The Effect of Comparison on the Perceived Similarity of Faces

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Abstract

This study investigates the effect of comparison on the perceived similarity of unfamiliar faces. Participants were asked to compare pairs of faces, and to list either their commonalities or the differences between them before rating their similarity. The results of the first experiment show that listing commonalities and differences can both increase the perceived similarity of the compared faces. This pattern of results is interpreted in line with structural alignment theory which posits that the detection of commonalities is an essential component of both similarity and difference comparisons. The results of the second study show that the effect of comparison on perceptual similarity is limited by the perceptual attributes of the compared faces. Under conditions where the compared faces are highly similar and the detection of commonalities do not require any mental manipulation, comparison has little or no effect on perceived similarity.

Keywords: Comparison; structural alignment; face perception.

Introduction

Comparison – the process of assessing commonalities and differences between two or more entities – is an integral aspect of human cognition. It plays a role in a wide variety of cognitive tasks including categorisation (Nosofsky, 1984), recognition memory (Shiffrin & Steyvers, 1997), problem solving (Ross, 1989) and decision making (Simonson, 1989). The current study investigates whether comparison also plays a role in visual cognition. Specifically, it addresses the question whether comparing visual stimuli affects the perceived similarity between them.

Tentative support for this notion is provided by the finding that comparing two labelled images results in an increase in their perceived similarity (Boroditsky, 2007, experiment 1). However, because the images used were labelled exemplars of common categories (e.g. horse, goat) it is not clear whether comparison has affected their perceptual similarity, their conceptual similarity, or both. Stronger evidence in support of the notion that comparison affects perceptual similarity is provided by the finding that comparing similar-looking novel objects increases their perceived similarity (Boroditsky, 2007, experiment 4). However, the novel objects used in this experiment were again labelled (e.g. Chico and Groucho). It remains unclear whether the participants were only rating the perceived visual similarity of the stimuli or whether their similarity ratings were also affected by conceptual inferences about 'Chicos' and 'Grouchos' they may have drawn during the comparison process. The latter interpretation is supported by findings that comparison plays an important role in the acquisition of conceptual knowledge (Gentner, Loewenstein & Thompson, 2003; Gentner & Namy, 1999). In the current study unlabelled pairs of unfamiliar faces were used as stimuli to allow the effects of comparison on perception to be dissociated from its effects on conceptual knowledge.

Face perception is a well studied phenomenon that is driven by the visual attributes of a face, as well as by a host of top-down influences. For example, the visual appearance of a face affects how well it is recognised (e.g. Bartlett, Hurry & Thorley, 1984; Light, Kayra-Stuart & Hollander, 1979; Valentine, 1991). Specifically, faces that are visually distinctive have been found to elicit fewer false positives when acting as distracters (Light Kayra-Stuart & Hollander, 1979; Valentine, 1991), to elicit more hits when acting as targets (Bartlett, Hurry & Thorley, 1984; Shepherd, Gibling & Ellis, 1991) and to be recognised faster (Valentine & Bruce, 1986a, 1986b). A well documented top-down influence on face perception is the availability of categorical information. A study using morphed images, which represented a continua of familiar famous faces, found that participants were better at discriminating between face pairs that straddle apparent category boundaries (i.e. where one comparison face is slightly more similar to famous face A; the other is slightly more similar to famous face B), than when both comparison faces are similar to the same famous face (Beale & Keil, 1995). More recently, categorical effects have also been observed for pre-experimentally unfamiliar faces, which were presented in conjunction with category labels (names) prior to the discrimination task (Levin & Beale, 2000; Kitukani, Roberson & Hanley, 2008). These findings illustrate that categorical effects in face perception can be induced quickly.

There is evidence to suggest that comparison may also act as a top down influence on face perception. A study on face memory conducted by Mäntylä (1997), found that focusing on differences between faces led to a greater number of 'remember' responses (explicit recollection) than did focusing on similarities. Conversely, focusing on similarities among faces was associated with a greater number of 'know' responses (familiarity). Mäntylä (1997) interprets these findings in light of the distinctiveness hypothesis. According to the distinctiveness hypothesis remembering is facilitated by perceptual and conceptual processes that focus encoding on the distinctive attributes of the information being encoded. Processes that emphasize similarities, on the other hand, facilitate familiarity-based recognition (Mäntylä, 1997).

Despite the observed differences in recollection experience, participants who focused on differences between faces did not recognize more faces correctly than participants who focused on similarities (Mäntylä, 1997).

Similarly, another study which investigated recognition accuracy for faces following dissimilarity and similarity comparisons also failed to find a significant difference in performance (Brown & Lloyd-Jones, 2005). The observed lack of memory advantage for difference focussed comparisons is somewhat surprising, considering the fact that dissimilar faces are so well remembered. Comparisons that focus on differences highlight the distinctive features of the compared faces, and are therefore expected to result in increased memory performance (Brown & Lloyd-Jones, 2005).

One possible explanation for the absence of a memory advantage for difference focussed comparisons is that the same cognitive process underlies both similarity and difference comparisons. A recent study, which investigated the effects of comparison on perceived similarity, found that comparing two things which are relatively similar increases the perceived similarity between the two items, even when the comparison task involves looking for differences (Boroditsky, 2007). According to Boroditsky (2007) the process of structural alignment underlies both similarity and difference comparisons. According to the structural alignment view, the discovery of meaningful differences involves first discovering similarities.

Experiment 1: similarity and dissimilarity comparisons

The present experiment investigates the effect of comparison processes on the perceived similarity of faces. According to the distinctiveness hypothesis, perceived similarity should decrease following dissimilarity comparisons and increase following similarity comparisons. According to structural alignment theory both similarity and dissimilarity comparisons should result in an increase in perceived similarity.

The present experiment also explores how the comparison process interacts with the perceptual attributes of faces. That is, whether the comparison process has a differential effect for pairs of similar faces compared to those that are dissimilar.

Method

Participants One hundred and sixty-two University of Southampton undergraduate students volunteered to take part. They were randomly allocated to the two treatment conditions: 86 students participated in the similar faces condition; the remaining 76 participated in the dissimilar faces condition.

Materials The stimuli consisted of pairs of black and white images of male faces obtained from the Psychological Image Collection at Stirling (http://pics.psych.stir.ac.uk). In a pilot study 51 volunteers were asked to judge the similarity of 3 target faces to 12 comparison faces on a Likert scale of 1 (not similar) to 7 (very similar). Each of the 36 pairs of faces consisted of one face presented in full frontal view (target face), and the other in a three-quarter view (comparison face). Three pairs of faces with high similarity ratings (M = 4.2, SD = 1.7) were used in the similar faces condition; and 3 pairs of faces with low similarity ratings (M = 1.6 SD = 0.8) were used in the different faces condition. Examples of these face pairs are shown in figure 1.

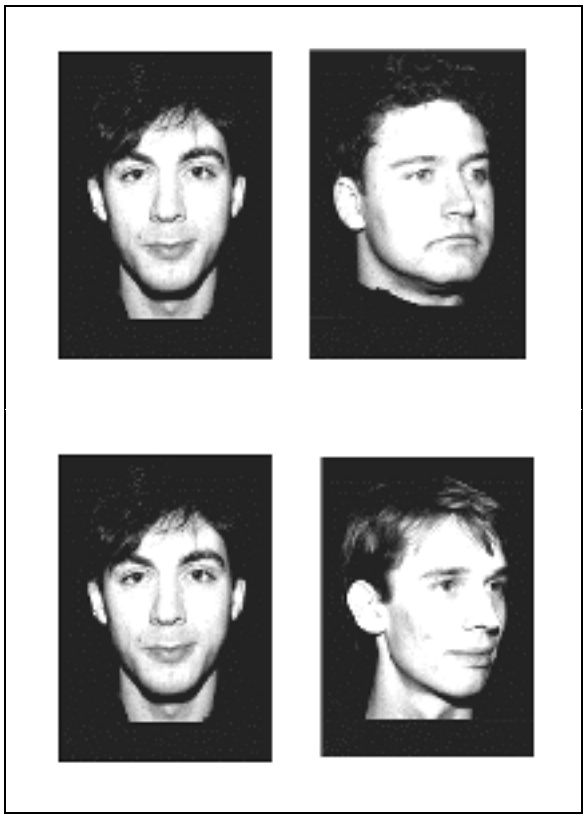

Figure 1: An example of the dissimilar (top row) and similar (bottom row) face pairs used in study 1.

Procedure The participants were asked to fill in a short 5 page booklet at the beginning of a lecture. Depending on the treatment condition the questionnaire contained either 3 similar or 3 dissimilar face pairs. Each participant completed a control condition, a similarity comparison condition and a difference comparison condition. In the control condition participants were asked to indicate on a Likert scale of 1 to 7 "how similar the two faces are". In the similarity comparison and difference comparison conditions this similarity rating was preceded by the question "Please describe 3 similarities (differences) between the two faces". The allocation of face pairs to the treatment conditions and the order of presentation were randomized across participants.

Results

A 3 (preprocessing condition: no preprocessing, similarity comparison, difference comparison) x 2 (stimulus type: similar faces, dissimilar faces) repeated measures ANOVA revealed a significant main effect of stimulus type (F(1,

160) = 2068.06, $p < .001$). This manipulation check confirms that participants indeed perceived the similar faces ($M = 3.8$, $SD = 1.3$) to be more similar in appearance than the dissimilar faces ($M = 2.3$, $SD = 1$).

Table 1: Mean similarity ratings (and associated standard deviations) for study 1

	All faces	**Similar faces**	**Dissimilar faces**
Control	2.87 (1.45)	3.6 (1.42)	2.04 (0.97)
Similarity comparison	3.18 (1.4)	3.92 (1.28)	2.32 (0.96)
Difference comparison	3.16 (1.31)	3.76 (1.24)	2.49 (1.01)

The mean similarity ratings, displayed in Table 1, indicate that faces which were compared prior to similarity judgments were perceived to be more similar to each other than pairs of faces which were not compared. The main effect of preprocessing was significant ($F(2, 320)= 4.92$, $p < .01$). Planned contrasts revealed that faces whose commonalities were assessed were subsequently perceived to be more similar to each other than face pairs in the no preprocessing condition ($F(1, 160) = 7.29$, $p < .01$). The same pattern of results was observed for faces whose differences were assessed prior to similarity judgments ($F(1, 160) = 8.38$, $p < .01$). The interaction between stimulus type and preprocessing condition was not significant ($F(2, 320) = 1.22$, $p = .3$).

Discussion

Faces that were compared prior to similarity judgments were perceived to be more similar to each other than face pairs which were not compared. An increase in perceived similarity was observed following both similarity and dissimilarity comparisons. This pattern of results can be interpreted in line with structural alignment theory (Gentner & Gunn, 2001). According to structural alignment theory the same underlying process is involved in both similarity and dissimilarity comparisons. In both comparison tasks the two visual representations need to be structurally aligned. During the structural alignment process, similarities are established first and related differences are noticed second. Thus, regardless of whether a comparison involves the identification of similarities or differences, the process of structural alignment always necessitates the perception of commonalities between the two representations.

The findings of the first study do not support the distinctiveness hypothesis - which predicts that focusing on differences between faces should lead to a decrease in their perceived similarity. Furthermore, the observed increase in perceived similarity following dissimilarity comparisons would also suggest that the results are not attributable to a judgment bias. If the participants were motivated to conform to perceived task demands, they would presumably have judged faces to be less similar to each other following dissimilarity judgments. Another explanation for the observed effects of comparison on similarity perception is that it might be attributable to participants' greater familiarity with the compared faces. The fact that compared faces had already been seen may have acted as an additional commonality between them during the similarity rating task. This alternative hypothesis was tested in the second experiment.

Experiment 2: other forms of preprocessing

The aim of the second experiment was to asses whether the finding of increased perceived similarity following comparison might be attributable to participants' greater familiarity with the stimuli or to the fact that these stimuli underwent deeper processing prior to similarity judgments.

To test these hypotheses a shallow and a deep processing condition were introduced. It is predicted that if familiarity with the stimulus pairs is the cause of the increase in perceived similarity observed in experiment 1, then both the shallow and the deep processing conditions should result in an increase in perceived similarity. If the increase in perceived similarity is attributable to the deeper processing of stimuli in the comparison conditions (rather than the comparison process *per se*), then only the deep processing condition should result in an increase in perceived similarity.

A further difference between the second experiment and the first is that the second experiment employs a more objective manipulation of stimulus similarity. In order to manipulate stimulus similarity in a systematic manner morphed images of faces were used.

Method

Participants One hundred and fifty-three Southampton University undergraduates volunteered to participate. They were randomly allocated to the two treatment conditions: 76 students participated in the similar faces condition; the remaining 77 participated in the dissimilar faces condition.

Materials The stimuli used in the "different faces" condition consisted of 10 morphed images of male faces that were generated by morphing 30 colour images obtained from the Productive Aging Laboratory Face Database (Minear & Park, 2004). The ten morphed faces were each composed of three different individual male faces. For the "different faces" condition the 10 stimuli were presented in pairs. Both faces in a pair were presented in a frontal view (see figure 2 top row). For the similar faces condition 5 further stimuli were generated by morphing the faces that were paired in the different faces condition (see figure 2 bottom row). For example, for face A and face B (paired in the different faces condition), the equivalent pair in the similar faces condition consisted of face A and a morphed face that was 50% face A and 50% face B. The morphing was done using Psychomorph face morphing software.

Procedure The procedure was the same as in experiment 1, with the addition of two further treatment conditions. In the shallow processing condition participants were asked to decide whether each face in a pair was older or younger than 40 years before rating the similarity between them. In the deep processing condition participants had to judge the apparent health of each of the two faces. A further difference to study 1 was that the similarity of the face pairs was rated on a Likert scale of 1 (not similar) to 9 (very similar), as opposed to a 1to 7 scale.

Figure 2: An example of the dissimilar (top row) and similar (bottom row) face pairs used in study 2.

Results

A 5 (preprocessing condition: no preprocessing, similarity comparison, difference comparison, shallow processing, deep processing) x 2 (Stimulus type: similar faces, dissimilar faces) repeated measures ANOVA revealed a significant main effect of stimulus type, ($F(1, 151) = 83.07$, $P < .001$). This manipulation check confirms that the similar faces ($M = 5.9$, $SD = 1.6$) were perceived to be more similar to each other than the dissimilar faces ($M = 4.3$, $SD = 1.7$).

There was a significant main effect of condition ($F(4, 604) = 3.23$, $P < .05$). Planned contrasts revealed that faces whose commonalities were assessed prior to similarity rating were perceived to be more similar to each other than face pairs in the no preprocessing condition ($F(1, 151) = 14.33$, $p < .001$). Planned contrasts between the no preprocessing condition and the difference comparison, shallow processing and deep processing conditions were not significant ($p > .1$). The interaction between stimulus type and preprocessing condition was significant, ($F(4, 604) = 2.40$, $p < .05$). To investigate this interaction the data for the similar and dissimilar faces were analysed separately. Repeated measures ANOVAs revealed a significant main effect of preprocessing for dissimilar faces ($F(4, 304) = 4.19$, $p < .01$) but not for similar faces ($F(4, 300) = 0.91$, $p = .46$). A contrast showed that similarity comparison increased the perceived similarity of dissimilar faces ($F(1, 76) = 15.57$, $p < .001$). The deep processing manipulation also led to an increase in the perceived similarity of dissimilar looking faces ($F(1, 76) = 4.03$, $p < .05$). The contrasts between the no preprocessing condition and the difference comparison and shallow processing conditions were not significant ($p > .1$).

Table 2: Mean similarity ratings (and associated standard deviations) for study 2

	All faces	**Similar faces**	**Dissimilar faces**
Control	4.84 (1.95)	5.8 (1.66)	3.9 (1.75)
Similarity comparison	5.41 (1.62)	6 (1.41)	4.83 (1.6)
Difference comparison	5.06 (1.84)	5.84 (1.69)	4.29 (1.65)
Shallow processing	5.1 (1.94)	6.13 (1.53)	4.09 (1.76)
Deep processing	5.1 (1.92)	5.84 (1.76)	4.36 (1.8)

Discussion

Comparing two dissimilar faces was found to increase the perceived similarity between them, but only when comparing for similarities. Difference comparisons did not result in similarity ratings that were significantly different from those of face pairs that had not been preprocessed. This pattern of results does not support the distinctiveness hypothesis, which would have predicted a significant decrease in the perceived similarity of faces that have undergone difference comparisons. However, the results only provide tentative support for the structural alignment hypothesis; although difference comparisons resulted in a slight increase in the perceived similarity of the different looking faces (see table 2), this increase was not significant.

Shallow preprocessing of individual faces in a pair did not lead to a significant increase in the perceived similarity between them. This finding suggests that mere familiarity with the faces that comprise a pair is unlikely to be the cause of increases in their perceived similarity following comparison.

Preprocessing of individual faces at a deep level of processing led to a significant increase in the perceived similarity of dissimilar faces. Although this finding suggests that the observed effects of comparison on perceived similarity might be ascribable to a more general effect of

stimulus preprocessing on perceived similarity, this interpretation should be treated with caution. In order to control for any effects of mode of presentation on perceived similarity, the two faces comprising a pair were presented simultaneously in all of the preprocessing conditions. Simultaneous presentation may have invited comparison of the faces in a pair. This strategy seems particularly likely in the deep processing condition in which participants were required to assess the perceived health of the two faces. In the absence of a criterion of what comprises a healthy looking face, participants may have judge the health of the two faces in a pair relative to each other. The issue of whether the observed effect of preprocessing is attributable to comparison of the two faces can be addressed in a future study, which employs a sequential mode of presentation.

Comparison did not lead to an increase in the perceived similarity of similar looking faces, nor did the two levels of processing manipulations. Paired faces in the similar faces condition had a very high level of similarity because the second face in each pair consisted of a 50% morph of the first. There were therefore many perceptual commonalities between these faces. It appears that for highly similar faces any influence of comparison on perceived similarity is small or non-existent. This relationship between the degree of the perceptual similarity between faces and the influence of comparison on their perceived similarity will be further explored in the general discussion.

General Discussion

The aim of the present study was to investigate whether comparing complex visual stimuli such as faces affects their perceived similarity. The first experiment found that both similarity and dissimilarity comparisons increased the perceived similarity of faces. The second experiment also found an increase in perceived similarity following comparison, but only for dissimilar faces which had been compared for similarities. Overall these findings suggest that comparing faces increases their perceived similarity. These results extend the finding obtained by Boroditsky (2007) that both similarity and dissimilarity comparisons increase the similarity ratings of exemplars of related categories (e.g. hoofed animals) and of similar novel objects. It is not clear from Boroditsky's (2007) study whether the comparison process has acted on perceptual similarity, on conceptual similarity or on both. In the current study, by using unfamiliar male faces as stimuli, the effects of comparison on perceptual similarity were dissociated from its effects on conceptual knowledge. The findings of the current study show that comparison can affect the perceptual similarity of unfamiliar faces.

The absence of an effect of comparison on the perceived similarity of similar faces in the second experiment highlights some of the limitations of the effects of comparison on perceptual similarity. In the first experiment a significant increase of perceived similarity was found for both similarity and dissimilarity comparisons. In the second experiment only similarity comparisons led to a significant increase in perceived similarity. A possible explanation for these differences lies with the visual attributes of the stimuli. In the first study one face in each pair was presented at an angle (three-quarter view); comparison of the two faces thus required a degree of mental manipulation. This was not the case in the second experiment, where both faces were presented in a frontal view. A further difference between the stimuli used in the two experiments is that, whereas the first used images of individuals, the second experiment employed morphed faces. The morphing process renders faces more homogenous by averaging their features and by removing some of their distinctive characteristics. Thus, the stimuli used in the second experiment were more homogenous, even in the different faces condition.

It appears that the effects of comparison on perceived similarity interact with the perceptual attributes of the stimuli. The greater the heterogeneity of the stimuli and the greater the amount of mental manipulation involved in the discovery of commonalities and alignable differences, the more pronounced the effect of comparison. The most pronounced effect of comparison was observed in the first experiment because the stimuli used were more heterogeneous (they depicted individual faces) and the comparison process necessitated mental manipulation (in order to align individual features). The stimuli used in the second experiment were highly homogenous and the discovery of commonalities between them did not require any mental manipulation. This might explain why the effect of comparison on perceived similarity was found to either be diminished (dissimilar faces) or absent (similar faces) in the second experiment.

A second aim of the current study was to explain the finding that faces which have undergone dissimilarity comparisons are not better remembered than those which have undergone similarity comparisons (Brown & Lloyd-Jones, 2005; Mäntylä, 1997). According to the distinctiveness hypothesis, dissimilarity comparisons should produce a memory advantage because the identification of differences focuses the viewer's attention to the distinctive (more memorable) features of a face. Structural alignment theory, on the other hand, posits that both similarity and difference comparisons involve the discovery of similarities and of alignable differences. According to this view similarity and difference comparisons should not have a differential effect on face memory. The finding of an increase in the perceived similarity of faces following both similarity and difference comparisons is as predicted by the structural alignment view. Thus, rather than focussing the viewer's attention to either the distinctive or non-distinctive (common) features of the compared faces as they intended, both comparison manipulations employed by Brown and Lloyd-Jones (2005) aided the perception of similarities and differences.

Although the faces used in the dissimilar faces condition in experiment 1 were quite dissimilar from each other they were not necessarily distinctive. A future study could explore whether the process of comparison also results in an

increase in the perceived similarity of highly distinctive faces.

The results from the present study suggest that comparison plays a role in visual perception. Specifically, comparison has been found to increase the perceived similarity of unfamiliar faces. Although there are no theoretical reasons to think otherwise, whether or not this finding extends to other complex visual stimuli (e.g. natural scenes), remains to be tested empirically. More crucially, the mechanism by which comparison affects the perceived similarity of faces needs to be established. Attention is one possible mechanism by which comparison might affect the perceived similarity of faces. The process of structural alignment highlights areas of commonalities between the compared face pairs. It is possible that these areas are attended more frequently or for longer during similarity ratings.

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