

Facial Emotions Improve Face Discrimination Learning

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Abstract

How visual experience modulates the ability to discriminate faces from one another is still poorly understood. The aim of this study is to investigate whether emotions may favor face discrimination learning. To this purpose, we measured face discrimination thresholds before and after a training phase, where participants are exposed to (task-irrelevant) subtle variations in face images from trial to trial. A task-irrelevant perceptual learning paradigm was used because it closely mimics the learning processes that daily occur, without a conscious intention to learn and without a focused attention on specific facial features. During the four sessions of training, participants performed a contrast-discrimination task on face images. The task-irrelevant features were face images variations along the morphing continuum of facial identity (Identity group) or face images variations along the morphing continuum of emotional expressions (Emotion group). A group of participants (Control group) did not perform the contrast training, but their face discrimination thresholds were measured with the same temporal gap between them as the other two groups. Results indicate a face discrimination improvement only for the Emotion group. Participants in the Emotion Group showed a discrimination improvement when tested with variations along the dimension of identity and with variations along the dimension of expression, even if identity variations were not used during training. The present results suggest a role of emotions in face discrimination learning and show that faces, differently from the other classes of stimuli, may manifest a higher degree of learning transfer.

Keywords: Face discrimination; Task-irrelevant perceptual learning; Emotions; Contrast discrimination.

Introduction

Several lines of evidence indicate that emotions influence face processing (Jackson, Linden, & Raymond, 2014), but little is known about the emotions effects on learning processes. It was found, for example, that perceptual learning can shape the timing of emotion perception (Pollak, Messner, Kistler, & Cohn, 2009) or that probabilistic reward learning is modulated by the presence of a task-independent emotional face (Watanabe, Sakagami, & Haruno, 2013). However, no studies have specifically investigated the effect of emotions on face discrimination learning.

In literature, the effect of visual experience on face recognition has been extensively investigated. Two of the classic effects in face processing (the “face-inversion effect”, Yin, 1969; the “other-race effect”, Malpass, & Kravitz, 1969) are due to differences in perceptual expertise with the stimuli: A better recognition for upright-faces is

due to the greater experience with upright-faces compared to upside-down faces. The worse recognition performance for other-race compared to same-race faces depends on our limited experience with the other-race face morphology.

In this study, we ask whether implicit learning can improve face discrimination and whether emotions, because of their arousal potential, may facilitate face discrimination learning.

We tested these hypotheses by means of a task-irrelevant perceptual learning (TIPL, Watanabe, Náñez, & Sasaki, 2001) paradigm. The design of the study comprised three phases: (1) Pre-training face discrimination thresholds were measured for face images variations produced by morphing between two faces with different identities and between two faces having the same identity, but different emotional expressions. (2) During four consecutive days, participants performed an image contrast discrimination task for successively-presented faces (task-irrelevant training). They were not informed that the faces also differed in terms of subtle variations along the dimension of identity or expression (task-irrelevant stimulus features). The task-irrelevant stimulus features, used in the training phase, differed across participants: the Identity Group was exposed to variations along the dimension of facial identity, the Emotion Group was exposed to variations along the dimension of facial expression. A third group (Control) did not undergo contrast training. (3) After a week from the pre-test, post-training face discrimination thresholds were measured again for stimulus variations along dimensions of identity and expression, for all three groups.

Methods

Participants

Twenty-six subjects (15 females; age range 25-45 years) participated voluntarily in the experiment.

Procedure

Pre-training and post-training tests. In both pre-training and post-training tests, perceptual discrimination thresholds were measured with a 2AFC delayed-matching task. Face discrimination thresholds were measured along two facial identity continua and along two emotional expression continua. In the case of the facial identity continua, participants were asked to indicate which of the two sequentially-presented faces was more similar to a comparison face (*i.e.* the image 100 of each facial identity continuum) which remained visible (on a separate computer

screen) throughout the experiment. In the case of the emotional expression continua, participants were asked to indicate which interval contained the happier face or the more angry face.

Face discrimination thresholds at 82% and 55% correct were measured for each participant and morphing continuum using the QUEST estimation procedure over 80 trials (Watson, & Pelli, 1983). Face discrimination thresholds were defined as the magnitude of the modification to a reference face (*i.e.* the frame 10 within the morphing continuum), expressed in terms of the morph-distance, necessary to reach the criterion success rates (*e.g.* Oruç, & Barton, 2011). Two interleaved QUESTs were run separately for each morphing continuum: One measured the success rate of 55%, the other measured the success rate of 82%.

Task-irrelevant training. Task-irrelevant training consisted of four successive training sessions spread out during four days within a week. During the training sessions, participants were asked to decide which of two sequentially presented faces had a higher contrast. No feedback was given on incorrect responses.

Contrast discrimination thresholds (ΔC), defined as the difference between the pedestal contrast and the modified contrast necessary to reach the criterion success rate, were estimated using a QUEST procedure. The contrast of a face presented in one of the two intervals was kept fixed (reference contrast), whereas the contrast of the other face was varied across trials. Each training block comprised four interleaved QUEST staircases. For two of these staircases, the root mean-squared (r.m.s.) reference contrast (*i.e.*, the standard deviation of the pixel intensities divided by mean pixel intensity) was set to 0.89; for the other two, the r.m.s. reference contrast was 1.32. Each QUEST procedure determined the contrast discrimination threshold providing 82% of correct discrimination after 80 trials. In every day of training, participants completed two training blocks, for a total of 640 trials.

Unknown to participants, each trial of the QUEST staircases also provided task-irrelevant image variations (at 82% discrimination threshold, or at 55% discrimination threshold) along the facial identity continuum (Identity group) or along the emotional expression continuum (Emotion group). Participants were provided face image variations at threshold or sub-threshold level because perceptual learning has been shown to be more effective when the task-irrelevant feature is below or near to the discrimination threshold (Sasaki, Nánéz, & Watanabe, 2010).

For the Identity group, of the four staircases within each training block used to measure contrast discrimination, one provided task-irrelevant variations along the two facial identity continua (the magnitude of the task-irrelevant stimulus variations was equal, for each participant, to the morph-distance identified by her/his 55% discrimination threshold); r.m.s. reference contrast was equal to 0.89. A second staircase provided task-irrelevant variations along

the two facial identity continua identified by the 82% discrimination thresholds of the participants; r.m.s. reference contrast was 0.89. A third staircase provided task-irrelevant variations along the facial identity continua corresponding to the 55% discrimination thresholds of the participants; r.m.s. reference contrast was 1.32. A fourth staircase provided task-irrelevant variations along the facial identity continua corresponding to the 82% discrimination thresholds of the participants; r.m.s. reference contrast was 1.32.

For the Emotion group, one staircase provided task-irrelevant variations along both the happy and angry emotional expression continua corresponding to the 55% discrimination thresholds of the participants; r.m.s. reference contrast was 0.89. A second staircase provided task-irrelevant variations along the two emotional expression continua corresponding to the 82% discrimination thresholds of the participants; r.m.s. reference contrast was 0.89. A third staircase provided task-irrelevant variations along the two emotional expression continua corresponding to the 55% discrimination thresholds of the participants; r.m.s. reference contrast was 1.32. A fourth staircase provided task-irrelevant variations along the two emotional expression continua corresponding to the 82% discrimination thresholds of the participants; r.m.s. reference contrast was 1.32. In the Emotion training group, therefore, each participant was shown task-irrelevant variations along both the neutral-happy and the neutral-angry morphing continua.

Results

Face-discrimination threshold ratios (post-training thresholds divided by pre-training thresholds) were computed for each participant in each condition. Lack of task-irrelevant learning gives a threshold ratio of 1; post-training facilitation is indicated by threshold ratios between 0 and 1; worse post-training than pre-training performance is indicated by threshold ratios larger than 1. The results are shown in Table 1.

The effect of Group (Identity training, Emotion training, Control) was statistically significant, $\chi^2_2 = 9.03$, $p = 0.0109$. For task-irrelevant training along the emotional expression dimension, we found a facilitation, $t_{35.69} = -2.73$, $p = 0.0097$, lowering the threshold ratio by about $12.5\% \pm 4.6$ (standard errors). Conversely, we found no learning effects for task-irrelevant training along the facial identity dimension ($t_{35.69} = 1.02$, $p = 0.3128$) and for the Control group ($t_{35.69} = 0.83$, $p = 0.4105$). The variables Morphed face dimension (facial identity dimension or emotional expression dimension) and Performance level (*i.e.* thresholds measured with success rates of 55% or 82%), together with their interactions with each other and with Group, were not statistically significant, $\chi^2_9 = 4.77$, $p = 0.8538$. We also examined face discrimination performance when participants were tested along the neutral-angry continuum or along the neutral-happy continuum, but we found no evidence of an effect of

the valence of the morphing continuum on the threshold ratio, $\chi^2_2 = 0.42, p = 0.8093$.

| Morphing continuum | Group | Threshold Ratio | S.E. |
|--------------------|----------|-----------------|------|
| Identity | Control | 0.99 | 0.04 |
| Identity | Emotion | 0.87 | 0.06 |
| Identity | Identity | 1.13 | 0.07 |
| Expression | Control | 1.01 | 0.03 |
| Expression | Emotion | 0.90 | 0.03 |
| Expression | Identity | 1.04 | 0.07 |

Table 1: Average threshold ratios as a function of Group and morphing continua.

For what concerns the contrast discrimination, we found an effect of (log) Day on contrast thresholds, $\chi^2_1 = 7.10, p = 0.0077$, indicating a performance improvement over the four days of practice. Neither the main effect of Reference contrast, $\chi^2_1 = 0.18, p = 0.6713$, nor the Reference contrast \times (log) Day interaction, $\chi^2_1 = 1.22, p = 0.2689$, were statistically significant.

Discussion

We asked whether passive stimulus exposure to task-irrelevant features (*i.e.*, small face image variations along the dimension of expression or identity) can produce a post-training improvement in face discrimination. We found that face discrimination sensitivity improved for the group of contrast training plus passive exposure to face images variations along the expression dimension, but not in the group with incidental exposure to variations along the identity dimension, nor for participants in the Control group (no task-irrelevant training). Importantly, we found a generalization of learning. The Emotion group showed a post-training discrimination enhancement when it was tested on face images variations along the expression dimension *and* when it was tested on novel facial image variations along the identity dimension (not shown during training).

The discrimination improvement for the untrained stimulus feature may depend on the use of images of the same person's face for both the face discrimination task (in the pre-training and post-training tests) and the task-irrelevant training. We speculate that participants, during training, were able to learn representations of faces that were more general than the "accidental views" shown during training. We suggest that visual perceptual learning for faces might show a greater degree of generalisability than other classes of stimuli.

A possible explanation for the effect of emotions on face learning is described by the "emotional tagging" mechanism proposed by Richter and Levin (2003). According to the authors, the arousal caused by an emotional experience tags a salient event and promotes facilitation of its consolidation in memory. "Emotional tagging" is a mechanism by which the amygdala marks an emotional experience as important

and strengthens neuroplasticity in different brain regions. Faces with emotional expressions can elicit an emotional experience. For example, Jackson, Linden and Raymond (2014) have found that the presence of emotional faces at encoding, but not at the retrieval phase, determines better face recognition. We suggest that a similar mechanism may underlie face discrimination learning under the stimulus conditions examined in the present experiment.

Some researchers have shown that threat-relevant facial expressions enhance sensory and memory processes more than non-threatening facial expressions (Jackson et al., 2014; Phelps, Ling, & Carrasco, 2006). Instead, learning studies have found that the arousal caused by positive emotions accentuates prototype learning systems mediated by perceptual representations and attenuates declarative-memory-mediated learning, while negative arousal reverses this pattern (e.g. Gorlick, & Maddox, 2013). Therefore, it may be expected that the effects of task-irrelevant learning on face discrimination are modulated by the emotional valence of the task-irrelevant features. The design of the present experiment, however, does not permit to test this hypothesis. In fact, during training, the Emotion group was exposed to stimulus variations along both the neutral-angry and the neutral-happy continua. In these circumstances, participants' post-training performance did not differ when they were tested with the neutral-angry continuum or with the neutral-happy continuum.

It is possible that task-irrelevant learning was facilitated by our specific training conditions. For example, it may be that learning does not occur if the faces shown during training differ for a change in viewpoint with the respect of faces used in the pre-training and post-training phases. This hypothesis requires further investigation.

Finally, we found that contrast discrimination sensitivity improved in the course of our experiment. This result can be interpreted as indicating that the amount of training used in our study was sufficient to produce sensory changes and supports the idea that our experimental conditions were adequate for studying face discrimination learning.

In summary, we found that face discrimination learning can also occur without explicit attention to the faces, but only when the task-irrelevant features provide emotion-related information.

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