Deciphering the Enigmatic Face: The Importance of Facial Dynamics in Interpreting Subtle Facial Expressions

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Abstract

Most studies investigating the recognition of facial expressions have focused on static displays of intense expressions. Consequently, researchers may have underestimated the importance of motion in deciphering the subtle expressions that permeate real life situations. In two experiments, we examined the effect of motion on perception of subtle facial expressions and tested the hypotheses that Motion improves affect judgment by (1) providing denser sampling of the expression, (2) providing dynamic information, (3) facilitating configural processing, and (4) enhancing the perception of change. Participants viewed faces depicting subtle facial expressions in four modes (Single-Static, Multi-Static, Dynamic and First-Last). Experiment 1 demonstrated a robust effect of motion and suggested that it was due to the dynamic property of the sequence. Experiment 2 suggested that the beneficial effect of motion is due to its role in perception of change. Together these experiments demonstrated the importance of motion in identifying subtle facial expressions.

Deciphering the Enigmatic Face: The Importance of Facial Dynamics

in Interpreting Subtle Facial Expressions

Facial expressions come in all varieties. Some are intense and sustained while others are subtle and fleeting. Despite the great diversity of facial expression displays, the vast majority of studies investigating the recognition of facial expressions have focused on static displays of intense emotions. As a result of this limited focus on exaggerated static facial expressions, it seem quite plausible that researchers may have underestimated the importance of factors such as motion which may be critical for deciphering the fleeting subtle expressions that permeate real life situations.

Although largely overlooked, a few investigators have examined the impact of motion in deciphering faces. However, these studies have either failed to find (Kamachi, Bruce, Mukaida, Gyoba, Yoshikawa, & Akamatsu, 2001) or provided only minimal evidence for a role of motion. For example**,** Dube (1997) found a non-significant tendency that the dynamic presentation led to a general increase in the identification rates and saliency judgments as compared to a static presentation. Harwood, Hall, and Shinkfield (1999) found that dynamic presentation improved perception of Sad and Angry but not other facial expressions of emotion. Using synthesized faces, Wehrle , Kaiser, Schmidt, and Scherer (2000) also found a non-significant tendency of the effect of dynamic over static presentation.[1]

One possible limitation of all of these studies is their reliance on the use of intense facial expressions. In addition to the problem of ecological validity with using strong facial expressions (Carroll & Russell, 1997; Tian, Kanade, & Cohn, 2001), intense expression may mask the subtle effects of dynamic displays, thereby contributing to previous failures to demonstrate a robust effect of motion on facial affect judgment.

How would motion improve perception of facial expressions? Ekman and Friesen (1982) and Hess and Kleck (1990, 1994), propose that the dynamic display of facial expressions provides unique information about the expressions that is not available in the static display, namely the temporal information of the expressions itself. Alternatively, moving expression sequences might provide a greater sample of the expressions by which to disambiguate the portrayed emotion. By definition, a moving sequence contains multiple static images, and hence offers a greater sample of the expressions in progress, than a single static display. This fact alone suggests the possibility that it is the additional static information that helps in disambiguating the emotion signal. This possibility, although implicitly recognized (Ekman & Friesen, 1978; Ekman & Friesen, 1984; Hess & Kleck, 1990), has not been tested empirically.

Previous studies examining the effects of motion (e.g. Dube, 1997, Wehrle et.al., 2000) have simultaneously varied both the number of frames and the dynamic characteristic of the display, thereby confounding the impact of motion with the additional information associated with multiple images. However, the importance of this additional information can be determined by comparing a dynamic sequence to a static sequence that presents the same frames with a mask between images, thereby attenuating the perception of motion. This Multi-Static condition was used in the current study.

Another way in which motion can affect perception of facial expression is through its role on the mode of processing employed by the observer. In face perception literature, a distinction often is made between configuration-based processing and feature-based processing (Bartlett & Searcy, 1993; Leder & Bruce, 2000; Leder, Candrian, Huber, & Bruce, 2001; McKelvie, 1995) with the former considering the relationship among features and the latter focusing on individual features. By using manipulations, such as face inversion, which disrupts configural processing, this research has demonstrated that face recognition is highly reliant on configural information (Bartlett & Searcy, 1993; Freire, Lee, & Symons, 2000; Hancock, Bruce, & Burton, 2000; Leder & Bruce, 2000; Leder et al., 2001). Although less conclusive, there also is some evidence that judgment of facial expressions may also depend in part on configural information (e.g. Bartlett & Searcy, 1993; McKelvie, 1995; Muskat, & Sjoberg, 1997; Searcy & Bartlett, 1996; White, 1999, 2000). Indeed such studies may have underestimated the potential role of configural information by exclusively relying on intense facial expressions. Consequently, they may have potentially overlooked the value of configural information in enhancing the decipherability of more subtle expressive information.

Although no prior research has explicitly examined the notion that dynamic facial displays might enhance configural processing, it seems reasonable that motion promotes the perception of coherence of facial features. Accordingly, synchronous movement of facial features may enable the interpretation of facial expression, in much the same way as individuals recover the nature of actions of an object through the synchronous motion of its elements (Braunstein, 1962; Cutting, Moore, & Morrison, 1988).

Experiment 1: The Effect of Motion and Orientation

In Experiment 1, we sought to find a robust effect of motion on the identification of facial expressions by examining whether dynamic displays that depicted the emergence of a subtle expression (Dynamic condition) would result in superior emotion identification relative to a condition in which only the final expression was presented (Single-Static condition). In addition, in order to assess the impact of the additional information associated with multiple-frames, a third condition (Multi-Static condition) was included in which the same series of images used in the Dynamic condition were interspersed with visual noise masks, thereby maintaining the informational content of the sequence but eliminating the experience of motion. If dynamic displays facilitate performance by providing more static information than single static displays, then performance in the Multi-Static and Dynamic conditions should be superior to performance in the Single-Static condition, and there should be no difference between the Multi-Static and the Dynamic conditions. Alternatively, if, movement is the critical aspect of dynamic displays, then performances in the Dynamic conditions should be significantly higher than that in both the Single-static and Multi-Static conditions.

In order to test the hypothesis that motion facilitates the configural processing of faces, we varied orientation (upright or inverted) in which the stimuli were presented. If the hypothesized effect of motion on emotion judgments is mediated by configural processing we should observe a significant interaction between motion and orientation.

Method

Participants

Participants were 68 undergraduate students (38 females) at the University of Pittsburgh who received class credit for participating. The majority of the participants were Caucasians (79%), with African-American and other ethnicity 8.8%, and 11.8% respectively. The rights of the participants were protected and applicable human research guidelines were followed.

Design

Experiment 1 was a 3 x 2 x 6 Mixed-Design. The Within-Subjects factors were Motion (Single-Static, Multi-Static and Dynamic) and Emotion (Anger, Disgust, Fear, Happy, Sad, and Surprise). The Between-Subjects factor was Orientation (Upright and Inverted).

Stimuli

The facial stimuli were derived from the Cohn-Kanade Facial Expression Database in which undergraduates were instructed to display facial expressions of basic emotions. They were video-recorded in real time (Kanade, Cohn, & Tian, 2000). In order to generate dynamic emotion displays that would be challenging to identify, full facial expression displays (originating at neutral baseline and progressing to full depiction of the emotion) were truncated so that they ended at the first visible display of the expression. These segments were then pre-tested in a pilot study in order to identify sequences that met the following two criteria:

1. The emotions must be correctly judged by 60% to 75% of the participants.
2. To allow configural processing, facial movement must involve more than 1 facial feature.

This pre-testing process resulted in the identification of 36 expression sequences from 29 posers (Caucasians, 22 females,) beginning at a neutral baseline, and progressing through 3 to 6 frames ending at a subtle facial expression of one of 6 basic emotions. Each emotion was represented by 6 sequences. Masks were created for each of the 36 sequences, using Photoshop 5.0., by filling in the face area (within an oval frame) with black and white Gaussian noise. The masks were used to prevent perception of motion in the Multi-Static condition and to orient the participants to the location of the face in the beginning of all sequences. All sequences were duplicated in 3 conditions: Single-Static, Multi-Static and Dynamic. Each sequence started with an oval-noise mask (presented for 200 ms). In the Single-Static condition, the mask was followed by the last image (target). In the Multi-Static condition, the mask was followed by the first (neutral) image of the sequence (500 ms), then the rest of the images (each for 500 ms) intermittently with the mask (200 ms) until the last image (target). In the Dynamic condition, the first image was presented for 500 ms after the initial mask, and was followed by the rest of the images presented in real time (30 fps). (see Figure 1)

Insert Figure 1 about here

Each sequence ended at an identical target picture in all conditions. Examples of the Single-Static, Multi-Static and Dynamic presentation in Upright and Inverted orientations can be seen at http://www.pitt.edu/~ambadar/stimuli.htm.

The resulting 108 sequences were divided into 3 sets of stimuli, counter balanced across conditions. Thus, on each set there were equal number of Single-Static, Multi-Static, and Dynamic sequences. In any given stimulus set, each sequence was presented only once. Each emotion was represented equally often in each set. The order of items within a set was randomized with one restriction; no same face was shown consecutively. All stimuli were duplicated and inverted to make the Inverted set.

Procedure

Participants, who were randomly pre-assigned to Upright or Inverted condition, viewed 1 of 3 randomly pre-assigned stimulus sets in a computer lab with 4 to 16 participants at a time. Participants were instructed to play each sequence at least once and to report responses only after they had reached the end (the last image) of the sequence. They were allowed to play the sequence as multiple times before making their judgment on a response sheet. For each item, participants made judgments about (1) the emotion that best described the facial expression, for which they chose among 7 options, Anger, Disgust, Fear, Happy, Sad, Surprise, and Neutral; (2) their confidence on 5-point Likert-type scale (1= not confident at all, to 5= very confident); and (3) report whether or not they perceived “motion” in the face (“Yes” or “No”). Motion was defined as “when you actually see the face move as in a movie clip”.

Results

Accuracy

Participants were substantially more accurate in identifying the emotion when the items were presented in Dynamic mode, $F(2,132)= 32.996$, $p<.001$, $\eta_p^2=.33$, relative to the two static conditions. The difference between the Single-Static and the Multi-Static presentations was not significant, $F(1,66)=2.584$, $p=.133$. There was a highly significant effect of Orientation, such that inversion impaired perception of facial expressions, $F(1,66)=78.822$, $p<.001$, $\eta_p^2=.54$. There was no interaction between orientation and motion. (See Figure 2).

Insert Figure 2. about here

Analysis of the effect of Emotion revealed a highly significant result, $F(5,100)=22.885$, $p<.001$, $\eta_p^2=.32$. Happy expressions were more likely, and Anger expressions were the least likely, to be judged correctly than other emotions.

Two-way interactions between Emotion and Motion, and between Emotion and Orientation were highly significant, $F(10,200)= 4.674$, $p<. 001$, and $F(5,100)=9.62$, $p< .001$. However, the 3 way interaction between Emotion, Motion, and Orientation was not significant.

The effect of Motion in the Upright condition showed similar pattern in all emotions except Happy and Sad. The pattern shows superiority of Dynamic conditions without significant differences between the two static conditions. (see Table 1).

Insert Table 1. about here

Confidence Ratings

There was a significant main effect of Motion on mean confidence ratings for correctly judged items, $F(2,132)=3.873$, $p<.05$. This main effect seemed to be driven by the difference between the Dynamic and the Multi-Static condition in the inverted orientation, $F(1,66)=6.965$, $p<.01$. Participants felt more confident with their judgments for Dynamic items than Multi-Static items, especially when the faces were upside down.

A similar effect was also found between Dynamic and Single-Static presentations in the Inverted Orientation but not in the Upright orientation. There was also a significant main effect of Orientation, $F(1,65)=4.940$, $p<.05$. The interaction between Motion and Orientation was not significant.

Perception of Motion

The main purpose of asking participants to report whether or not they perceived “motion” in the face was as a manipulation check, that is, participants should perceive motion in the dynamic presentation but not in the two static presentations. Statistical analysis was done on percentage of items in which movement was reported in each Motion condition. On average, 87% of items in the Dynamic condition were reported as showing movement, whereas in the Single-Static and Multi-Static conditions the perception of motion was negligible (3% or 1 item in the Single-Static and 13% or 4 items in the Multi-Static conditions). The effect of Motion was highly significant, $F(1,66)=363.537$, $p<.001$, and was observed in both the upright and inverted orientation, $F(1,66)<1$.

Discussion of Experiment 1

The results of Experiment 1 confirmed the hypothesis that motion improves perception of facial expressions. Participants were much more accurate and confident in judging the facial expression when they viewed a moving display of facial expression relative to when the face was static. This beneficial effect of motion was observed in all emotion tested except Happy. Experiment 1 also showed that inverted depictions of subtle facial expressions are harder to judge than upright ones, which suggests that configural processing contributes to perception of facial expression.

The lack of significant difference between the Single-Static and the Multi-Static conditions suggests that additional information alone is not enough to improve perception of facial expression significantly, and therefore, the beneficial effect of motion observed in this study could not be due to the fact that motion provides extra static information.

The lack of interaction effect between Motion and Orientation argues against the idea that motion improves perception of facial expression by facilitating configural processing. Thus, Experiment 1 suggests that the beneficial effect of motion is due to something inherent in the dynamic property itself.

The question remains “What is it in the dynamic property that is responsible for such a huge effect?” One possibility is that temporal characteristics of the expression that is unique to each emotion, such as its velocity (Schmidt, Cohn, & Tian, 2003), assisted participants in identifying the portrayed emotion.

Alternatively, motion simply enhanced the perception of changes in the face. In other words, the movement of facial features allows perceivers to observe what was changed in the composition of the facial features, whereas, in static pictures perceivers had to envisage the course of changes and hence could be less accurate. The idea that it is difficult to observe change in two static pictures has been studied quite extensively in the literature of change blindness (Levin & Simons, 1997; O'Regan, Deubel, Clark, & Rensink, 2000; O'Regan, Rensink, & Clark, 1999; Rensink, 2000; Rensink, O'Regan, & Clark, 1997, 2000; Simons & Levin, 1998; Simons & Levin, 2003). The results of Experiment 1 suggest that Motion might enhance sensitivity to facial changes. The above hypotheses were tested in Experiment 2.

Experiment 2: Unique temporal characteristics versus change sensitivity

If unique temporal characteristicof each emotion is necessary to improve perception of facial expressions, then changes in the temporal information will alter the beneficial effect of Motion. To test this hypothesis a new condition was added that contained only the first and the last images of the sequence. This new condition (First-Last) substantially changes the temporal characteristics of the facial expressions while preserving the perception of motion. (see Figure 1d).

If Motion increases sensitivity to changes then there should be no difference between the Dynamic and the First-Last conditions. If, however, the temporal characteristic is important, then perception of the Dynamic items should be superior to the First-Last items, and there should be no difference between the First-Last and the two static conditions.

Experiment 2 also addresses an unexciting account of the result of Experiment 1 that the superiority of the Dynamic display might have arisen because participants viewed the Dynamic items more times than the Static displays. To test this possibility we recorded and analyzed the frequency with which participants reviewed the faces in all conditions.

Method

Participants

Participants were 64 undergraduates at the University of Pittsburgh who received class credit for participating.

Design

Experiment 2 used a 4x6 Within-Subjects Design. The Within-Subjects factors were Motion (Single-Static, Multi-Static and Dynamic and First-Last.) and Emotion (6 basic emotions). Each Emotion is represented by 4 items, 1 in each of the 4 Motion conditions.

Stimuli

Stimuli were 24 sequences from 24 posers (18 females) from the stimulus pool used in Experiment 1. The procedure for creating and dividing stimuli into sets was the same as in Experiment 1.

Procedure

The procedure of Experiment 1 was replicated with the following modifications. Participants viewed the sequence and recorded their judgments in a computer using a Visual Basic program. The program was designed so that participants could make their judgments only after they had completed viewing of a sequence. Participants were allowed to play the sequence as many times as needed and the frequency of playing was recorded and analyzed. Up to 4 participants were run at a time.

Results

Frequency of Play

The issue raised in Experiment 1 that Dynamic items were judged more accurately because they were played more times than the static items was not supported. The frequency at which participants played the sequence were virtually the same among Motion Conditions: 1.44, 1.43, 1.50.and 1.48 for Single-Static, Multi-Static, Dynamic, and First-Last, respectively, $F(3,189)=1.124$, $p = .341$

Accuracy

Participants were far more accurate in judging facial expressions when the items were presented in Dynamic and First-Last mode relative to the Single-Static and Multi-Static mode, $F(3,189)=54.504$, $p <.001$, $\eta_p^2=.46$. The difference between the two static modes was not significant, $F(1,63)=1.214$, $p>.1$, and neither was the difference between Dynamic and First-Last conditions, $F(1,63)<1$.

The main effect of Emotion was highly significant, $F(5,315)=20.849$, $p<.001$, $\eta_p^2=.25$. This effect was driven mainly by “Happy advantage” phenomenon, that is, participants were much more accurate in recognizing a Happy expression than any other emotional expressions.

Interaction between Motion and Emotion was significant, $F(15, 945)=3.17$, $p<.001$, $\eta_p^2=.048$. Post hoc comparisons among Motion conditions in each emotion revealed that on all emotions, except Fear, the effect of Motion was highly significant, while the differences between the two static conditions and between Dynamic and First-Last conditions were not significant. (see Table 1).

Confidence Ratings

There was a significant main effect of Motion on mean confidence ratings for correctly judged items, $F(3,213)=62.175$, $p<.001$. The difference between Single-Static and Multi-Static was not significant, $F(1,98)<1$. Participants were more confident with their judgments of the Dynamic items than for the Multi-Static or First-Last items, $F(1,164)= 8.164$, $p=.004$ and $F(1,131)=109.492$, $p<.001$, respectively. They were also more confident in the First-Last condition relative to the Multi-Static condition, $F(1,132=145.094$, $p <.001$.

Discussion of Experiment 2

Experiment 2 replicated the results of Experiment 1 in all dependent variables. Participants were more accurate and more confident in judging facial expressions in the condition in which they perceived motion (Dynamic and First-Last) compared to the conditions in which motion perception was prevented. This effect was observed on all but 1 basic emotion tested (Fear). The possibility that participants viewed the dynamic items more often than the static items was discounted in Experiment 2. Participants viewed. the sequence on average 1.5 times regardless of Motion Conditions. Experiment 2 also replicated that the beneficial effect of Motion seems to be attributable to something inherent in the dynamic property itself rather than to the fact that motion provides extra static information. More specifically, the results showed that motion increases human sensitivity to changes of facial feature compositions as a result of the facial expression and this enhanced ability improves accuracy in identifying the emotion portrayed.

General Discussion

Experiment 1 and 2 demonstrated the importance of motion in facilitating the perception of facial expressions. Subtle facial expressions that were not identifiable in static presentations suddenly became apparent in a dynamic display. Importantly, and in contrast to prior studies using more intense facial expressions (e.g. Dube, 1997; Harwood, Hall, & Shinkfield, 1999; Kamachi, Bruce, Mukaida, Gyoba, Yoshikawa, & Akamatsu, 2001; Wehrle , Kaiser, Schmidt, and Scherer, 2000), this effect of motion was highly robust and observed (across the two experiments) for all six basic emotions examined.

The present set of studies also helped to rule out a number of possible mechanisms by which motion might have enhanced the recognition of subtle expressions. Although configural processing was found to be important for expression identification (as indicated by the deficit in performance for inverted faces), the absence of an interaction between motion and inversion indicated that the effects of motion are not mediated by configural processing. The benefits of dynamic displays were not due to the increases of facial information inherent in multi-frame sequences, as demonstrated by the fact that non-dynamic multi-frame sequences failed to produce a comparable benefit. Finally, the unique temporal characteristics of each emotion associated with dynamic displays also cannot explain their advantages, as comparable benefits were observed with displays that only included the first and last frame, and thus eliminated any cues regarding the original temporal unfolding of the expression.

The fact that, in the absence of a visual noise mask, a single shift between the first and last images of the dynamic sequences produced the full benefit associated with the dynamic sequence suggests that the critical advantage afforded by the dynamic displays is their ability to enable participants to perceive the change between the neutral base frame and the final subtle expression. This result also suggests that perception of facial expressions might be subject to the same change blindness phenomenon as have been robustly observed in other types of perception tasks. Although additional research is needed to fully flesh out the relationship between the present paradigm and change blindness studies (e.g. Levin & Simons, 1997; O'Regan et al., 1999) the parallels of the phenomena are striking. In both cases, individuals are readily able to extract information stemming from the difference between multiple images when they are simply presented one after the other, but largely incapable of extracting the very same information when the images are interspersed by a brief noise mask. Given these parallels and the failure to find evidence for any of the alternative roles of motion considered, it seems quite likely that the benefits of motion observed in these studies stem from its ability to enhance individuals perception of the way in which expressions have changed. The present findings thus suggest that motions' role in the detection of change, a central though often underemphasized aspect of the change blindness paradigm, is critical in mediating individuals' sensitivity to the communication of emotion.

Finally, although the primary import of this work is its demonstration of the importance of motion for the deciphering of facial expression, it also highlights the significance of another typically under-examined aspect of expressions; namely their frequent subtlety. Using subtle facial expressions, we readily observed the impact of two variables (motion and inversion) that have frequently eluded prior investigations using the standard intense facial expression displays. We can only speculate about what other important aspects of facial decoding may be revealed if researchers were to more regularly consider the processes associated with deciphering the enigmatic face.

References

Bartlett, J. C., & Searcy, J. (1993). Inversion and Configuration of Faces. *Cognitive Psychology, 25*(3), 281-316.

Bartlett, M., Hager, J., Ekman, P., & Sejnowski, T. (1999). Measuring Facial Expressions by Computer Image Analysis. *Psychophysiology, 36*, 253-264.

Braunstein, M. L. (1962). Depth Perception in Rotation Dot Patterns: Effect of Numerosity and Perspective. *Journal of Experimental Psychology, 64*, 415-420.

Carroll, J. M., & Russell, J. (1997). Facial Expression in Hollywood's Portrayal of Emotion. *Journal of Personality and Social Psychology, 72*, 164-176.

Cutting, J. E., Moore, C., & Morrison, R. (1988). Masking the Motions of Human Gait. *Perception and Psychophysics, 44*(4), 339-347.

Dube, S. P. (1997). *Visual Bases for the Perception of Facial Expressions: A look at some dynamic aspects.* Unpublished Dissertation, Concordia university, Montreal, Canada.

Edwards, K. (1998). The Face of Time: Temporal cues in facial expressions of emotions. *Psychological Science*, 9(4), 270-276.

Ekman, P., & Friesen, W. V. (1978). *Facial Action Coding System (FACS): A Technique for the Measurement of Facial Movement.* Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., & Friesen, W. V. (1984). *Unmasking the Face: A Guide to Recognizing Emotions From Facial Expressions*. Palo Alto, CA: Consulting Psychologists Press.

Freire, A., Lee, K., & Symons, L. A. (2000). The Face-inversion effect as a deficit in the encoding of configural information: Direct evidence. *Perception, 29*, 159-170.

Hancock, P. J. B., Bruce, V., & Burton, A. M. (2000). Recognition of Unfamiliar Faces. *Trends in Cognitive Sciences, 4*(9), 330-337.

Hess, U., & Kleck, R. E. (1990). Differentiating Emotion Elicited and Deliberate Emotional Facial Expressions. *European Journal of Social Psychology, 20*, 369-385.

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

Kanade, T., Cohn, J. F., & Tian, Y. (2000). *Comprehensive Database for Facial Expression Analysis.* Paper presented at the Fourth IEEE International Conference on Automatic Face and Gesture Recognition (FG00). Grenoble, France.

Leder, H., & Bruce, V. (2000). When inverted faces are recognized: The role of configural information in face recognition. *The Quarterly Journal of Experimental Psychology A, 53*(2), 513-536.

Leder, H., Candrian, G., Huber, O., & Bruce, V. (2001). Configural Features in the Context of Upright and Inverted Faces. *Perception, 30*(1), 73-83.

Levin, D., T, & Simons, D., J. (1997). Failure to detect changes to attended objects in motion pictures. *Psychonomic Bulletin and Review., 4*(4), 501-506.

McKelvie. (1995). Emotional Expression in Upside-down Faces: Evidence for Configurational and Componential Processing. *British Journal of Social Psychology, 34*(3), 325-334.

Muskat, J. A., & Sjoberg, W. G. (1997). Inversion and the Thatcher Illusion in Recognition of Emotional Expression. *Perceptual and Motor Skills, 85*, 1262.

O'Regan, J. K., Deubel, H., Clark, J. J., & Rensink, R. A. (2000). Picture changes during blinks: Looking without seeing and seeing without looking. *Visual Cognition, 7*(1-3), 191-211.

O'Regan, J. K., Rensink, R. A., & Clark, J. J. (1999). Change-blindness as a result of "mudsplashes." *Nature, 398*(6722), 34.

Rensink, R. A. (2000). When good observers go bad: Change blindness, inattentional blindness, and visual experience. *Psyche: An Interdisciplinary Journal of Research on Consciousness, 6*(9), NP.

Rensink, R. A., O'Regan, J. K., & Clark, J. J. (1997). To see or not to see: The need for attention to perceive changes in scenes. *Psychological Science, 8*(5), 368-373.

Rensink, R. A., O'Regan, J. K., & Clark, J. J. (2000). On the failure to detect changes in scenes across brief interruptions. *Visual Cognition, 7*(1-3), 127-145.

Searcy, J. H., & Bartlett, J. C. (1996). Inversion and Processing of Component and Spatial-Relational Information in Faces. *Journal of Experimental Psychology: Human Perception and Performance, 22*(4), 904-915.

Schmidt, K.L., Ambadar, Z., Cohn, J.F. *Timing of Lip Corner Movement Affects perceived Genuineness of Smiles*. Manuscript submitted for publication.

Schmidt, K.L., Cohn, J.F., and Tian, Y. (2003). Signal characteristics of spontaneous facial expressions: Automatic movement in solitary and social smiles. *Biological Psychology.* 65(1), 49-66.

Simons, D., J, & Levin, D., T. (1998). Failure to detect changes to people during a real-world interaction. *Psychonomic Bulletin and Review., 5*(4), 644-649.

Simons, D. J., & Levin, D. T. (2003). *What makes change blindness interesting?* (Vol. 42). San Diego, CA: Academic Press.

Tian, Y., Kanade, T., & Cohn, J. F. (2001). *Recognizing Action Units for Facial Expression Analysis.* Paper presented at the IEEE Transactions on Pattern Analysis and Machine Intelligence.

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*(1), 105-119.

White, M. (1999). Representation of Facial Expressions of Emotion. *American Journal of Psychology, 112*(3), 371-381.

White, M. (2000). Parts and Wholes in Expression Recognition. *Cognition and Emotion, 14*(1), 39-60.

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Footnotes

[1] Edwards (1998) found that subjects could reproduce the progression of facial expressions from a scrambled set of photographs and concluded that subjects were using temporal information. However, because the displays were static and motion was absent, these findings provide evidence only that the sequence of facial expressions can be inferred from static cues.

[2] This result does not mean that people are insensitive to the temporal information of facial expressions. A recent study by Schmidt, Ambadar and Cohn (submitted) demonstrated that individuals critically rely on the temporal information of a smile in order to assess its authenticity.

Table 1.

Accuracy of Emotion Judgment for Each Emotion and Motion Condition-Experiment 1 and Experiment 2.

	Mean and SE of judgment accuracy					Effect of Motion	Planned Comparisons			
Emotion	SS	MS	Dy	FL	TOTAL		SS - MS	SS - Dy	MS - Dy	Dy - FL
Exp. 1										
Upright										
Anger	.36 (.03)	.32 (.06)	.53 (.06)	NA	.40(.03)	*	ns	*	*	NA
Disgust	.44 (.06)	.35 (.07)	.70 (.06)	NA	.45(.03)	**	ns	**	**	NA
Fear	.50(.08)	.55 (.08)	.72(.05)	NA	.52(.04)	*	ns	**	ns	NA
Happy	.83 (.03)	.62 (.06)	.85 (.05)	NA	.74(.03)	**	*	ns	**	NA
Sad	.53 (.08)	.66 (.07)	.73 (.03)	NA	.62(.05)	ns	ns	*	ns	NA
Surprise	.24(.07)	.22 (.09)	.70 (.08)	NA	.29(.04)	***	ns	***	**	NA
TOTAL	.43 (.03)	.40 (.03)	.65 (.03)	NA		***	ns	***	***	NA
Inverted										
Anger	.20 (.05)	.15 (.04)	.38 (.05)	NA	.24(.03)	**	ns	*	**	NA
Disgust	.29 (.07)	.16 (.06)	.35 (.06)	NA	.24(.03)	ns	ns	ns	*	NA
Fear	.20 (.05)	.17 (.07)	.20 (.04)	NA	.20(.03)	ns	ns	ns	ns	NA
Happy	.59 (.07)	.53 (.07)	.74 (.06)	NA	.58(.04)	ns	ns	ns	*	NA
Sad	.29 (.06)	.24 (.04)	.21(.05)	NA	.26(.02)	ns	ns	ns	ns	NA
Surprise	.27 (.05)	.32 (.09)	.71 (.08)	NA	.33(.03)	**	**	**	*	NA
TOTAL	.28 (.02)	.22 (.02)	.42 (.02)			***	*	**	***	
Exp. 2										
Anger	.25 (.06)	.19 (.05)	.66 (.06)	.72 (.06)	.47(.03)	***	ns	***	***	ns
Disgust	.41 (.06)	.44 (.06)	.77 (.05)	.73 (.06)	.59(.03)	***	ns	***	***	ns
Fear	.42 (.06)	.58 (.06)	.50 (.06)	.53 (.06)	.51(.03)	ns	*	*	ns	ns
Happy	.63 (.06)	.67 (.06)	.92 (.03)	.89 (.04)	.78(.03)	***	ns	***	***	ns
Sad	.34 (.06)	.31 (.06)	.63 (.06)	.59 (.06)	.47(.03)	***	ns	***	***	ns
Surprise	.19 (.04)	.25 (.05)	.66 (.06)	.63 (.06)	.48(.02)	***	ns	***	***	ns
TOTAL	.39(.02)	.43(.02)	.69(.03)	.69(.02)		***	ns	***	***	ns

Note: SE=Standard error; SS=Single-Static; MS=Multi-Static; Dy=Dynamic; FL=First-Last; NA= Not applicable, Experiment 1 did not include First-Last condition; *= p<.05; **= p<.01; ***=p<.001; ns=not significant.

Figure Captions

Figure 1. Diagram of Stimulus Presentation in Four Motion Conditions.

Note: Experiment 1 included a, b and c. Experiment 2 included a,b,c,and d. The example in the diagram includes a sequence of 4 images.

Figure 2. Effect of Motion and Orientation on Accuracy of Emotion Judgment-Experiment 1.

Figure 3. Effect of Motion on Accuracy of Emotion Judgment-Experiment 2.

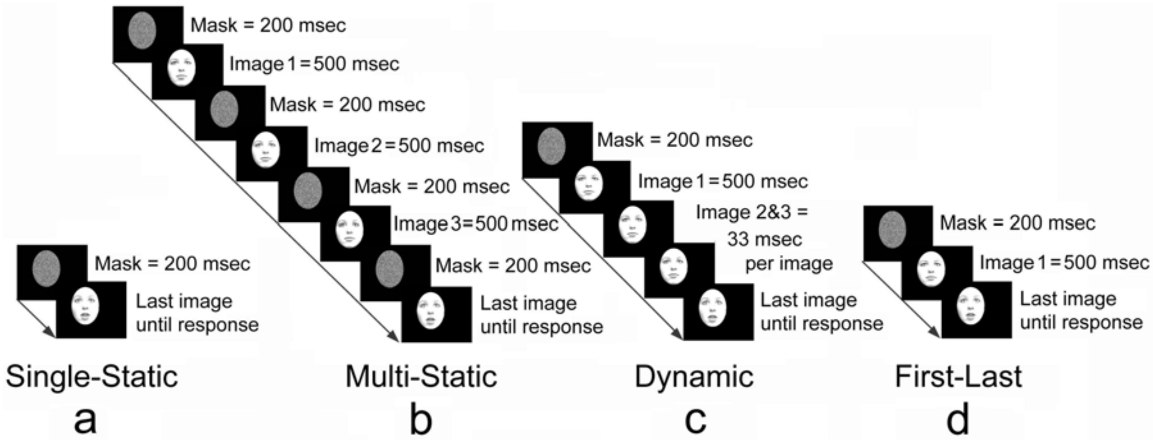

Mask = 200 msec
Image 1 = 500 msec
Mask = 200 msec
Image 2 = 500 msec
Mask = 200 msec
Image 3 = 500 msec
Mask = 200 msec
Last image until response
Mask = 200 msec
Last image until response
Mask = 200 msec
Image 1 = 500 msec
Image 2&3 = 33 msec per image
Last image until response
Mask = 200 msec
Image 1 = 500 msec
Last image until response
Single-Static
a
Multi-Static
b
Dynamic
c
First-Last
d

Figure 1

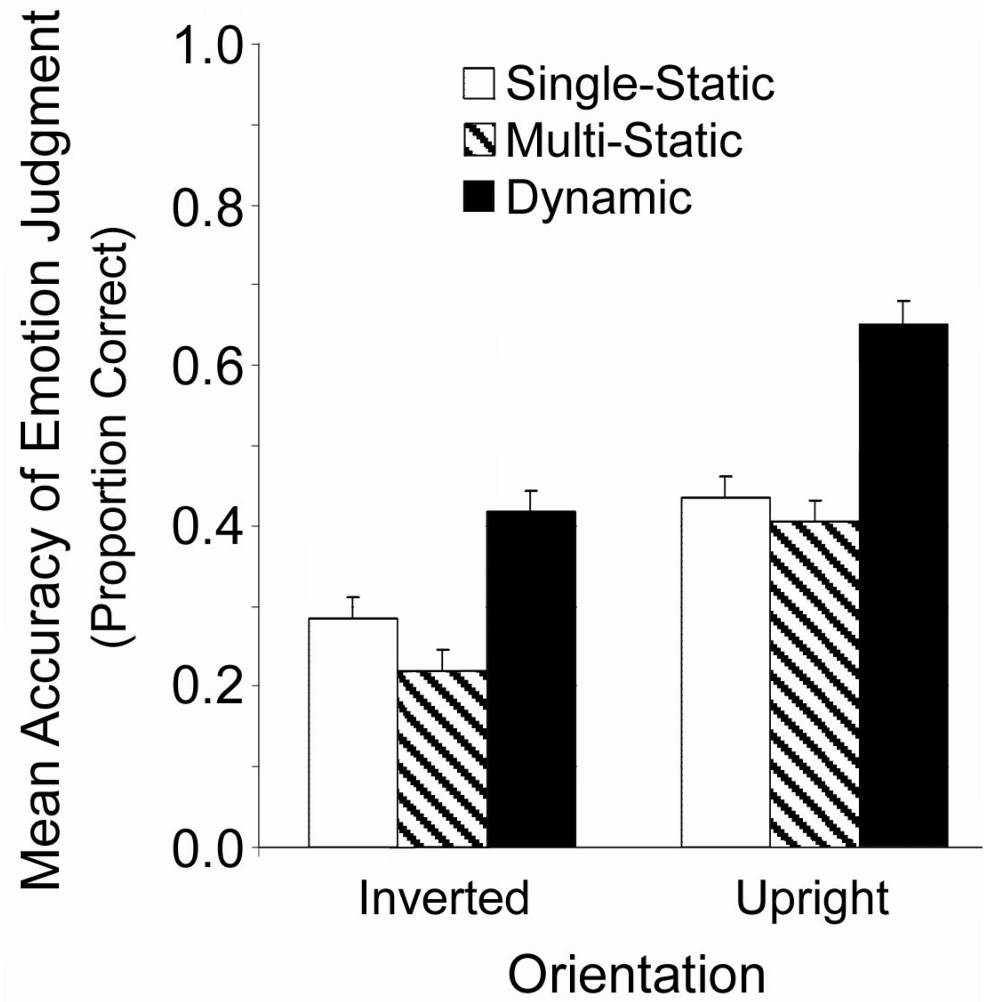
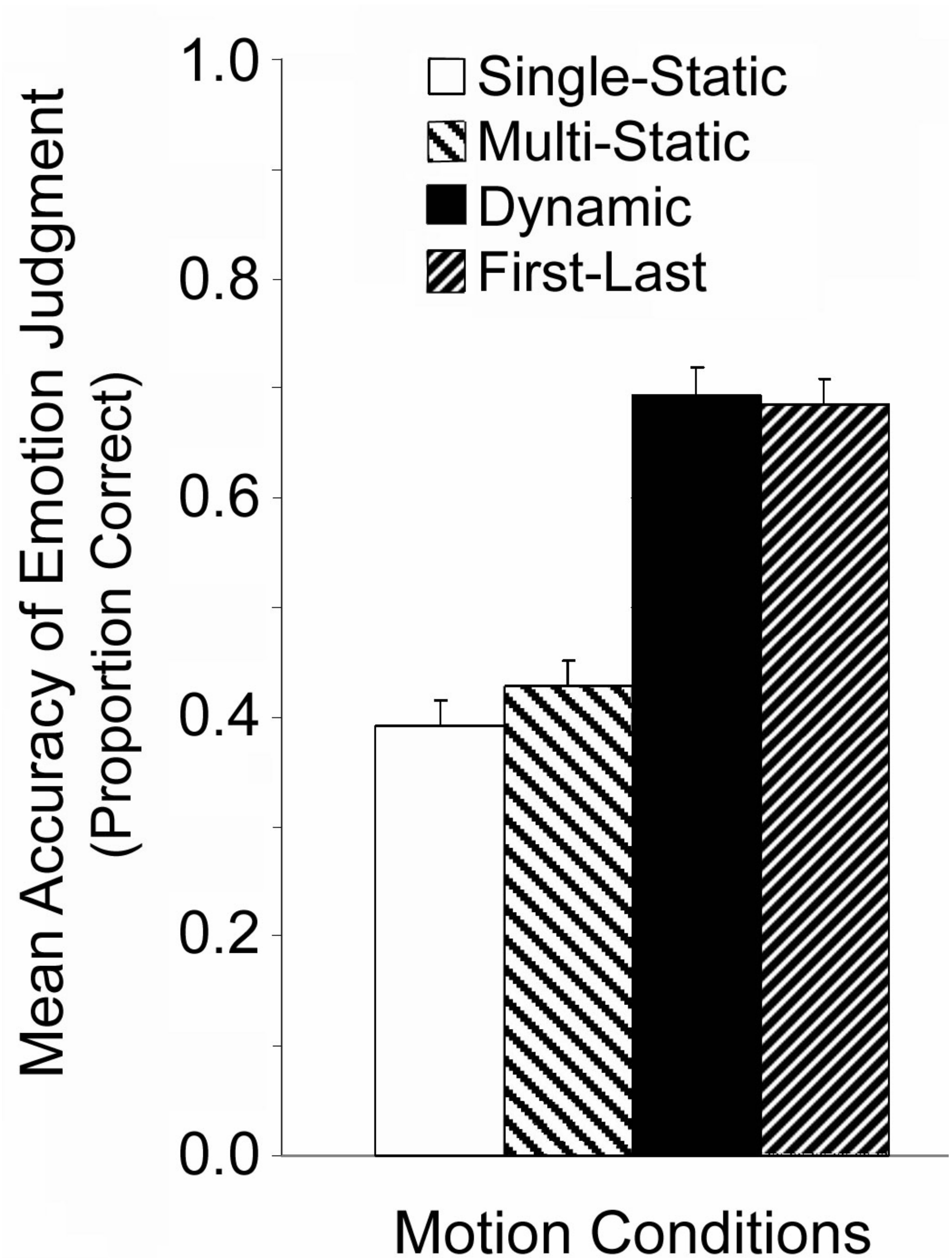

Mean Accuracy of Emotion Judgment
(Proportion Correct)
1.0
0.8
0.6
0.4
0.2
0.0
Single-Static
Multi-Static
Dynamic
Inverted
Upright
Orientation

Figure 2



Mean Accuracy of Emotion Judgment
(Proportion Correct)
1.0
0.8
0.6
0.4
0.2
0.0
Single-Static
Multi-Static
Dynamic
First-Last
Motion Conditions

Figure 3