Effects of Dynamic Facial Expressions of Positive and Negative Emotions on Recognition Memory

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Abstract

Learning with dynamic facial expressions often results in higher face recognition performance than with static images. However, few studies have used both positive and negative facial expressions to investigate the effects of dynamic facial expression information on recognition memory. The present study examined whether the effect of dynamic facial expressions depends on the type of facial expression used during the learning and recognition phases. Participants viewed individuals with smiling or angry expressions in either static or dynamic images in a learning session. Participants then performed a recognition task using static images with neutral, angry, or smiling expressions. The results showed that when tested with the neutral static faces, the advantage of the dynamic expression was observed regardless of the facial expression during learning (Experiment 1). However, when tested with the angry static faces, the dynamic expression advantage was not observed, but the recognition performance was better for the faces learned with the angry static faces (i.e., identical to the faces in the recognition task) (Experiment 2). In the recognition task with the static smiling faces, the advantage of dynamic expression was again observed in addition to the emotion congruency effect (i.e., better performance for the faces learned with the smiling expression) (Experiment 3). These results suggest that the effect of dynamic facial expression information on recognition depends on the type of facial expression during learning and recognition.

Keywords: facial expression, recognition, memory, static, dynamic

Introduction

An earlier theory of face processing assumed that facial expressions were largely unrelated to face memory (e.g., Bruce & Young, 1986). However, people we encounter in our daily lives display a wide variety of facial expressions. Studies designed to accurately reflect such situations have shown that facial expressions do affect face memory. For example, memory performance for faces with positive expressions, such as smiles, is higher than that for negative or neutral expressions, such as angry or fearful faces (smile dominance effect: e.g., Yoshikawa, 1999). However, it has also been reported that negative facial expressions (angry, fearful, and sad faces) lead to higher memory performance than smiling and neutral faces (e.g., Sergerie, Lepage, & Armony, 2005, 2006). A unified explanation for the effects of facial expressions on face memory is still lacking.

In recent years, research on facial expressions has increasingly used dynamic rather than static images. Dynamic facial expressions are processed more naturally than static expressions (Krumhuber, Kappas, & Manstead, 2013; Sato, Kochiyama, & Uono, 2015), improve the detection and judgment of facial expressions (Ambadar, Schooler, & Cohn, 2005), and increase the arousal, emotional valence, and strength of facial expressions (Sato & Yoshikawa, 2007; Sato et al., 2013; Biele & Grabowska, 2006). In addition to these effects of dynamic information on facial expression perception, several studies have also shown that learning with dynamic facial expressions leads to higher face recognition performance than with static expressions (Lander & Bruce, 2003; Pike et al., 1998). However, few studies have examined the effects of dynamic facial expression information on recognition memory using both positive facial expressions, such as smiles, and negative facial expressions, such as angry faces. Since both dynamic presentation and facial expression type affect face recognition memory, it would be informative to examine a possible interaction between them.

The present study investigated whether the effect of dynamic facial expressions on recognition memory depends on the type of facial expression used during the learning phase and the recognition test. Participants first viewed individuals with smiling or angry expressions in either static or dynamic images in a learning session. Then, in a recognition session, they indicated how well they recognized each individual presented as a static image. In Experiment 1, the recognition task was performed with static images of individuals with neutral expressions. In Experiment 2, the recognition task was performed with static images of individuals with angry expressions. Finally, in Experiment 3,

In L. K. Samuelson, S. L. Frank, M. Toneva, A. Mackey, & E. Hazeltine (Eds.), *Proceedings of the 46th Annual Conference of the Cognitive Science Society.*

participants performed the task using static images with smiling expressions.

Experiment 1: Recognition with neutral expression

Method

Participants A total of 108 adults with normal or corrected-to-normal vision participated in the experiment (mean age 47.94 years, standard deviation 10.44).

Stimuli Color still pictures of faces with neutral, angry, and smiling expressions and movies with angry and smiling expressions were obtained from the Yonsei Face Database (Chung et al., 2019). The models in the database were Asian females and males. The pictures and movies were taken from the front. The movies were trimmed to 4 seconds. Using FaceReader software (version 8.1), we selected 30 individuals who showed stronger facial expressions in the movies for each gender. This resulted in a total of 180 still pictures (individual [30] x facial expression [3] for each gender [2]) and 120 movies (individual [30] x facial expression [2] for each gender). In addition, one smiling movie, one angry movie, one smiling picture, and one angry picture were randomly selected from the database as filler stimuli.

Procedure Participants were recruited through an online platform (Yahoo! Crowdsourcing) and participated in the experiment online. The experiment consisted of two sessions. In the first learning session, participants viewed individuals with angry or smiling expressions in either static images (still pictures) or dynamic images (movies). For each gender, the 30 individuals were counterbalanced and assigned to one of 5 conditions: Static Smile (SS), Static Angry (SA), Dynamic Smile (DS), Dynamic Angry (DA), and Not Shown (NS). Each condition contains 5 individuals for each gender, except for the NS condition, which contains 10 individuals (Table 1). Individuals assigned to the NS condition did not appear in the learning session. The order of presentation was randomized. Two filler stimuli were added before and after the presentation of the 40 stimuli in the learning session. Each picture and movie lasted 4 seconds, and participants proceeded to a trial by clicking a button on the screen. No specific instructions were given in the learning session, except that there would be a task related to the faces later. In the recognition session, all 60 individuals, including the 20 in the NS condition, were presented as static images with neural expressions in a random order. The individuals in the filler stimuli were not presented in the recognition session. Participants reported how well they recognized each individual using a 6-point Likert scale (1: never seen, 2: seen, 3: probably never seen, 4: probably seen, 5: seen, 6: definitely seen).

Table 1. Stimuli used in the learning session.

	SS	SA	DS	DA	NS	Total
Female	5	5	5	5	5	20
Male	5	5	5	5	5	20

Results and Discussion

For each participant, a mean recognition performance was calculated by averaging the recognition performances for each learning condition (SS, SA, DS, or DA). The group means of recognition performance are shown in Figure 1. A repeated measures ANOVA was performed with the two factors of presentation format and facial expression during the learning session. It showed that the main effect of presentation format was significant (F(1, 107) = 51.49, p < .001, η_p^2 = .33), while that of facial expression was not (F(1, 107) = 0.16, p < .693, η_p^2 = .001). The interaction between presentation format and facial expression was not significant (F(1,107) = 3.36, p = .07, η_p^2 = .03). Multiple comparisons with Bonferroni correction revealed that mean recognition performance was significantly higher for dynamic stimuli (DS and DA) than for static stimuli (SS and SA) (p < .001).

The results of Experiment 1 showed that the dynamic presentation of facial expressions improved recognition memory for the faces when tested with static neutral expressions. This is consistent with the results of previous studies showing that learning with dynamic facial expressions resulted in higher face recognition performance than with static images (e.g., Pike et al., 1997; Lander & Bruce, 2003).

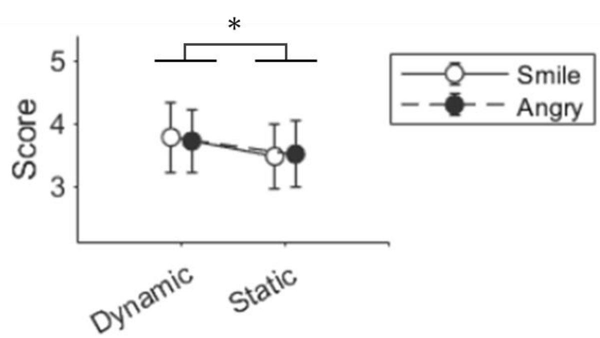

Figure 1. Mean scores of recognition with neutral expression (Experiment 1)
(* p < .001)

Experiment 2: Recognition with angry expression

Method

A total of 102 adults with normal or corrected-to-normal vision participated in the experiment (mean age 50.32 years, standard deviation 9.14). The stimuli and procedure were identical to those of Experiment 1, except that in the recognition session, the static images were presented with angry expressions.

Results and Discussion

The group means of recognition performance in Experiment 2 are shown in Figure 2. A repeated measures ANOVA showed that the main effect of facial expression was significant ($F(1, 101) = 104.27$, $p < .001$, $\eta_p^2 = .51$), but the main effect of presentation format was not ($F(1, 101) = 0.79$, $p = .38$, $\eta_p^2 = .008$). The interaction was significant ($F(1, 101) = 11.25$, $p < .005$, $\eta_p^2 = .10$). Multiple comparisons with Bonferroni correction revealed that mean recognition performance was significantly higher in the SA and DA conditions than in the SS and DS conditions, respectively (*p*s < .001). Performance was also higher in the SA condition than in the DA condition ($p < .05$).

In Experiment 2, recognition performance was generally better when learning with the angry faces. This is not surprising because the recognition task was performed with the static angry faces (emotion congruency effect). However, recognition performance was better when learning with the static angry faces than with the dynamic angry faces, probably because the stimuli in the learning and recognition sessions were identical (for both emotion and presentation format) in the SA condition. Thus, the advantage of dynamic facial expressions for learning was not observed in Experiment 2.

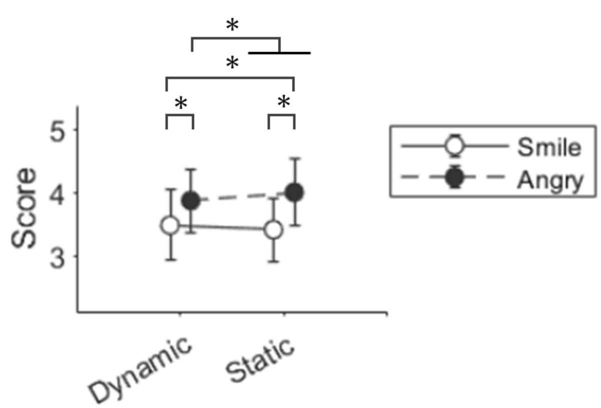

Figure 2. Mean scores of recognition with angry expression (Experiment 2)
(* $p < .001$)

Experiment 3: Recognition with smiling expression

Method

A total of 103 adults with normal or corrected-to-normal vision participated in the experiment (mean age 51.20 years, standard deviation 8.17). The stimuli and procedure were identical to those of Experiment 1, except that in the recognition session, the static images were presented with smiling expressions.

Results and Discussion

The group means of recognition performance are shown in Figure 3. A repeated measures ANOVA revealed significant main effects of presentation format ($F(1, 102) = 7.63$, $p = .01$, $\eta_p^2 = .07$) and facial expression ($F(1, 102) = 82.29$, $p < .001$, $\eta_p^2 = .45$), while the interaction was not significant ($F(1, 102) = 0.82$, $p = .37$, $\eta_p^2 = .008$). Multiple comparisons with Bonferroni correction revealed that mean recognition performance was significantly higher for the smiling stimuli (SS and DS) than for the angry stimuli (SA and DA) (*ps* < .001).

Similar to the results of Experiment 2, recognition performance was higher when the faces were learned with the congruent (i.e., smiling) faces. However, unlike Experiment 2, the general advantage of dynamic facial expressions in face learning was replicated in Experiment 3. Note that the participants viewed exactly identical stimuli for the learning and recognition sessions in the SS condition, but not in the DS condition, where they viewed the smiling face movies for learning and the static smiling faces for recognition. Nevertheless, recognition performance in the DS condition was not worse than in the SS condition. This result can be interpreted as the expected decrease in recognition performance by incongruent format being compensated by the advantage of dynamic facial expressions in learning.

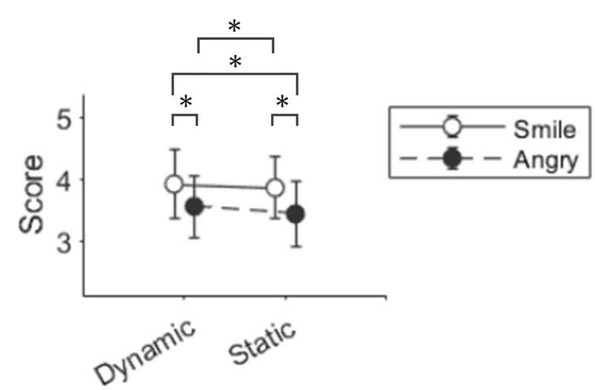

Figure 3. Mean scores of recognition with smiling expression (Experiment 3)
(* $p < .001$)

General Discussion

The present study investigated whether the effect of dynamic facial expression on face learning depends on the type of facial expression used during the learning and recognition phases. The results showed that when tested with the neutral static faces (Experiment 1), the advantage of dynamic expression was observed regardless of the facial expression used during learning. However, when tested with the angry static faces (Experiment 2), the dynamic expression advantage was not observed, but the recognition performance was better for the faces learned with the angry static faces (i.e., identical to the faces in the recognition task; emotion congruency effect). On the other hand, in the recognition task with the smiling static faces (Experiment 3), the advantage of the dynamic expression was again observed in addition to the emotion congruency effect (i.e., better performance for the faces learned with the smiling expression). In the present study, the experiments differed only in the emotions of the static faces during the recognition session: neutral faces in Experiment 1, angry faces in Experiment 2, and smiling faces in Experiment 3. However, the advantage of dynamic expressions emerged differently. The present results suggest that the effect of dynamic facial expression information on recognition depends on the type of facial expression during learning and recognition.

The present study partially replicated the advantage of dynamic expressions reported in previous studies (e.g., Pike et al., 1997; Lander & Bruce, 2003). O'Toole, Roark, & Abdi (2002) attributed such memory enhancement with dynamic faces to the availability of information about the three-dimensional structure of faces; dynamic faces facilitate the perception of the face as a three-dimensional object, making it easier to remember the face as a person. In support of this explanation, Pike et al. (1997) found that rigid-body motion, such as changes in face orientation, facilitated face learning. However, our results suggest that the advantage of dynamic expression depends on the facial expression. In particular, the recognition performance of the static angry faces was better when learning with the static faces than with the dynamic faces. Thus, the effect of dynamic information cannot be explained simply by the accessibility of information about the structure of the face as a three-dimensional object. Lander and Bruce (2003) showed that not only rigid body movements, but also changes in facial expression and gaze direction improved recognition performance and argued that the addition of social information also influenced face memory. Our results on the interaction between dynamic information and facial expressions are consistent with their findings.

The advantage of dynamic expression was observed when the target faces were shown with neutral and smiling expressions, but not with angry expressions, in the recognition session. It is important to note that in the congruent emotion cases (i.e., learned with smiling and angry expressions and tested with smiling and angry expressions, respectively), the stimuli were identical in the static cases but not in the dynamic cases. And this advantage of format congruency seemed to be equated with the advantage of dynamic presentation only in the case of smiling faces (Experiment 2 and Experiment 3).

The smile dominance effect is robustly found across a variety of experimental methods. However, in many cases, the face stimuli used for learning and the face stimuli used for recognition tests were different (different image recognition: e.g., D'Argembeau et al., 2003; D'Argembeau & van der Linden, 2007; 2011). In order to recognize a person from different images, observers must remember the constant features of the person's face, because in a recognition test the stimuli vary in several aspects (facial expression, face orientation, gaze, etc.). Thus, the results of experiments with different image recognition tasks point to the possibility that smiling facilitates the memory of the person's unique features or the formation of memory representations of the person itself. These correspond to the dynamic cases in the present study, and our finding of the dynamic advantage for smiling expressions is consistent with this explanation.

In contrast, studies reporting higher memory performance for negative facial expressions, such as angry faces, have consistently used the identical images for the learning and recognition phases (same image recognition: e.g., Sergerie, Lepage, & Armony, 2005, 2006). These correspond to the static cases in the present study, and the results are partially consistent with the previous studies, as the recognition performance of the static angry faces was higher for learning with static faces than for learning with dynamic faces. Angry faces may be a factor that facilitates the formation of memory representations for the "stimulus image" or "event".

The results of the present study imply that smiles facilitate memory for the person, and therefore dynamic information was used effectively, and that angry expressions tend to be perceived as events rather than as characteristics of the person, and therefore dynamic information was not used. Rymarczyk et al. (2016) compared automatic imitation of facial expressions for static and moving images of smiling and angry faces. They found that, compared to the static images, the moving images of smiling faces elicited greater activity in the greater zygomatic and orbicularis oculus muscles during facial mimicry of smiling faces. However, none of the facial muscles showed activity for angry faces. Their results suggest that facial mimicry of emotion occurs only for positive emotions and is enhanced by dynamic information. This can be seen as support for the hypothesis of the present study that smiles are processed more as dynamic information to represent "people" and angry faces are processed more as static images to represent "events". Further research is warranted to test this hypothesis.

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*(5), 403-410.

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

Bruce, V., & Young, A. (1986). Understanding face recognition. *British Journal of Psychology, 77*(3), 305-327.

Christie, F., & Bruce, V. (1998). The role of dynamic information in the recognition of unfamiliar faces. *Memory & Cognition, 26*, 780-790.

Chung, K. M., Kim, S., Jung, W. H., & Kim, Y. (2019). Development and validation of the Yonsei face database (YFace DB). *Frontiers in Psychology, 10*, 2626.

D'Argembeau, A., Van der Linden, M., Comblain, C., & Etienne, A. M. (2003). The effects of happy and angry expressions on identity and expression memory for unfamiliar faces. *Cognition & Emotion, 17*(4), 609-622.

D'Argembeau, A., & Van der Linden, M. (2007). Facial expressions of emotion influence memory for facial identity in an automatic way. *Emotion, 7*(3), 507-515.

D'Argembeau, A., & Van der Linden, M. (2011). Influence of Facial Expression on Memory for Facial Identity: Effects of Visual Features or Emotional Meaning? *Emotion, 11*(1), 199-201

Krumhuber, E. G., Kappas, A., & Manstead, A. S. R. (2013). Effects of dynamic aspects of facial expressions: A review. *Emotion Review, 5*(1), 41-46.

Lander, K., & Bruce, V. (2003). The role of motion in learning new faces. *Visual Cognition, 10*(8), 897-912.

O'Toole, A. J., Roark, D. A., & Abdi, H. (2002). Recognizing moving faces: A psychological and neural synthesis. *Trends in Cognitive Sciences, 6*(6), 261-266.

Pike, G. E., Kemp, R. I., Towell, N. A., & Phillips, K. C. (1997). Recognizing moving faces: The relative contribution of motion and perspective view information. *Visual Cognition, 4*(4), 409-438.

Rymarczyk, K., Żurawski, Ł., Jankowiak-Siuda, K., & Szatkowska, I. (2016). Do dynamic compared to static facial expressions of happiness and anger reveal enhanced facial mimicry? *PLoS ONE, 11*(7), e0158534.

Sato, W., & Yoshikawa, S. (2007). Enhanced experience of emotional arousal in response to dynamic facial expressions. Journal of Nonverbal Behavior, 31, 119-135.

Sato, W., Fujimura, T., Kochiyama, T., & Suzuki, N. (2013). Relationships among Facial Mimicry, Emotional Experience, and Emotion Recognition. *PLoS ONE, 8*(3), e57889.

Sato, W., Kochiyama, T., & Uono, S. (2015). Spatiotemporal neural network dynamics for the processing of dynamic facial expressions. *Scientific Reports, 5*, 12432.

Sergerie, K., Lepage, M., & Armony, J. L. (2005). A face to remember: emotional expression modulates prefrontal activity during memory formation. *Neuroimage, 24*(2), 580-585.

Sergerie, K., Lepage, M., & Armony, J. L. (2006). A process-specific functional dissociation of the amygdala in emotional memory. *Journal of Cognitive Neuroscience, 18*(8), 1359-1367.