of smile onsets, smile type (deliberate or spontaneous) continued to contribute to variation in maximum speed and an independent effect on duration was also observed. This suggests that type of smile was shown to have an effect on maximum speed and duration beyond that attributable to amplitude difference. For smile offsets, smile type did not appear to contribute significantly to variance in maximum speed or duration, once amplitude difference was controlled. The effect of type of smile on offset movement parameters seem to be due to its effect of amplitude difference.

Deliberate and spontaneous smiles did not differ in the asymmetry of the movement, even when amplitude differences between deliberate and spontaneous smiles were controlled. The level of symmetry in lip corner movement is striking, especially for amplitude which corresponds most closely to what is measured in typical perceptual studies of asymmetry. We acknowledge that asymmetry of movement may not reflect the asymmetry of appearance that the results of past perceptual studies have likely reflected, as our study measured only movement at the lip corner. Additionally, the relatively high amount of symmetry seen in these smiles may result from the fact that in a majority of cases, both deliberate and spontaneous smiles are accompanied by *Orbicularis oculi* activity. In previous investigations, this marker has been associated with increased symmetry of smiling and this may also be the case for our results.

The presence of *Orbicularis oculi* activity in the majority of deliberate smiles was somewhat unexpected, given the association of "smiles of enjoyment" with descriptions of spontaneous smiling in the literature (Ekman et al., 1990; Frank et al., 1993; Soussignan, 2002). This observation is not unprecedented, however, as a previous study found evidence of *Orbicularis oculi* activity in posed smiles of 21 of 24 participants (Smith, Smith, & Ellgring, 1996). Also, more intense movements of *Zygomaticus major* are known to be accompanied in many cases by *Orbicularis oculi* activity (Ekman & Friesen, 1978). This seems to be the case in the smile sample included in the current study; the deliberate smiles tended to have moderate to high amplitude which may have resulted in the high frequency of *Orbicularis oculi*. On the other hand, not all spontaneous smiles in the current study are accompanied by *Orbicularis oculi* activity. Considering the experimental context from which the spontaneous smiles were sampled in our study, there was no reason to assume that spontaneous smiles would have been more likely than deliberate smiles to have *Orbicularis oculi* activity. Especially in the context of the directed action facial task used in this study, spontaneous smiles were not necessarily more likely to be expressions of joy than are deliberate smiles. Spontaneous smiles are not always expressions of joy; spontaneous smiles produced in the context of directed facial action tasks may represent true amusement, either at the task instructions or at the participant's own efforts to accomplish the task (e.g., Frank et al., 1993; Keltner, 1995). Alternatively, they may represent embarrassment at a failure to produce some of the more difficult facial actions, or simply a social signal of politeness directed toward the instructor (Ambadar, Cohn, & Reed, 2005). Non-enjoyment spontaneous smiles such as social smiles often lack *Orbicularis oculi* activity. In any case, all these aspects suggest that if the above conditions do have an effect on the results of the current study, they would have biased results towards no differences between spontaneous and deliberate smiles. The fact that even under these conditions we still found significant differences between spontaneous and deliberate smiles suggests that there are true differences in the movement characteristics between smiles that are deliberately produced and those that are spontaneously expressed.

Because the generation of spontaneous smiles was not controlled in the research context, it may be the case that not all of the spontaneous smiles showed joy or positive emotion. The spontaneous smiles in this study were variable, although consistently smaller and slower than deliberate smiles (see Figure 3. for an example). Therefore we investigated the role of the amplitude of the smile, in contrast to smile type, in creating the differences we observed. Differences in speed and duration were linked to differences in smile amplitude in lip corner movement during deliberate and spontaneous smiles, although controlling for smile amplitude difference did not completely eliminate the independent effects of smile type on speed and duration of onset. Interestingly, the differences in amplitude, and associated differences in speed and duration were consistent across individuals. Regardless of the motivation for spontaneous smiling, which may have varied from individual to individual, it is significant that the spontaneous smiles were smaller and slower. Do individuals deliberately pose large smiles when asked to display joy? Or is it possible that they do not accurately portray their own typical displays of emotion in the face when asked to do so deliberately? Further studies that can both address natural variation in spontaneous smiling, as well as explore the nature of deliberate facial expression are necessary to resolve these remaining issues.

Differences between deliberate and spontaneous smiles in this study were likely not due to the presence or absence of *Orbicularis oculi* activity in smiles. Repeated measures analysis that was restricted to participants who consistently displayed *Orbicularis oculi* activity produced results that were consistent with the contrasts between deliberate and spontaneous smiles obtained from the full sample. In contrast to the findings of Frank et al. (1993), spontaneous smiles with *Orbicularis oculi* activity in this sample were not significantly different in total duration than smiles that lacked this activity, again suggesting that certain characteristics that may be associated with spontaneous smiles in general whether they have additional facial actions or not.

The results partially support what others have previously found using different methods; deliberate and spontaneous smiles look different because the movement of the lips is different. There are several questions remaining, however: why were spontaneous smiles smaller and slower in this sample, and is this a difference that makes a difference in perception? There is evidence that speed of smiling is an important factor in the social context. A possible explanation lies in the social signaling interpretation of smiling. It makes sense that spontaneous smiles would be smaller than deliberate ones because facial displays in context are subject to multiple constraints, including the need for flexibility in producing other movements and speech. Because the smile display is used so frequently and in the context of other facial movements, it may be that producing the smallest recognizable version of the smile is optimal (Schmidt & Cohn, 2001).

Deliberate smiles were also faster, which corresponds with the finding that relatively faster smiles have produced less favorable judgments of genuineness in computer simulated smiles (Krumhuber & Kappas, 2005). If faster smiles are perceived as more deliberate, perhaps this is due to the fact that deliberate smiles are generally faster. By focusing on the differences between deliberate and spontaneous smiling in the same individuals, we have been able to identify subtle, systematic differences in smiling. Investigating these differences between deliberate facial expressions and all other facial displays, whether primarily social or emotion elicited is essential for further understanding of the nature and role of spontaneous facial expression in social interaction.

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Table 1

Lip Corner Movement and Asymmetry in Deliberate and Spontaneous Smiles (N=64)

	Smile onset				Smile offset			
	Deliberate		Spontaneous		Deliberate		Spontaneous	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Duration	.555	.169	.591	.259	.643*	.173	.555	.251
Maximum Speed	.030**	.011	.012	.007	.024**	.013	.012	.009
Amplitude	.187**	.050	.094	.054	.142**	.065	.083	.054
Asymmetry of Duration	.022	.125	-.017	.225	.007	.245	-.014	.258
Asymmetry Maximum Speed	.0002	.012	.0009	.008	-.001	.013	-.0002	.007
Asymmetry Amplitude	.005	.063	.002	.044	-.002	.058	-.0016	.036

† p<.10, * p<.05, ** p<.01

Table 2

Lip Corner Movement and Asymmetry in Deliberate and Spontaneous Smiles of Participants Displaying O. oculi Activity (n=39 with O. oculi in both smiles)

	Smile onset				Smile offset			
	Deliberate		Spontaneous		Deliberate		Spontaneous	
	M	SD	M	SD	M	SD	M	SD
Duration	.533*	.147	.639	.277	.648	.171	.606	.230
Maximum Speed	.032**	.011	.014	.007	.025**	.014	.015	.008
Amplitude	.192**	.050	.111	.053	.150*	.067	.103	.052
Asymmetry of Duration	.013	.125	-.004	.260	.065	.273	-.012	.273
Asymmetry Maximum Speed	-.0001	.014	.0004	.005	-.004	.011	-.0004	.008
Asymmetry Amplitude	.009	.074	-.0008	.0437	-.013	.055	-.005	.041

† *p*<.10, * *p*<.05, ** *p*<.01

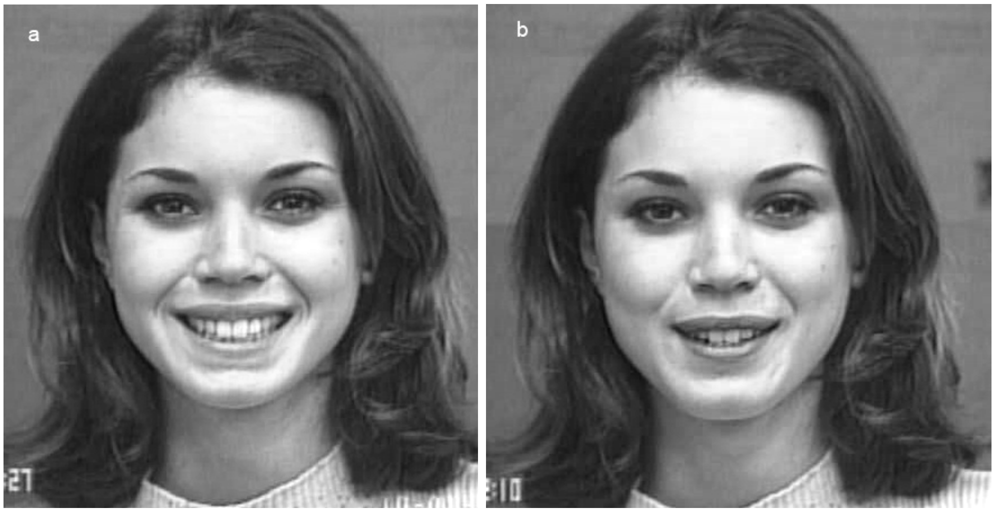
Figure Captions

Figure 1. Smiles of one participant (a. deliberate, b. spontaneous)

Figure 2. Automated Facial Image Analysis (AFIA) of lip corner movement (a. neutral image, b. neutral image with tracking points marked, c. peak smile image with tracking points marked)

Figure 3. Displacement of the lip corner tracking point during smile

Figure 1.



Figure

2.

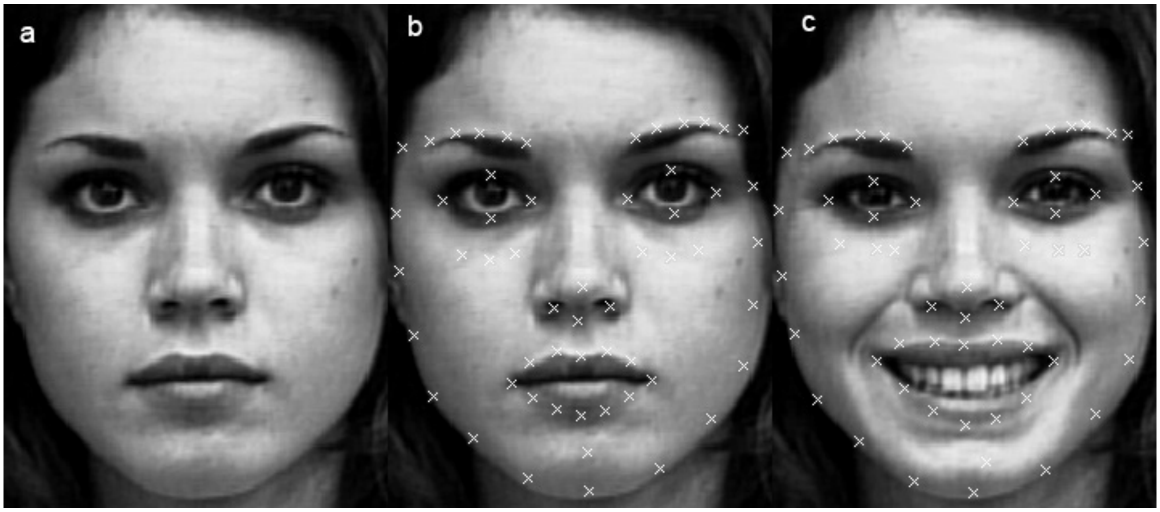


Figure 3.