MOVING SMILES: THE ROLE OF DYNAMIC COMPONENTS FOR THE PERCEPTION OF THE GENUINENESS OF SMILES

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ABSTRACT: Three experiments were conducted to examine whether the temporal dynamics of Duchenne-smiles influenced the perception of smile authenticity. Realistic computer-generated Duchenne-smiles that varied in their onset- and offset-durations (Experiment 1), or only in their offset-duration (Experiment 2), or in both their onset- and apex-durations (Experiment 3), were created using Poser 4 software. Perceived genuineness varied monotonically with the duration of each manipulated dynamic component. The results are in accordance with Ekman and Friesen's (1982) observations regarding the duration of smiles of enjoyment, which suggest that each dynamic component has a distinct duration range that can influence the perceived genuineness of smiles.

KEY WORDS: dynamics; emotions; facial expressions; perception of emotions.

Subtle facial movements are *moving* in a literal as well as in a metaphorical sense, in that they are able to shape the perceived meaning of our verbal and nonverbal messages in interpersonal communication, as well as affect the dynamic process of interaction itself (see Kappas & Descôteaux, 2003). Much of the research on the decoding of facial expressions has focused on the importance of certain static configurations for the attribution of emotional states (see Wallbott & Ricci Bitti, 1993). However, our perceptions are not merely shaped by the configuration itself, but by how facial expressions appear and disappear from the face (see Russell, Bachorowski, & Fernández-Dols, 2003). Specifically, functionally distinct information can be provided by the temporal properties of facial behavior. Indeed, only few past studies have demonstrated that dynamic

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We wish to thank Jesse Spencer-Smith for sharing the AU morph targets that have been developed in the context of his research.

properties play an important role for the identification/discrimination of emotional expressions (e.g., Bassili, 1979; Bruce & Valentine, 1988; Kamachi, Bruce, Mukaida, Gyoba, Yoshikawa, & Akamatsu, 2001; Wehrle, Kaiser, Schmidt, & Scherer, 2000). Some of these findings indicated a recognition advantage for dynamic facial expressions versus static representations. Further, Edwards (1998) also showed that perceivers are attuned to the fine changes as they occur as a facial expression develops over time. More recently, Sato and Yoshikawa (2004) investigated the role of onset duration on the artificiality of morphed expressions for several emotions.

Clearly, the slowly growing number of studies investigating the perception of dynamic expressions is encouraging. However, we argue that it is not sufficient to show whether an expression such as a smile is recognized as a smile, or as a ''prototypical expression of happiness''. The simple icon of a yellow circle with a curved line and two dots (the ''smiley face'') is arguably recognized universally as a happy expression. And yet, we know that the drawing *is* not happy—it is just an abstraction. Identifying the emotion category that a pattern of facial muscle activation/displacement of facial features is associated with, is only one of many emotion—and interaction-relevant processes in decoding nonverbal information. Clearly, other inferences are drawn as well by both interaction partners and have consequences for the continued interaction (see also Kappas & Descôteaux, 2003). Thus, we must go beyond a dichotomous conception in the decoding of facial displays. What emotional states do perceivers really infer from the display? Is it possible to identify an expression as a happy one and yet have the impression that a sender might not be happy at all? In other words, we must also ask whether a given expression is perceived as being *convincing* in such a way that observers truly have the impression that a sender is happy or amused. In fact, the notion that certain dynamic aspects may also convey critical information about the genuineness of an expression has received comparatively little attention. While the recent study of Sato and Yoshikawa (2004) tested 'naturalness' of expressions as a function of onset duration, this is likely to relate to the *plausibility* of expressions. In this sense, an expression may appear *natural* regardless of whether it appears genuine or not. In the present article, we investigate instead the communicative function of the dynamic components of smiles with an emphasis on their genuineness.

Within the study of the relationship between happiness and facial expressions, the smile has received considerable attention since it is ubiquitous, believed to be universal, and appears early in life. Yet smiles occur not only in conjunction with a positive affect, but they can also hide or mask a negative emotion (Ekman, 1985). Given the diversity of possible meanings Ekman and his colleagues (e.g., Ekman & Friesen, 1982; Frank & Ekman, 1993; Frank, Ekman, & Friesen 1993) have proposed to treat the term *smile* not as a single behavioral category, but rather to draw distinctions and specify some major differences between felt emotional smiles and false smiles deliberately shown to simulate enjoyment. One of the most replicated and best-documented criteria for this differentiation (see also Frank & Ekman, 1993) is the combined contraction of the *Zygomaticus Major* muscle and the *Orbicularis Oculi, Pars Lateralis* muscle—widely described as the so-called Duchenne-smile. Most past psychological research has focused on this morphological smile-marker and its purported link to positive emotion (but see Kappas, 2003).

Surprisingly, there is very little research on the importance of the *dynamic* aspects objectively differentiating *felt* and *false* smiles. According to Ekman and Friesen (1982) *felt* smiles are characterized by a duration between 500 and 4000 ms as opposed to *false* smiles that can be shorter or longer. Furthermore, a distinction can be made at a more microscopic level regarding the dynamic nature of their onset, apex, and offset phases. Specifically, the onset time in *false* smiles would usually be too short, giving an abrupt appearance to the smile. The apex-duration, however, would be too long with an offset-timing that is not smooth, but rather abrupt. Weiss, Blum, and Gleberman (1987) provided evidence for some of the temporal differences between posed smiles and smiles reflecting an underlying positive affect. They found that participants, who were hypnotized to experience pleasure in reaction to a corresponding emotion cue, showed smiles with longer and smoother onset actions as compared to when they were simulating pleasure. Similarly, Hess and Kleck (1990) showed for posed expressions (intentionally employed positive expressions to mask disgust) shorter onset and offset times than for emotion-elicited expressions of felt joy. Further, Bugental (1986) found that mothers' smiles shown to unresponsive children in a public situation revealed more abrupt offsets. For these fast-fading smiles, however, it could not be determined whether they were attributable to social rules rather than reflecting an underlying affect (for a critical review, see Hess & Kleck, 1990). It is also noteworthy that Schmidt, Cohn, and Tian (2003) found, based on an analysis of a large number of spontaneous smiles using FACS (Facial Action Coding System, Ekman, & Friesen, 1978), automated facial analysis, and electromyographic recordings, that the onset-phase of spontaneous smiles showed highly consistent temporal characteristics.

While all of these studies support the notion that dynamic components may provide correlates to the "genuineness" of a smile, it remains unclear whether they also provide perceptible and meaningful information to a perceiver. A recent study by Gosselin, Perron, Legault, and Campanella (2002) addressed this issue partially using actor portrayals that were presented to adults and children. Presenting complete smiles, onset and apex, or apex only, they found a slight influence of their mode of presentation on the attribution of genuineness. However, it would be interesting to know what effects the specific timings of these dynamic components have. In the present study, we investigate the salience of dynamic cues and their function for the decoding of the smile-expression. To our knowledge, no systematic attempt has been made to illuminate the role of the dynamic components in the perception of the smile-genuineness. More specifically, the present research aims to investigate the importance of dynamic aspects for the evaluation of the degree of smile-genuineness.

One of the problems of testing parametrically the contribution of specific dynamic features is that it is not possible, even for trained encoders, to produce voluntarily and precisely a well-defined range of durations for specific components, such as the onset of a smile (see also Kappas, Hess, & Scherer, 1991 for a discussion of related issues regarding vocal cues to emotion).

Studies interested in showing a fine-grained effect for specific durations of dynamic components, consequently, have to take recourse to facial synthesis or resynthesis.[1] Only recently have affordable and flexible facial synthesizers become widely available. One of these commercially available animation tools is Poser (Curious Labs). Not only is the creation of dynamic changes of the surface-based face models relatively easy, but Spencer-Smith et al., (2001) have published a series of validated templates, so called *morph targets*, that allow manipulation of faces in terms of Action Units, as defined by Ekman and Friesen's FACS (1978), arguably the *lingua franca* of facial expression research. The present study uses synthetic faces produced by the Poser 4 program. It does so because of the possibility of controlling dynamics in 3D space at a high degree of resolution. Further, the current article also intends to show the feasibility of such an approach.

If the dynamic components can actually provide information to an observer concerning the state of the sender, regardless of the veracity of whether this information is indeed a reliable correlate, then we would expect that the onset-, apex-, and offset-durations of the Duchenne smiles significantly influence a decoder's perception of the degree of smile-genuineness. Three experiments were conducted—each addressing a specific component (onset, apex, or offset) alone or in combination—in order to assess the impact of these dynamic components and their respective contribution to the judgment ratings. We expect, based on the objective differences described in the literature, that short onsets or offsets will be perceived as being less genuine than longer ones.

Experiment 1

This experiment examined whether the durations of the onset and the offset of Duchenne-smiles influenced the perception of their authenticity. Five different onset-durations and five different offset-durations were selected on the basis of informal pretests and were shown by two synthetic faces. Judgment ratings regarding the degree of perceived smile-genuineness were recorded for each dynamic stimulus.

Method

Participants. Thirty-five participants (15 females, 20 males) ranging in age from 19 to 38 years (M=22.9), took part individually in Experiment 1. All of them were students at the University of Hull, UK and did not receive remuneration for their participation.

Stimulus material. Computer generated facial expressions were created using Poser 4 (Curious Labs). Two different male characters were synthesized by altering the facial structure and type of hair of a standard male figure that was supplied with the software package (see Figure 1). To create the dynamic expression stimuli of the Duchenne-smile, Action Unit 6 and 12 were loaded using morph targets created and validated by Spencer-Smith et al., (2001).[2] The target magnitude for the peak smiling expression (apex) for Action Unit 12 was set to 0.6 and for the Action Unit 6 morph target to 0.3.

For each Poser-face, 5 onset- (4, 7, 10, 13, and 16 frames) and 5 offset (5, 8, 11, 14, and 17 frames) durations were selected and generated at a frame rate of 30 images per second. Onset refers to the duration between neutral face and the full-blown expression as described above. Offset refers to the duration of the transformation of the full-blown expression back to neutral. Intensity changes from frame to frame were linear and dependent on the slope of change implied by the duration of onset and offset phases respectively.

The offset-stimuli commenced with a time period of 30 frames (1 s) at the apex, and continued for 1 s of neutral face after the offset.

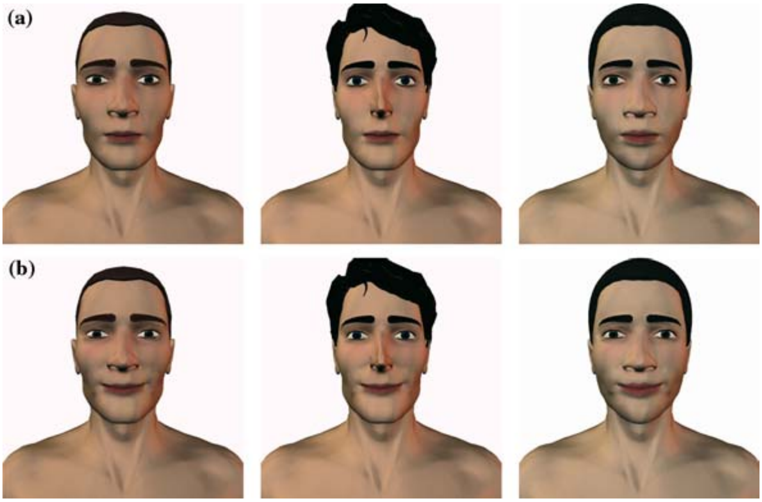

Figure 1. Poser-faces 1, 2 and 3, as used in Experiment 2. The first two faces were also used in Experiments 1 and 3. Panel (a) shows a neutral facial expression for all three faces. Panel (b) shows the Duchenne-smile with Action Unit 12 morph target at an intensity of 0.6 and Action Unit 6 morph target at an intensity of 0.3.

Correspondingly, the onset stimuli commenced with a time period of 30 frames at a neutral position and continued 1 s at apex after the onset. The animation clips covered for each offset-stimulus a time period of 77 frames (2.5 s) and for each onset-stimulus a duration of 76 frames (2.5 s).

Procedure. After participants arrived individually for the experimental session, they were seated at a table with a 19″ computer screen and a mouse and the general goal of the experiment was explained to them. Detailed instructions regarding the experimental task and the stimuli were presented using Authorware Professional 5.2. (Macromedia).
The instruction was as follows:

> In the following few minutes you are going to see some computer generated movies that are all very similar in that you will see two different people smiling. There are small differences between each smile and, in fact, you will never see exactly the same smile twice.
>
> Your task is not to try to analyze how these smiles resemble each other or what these differences are, but we want to know how you perceive this smile in the sense of whether it appears genuine or not.

A genuine smile would be a smile that someone shows while she/he is joyful, happy, or amused. Of course these are computer generated images so none here is truly happy. However, the stimuli reflect certain aspects of smiles that differ in real people in real situations and we want you to try as hard as you can to judge how felt, unfelt, each smile appears to you. This is a difficult task, but it can be done. There is no right or wrong answer—we are not interested in how well you are doing, but instead we try to understand how we all, in general, make decisions about how someone feels based on what they show on their face.

Participants were subsequently instructed in the use of the mouse to indicate their ratings and a practice trial was performed. After answering any of the participants' remaining questions regarding the procedure, the experimenter left the room. Each stimulus appeared for 2.5 s (77 frames for offset-stimuli, 76 frames for onset-stimuli). It was immediately replaced by a 7-point Likert-scale on which the participants had to rate how genuine they perceived the smile expression of the stimulus person (0-extremely genuine; 6-extremely fake). Following the completion of the judgment scale, participants clicked a 'Continue' button on the screen to initiate the next stimulus presentation.

A complete within-subjects design was used. For the onset-stimuli, five different onset-durations shown by two different Poser-faces were presented twice. In addition, five different offset-durations were included with two different Poser-faces and also once repeated. Hence, each participant evaluated 40 stimulus presentations in random order. After the experiment, participants were debriefed and all their questions were answered.

Results

Analyses of variance (ANOVA) were used to examine the impact of the onset- and offset-duration on the perception of smile-genuineness. Differences in the judgment ratings between single levels of the onset- or offset-factor were analyzed by means of a priori contrasts.

Effects of onset-duration. For the 20 onset stimuli, a repeated measures analysis of variance (ANOVA) with the three factors Onset-duration (4, 7, 10, 13, and 16 frames), Poser-face (1 and 2) and Repetition was conducted on participants' ratings. As expected, a significant main effect of Onset-duration, $F(4, 136)=11.30$, $p < .001$, indicated that judges' ratings of the degree of smile-genuineness were significantly influenced by the onset-duration. The analysis revealed no significant main effects for the Poser-face, $F(1, 34)=.30$, $p < .58$, and Repetition, $F(1, 34)=2.04$, $p < .16$, and also for none of the interactions, suggesting that only the onset-duration was used by participants to determine the genuineness of the smile-expression. Polynomial contrasts showed a significant linear trend for the genuineness ratings with respect to the onset-durations, $F(1, 34)=25.96$, $p < .001$, suggesting that the perception of smile genuineness varied linearly within the five onset-durations. Means and standard errors for the onset-durations are presented in Table 1. In general, participants perceived the smile as more genuine, the longer the onset-duration was. Pairwise comparisons indicated that smiles with the shortest onset-duration (4 frames) were perceived as significantly more fake than those with the longest onset-duration (16 frames), $F(1, 34)=22.42$, $p < .001$. This was also found for the 7 frame onset-duration which was judged as significantly more fake than the 16 frame onset-duration, $F(1, 34)=6.13$, $p < .05$.

Effects of offset-duration. For the 20 offset stimuli, a 5 (Offset-duration 5, 8, 11, 14, and 17 frames) $\times$ 2 (Poser-face 1, 2) $\times$ 2 (Repetition) repeated measures analysis of variance (ANOVA) was conducted on the ratings of perceived smile-genuineness. Consistent with expectations, a significant main effect for Offset-duration emerged, $F(4, 136)=3.00$, $p < .05$, indicating that the offset-duration influenced the perception of

TABLE 1

Means and Standard Errors (n = 35) for Genuineness as a Function of Onset-Duration

Onset-duration			
frames	ms	*M*	*SE*
4	132	3.37	.18
7	231	2.77	.15
10	330	2.70	.15
13	429	2.46	.15
16	528	2.40	.15

Note. Judgments were made on a 7-point Likert-scale (0 = extremely genuine, 6 = extremely fake).

smile-genuineness. In addition, analyses also yielded an unpredicted main effect for the Poser-face on the judgment ratings, $F(1, 34)=7.05$, $p < .05$. A closer examination of the means showed that smiles expressed by Poser-face 2 were perceived as significantly more fake ($M=3.31$, $SE=.13$) than those expressed by Poser-face 1 ($M=3.06$, $SE=.13$, $p=.012$) regardless of how long the offset-duration was. No main effect for Repetition was found, $F(1, 34)=.81$, $p < .37$, but a trend for the Offset x Poser-face x Repetition interaction emerged, $F(4, 136)=2.40$, $p< .06$.

Polynomial contrast analyses for the offset-factor revealed a significant linear trend across the five offset-durations, $F(1, 34)=7.31$, $p < .05$, indicating that the genuineness ratings varied linearly as a function of the offset-duration. Means and standard errors are presented in Table 2. Planned contrasts comparing the means of the judgment ratings for the five offset-durations were statistically significant for the longest (17 frames) and shortest (5 frames) offset-duration, $F(1, 34)= 1.90$, $p < .01$. Thus, smiles with an offset-duration of five frames were perceived as significantly more fake than those with a 17 frame offset-duration.

Discussion

The results of Experiment 1 revealed that, as predicted, the onset- and offset-duration influenced judges in their perception of smile-genuineness. This suggests that the onset- and offset-duration provided critical information

TABLE 2

Means and Standard Errors (*n* = 35) for Genuineness as a Function of Offset-Duration

Offset-duration			
frames	ms	*M*	*SE*
5	165	3.46	0.14
8	264	3.11	0.17
11	363	3.21	0.14
14	462	3.09	0.14
17	561	3.04	0.14

Note. Judgments were made on a 7-point Likert-scale (0= extremely genuine, 6= extremely fake).

about the degree to which the smile would correspond to a positive state according to the raters. Genuineness ratings indicated that Duchenne-smiles with a longer onset- or offset-time were perceived as more genuine than those with a shorter duration. These findings are in line with assumptions made by Ekman and Friesen (1982) regarding the encoding of smiles, according to which false smiles have shorter onset- and offset-durations compared to felt ones. Results of Bugental (1986), Hess and Kleck (1990), and Weiss, Blum, and Gleberman (1987) are also consistent with the data, showing shorter onset- and offset-times for deliberately shown smiles than for felt smiles on the sender's side. The duration of the onset and offset, therefore, seems to be not just a potential indicator for the genuineness of the emotional expression of the sender, but also for the judgment of the degree of perceived smile-genuineness on the decoder's part.

The fact that the stimulus face equally influenced the perceived genuineness of the smile-offset indicated that participants did not solely rely on this dynamic marker. This finding is puzzling, particularly as no such effect occurred for onset-duration as an additional cue to rate the degree of smile-genuineness. However, it remains arguable that the offset-stimulus itself may have conveyed a confusing source of information independent of the duration. In this experiment, a neutral expression of the stimulus face was shown after the end of the offset-movement for approximately 1 s (30 frames), which has possibly evoked the impression of a blank 'staring' face. Confusing participants by adding a different emotional expression, judges might have consequently taken other features, like differences in facial morphology, into account to rate the genuineness of the smile-expression. To assess this possibility, Experiment 2 was conducted to examine only the impact of the offset-duration on the judgment ratings of the Duchenne-smile with a wider variation of encoder faces.

Experiment 2

In Experiment 2, we examined more closely the impact of the offset-duration on the perceived smile-genuineness. For this, two additional offset-durations were added to those of the first experiment and three Poser-faces were used as stimuli. The time interval showing a neutral emotional expression at the end of each stimulus was shortened to two frames to exclude the possibility of a staring face after the end of the offset smile-movement.

Method

Participants. Forty participants (27 females, 13 males), ranging from 19 to 45 years (M=24.6) individually took part in Experiment 2. All of them were students at the University of Hull, U.K. and did not receive remuneration for their participation. None of them had taken part in Experiment 1.

Stimulus material. In addition to the two stimulus figures used in Experiment 1, a third male character was created using Poser 4 software (see Figure 1). For each face, seven different offset-durations (5, 8, 11, 14, 17, 20, and 23 frames at 30 frames/ per second) were generated by loading Action Unit 6 and 12 morph targets and specifying a transition time between the Duchenne-smiling face (AU 6+12 morph targets at apex) and the neutral face. The two levels of Action Unit 6 and 12 morph targets for the peak smiling expression were set at the same intensity as in Experiment 1. All seven offset-stimuli covered a time period of 55 frames (1.8 s) and were expressed by each of the three Poser figures.

Procedure. The procedure was identical to that in Experiment 1. Each stimulus appeared on the screen for 1.8 seconds (55 frames) and was immediately replaced by the rating scale. Participants evaluated in random order, the total set of 42 stimuli (7 Offsets x 3 Poser-faces x 2 Repetitions).

Results

A repeated measures analysis of variance (ANOVA) with the three factors Offset-duration (5, 8, 11, 14, 17, 20, and 23 frames), Poser-face (1, 2 and 3) and Repetition was carried out for participants' ratings of genuineness of the expressions. As in Experiment 1, the analysis revealed a significant main effect for Offset-duration, $F(6, 234)=2.43$, $p < .05$, and for Poser-face $F(2, 76)=18.14$, $p < .00$, indicating that both the offset-duration and the type of stimulus face influenced the judgment of the smile-genuineness. For the Offset-duration, polynominal contrasts replicated a linear trend in the genuineness ratings across the seven different offset-timings $F(1, 39)=6.02$, $p < .05$. Means and standard errors are presented in Table 3. In general, smiles with a longer offset-duration were perceived as being more genuine than their shorter counterparts. Planned contrast analyses for the offset-factor yielded that smiles with a five frame offset-duration were perceived as significantly more fake than those with a 23 frame offset-duration, $F(1, 39)=6.88$, $p < .05$. In addition, also the eight

TABLE 3

Means and Standard Errors (n = 40) for Genuineness as a Function of Offset-Duration

Offset-duration			
frames	ms	*M*	*SE*
5	165	3.40	.11
8	264	3.26	.11
11	363	3.05	.10
14	462	3.07	.12
17	561	3.13	.10
20	660	3.11	.11
23	759	3.03	.12

Note. Judgments were made on a 7-point Likert-scale (0 = extremely genuine, 6 = extremely fake).

frame offset-duration differed significantly from the longest one in the sense that it was judged as more fake, $F(1, 39) = 4.62$, $p < .05$. Within the time range from 11 to 23 frames, no significant differences appeared between each level of offset-duration and the subsequent one. A significant departure from the linear trend, therefore, could not be confirmed. These findings substantiate the results obtained in Experiment 1 and suggest the existence of a distinct duration range between 5 and 23 frames of the smile-offset with regard to its influence on perceived genuineness.

No main effect for Repetition emerged, $F(1, 39)=2.94$, $p < .09$, however a significant interaction between Repetition and Poser-face was obtained, $F(2, 78)=3.60$, $p < .05$. Depending on the number of repetitions, the genuineness ratings of smiles expressed by the 3 different Poser-characters differed significantly. In general, planned comparisons of means showed that smiles expressed by Poser-face 3 were judged as significantly more fake (M=3.48, SE=.12) than those expressed by Poser-face 1 (M= 2.77, SE=.08, p=.000) and Poser-face 2 (M=3.19, SE=.10, p=.01).

Discussion

The effects of offset time and the interaction of this effect with the identity of the face were replicated with an independent sample. Hence, we are quite sure that these findings are not a statistical fluke and do not depend on the presence of a blank 'staring' face after the offset, present in the first experiment. How can the effect of the encoder face be interpreted? The importance of morphological features (i.e., the stimulus face) for the evaluation of the degree of smile-genuineness, regardless of the offset-duration, suggests the effect of a demeanor bias. According to Hess and Kleck (1994) and DePaulo (1991, for an overview), a tendency exists for some stimuli persons to be seen as relatively honest or dishonest independent of their actual veracity (see also O'Sullivan, 2003). Hence, factors like facial morphology and hairstyle could have influenced judges in this experiment in their perception of smile-genuineness in that smiles shown by a specific person were seen as generally more fake. However, relating the present findings to those of Experiment 1, the type of stimulus face was only found to influence the perception of smiles with different offset-durations, but not with different onset-durations. The salience of the stimulus face for the perception of the smile-offset, therefore, rather supports the notion of a different time variation pattern. It must be argued, that the velocity of smile expressions in the present research was only established as a linear rate of change, in the way that the face moved linearly from the peak of the smiling-expression (apex) to a neutral expression. This linear velocity may be appropriate for the representation of the smile-onset, however, the same time variation pattern may differ for the smile-offset, which might be better characterized by several accelerations, decelerations, and stepwise intensity changes. Supportive evidence for this notion comes from encoding studies (Frank et al., 1993; Hess, & Kleck, 1990), suggesting that the time course of the smile-offset even in felt smiles may not be linear but rather inconsistent and irregular. The smile-expression as conceptualized in this experiment by a linear offset-speed, therefore, might have failed to represent a naturalistic smile-expression. It is important to reiterate that it is unlikely that there was an interaction of specific facial features in the morphing process that would create artifacts—if this were the case, the same effects should have been shown for the onset stimuli in Experiment 1. The next logical step would be to analyze what facial features interact with dynamic movements to yield the effects demonstrated in Experiments 1 and 2. However, there are a variety of dimensions on which synthetic and real faces can differ. The goal of this series of studies was to identify the importance of specific dynamic components and so we chose to note the effect of morphology for pursuit of this question at a later time, and to continue with the systematic study of the dynamic components. In the third experiment of the series, we wanted to investigate the impact of the duration of the smile apex on perceived genuineness.

Experiment 3

This experiment was intended to measure the influence of the apex-duration of Duchenne-smiles on the perception of their genuineness, as well as to replicate the findings from Experiment 1 regarding the onset-duration. For this, the longest and the shortest onset-duration from the first experiment and six different apex-durations were selected.

Method

Participants. Thirty-five (26 females, 9 males) students from the University of Hull, ranging in age from 19 to 47 years (M=22.6), took part individually in Experiment 3. They did not receive remuneration for their participation and none of them had taken part in either Experiment 1 or 2.

Stimulus material. The same two male characters as in Experiment 1 were used as stimuli in Experiment 3 (see Figure 1). For each face, two different onset-durations (4 and 16 frames) and six different apex-durations (11, 29, 59, 89, 119, and 149 frames) were generated by loading Action Unit 6 and 12 morph targets. Both levels of morph targets were set for the Duchenne-smile (AU 6+12 morph targets at apex) at the same intensity as in Experiments 1 and 2. All stimuli started at a neutral position for 10 frames and moved afterwards linearly for one of the two onset-durations to an expressive smiling face (AU 12 morph target intensity at 0.6; AU 6 morph target intensity at 0.3) that was held at one of the six apex-durations. The exact duration for each of the 12 stimuli is shown in Table 4.

Procedure. The procedure was identical to that in Experiment 1 and 2. Participants evaluated 48 presentations (2 Onsets x 6 Apexes x 2 Poser-faces x 2 Repetitions) in random order.

Results

A repeated measures analysis of variance (ANOVA) with the within-subjects factors Onset-duration (4 and 16 frames), Apex-duration (11, 29, 59, 89, 119, and 149 frames), Poser-face (1, 2), and Repetition was conducted on authenticity ratings. Consistent with our expectations, a main effect for Onset-duration, $F(1, 34)=8.56$, $p < .01$, and Apex-duration, $F(5, 170)=2.52$, $p < .05$, emerged. No significant main effect for Poser-face,

TABLE 4

Stimulus Durations Used in Experiment 3 with 2 Different Onset and 3 Different Apex Durations, including Means and Standard Errors (*n* = 35) for Genuineness

	Duration (frames)			Duration (s)		
	Stimulus phase					
Stimulus	Onset	Apex	Total	Total	*M*	*SE*
1	4	11	25	.8	3.06	.19
2	4	29	43	1.4	3.16	.16
3	4	59	73	2.4	3.01	.18
4	4	89	103	3.4	3.10	.15
5	4	119	133	4.4	3.22	.16
6	4	149	163	5.4	3.34	.17
7	16	11	37	1.2	2.34	.16
8	16	29	55	1.8	2.50	.16
9	16	59	85	2.8	2.66	.16
10	16	89	115	3.8	2.66	.14
11	16	119	145	4.8	2.63	.16
12	16	149	175	5.8	2.79	.17

Note. 1 frame = 33 ms; all stimuli were prefaced with a neutral expression for 10 frames (i.e. .33s). Judgments were made on a 7-point Likert scale (0 = extremely genuine, 6 = extremely fake).

F (1, 34)=1.63, $p < .21$, and Repetition, F (1, 34)=.69, $p < .41$ was found and also none of the interactions were statistically significant. For the Onset-duration, significant differences in the perceived genuineness of smiles as observed in Experiment 1 were replicated, in the sense that smiles with a four frame onset-duration were seen as significantly more fake (*M*=3.15, *SE*=.14) than those with a 16 frame onset-duration (*M*= 2.60, *SE*=.13, *p*=.006). This was shown regardless of how long the smile was held constant at peak intensity. The results obtained in this experiment support the importance of the duration range between 4 and 16 frames regarding their effect on the perception of smile-genuineness. The duration of the smile-apex was shown to be independently important. Polynomial contrasts showed that the genuineness-ratings of the smile expression varied linearly with the apex-duration, suggesting that the judgments fitted a linear function, $F\ (1,\ 34)=8.67$, $p < .01$. In general, participants perceived smiles as being more genuine, the shorter the apex-duration was. This finding is again consistent with observations made by Ekman and Friesen (1982) that apex-duration in false smiles may be ''too long''. Planned comparisons of the means revealed a significant difference between the longest (149 frames) and the shortest (11 frames) apex-duration, $F(1,\ 34)=10.02$, $p < .01$. Smiles that were held for 149 frames at the apex were judged as significantly more fake than those with an apex-duration of 11 frames.

Discussion

Combining the two onset-durations with the six apex-durations—resulting in a set of 12 different stimuli durations—allowed considering the perception of the overall duration of the smile-expression. According to Ekman and colleagues (e.g., Ekman & Friesen, 1982; Frank et al., 1993), naturally occurring felt smiles are possibly between 500 ms and 4 s compared to other types of smiles, which might be shorter or longer in duration. The results of the present experiment suggest that similar time windows were relevant for the interpretation of smiles as well. Smiles shown for approximately 5 s (149 frames apex-duration), but not those which lasted about 4 s (119 frames apex-duration), were perceived as significantly more fake than smiles with the shortest apex-duration (11 frames). That is, only smiles with the longest apex-duration, which were clearly outside the .5–4-s range, were perceived as significantly more fake than their shorter counterparts which matched this time range, $F(1,\ 34)=10.02$, $p < .01$. These findings are of particular interest in the context of Ekman and Friesen's (1982) original assumptions of the duration of felt smiles on the sender's side.

Neither onset-duration nor the duration of the apex interacted with the face used. This underlines our hypothesis that these effects, as demonstrated in Experiments 1 and 2 are indeed specific to offsets.

General Discussion

The goal of the present studies was to illuminate the role of dynamic components in the perception of smile-genuineness. Several experiments have been reported that addressed the question whether the onset-, apex-, and offset-duration of Duchenne-smiles influenced participants in their judgments regarding the authenticity of the smile-expression. Consistent with the proposed hypotheses, all three experiments confirmed the importance of the onset-, apex-, and offset-duration of Duchenne-smiles in the judgment of the degree of smile-genuineness. The dynamics, therefore, may reveal some important cues concerning the underlying meaning of an expression, which are decoded by observers in the perception of facial displays. So far, this salience of the dynamic properties and their function as communicative acts in expression perception has not been found in the literature to be straightforward. Hess, Kappas, Kleck, McHugo, and Lanzetta (1989), for example, indicated that temporal differences between posed smiles and those reflecting an underlying positive affect were not considered by participants when rating the happiness of the sender. Likewise, Hess and Kleck (1994) showed that the speed of the onset of dynamic facial expressions did not contribute significantly to observers' judgments regarding whether the expression was spontaneous or posed. It must be argued, however, that both studies do not provide evidence against the results obtained in this research since different issues were addressed. The aim of the present paper was to demonstrate the respective contribution of each dynamic component to the degree of judged smile-authenticity. On the basis of participants' tendencies to rate some smiles as being more authentic than others, all experiments showed that the genuineness-ratings of Duchenne-smiles increased the longer the onset- or offset-duration and the shorter the apex-duration were, at least within the time frame studied here. These findings are consistent with Ekman and Friesen's (1982) assumptions regarding the objective timing differences between felt and false smiles. Likewise, the results by Bugental (1986), Weiss et al. (1987), and Hess and Kleck (1990) provide empirical evidence that the onset-, apex-, and offset-duration significantly differ in posed and spontaneous smiles. The fact that these differences in the duration range are relevant for judging the degree of perceived smile-genuineness is clearly demonstrated in the present contribution.

Plausibly many readers will worry about the artificiality of the faces used and the possibility to generalize the present findings to the real world. It is clear that the advantage of being able to manipulate very specifically a particular feature or cue cannot outweigh the issue of artificiality. The stimuli used in this study, however, were subject to informal pretests with various colleagues and students as to their 'plausibility'. More studies, of course, need to be done with different faces that represent exemplars on a broad range of variations including age and gender to test whether specific ''sensitive'' ranges of onset, apex, and offset durations can be replicated with many different stimulus forms. The current study has been restricted to male stimulus faces because of technical reasons. A particularly interesting question, however, would refer to possible sex effects in the authenticity ratings of smiles in men and women. Given the gender stereotype that women smile more than men (Hall, 1984, 1985), the cue quality of dynamic components may differ depending both on the sex of the sender and perceiver. The inclusion of male and female stimulus faces seems, in any case, a necessary prerequisite for future studies. A sample of naturally occurring smiles should be employed and the findings established using the synthetic method to predict the subjective perception should be used.

The issue of categorical versus continuous ratings of authenticity gains important methodological consideration and it is probably useful in this regard to reflect briefly on how to measure the genuineness of a smile—another potential point of contention. One could hold the extreme position that a smile can be only genuine, or not. The former being the case where a facial expression is perceived as corresponding to the underlying affective state. Any level of control, up to a fully posed smile in the absence of any affective state, or even a negative affective state, would be not genuine. Thus, some researchers interpret genuineness as a dichotomous variable (see Gosselin et al., 2002). However, it appears that in interaction we do make inferences regarding whether there is *some* divergence between underlying state and expression or complete independence. In fact, Hess et al. (1989) argued ''that the 'felt-false' distinction is an oversimplification. It seems plausible to assume that facial expressions vary on a continuum with regard to the degree to which they reflect either an underlying emotion or a voluntary effort ...''(p. 123). Thus, Hess et al. (1989) measured the perceived genuineness indirectly by using two rating scales, one relating to the intensity of the expression and the other relating to the intensity of the underlying affective state. In this case the argument was that high-intensity expressions associated with low-intensity attributed feeling states, or low-expression intensity expressions associated with high-intensity attributed feeling states, represented examples that could be described as being not very genuine. In the present study, a simpler approach was used in that a single scale was employed where participants indicated ''how genuine'' an expression was. Specific care was taken to ensure that the instructions were very clear as to the meaning of that single scale. In a previous study we compared ratings on a simple scale with a rank-order of a complete pair-wise comparison regarding how genuine a series of manipulated images was (Tremblay et al., 1993). The correlation between both means of measuring perceived genuineness, for the single encoder used in that study was > .95. Thus, we have confidence that the simple genuineness scale is adequate for the task at hand.

The impact of both the offset-time and the type of stimulus person on the authenticity ratings of smiles with different offset-durations in Experiments 1 and 2 has raised the issue of the operationalization of smile offset movements per se. It was argued that the linear time variation pattern chosen in this research might have failed to represent a realistic offset-movement, thus increasing the influence of extraneous sources of information. There is empirical evidence suggesting that nonlinear offsets are indeed perceived as being more natural. Shimoda, Yang, and Yoshikawa (2000) gave participants the possibility to control the velocity of expression-offsets and could show that participants did not choose a linear velocity but rather a velocity that is initially rapid and afterwards decreases or one that is characterized by a rapid deceleration at the end of the movement. These appeared to yield a more natural impression. Clearly, future research will have to examine different time variations of the smile-offset and their respective influence on the perception of the smile-expression. This would provide important new insights not only into the role of the duration of the dynamic properties in the perception of the Duchenne-smile, but also into the influence of the type of movement pattern.

The selected duration range for each dynamic component as chosen in this research was based on informal pretests. Specifically, for the onset we took the findings of Schmidt and Cohn (2001) into consideration, which showed that spontaneous smiles to jokes in a comedy routine averaged 15.7 (SD=8.4) frames. Future research, of course, might be aimed at testing a larger time range for each dynamic component. Such an approach would allow addressing questions regarding the *boundary conditions* of the genuineness-ratings of the Duchenne-smile. Thus, one may speculate whether a longer onset-, and offset-duration, outside the selected duration range of this paper, is still rated as more genuine than their shorter counterparts. The finding that extremely short onsets and offsets were perceived as unnatural may also refer to extremely long ones as well. In other words, there must be a limit to the optimal length of a genuinely perceived onset and offset. Furthermore, we only focused on the single impact of the dynamic components, also keeping morphological parameters such as the combined contraction of Action Unit 6 and 12 (Duchenne-marker) constant. Given that the aim of the present paper was to demonstrate the role of the dynamic properties of the Duchenne-smile, the isolated variation of the onset-, apex-, and offset-time provided crucial insights into the process of expression perception. A logical next step would be a capstone study, varying onset-, apex-, and offset-durations respectively. This would not only allow an ultimate comparison of all three components, but also more closely represent the kind of stimulus normally encountered in natural interactions. More research is needed to determine the signal value of the dynamics in relation to each other and in conjunction with morphological components and communicative acts such as words, intonation, and gestures. The whole context may contribute to a mental representation of the communicative situation and thus shape the boundaries of a perceived message. In particular, the integration of ''movement-independent morphological patterns and movement-dependent temporal patterns'' (Wehrle et al., 2000, p. 116) in the perception of the smile-expression demands further examination. Such an approach also involves the conception of multiple measures in the study of facial expressions. The single item rating of genuineness as used in this study certainly depicts a narrow view of how these stimuli were perceived in general. Studies in our laboratory, however, are currently in progress that link these judgments with other aspects of person perception. The present work, using computer animation, may constitute a first *systematic* step toward disentangling the meaning of the dynamics in the perceptual processing of facial expressions. Continuing this type of research may lead to clear diagnostic predictions regarding the perception of genuineness in naturally occurring smiles.

Notes

1. Kappas (1993) used the term *resynthesis* to refer to artificially created dynamic facial stimuli either based on a resequencing of existing film/video frames (time-stretching), or on the creation of new intermediate frames using morphing techniques that are then animated (e.g., Girard & Kappas, 1998; Kamachi et al., 2001; Sato & Yoshikawa, 2004).
2. The Action Unit morph targets are available free of charge and can be loaded from a publicly accessible Internet location (https://netfiles.uiuc.edu/jbspence/www/audown.html).

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