Contextual Influences on Dynamic Facial Expressions

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Participants viewed dynamic facial expressions that moved from a neutral expression to varying degrees of angry, happy, or sad or from these emotionally expressive faces to neutral. A contrast effect was observed for expressions that moved to a neutral state. That is, a neutral expression that began as angry was rated as having a mildly positive expression, whereas the same neutral expression was rated as negatively valenced when it began with a smile. In Experiment 2, static expressions presented sequentially elicited contrast effects, but they were weaker than those following dynamic expressions. Experiment 3 assessed a broad range of facial movements across varying degrees of angry and happy expressions. We observed momentum effects for movements that ended at mildly expressive points (25% and 50% expressive). For such movements, affect ratings were higher, as if the perceived expression moved beyond their endpoint. Experiment 4 assessed sad facial expressions and found both contrast and momentum effects for dynamic expressions to and from sad faces. These findings demonstrate new and potent contextual influences on dynamic facial expressions and highlight the importance of facial movements in social–emotional communication.

Consider the following scenario: At a gathering, you look up from a conversation and see an unfamiliar face turn and smile at you. Now consider the expression in reverse: You look up and see someone smiling at you, but the expression fades into a blank stare. Such social interchanges highlight the potency of dynamic facial expressions and exemplify the importance of the relative nature of emotional status across time (see Mussweiler, 2003; Trope, 1986). Indeed, we never interpret facial expressions as static, momentary images, yet the preponderance of extant psychological studies have focused on such isolated stimuli. In everyday experiences, facial expressions move in a rich contextual environment as they track and signal social–emotional interchanges.

Investigations of contextual influences on facial expressions have a broad and illustrious history. Among filmmakers, the Kuleshov effect is a well-known cinematic technique used to enhance emotional expression. Lev Kuleshov, an early Soviet director, interspersed shots of an actor exhibiting a neutral expression with shots of a child's coffin, a woman, and a plate of soup (Levaco, 1974). The same neutral expression appeared to change depending on the shot that preceded it. Psychological studies of the Kuleshov effect have confirmed the impact of pictorial context on facial expressions (Aviezer et al., 2008; Mobbs et al., 2006; Munn, 1940; Wallbott, 1988). In most cases, an emotional pictorial scene amplifies the potency of a facial expression, although in some cases

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it even changes its quality, such as from surprise to horror or from fear to anger (Aviezer et al., 2008; Marian & Shimamura, 2012; Munn, 1940).

In another line of study, Halberstadt and Niedenthal (2001) examined contextual influence on memory for emotional facial expressions. Participants were shown faces that were digitally morphed to be equal blends of two expressions, such as a mixture of an angry and happy face. For half of these blends, participants were asked to "explain why this woman is happy," and for the other half they were asked to "explain why this woman is angry." Later, memory for the faces was assessed by having participants select the morphed blend that corresponded with the one that was previously presented. Responses were biased toward task demands, such that happier blends were selected for faces previously assigned to the happy task and angrier blends were selected for faces previously assigned to the angry task. Other findings suggest that faces are remembered better when presented with happy expressions than with angry expressions (D'Argembeau, Van der Linden, Complain, & Etienne, 2003; Shimamura, Ross, & Bennett, 2006).

Despite these context-congruent effects, others have observed contrasting or opposing effects when a neutral face is paired with an expressive one. Tanaka-Matsumi, Attivissimo, Nelson, & D'Urso (1995) presented alternating pairs of faces in rapid succession, such as a neutral face alternating with an angry face. Ratings of the neutral face were biased in the opposite direction as its pair. Thus, a neutral face alternating with an angry face was perceived as happier than baseline, yet the same neutral expression alternating with a happy face was perceived as angrier than baseline. Similar contrast effects have been observed in adaptation studies in which perceptual aftereffects were induced by extended viewing of an expressive face. Webster, Kaping, Mizokami, and Duhamel (2004) showed an angry or happy face for 3 min. Thereafter, participants were presented a series of morphed blends of various angry–happy proportions and made categorical (happy or angry) judgments. From these responses, estimates of the boundary between the two categories were calculated and shown to be biased away from the adapting expression. For example, after participants looked at a happy face, a morphed blend that was previously perceived as an equal blend of angry and happy appeared as angry. Similar contrast aftereffects have been observed for disgust–surprise blends (Webster et al., 2004) and happy–sad blends (Rutherford, Chattha, & Krysko, 2008). Even simultaneous presentations of neutral and expressive faces can induce contrast effects. In one study (Russell & Fehr, 1987), a neutral face presented alone was described as "calm," whereas the same face presented next to a smiling face was described as "sad."

Compared with static expressions, dynamic expressions tend to elicit more potent responses because they can increase face recognition, affect discrimination, and affect intensity (Biele & Grabowska, 2006; Hill & Johnson, 2001; Kamachi et al., 2001; Pilz, Thornton, & Bulthoff, 2006; Wehrle, Kaiser, Schmidt, & Scherer, 2000). In one study (Ambadar, Schooler, & Cohn, 2005), participants were presented very brief video clips of facial expressions such that they depicted only the first hint of an emotion. Even for these brief movements, participants were better at identifying the target emotion than when they viewed only its ending frame. In a neuroimaging study, LaBar, Crupain, Voyvodic, and McCarthy (2003) presented video clips of digitally morphed expressions that moved from neutral to either angry or fearful expressions. Compared with static presentations, dynamic expressions resulted in greater activation in face representation regions, such as the fusiform gyrus, and in regions involved in emotional processing, such as the amygdala and ventromedial prefrontal cortex. Additionally, dynamic expressions activated the superior temporal sulcus, an area known to be involved in the perception of socially relevant biological movement, such as eye gaze.

Yoshikawa and Sato (2006) replicated the neuroimaging findings of LaBar et al. (2003) and suggested that amplified behavioral and neural responses observed with dynamic facial expressions resulted from a momentum effect that exaggerated the perceived emotion of a moving face. According to this hypothesis, as participants view an expression moving from a neutral to an expressive state, they mentally carry the expression past the point of the ending frame, thus enhancing the expression. This form of representational momentum has been observed in other studies of perceived or implied movement (see Freyd, 1987; Freyd & Finke, 1984). To test this hypothesis, Yoshikawa and Sato (2008) showed participants video clips of dynamic expressions that moved from neutral to 100% or 80% expressive (anger, disgust, fear, happy, sad, surprised). After viewing the clip, they were asked to select a face that matched the expression of the final frame. Momentum effects were observed such that participants selected faces that were more emotionally expressive than the actual final frame of the clips. Furthermore, the velocity of the movement influenced the magnitude of the effect: The faster the movement, the greater the momentum bias effect.

It is worth noting that studies of dynamic expressions generally assess facial expressions that start with a neutral expression and then move to an emotionally expressive one (Ambadar et al., 2005; Biele & Grabowska, 2006; LaBar et al., 2003; Sato & Yoshikawa, 2004; Thorton & Kourtzi, 2002; Yoshikawa & Sato, 2006). Yet in studies of static expressions, contextual influences have often been observed for neutral expressions presented with or immediately after an expressive face (Russell & Fehr, 1987; Tanaka-Matsumi et al., 1995). In a recent neuroimaging study, Sato, Kochiyama, and Yoshikawa (2010) assessed dynamic facial expressions that moved from a happy or fearful expression to a neutral state. These "backward" moving video clips were used as controls for "forward" movements because the amount of visual motion would be the same, yet the emotional intensity between the two may be different. Indeed, when asked, "How did you feel emotionally when you viewed the stimuli?" participants rated the "backward" clips as less emotional than the "forward" clips. Moreover, greater left amygdala activity was observed for forward-moving fearful and happy expressions than for their "backward" counterparts. In the study by Sato et al. (2010), participants were asked to rate the emotion of the entire dynamic presentation. Thus, it is unclear to what extent contextual effects occurred for the ending neutral expression in "backward" moving clips.

Will a smiling face that fades to a neutral state appear negatively valanced? Conversely, will an angry or sad face that moves to a neutral expression appear positively valanced? To our knowledge, no published report has assessed the perceived emotion of a neutral expression when it has moved dynamically from a previously expressive face. In the present series of experiments, we explored both contrast and momentum effects that follow dynamic facial expressions. Participants rated the affective valence of the starting and ending frame of a video clip depicting a face that moved from one expression to another. Expressions either ended at a neutral state or moved to different levels of expression (e.g., 100% happy, 50% happy). In this way, we assessed the ways in which dynamic expressions influence the interpretation of a face at the end of a facial movement.

EXPERIMENT 1

METHODS

Participants

Twenty-four undergraduates (20 women and 4 men) were recruited from the research participation pool at the University of California, Berkeley, and received course credit for their participation. Participants averaged 21.8 years of age.

Stimuli and Design

Digital images were obtained from the NimStim set of facial expressions (Tottenham et al., 2009). From this set, we obtained images of angry, happy, and neutral expressions from 18 different faces. We modified these faces using Adobe Photoshop software to minimize differences in face size, luminosity, and hair style. We also eliminated collars and converted the color images to gray scale. We refer to these original angry and happy expressions as 100% angry and 100% happy faces, respectively.

We used morphing software (Abrosoft FantaMorph, http://www.fantamorph.com) to create six sets of video clips. We began with the 18 neutral and 100% angry faces and morphed each of them to create dynamic expressions that started with a neutral expression and moved to 100% angry. We then created a set of video clips with the reversed movement. These clips began with a 100% angry expression and moved to a neutral one. Two other sets were created in the same manner using the neutral and 100% happy faces. Two more sets were created by cropping and pasting together these newly created clips. One set of clips moved from 50% angry to neutral and then to 50% happy. The other set included reversals of the previous set such that expressions moved from 50% happy to neutral then to 50% angry. Presentation software (Neurobehavioral Systems, Albany, CA) was used to present the video clips and record responses. Movements of these morphed expressions were somewhat slower than natural expressions. Velocity of expression could influence affect ratings, and therefore we controlled for any differences by equating the duration of the movement for all expressions. Actual video clips can downloaded at http://conium.org/~shimlab/ShimDemo.html.

Procedure

Participants were seated in front of a computer in a testing room and viewed the six sets of video clips in a randomized order. Each set included 18 different faces, so participants viewed a total of 108 trials. For each trial, a still image of the starting face appeared for 2 s, and participants rated the affective valence of the face. Responses were made by moving a cursor along a horizontal scale with endpoints labeled "very negative" and "very positive" (Figure 1). Participants moved the cursor along the scale and finalized their decision with a button click. Responses were scored as a pixel unit along the scale, with 0 at its midpoint and its ends anchored at −200 (*very negative*) and +200 (*very positive*). Half of the participants used a scale in which "very negative" was positioned as the leftmost value, and the other participants used a scale in which "very negative" was positioned as the rightmost value. After the rating of the starting expression, a 4-s video clip began in which the starting face moved to a different facial expression. When the clip ended, the ending expression was displayed for 2 s and the affect rating scale reappeared, at which time participants rated the expression of the ending expression. Between trials, a blank screen lasting 4 s was presented.

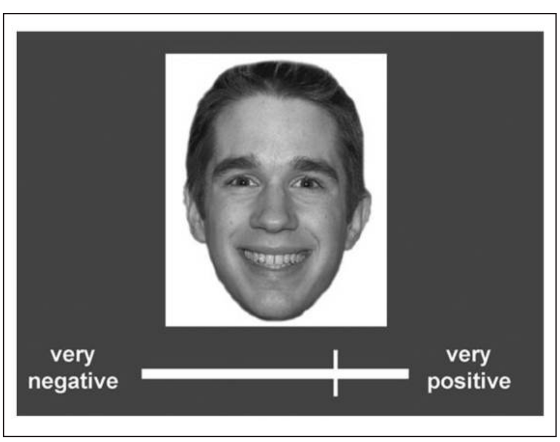

FIGURE 1. Affect rating procedure. Participants viewed 4-s video clips of dynamic facial expressions and rated the beginning and ending expressions of each clip

From these trials, we obtained two ratings for each of six facial expressions: (1) 100% angry face that started or ended with a neutral expression, (2) 50% angry face that started or ended with a 50% happy expression, (3) neutral face that started or ended with a 100% angry expression, (4) neutral face that started or ended with a 100% happy expression, (5) 50% happy face that started or ended with a 50% angry expression, and (6) 100% happy face that started or ended with a neutral expression. Figure 2 shows samples of the starting and ending frames used in each of the six video clip conditions. A bias score (ending rating − starting rating) was used to evaluate the change in affective response to an expression that ended a dynamic expression compared with the same face presented at the start.

RESULTS AND DISCUSSION

Table 1 displays mean affect ratings for the starting and ending faces for each of the six expression condi-

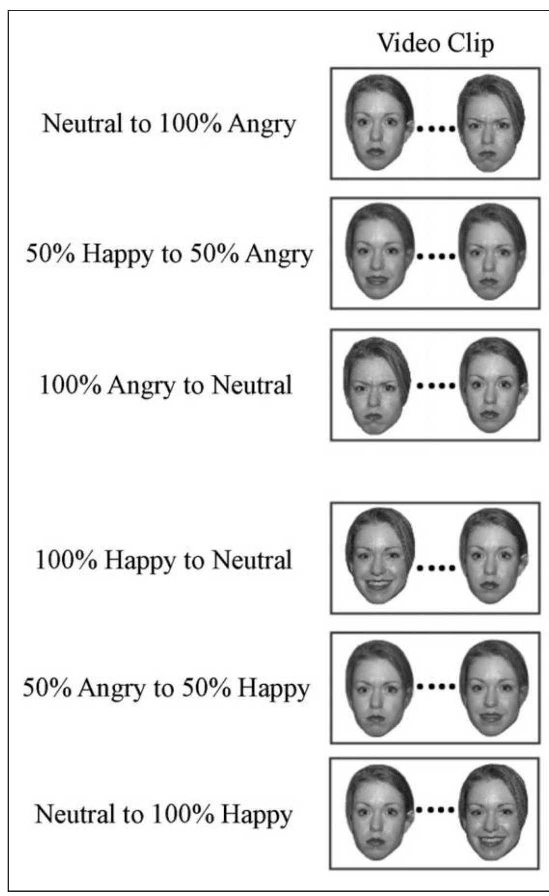

FIGURE 2. Examples of starting and ending facial expressions presented in the 6 dynamic expression conditions, Experiment 1

tions (affect scale ranged from –200 = *very negative* to 200 = *very positive*). These ratings were subjected to a 6 × 2 repeated-measures ANOVA with expressions and bias score (starting vs. ending rating) as independent variables. A main effect of expression showed that participants could reliably vary their affect judgments according to the level of expression (from 100% angry to 100% happy; see Table 1), $F(5, 23) = 297$, $p < .001$. The main effect of bias (starting vs. ending position) was not significant, $F(1, 23) = 2.0$, $p = .17$, although there was a significant expression × bias interaction, $F(5, 23) = 6.6$, $p = .001$.

Pairwise comparisons of the bias score revealed the nature of the interaction. Specifically, only the two neutral conditions produced reliable bias effects. A neutral expression that started as 100% angry was rated more positively than the same neutral expression viewed at the start of a trial, $t(23) = 3.95$, $p < .001$. Yet a neutral expression that started as 100% happy was rated more negatively than baseline (starting) ratings, $t(23) = 11.18$, $p < .001$. No other expression produced significant bias scores, although the bias score of the 50% angry, which began as a 50% happy expression, was marginally significant, $t(23) = 1.94$, $p = .065$. In this case, the movement from 50% happy to 50% angry caused the ending face to appear slightly more negative than its baseline (i.e., starting) expression, suggesting a momentum effect for expressions that moved to 50% angry.

EXPERIMENT 2

The findings from Experiment 1 demonstrated a potent emotional contextual contrast effect. Neutral faces were strongly influenced by their prior dynamics. If an angry face moved to neutral, it appeared to express positive emotion, whereas the same neutral expression that began as a happy one was interpreted negatively. The potency of these contrast effects was striking and can be appreciated only by viewing the actual video clips (see http://conium.org/~shimlab/ShimDemo.html). Yet contrast effects have been observed by pairing static neutral expressions with emotionally expressive ones (Russell & Fehr, 1987; Tanaka-Matsumi et al., 1995; Webster et al., 2004). Thus, in Experiment 2, we assessed the degree to which contrast effects could be obtained sequentially though without dynamic movement.

METHODS

Participants

Participants were 24 undergraduates (19 women, 5 men; mean age = 20.6 yr) from the University of California, Berkeley, who received course credit for their participation. None had participated in the previous experiment.

Design and Procedure

The design and procedure were the same as those used in Experiment 1, only in this experiment the video clips were replaced with a blank screen. Thus, participants viewed static transitions of facial expressions, with the same timing parameters and rating procedure as those used in Experiment 1. Specifically, for each trial participants rated the affective valence of one face (the "first" face) presented for 2 s, which was followed by a blank screen displayed for 4 s, and

TABLE 1. Ratings of Emotional Valence for Starting and Ending Faces Using Dynamic Video Clips, Experiment 1

Dynamic face condition	Starting face rating	Ending face rating	Bias score (*SEM*)
100% Angry (w/neutral)	–112.37	–112.13	0.23 (3.48)
50% Angry (w/50% happy)	–54.90	–61.29	–6.39 (3.29)
Neutral (w/100% angry)	–4.81	3.31	8.12 (2.06)**
Neutral (w/100% happy)	–4.39	–15.56	–11.18 (2.68)**
50% Happy (w/50% angry)	65.68	65.64	–0.05 (2.32)
100% Happy (w/neutral)	130.79	130.18	–1.61 (2.86)

Note. *Each expression was rated as a starting face and as an ending face (e.g., 100% angry rated before it moved to a neutral expression and after moving from a neutral expression). The influence of movement is reflected in the bias score = ending rating – starting rating.*
**$p < .001$, *nonsignificant scores,* $p > .05$.

then rated the affective valence of the same face with a different expression (the "second" face) presented for 2 s. With the sequence of the two face presentations separated by the original 4-s interstimulus interval, we avoided perceived dynamic movements that could be induced by more rapid sequences (i.e., the phi phenomenon).

RESULTS AND DISCUSSION

Table 2 displays mean affect ratings for the first and second appearance of two static faces presented sequentially. Ratings were subjected to a 6 × 2 repeated-measures ANOVA with expressions and bias score (starting vs. ending rating) as independent variables. As in Experiment 1, participants reliably varied their affect judgments according to the level of expression (from 100% angry to 100% happy; see Table 2), $F(5, 23) = 185$, $p < .001$. The main effect of bias (first vs. second ratings) was not significant, $F(1, 23) = 1.3$, $p = .27$, although there was a significant expression × bias interaction, $F(5, 23) = 4.2$, $p = .002$. In pairwise comparisons, only two conditions showed a bias effect. First, neutral expressions preceded by a 100% angry face appeared less negative, $t(23) = 2.05$, $p = .05$, consistent with the contrast effect observed in Experiment 1 and previous studies using successive presentations of static angry and neutral faces (Tanaka-Matsumi et al., 1995). We also observed a contrast effect for 50% happy faces preceded by a 50% angry face. These happy faces were judged more negative than baseline starting faces, $t(23) = 3.14$, $p < .01$. The bias effect for neutral faces preceded by a 100% happy face was not significant, $t(23) = 1.06$, $p = .30$, although it was numerically biased in the same direction as the comparable condition in Experiment 1.

To assess the difference between static and dynamic expressions, we compared the effect sizes of the bias effects on neutral expressions (following 100% angry or 100% happy expressions) observed in this experiment (static faces) with those observed in Experiment 1 (dynamic faces) (Figure 3). Statistical analyses (Cohen's d) of these conditions revealed significantly greater bias effects from dynamic facial expressions than from sequentially presented static faces ($p < .05$). Taken together, these findings confirmed previous findings of contrast effects using successive static faces (Tanaka-Matsumi et al., 1995; Webster et al., 2004), although they demonstrate greater potency of dynamic facial expressions over static presentations.

EXPERIMENT 3

In Experiments 1 and 2, contrast effects were observed for neutral faces that started as either 100% angry or 100% happy, but momentum effects were not generally observed. Specifically, among 50% and 100% happy and angry faces, only 50% angry expressions were rated marginally more negative as they appeared to move toward a more expressive face. Perhaps more potent momentum effects would be observed if the ending expressions were not so expressive. In this experiment, we explored more fully the range of dynamic facial expressions. We assessed

TABLE 2. Ratings of Emotional Valence Using Static Presentations, Experiment 2

Static face condition	First face rating	Second face rating	Bias score (*SEM*)
100% Angry (w/static neutral)	–106.62	–102.72	3.90 (209)
50% Angry (w/static 50% happy)	–53.83	–55.46	–1.63 (2.28)
Neutral (w/static 100% angry)	–7.07	–4.56	2.51 (1.22)*
Neutral (w/static 100% happy)	–8.57	–10.13	–1.56 (1.48)
50% Happy (w/static 50% angry)	60.84	53.31	–7.05 (2.40)*
100% Happy (w/static neutral)	119.09	116.28	–2.81 (3.70)

Note. *Each static expression was rated as a first face and a second face (e.g., 100% angry followed by a neutral face). Bias score = ending rating – starting rating.*
*$p < .05$, nonsignificant scores, $p > .05$.

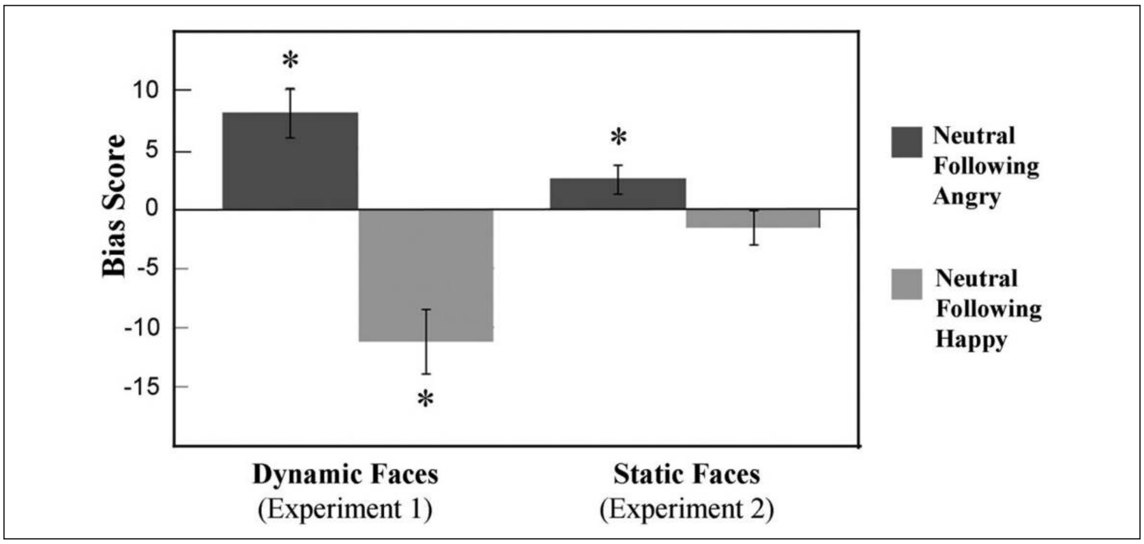

FIGURE 3. Bias scores (ending face – starting face) of neutral expressions following dynamic expressions (Experiment 1) and static expressions (Experiment 2). Contrast bias effects were prominent after dynamic expressions. That is, a neutral face that was previously angry was viewed positively, whereas the same neutral face that was previously happy was viewed negatively

facial expressions that moved to neutral or to 25%, 50%, 75%, and 100% angry or happy expressions. In this manner, we could determine whether bias effects occur only for putatively neutral faces or whether mildly expressive faces (e.g., 25% expressions) would show a momentum bias effect.

METHODS

Participants

Thirty-six undergraduates (22 women, 14 men; mean age = 21.2 yr) participated in this experiment. None had participated in either of the previous two experiments.

Design and Procedure

The design and procedure were the same as those used in Experiment 1, only in this experiment we extended the range of dynamic facial expressions. In addition to the six conditions used in Experiment 1 (neutral to 100% angry, 100% angry to neutral, neutral to 100% happy, 100% happy to neutral, 50% angry to 50% happy, 50% happy to 50% angry), four new conditions were presented: 75% angry to 25% happy, 25% angry to 75% happy, 75% happy to 25% angry, and 25% happy to 75% angry. All of these movements moved to a neutral expression and then to an expressive state. In this manner, we varied the starting and ending expressions but kept constant the velocity and duration of movement.

RESULTS AND DISCUSSION

Table 3 displays mean ratings for starting and ending expressions. These ratings were subjected to a 10 × 2 repeated-measures ANOVA with expressions and bias score (starting vs. ending rating) as independent variables. As in Experiment 1, participants reliably varied their affect judgments according to the level of expression from a mean rating of −121.94 for 100% angry to a mean rating of 141.65 for 100% happy, $F(9, 35) = 619$, $p < .001$. The main effect of bias (starting vs. ending position) was significant, $F(1, 35) = 7.3$, $p = .01$, and there was a significant expression × bias interaction, $F(9, 35) = 15.5$, $p < .001$. Planned comparisons of the bias effects showed that in addition to replicating the contrast bias effects for the neutral conditions, significant momentum bias effects were observed for dynamic expressions that moved to 25% angry, 25% happy, and 50% angry, $ts(35) > 3.58$, $ps < .001$ (Figure 4). That is, ratings of affective valance were higher when a facial expression ended as a partially expressive happy or angry expression.

The momentum effect observed in this experiment was not symmetric as the 50% angry expression

TABLE 3. Ratings of Emotional Valence for Starting and Ending Faces Using Dynamic Video Clips, Experiment 3

Dynamic face condition	Starting rating	Ending rating	Bias score (*SEM*)
100% Angry (w/neutral)	–121.94	–125.79	–3.85 (2.58)
75% Angry (w/25% happy)	–98.51	–102.50	–3.99 (3.28)
50% Angry (w/50% happy)	–58.71	–67.49	–8.78 (2.45)**
25% Angry (w/75% happy)	–13.82	–28.86	–15.04 (2.24)**
Neutral (w/100% angry)	–4.12	8.19	12.31 (1.78)**
Neutral (w/100% happy)	–3.97	–15.04	–11.07 (2.13)**
25% Happy (w/75% angry)	25.66	40.05	14.39 (2.07)**
50% Happy (w/50% angry)	72.62	73.24	0.62 (2.32)
75% Happy (w/25% angry)	115.55	112.54	–3.00 (2.60)
100% Happy (w/neutral)	141.65	140.28	–1.38 (1.95)

Note. *Bias score = ending rating – starting rating.*
**p < .001, nonsignificant scores, p > .05.

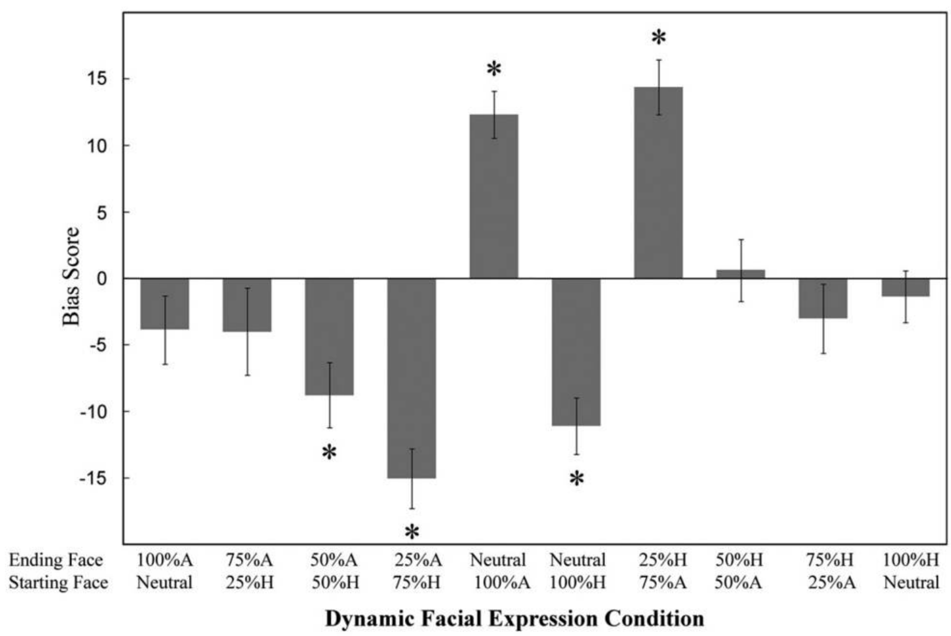

FIGURE 4. Bias scores across a spectrum of dynamic facial movements, Experiment 3. In addition to contrast effects observed for movements to neutral expressions, significant momentum effects were observed for movements to mild but not to strong expressions. Specifically, affect ratings for expressions that moved to 25% or 50% angry (A) or to 25% happy (H) were viewed as more expressive than baseline (starting) ratings

exhibited a significant momentum effect, whereas the 50% happy expression did not (in Experiment 1, the bias effect for 50% angry expressions approached statistical significance). One explanation for this asymmetry is that changes in expressiveness may be nonlinear as we move toward fully expressive faces. That is, a 50% angry face may not actually look as negatively valanced as a 50% happy face looks positively valanced. Indeed, baseline scores (i.e., starting faces) for 50% angry expressions averaged –58.71, whereas those for 50% happy averaged 72.62. Because only neutral or mildly expressive faces appear to show bias effects, the 50% happy face may have appeared too fully formed and thus resistant to the influence of movement.

EXPERIMENT 4

In this experiment we tested another expressive dimension, happy to sad faces. Previous studies using static faces have demonstrated contrast aftereffects between happy and sad expressions (Rutherford, Chattha, & Krysko, 2008). We therefore applied the same experimental paradigm as in Experiment 1 to explore dynamic facial expressions that moved from sad to happy.

METHODS

Participants

Twenty-four undergraduates (15 women, 9 men; mean age = 22.2 yr) participated in this experiment. None of these people participated in any of the previous experiments in this series.

Design and Procedure

The experimental design and procedure were identical to those of Experiment 1 except that the previous video clips using angry expressions were replaced with clips using sad expressions. As in Experiment 1, a total of six video clip conditions were presented: neutral to 100% sad, 50% happy to 50% sad, 100% sad to neutral, 100% happy to neutral, 50% sad to 50% happy, and neutral to 100% happy. Within each condition, we created a set of 18 video clips each with a different face. For each trial, participants rated the affect (from very positive to very negative) of the starting and ending expressions.

RESULTS AND DISCUSSION

Table 4 displays mean affect ratings for the starting and ending faces for each of the six happy–sad expression conditions. These ratings were subjected to a 6 × 2 repeated-measures ANOVA with expressions and bias score (starting vs. ending rating) as independent variables. These results were comparable to those obtained with the angry–happy conditions used in Experiment 1. Specifically, participants reliably varied their affect judgments according to the level of expression, $F(5, 23) = 326$, $p < .001$. The main effect of bias (starting vs. ending position) was not significant, $F(1, 23) = 1.0$, $p = .32$, although there was a significant expression × bias interaction, $F(5, 23) = 8.7$, $p = .001$.

Pairwise comparisons of the bias score revealed contrast effects for the neutral conditions and momentum effects for expressions that moved to 50% happy and 50% sad (see Table 4). Neutral faces that started as 100% sad expressions were rated positively, bias effect = 6.24, $t(23) = 4.83$, $p < .001$. We also replicated the negative contrast bias for neutral faces that started as 100% happy, bias effect = –9.25, $t(23) = 8.41$, $p < .001$. Yet, unlike findings from Experiments 1 and 3, we observed a significant momentum effect for dynamic expressions that moved to 50% happy, bias effect = 4.65, $t(23) = 2.27$, $p < .05$. We also observed

TABLE 4. Ratings of Emotional Valence for Starting and Ending Faces Using Happy and Sad Dynamic Video Clips, Experiment 4

Dynamic face condition	Starting rating	Ending rating	Bias score (*SEM*)
100% Sad (w/neutral)	–98.49	–101.47	–2.98 (3.04)
50% Sad (w/50% happy)	–50.44	–56.75	–6.31 (2.78)*
Neutral (w/100% sad)	–4.35	1.89	6.24 (1.29)**
Neutral (w/ 100% happy)	–3.35	–12.59	–9.25 (1.10)**
50% Happy (w/ 50% sad)	51.41	56.06	4.65 (2.05)*
100% Happy (w/ neutral)	106.29	107.42	1.13 (2.14)

Note. *Bias score = ending rating – starting rating.*
***p < .001. *p < .05.*

a comparable momentum effect for expressions that moved to 50% sad, bias effect = −6.31, $t(23) = 2.26$, $p < .05$. Thus, compared with dynamic expressions presented in the context of angry and happy faces, the presentation of sad and happy faces appeared more sensitive to momentum effects.

It is interesting to note that in this experiment, the sad expressions were rated as less intense than the angry expressions used in Experiments 1 and 3. At first blush, this suggests that the sad faces were simply not as intense. However, happy expressions were rated as less intense in this experiment than in previous ones, although the same faces were used in all three experiments. Perhaps participants were incorporating both valence and arousal ratings into a single measure. In any event, the lowering of the affective ratings, particularly for the 50% expressions, may have made them more malleable to contextual influences.

GENERAL DISCUSSION

Dynamic facial expressions that ended as a neutral expression induced potent and reliable contrast effects. A neutral face that began with an angry expression was rated positively compared with baseline, whereas the same neutral face was rated negatively when it began as a smile. Such contrast effects were observed for neutral expressions that started as angry (Experiments 1 and 3), happy (Experiments 1, 3, and 4), or sad (Experiment 4). The potency of these effects can be fully appreciated only by viewing dynamic expressions that fade to neutral (see http://conium.org/~shimlab/ShimDemo.html), as the ending neutral expression actually looks different depending on its temporal context. Angry faces that move to neutral appear somewhat amused, whereas smiling faces that turn to a blank stare appear annoyed or grumpy. Similar contrast effects have been observed using static neutral faces presented sequentially (Tanaka-Matsumi et al., 1995), although Experiment 2 showed that bias effects from sequential static faces are weaker than those observed with dynamic expressions. To our knowledge, this is the first report of a contrast context effect following dynamic facial expressions.

To what extent do dynamic facial expressions induce momentum bias effects? Representational momentum was first reported by Freyd and Finke (1984; Finke & Freyd, 1985), who found that "visual memory of the final position of an object is systematically distorted by a preceding series of displays that imply continuing motion of the object" (Finke & Freyd, 1985, p. 780). In Freyd and Finke (1984), participants were presented a sequence of three rectangles, each of which was angled more than the previous one, thus inducing a rotational movement. A target rectangle then appeared, and participants determined whether this rectangle was the same as the final one in the sequence. The target rectangle was positioned at the same orientation as the third rectangle or rotated slightly further or less. Responses were biased toward the momentum of the movement, such that distractors that were rotated slightly further were confused with the actual target.

Findings of representational momentum suggest that we carry over or continue the movement implied by recent experience. Such influences may describe the properties of various kinds of visual movements, yet they are particularly relevant with respect to dynamic facial expressions. Experiment 3 assessed a broad range of dynamic expressions that moved to varying degrees of angry and happy. Momentum effects were observed for expressions that moved to 25% and 50% angry and to 25% happy (see Figure 4). These ending expressions were rated more strongly than their counterpart baseline (starting) ratings, suggesting that the expressive movement was carried further than its actual ending point. Expressions that moved to 75% or 100% angry or happy did not exhibit momentum biases because their ratings were not significantly influenced by movement. Thus, momentum effects appeared to diminish as the ending face became more expressive.

In Experiment 4, we assessed dynamic expressions that moved to and from sad expressions. Just as with angry expressions, neutral faces that began as sad appeared more positive compared with baseline ratings (see Table 4). Moreover, a momentum effect was observed for expressions that moved to 50% sad as they were rated more negatively than baseline ratings. Interestingly, in the context of sad dynamic expressions, happy expressions were rated as less positive and also elicited a significant momentum effect for movements to 50% happy, a finding that did not occur in the context of angry faces (Experiments 1 and 3). Thus, it is important to note that facial expressions can be more globally influenced by the overarching context in which they are presented. Happy faces presented in the context of angry faces are rated more positively than the same faces presented in the context of sad faces.

Yoshikawa and Sato (2008) assessed representational momentum effects for dynamic facial expressions that moved to 100% or 80% expressive (anger, disgust, fear, happy, sad, surprise). They measured the influence of momentum by having participants select a morphed blend that matched the final frame of a dynamic expression. Decisions were made by moving a sliding scale that varied the morphed blend from neutral to very expressive until a blend was judged as the same as the final frame. Small but reliable momentum effects were observed for faces that ended at 100% expressive, and more substantial effects were observed for expressions that ended at 80% expressive. Interestingly, the momentum bias increased with the velocity of the movement.

In the present study, we did not find momentum biases for faces that moved to 75% or 100% expressive, even though ratings for these expressions were well below potential ceiling effects. Differences in test measures between the two studies may have caused the discrepancy. For example, we presented a single dimension (e.g., happy to angry or happy to sad), whereas Yoshikawa and Sato (2008) presented six different expressions. Also, we presented a range of facial expressions that moved to various points, whereas participants in Yoshikawa and Sato (2008) viewed only expressions that ended at expressive values of 100% (Experiment 1) or 80% (Experiment 2). Finally, the two experiments differed in the type of response: Whereas we used a sliding numerical scale, Yoshikawa and Sato (2008) used a sliding face scale. It is unclear which of these differences caused the momentum effects to occur significantly for highly expressive faces in the Yoshikawa and Sato (2008) study but not in ours. In any event, within the purview of the present study, it is certainly the case that momentum effects for expressions that move to mildly expressive points (25% or 50% expressive) are stronger than those that occur at more expressive points (75% or 100% expressive).

To what extent do contrast and momentum effects depend on the same processes? Momentum effects magnify or amplify the intensity of an expression, whereas contrast effects actually move neutral expressions in the opposite direction of a previous expression. With dynamic contrast effects, the impression is striking in that it actually appears as if the so-called neutral expression has already moved past and toward the opposite direction. Yet by this characterization, the concept of momentum seems appropriate, as if motion between two affective poles can swing like a pendulum from one endpoint to the other. Thus, it may be that processes that drive contrast and momentum effects are quite similar and may be influenced by similar variables. For example, contrast effects, like momentum effects, may be influenced by the velocity of movement. However, such analyses are not straightforward as changes in velocity are confounded with changes in duration, and previous studies of perceptual aftereffects (Webster et al., 2004) suggest that contrast effects can be strongly influenced by duration.

Findings of contrast effects for dynamic facial expressions are diametrically opposite to those observed for successive presentations of pictorial scenes and faces (i.e., the Kuleshov effect). A neutral face presented after a positive scene is rated positively, whereas the same face presented after a negative scene is rated negatively (Mobbs et al., 2006). Similar results have been obtained when neutral faces are superimposed onto emotionally laden scenes (Righart & de Gelder, 2006, 2008). In these studies, facial expressions are perceived as congruent with the emotion generated by the pictorial scene. Neurocognitive analyses of context-congruent effects suggest that such influences occur at early stages of information processing and may involve the integration of gist information with facial expressions (Righart & de Gelder, 2006). Contrast effects may depend less on early gist information and more on a sequential processing of the movement or "meaning" between two distinct facial expressions. In the present study, the sequential processing of the movement is clear because it starts with an expressive face, say a smiling face, and ends with the same face exhibiting a neutral expression. Thus, the social meaning is that the person was happy and is now not happy. Contrast effects demonstrate that "not happy" is actually perceived as negatively valanced rather than neutral.

The present findings exemplify the importance of dynamic facial expressions in the interpretation and attribution of emotional disposition. The temporal dynamics of facial expressions, the ways in which they change from moment to moment, are potent features in emotion recognition. In particular, they develop a contextual framework by which emotional dispositions can be tracked across time (see Trope, 1986). Thus, just as pictorial context can change the perceived emotion of a facial expression (Aviezer et al., 2008; Marian & Shimamura, 2012), temporal context (e.g., what emotion was expressed just previously) can alter the perceived disposition of an individual. Our findings stress the importance of using dynamic facial expressions as a way of capturing the influence of temporal context on emotion recognition. Indeed, the application of moving images rather than static ones offers a useful means of assessing the emotional dynamics of social interchanges.

In conclusion, new and potent contrast effects were observed for dynamic expressions that ended as neutral expressions. Such facial movements are rarely considered in psychological investigations because they are typically viewed as "backward" movements (e.g., Sato et al., 2010). Yet in everyday situations facial expressions are ever-changing, and movements to a neutral state have significant social–emotional impact. Contrast effects were observed for neutral expressions that were previously happy, angry, or sad, and for each movement, the expression appeared to swing past neutral and move toward the opposite pole from where it began. Such apparent movements suggest that contrast effects have similar qualities to momentum bias effects, which were observed for dynamic faces that moved to mildly expressive points (25% to 50% expressive). Contextual effects, such as those observed here, carry significant weight and offer important clues to how we perceive and communicate social–emotional signals.

NOTE

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REFERENCES

Ambadar, Z., Schooler, J. W., & Cohn, J. F. (2005). Deciphering the enigmatic face: The importance of facial dynamics in interpreting subtle facial expressions. *Psychological Science, 16,* 403–410.

Aviezer, H., Hassin, R. R., Ryan, J., Grady, C., Susskind, J., Anderson, A., . . . Bentin, S. (2008). Angry, disgusted, or afraid? Studies on malleability of emotion perception. *Psychological Science, 19,* 724–732.

Biele, C., & Grabowska, A. (2006). Sex differences in perception of emotion intensity in dynamic and static facial expressions. *Experimental Brain Research, 171,* 1–6.

D'Argembeau, A., Van der Linden, M., Complain, C., & Etienne, A.-M. (2003). The effects of happy and angry expressions on identity and expression memory for unfamiliar faces. *Cognition & Emotion, 17,* 609–622.

Finke, R. A., & Freyd, J. J. (1985). Transformations of visual memory induced by implied motions of pattern elements. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11,* 780–794.

Freyd, J. J. (1987). Dynamic mental representations. *Psychological Review, 94,* 427–438.

Freyd, J. J., & Finke, R. A. (1984). Representational momentum. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10,* 126–132.

Halberstadt, J. B., & Niedenthal, P. M. (2001). Effects of emotion concepts on perceptual memory for emotional expressions. *Journal of Personality and Social Psychology, 81,* 587–598.

Hill, H., & Johnson, A. (2001). Categorizing sex and identity from the biological motion of faces. *Current Biology, 1,* 880–885.

Kamachi, M., Bruce, V., Mukaida, S., Gyoba, J., Yoshikawa, S., & Akamatsu, S. (2001). Dynamic properties influence the perception of facial expressions. *Perception, 30,* 875–887.

LaBar, K. S., Crupain, M. J., Voyvodic, J. T., & McCarthy, G. (2003). Dynamic perception of facial affect and identity in the human brain. *Cerebral Cortex, 13,* 1023–1033.

Levaco, R. (1974). *Kuleshov on film: Writings by Lev Kuleshov.* Berkeley: University of California Press.

Marian, D. E., & Shimamura, A. P. (2012). Emotions in context: Pictorial influences on affective attributions. *Emotion, 12,* 371–375.

Mobbs, D., Weiskopf, N., Lau, H. C., Featherstone, E., Dolan, R. J., & Frith, C. D. (2006). The Kuleshov effect: The influence of contextual framing on emotional attributions. *Social Cognitive and Affective Neuroscience, 1,* 95–106.

Munn, N. L. (1940). The effect of knowledge of the situation upon judgment of emotion from facial expressions. *Journal of Abnormal & Social Psychology, 35,* 324–338.

Mussweiler, T. (2003). Comparison processes in social judgment: Mechanisms and consequences. *Psychological Review, 110,* 472–489.

Pilz, K. S., Thornton, I. M., & Bulthoff, H. H. (2006). A search advantage for faces learned in motion. *Experimental Brain Research, 171,* 436–447.

Righart, R., & de Gelder, B. (2006). Context influences early perceptual analysis of faces: An electrophysiological study. *Cerebral Cortex, 16,* 1249–1257.

Righart, R., & de Gelder, B. (2008). Rapid influence of emotional scenes on encoding of facial expressions: An ERP study. *Social Cognitive and Affective Neuroscience, 3,* 270–278.

Russell, J. A., & Fehr, B. (1987). Relativity in the perception of emotion in facial expressions. *Journal of Experimental Psychology: General, 116,* 223–237.

Rutherford, M. D., Chattha, H. M., & Krysko, K. M. (2008). The use of aftereffects in the study of relationships among emotion categories. *Journal of Experimental Psychology: Human Perception and Performance, 34,* 27–40.

Sato, W., Kochiyama, T., & Yoshikawa, S. (2010). Amygdala activity in response to forward versus backward dynamic facial expressions. *Brain Research, 1315,* 92–99.

Sato, W., & Yoshikawa, S. (2004). The dynamic aspects of emotional facial expressions. *Cognition & Emotion, 18,* 701–710.

Shimamura, A. P., Ross, J. G., & Bennett, H. D. (2006). Memory for facial expressions: The power of a smile. *Psychonomic Bulletin & Review, 13,* 217–222.

Tanaka-Matsumi, J., Attivissimo, D., Nelson, S., & D'Urso, T. (1995). Context effects on the judgment of basic emotions in the face. *Motivation and Emotion, 19,* 139–155.

Thornton, I. M., & Kourtzi, Z. (2002). A matching advantage for dynamic human faces. *Perception, 31,* 113–132.

Tottenham, N., Tanaka, J., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., . . . Nelson, C. A. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research, 168,* 242–249.

Trope, Y. (1986). Identification and inferential processes in dispositional attribution. *Psychological Review, 93,* 239–257.

Wallbott, H. G. (1988). In and out of context: Influences of facial expression and context information on emotion attributions. *British Journal of Social Psychology, 27,* 357–369.

Webster, M. A., Kaping, D., Mizokami, Y., & Duhamel, P. (2004). Adaptation to natural facial categories. *Nature, 428,* 557–561.

Wehrle, T., Kaiser, S., Schmidt, S., & Scherer, K. R. (2000). Studying the dynamics of emotional expression using synthesized facial muscle movements. *Journal of Personality and Social Psychology, 78,* 105–119.

Yoshikawa, S., & Sato, W. (2006). Enhanced perceptual, emotional, and motor processing in response to dynamic facial expressions of emotion. *Japanese Psychological Research, 48,* 213–222.

Yoshikawa, S., & Sato, W. (2008). Dynamic facial expressions of emotion induce representational momentum. *Cognitive, Affective, & Behavioral Neuroscience, 8,* 25–31.