Holistic and Part-based Processes in Recognition of Upright and Inverted Faces

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Abstract

Participants made a same-different judgment of the internal features of two faces presented simultaneously on screen. Whereas responding to upright faces on "same" trials relied upon holistic processing strategies, responding to upright faces on "different" trials, as well as responding to inverted faces, relied upon part-based processing strategies. Our results are also contrary to earlier reports in that we found that when attention is focused upon the internal features, presentation of these features alone is sufficient to form a discrimination judgment.

Introduction

One line of evidence concerning possible dissociations between face and object processing (e.g., Moscovitch, Winocur, & Behrmann, 1997) concerns the differential effects of inversion on recognition of faces and objects. The greater detrimental effect of inversion upon faces than objects is well-documented (e.g., Bartlett & Searcy, 1993). Specifically, inversion of faces relative to the viewer results in impaired encoding; this effect is greater for faces than for most, but not all (Diamond & Carey, 1986), other objects. Moreover, the available evidence indicates that inversion has a greater effect upon the encoding and subsequent discrimination of the spatial-relational (i.e., configurational) information contained in facial stimuli than it does on discrimination of isolated facial components (e.g., eyes). Indeed, several researchers maintain (e.g., Farah, Tanaka, & Drain, 1995) that whereas recognition of upright faces may rely upon holistic or "configurational" representation schemes, recognition of inverted faces, much like objects, may be reliant upon part-based decompositional strategies. In a pattern of findings similar to the reported dissociation between processing of faces and objects, several researchers report that whereas responding on "same" trials in same-different tasks may rely upon rapid, global modes of processing, responding on "different" trials may instead rely on more analytic or feature-based comparisons (e.g., Taylor, 1976). In fact, this pattern of responding may extend to same-different tasks involving facial stimuli (e.g., Bradshaw & Wallace, 1971).

The present experiment examined these claims in light of one aspect of facial processing that has received some attention in the recent literature: the relationship between the internal (eyes, nose, and mouth) and external (chin, forehead, and hairline) facial features. Claims of differential processing of these features with regards to both familiar and unfamiliar faces are well-documented. For example, whereas some studies (e.g., Nachson, Moscovitch, & Umiltà, 1995) that used different experimental methods provided evidence that external features are more efficacious than internal features in matching tasks for unfamiliar faces, other studies (e.g., Young et al., 1985) have failed to replicate this pattern of findings. By contrast, the results of other researchers (e.g., Ellis, Shepard, & Davies, 1979) converge on the finding that recognition of familiar faces is achieved best through presentation of the internal features.

In the present series of experiments, we proposed to investigate differential processing of the internal and external facial features through a series of manipulations involving same-different judgments of unfamiliar faces. We investigated these claims using an inversion paradigm by initially presenting participants with an upright face and testing their ability to make same-different judgments between this face and a comparison face that was presented either upright or inverted.

Experiment 1

Method

In the first experiment, participants were initially presented with a whole face at study (internal and external features present) and were required to make a same-different judgment of a comparison face. There were four different sets of comparison faces: i) upright faces (whole face); ii) upright faces (internal features only); iii) inverted faces (whole face) and; iv) inverted faces (internal features only). Twenty-four right-handed undergraduate students participated in the experiment; participants made their same-different judgment following simultaneous presentation of a vertically-aligned test and comparison face. "Same" in this experiment referred to full congruency between the internal features of study and comparison faces; the external features were held constant across study and comparison presentations. Each session involved 128 test presentations; sixty-four were "same" judgments and sixty-four "different" judgments.

Because initial study presentations involved *upright* whole faces, we reasoned that participants would rely upon holistic or configurational processing strategies at encoding of these stimuli (e.g., Farah et al., 1995). Indeed, we expected these strategies to result in superior performance for whole (internal and external features) rather than part (internal features only) presentations of comparison faces on upright "same" trials where a match would be provided between holistic processing

strategies for study and comparison faces that dictated attention to the entire face. By contrast, presentations of whole comparison faces would no longer be favored on upright "different" trials and on all inverted comparison presentations ("same" or different"), when discrimination performance may be based upon individual (separate) consideration of the internal and external features as the result of viewers' reliance upon analytic or part-based encoding strategies.

Results and Discussion

Indeed, the findings of this experiment were consistent with these predictions. Our results were confirmed using a factorial ANOVA design. Mean accuracy scores were entered into a 2 (Mode of Responding: Same and Different) X 2 (Target Orientation: Upright and Inverted) X 2 (Target Format: Part and Whole) factorial ANOVA with Mode of Responding, Target Orientation, and Target Format treated as within-subjects factors. Median reaction times were calculated for each subject for each condition; only reaction times for accurate responses were included in the analysis. We eliminated from the analysis all reaction times that fell more than two standard deviations from the mean and calculated new medians using the remaining data. Testing revealed a main effect of Target Orientation ($p < .001$); upright faces were processed more efficiently than were inverted faces [REGW-Q ($p < .05$)]. A three-way interaction between Mode of Responding, Target Orientation, and Target Format ($p < .05$) confirmed that whereas responding for upright items on "same" trials varied as a function of part versus whole presentations ($p < .01$), responding did not vary for either upright "different" responses ($p > .05$) or inverted "same' ($p > .05$) and "different" ($p > .05$) responses. Hence, viewers exhibited superior performance for whole, rather than part, comparison faces upon upright "same" presentations only (see Table 1).

Table 1: Experiment 1: Mean accuracy and reaction time by mode of response and target format.

	Same-Upright	Same-Inverted	Different-Upright	Different-Inverted
ACCURACY				
Part	0.94	0.82	0.90	0.76
Whole	0.98	0.81	0.91	0.77
REACTION TIME (in ms)				
Part	1642.94	2154.79	1582.15	2056.13
Whole	1475.29	2146.02	1645.04	2023.52

Analysis of participants' mean accuracy scores revealed a main effect of Target Orientation [$p < .001$; REGW-Q ($p < .05$)]; upright faces were processed more accurately than were inverted faces. The three-way interaction between Mode of Responding, Target Orientation, and Target Form, however, failed to attain significance, ($p > .05$) (see Table 1).

Although analysis of the accuracy scores revealed little evidence of differences in participant responding, viewers nonetheless exhibited more efficient performance for whole comparison faces on upright "same" trials; this finding may stem from a reliance upon holistic encoding strategies requiring attention to the entire comparison face, as would also be the case at encoding of study faces. We found little evidence of differences in responding to part versus whole faces on upright "different" trials; an initial reliance upon holistic processing strategies at encoding of the study faces may have counteracted more part-based representations of comparison faces that relied upon separate consideration of the internal and external features. Similar processes likely resulted in no differences being observed for part versus whole comparison faces on inverted trials ("same" or "different").

Experiment 2

Method

In a second experiment, we examined whether initial presentation of internal features alone would heighten viewers' reliance upon these features for discrimination. Hence, we conducted a second experiment identical to the first, with the exception that study faces were comprised of the internal features only. Initial encoding of the internal features was expected to result in superior performance being observed for part rather than whole comparison faces, regardless of the mode of responding required, or the target orientation of the stimuli. Although initial presentation of upright study faces may have engaged holistic encoding strategies, viewer representations would nonetheless include the internal features only. On upright "same" trials, such representations would be congruent with holistic representations of part (internal features) comparison faces only. Moreover, because upright "different" and all inverted trials may rely upon part-based encoding strategies, we also expected to observe superior performance for part faces on these trials. Indeed, part-based decompositional strategies may require attention to individual facial features such as the eyes, nose, and mouth contained in the internal features. Under such conditions, the external features may prove distracting at test, when attention may be focused on the internal features alone.

Results and Discussion

Our findings were consistent with these predictions. Analysis of participants' median reaction time scores indicated main effects of Target Orientation ($p < .001$) and Target Format ($p < .001$); upright faces were processed more efficiently than inverted faces and part faces were processed more efficiently than whole faces [REGW-Q (ps $< .05$)]. The three-way interaction between Mode of Responding, Target Orientation, and Target Format also approached significance ($p < .07$); viewers exhibited superior performance for part, rather than whole, presentations of comparison faces upon upright "same" ($p < .001$) and "different" ($p < .001$) trials, and inverted "same" trials ($p < .001$). Such differences were not apparent on inverted "different" trials ($p > .05$) (see Table 2).

Analysis of participants' mean accuracy scores also revealed main effects of Target Orientation ($p < .001$) and Target Format ($p < .01$); upright faces were processed more accurately than were inverted faces and part faces were

processed more accurately than were whole faces [REGW-Q (ps < .05)] (see Table 2).

Table 2: Mean accuracy and reaction time by mode of response and target format

	Same-Upright	Same-Inverted	Different-Upright	Different-Inverted
ACCURACY				
Part	0.98	0.90	0.93	0.75
Whole	0.94	0.89	0.84	0.77
REACTION TIME (in ms)				
Part	1230.77	1981.23	1549.10	2351.64
Whole	1893.10	2578.21	2121.15	2443.56

Thus, the results of Experiment 2 were consistent with our suggestion that initial encoding of the internal features alone would result in superior performance being observed for part rather than whole comparison faces. Although faster responding for part faces was not observed for inverted faces on "different" trials, an inspection of the response data indicated that "different" trials may have engaged time-consuming serial processing strategies not required for "same" responses (e.g., Taylor, 1976). Moreover, in contrast to previous investigations of recognition performance for unfamiliar faces (e.g., Nachson et al., 1995), these results also indicate that attending to the internal features alone is sufficient to form a discrimination judgment. These findings are in line with earlier suggestions by Moscovitch and his colleagues (Moscovitch et al., 1997) that the internal features may carry the burden of information in facial recognition processing. Indeed, the external features may prove an unnecessary distraction at test when attention is focused on the internal features alone. The slower and less accurate responding observed for presentations of comparison faces comprised of both the internal and external features upon all upright presentations of comparison faces, as well as on inverted "same" trials, indicates that these features may add no new or informative information for discrimination.

Discussion

Our experiments provide clear evidence that whereas responding to upright faces on "same" trials may rely upon holistic or configurational processing strategies, responding to upright faces on "different" trials, as well as to inverted faces, relies upon part-based or decompositional processing strategies. In addition, contrary to earlier reports that recognition of unfamiliar faces may be most efficacious following presentation of the external features (e.g., Naschon et al., 1995), we found that presentation of the internal features alone is sufficient to form a discrimination judgment when attention is focused upon these features. Future experiments are planned to determine whether the same pattern of responding will extend to the processing of objects (e.g., houses).

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