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Journal of Experimental Social Psychology 39 (2003) 270–278

Journal of Experimental Social Psychology

www.elsevier.com/locate/jesp

Featural processing in face preferences

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Received 30 April 2001; revised 15 April 2002

Abstract

Two experiments examined how practice and time pressure influence holistic processing, defined as the relative importance of feature interactions, in a face preference task. Participants rated 32 cartoon faces that varied along five dichotomous features (Experiment 1) or 27 realistic morphed faces that varied along three trichotomous dimensions (Experiment 2), under high and low time pressure (operationalized as a short vs. long stimulus presentation time), over a series of experimental blocks. In both experiments, the overall importance of facial features, but not of feature interactions, increased over blocks and, in one condition of Experiment 1, under high vs. low time pressure. Analyses of idiosyncratic importance indicated that the feature effects were due to the increasing importance of participants' idiosyncratically most influential features. Functional differences between face preferences and face recognition are offered to explain and predict when facial features will be processed independently vs. holistically.

Keywords: Faces; Preference; Liking; Dimensions; Features; Morphing; Holism

Identifying and processing human faces—complex stimuli that may differ in extremely subtle ways—are difficult but essential social tasks, yet ones at which humans are extraordinarily adept. Ellis (1986) estimates that we can name on the order of 700 faces of people we know, and can recognize many times more, even when the faces have been presented only once, when recall follows a long delay (Chance, Goldstein, & McBride, 1975), or when viewing conditions are degraded (Ellis, 1981).

Such exceptional skill, it has been argued, is linked to our ability to encode faces in terms of featural interactions—as opposed to independent facial features (Farah, 1992). The ability to process facial features interactively, or "holistically," is evidenced by the discovery of interdependencies in the perception of individual facial features (e.g., Bradshaw & Sherlock, 1982; Carey & Diamond, 1994; Haig, 1984; Sergent, 1984; Tanaka & Farah, 1993; Young, Hellawell, & Hay, 1987). Tanaka and Farah (1993), for example, demonstrated that facial features are easier to identify when presented on the faces they belong to, than when presented in the context of a new face, indicating that the features are not represented as independent parts in memory (cf. Bower & Glass, 1976; Palmer, 1977). Relatedly, Sergent (1984) found that the time to process multiple facial features that differ in salience was actually less than the time to process the most salient feature by itself. This could only be the case, she argued, if the features were processed interactively, a conclusion further supported by statistical interactions in regression analyses predicting same–different response times from featural differences. In addition, Sergent (1984) found that the multidimensional scaling solution of her stimulus faces (which varied on three orthogonal dimensions) deviated from the cubic structure expected if the dimensions had been processed independently.

Additional evidence for holism comes from findings that face recognition can be disrupted by manipulations designed to interfere with holistic processing. For example, the effects reported by Sergent (1984), Tanaka and Farah (1993), and Young et al. (1987) were not observed, and in some cases were reversed, when the stimulus faces were inverted. Performance differences between upright and inverted faces, known generally as

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doi:10.1016/S0022-1031(02)00526-7

the "face inversion effect" (see Valentine, 1988, for review), are presumably due to the fact that inversion denies perceivers access to the holistic information on which face perception depends. Unfamiliar stimuli, such as scrambled faces, drawings of houses (Tanaka & Farah, 1993), and other-race faces (Rhodes, Tan, Brake, & Taylor, 1989) also fail to show either the face inversion effect or the advantage for feature-in-face recognition.

Face recognition vs. preference

The fact that inversion and other manipulations can disrupt face recognition suggests that holistic processing is at least partially a functional strategy learned in response to the importance and difficulty of this task. Evidence from other stimulus domains suggests that people are particularly likely to rely on holistic information in relatively taxing situations, such as when they are young (Kemler, 1983; Smith, 1989; Smith & Kemler, 1978), under pressure to respond (Ward, 1983), distracted (Smith & Kemler Nelson, 1984), under high cognitive load, or when stimuli are confusable or complex (Smith, 1981; Smith & Kemler Nelson, 1984; see Foard & Kemler-Nelson, 1984, for review). Holistic processing simplifies face recognition both by allowing for simultaneous processing of multiple features (Garner, 1974), and by increasing the discriminability between similar faces by exaggerating small featural differences (e.g., Haig, 1984). Thus, people's interactive processing of facial features may be partially a necessary, well-learned strategy to cope with the importance and difficulty of face recognition.

Social interaction, however, involves not only recognition of other people, but also evaluation of them, and these two judgments do not necessarily rely on identical cognitive processes. Indeed, Zajonc (1980, 1984) has argued that recognition and preference are independent, citing research on the mere exposure effect (Zajonc, 1968; see Bornstein, 1989, for review), in which people like and are more attracted to stimuli they have seen before, even when their recognition of those stimuli is at chance levels (Kunst-Wilson & Zajonc, 1980; Moreland & Zajonc, 1977, 1979; but see Birnbaum & Mellers, 1979; Mandler, Nakamura, & Van Zandt, 1987). If recognition of faces is independent of preferences for faces, the question remains open regarding whether and when the latter rely on holistic processing.

Furthermore, this question cannot be addressed using standard recognition-based indices of holistic processing (e.g., the face inversion effect), because no true criterion for accuracy exists for preference judgments. However, a series of studies by Levine, Halberstadt, and Goldstone (1996) suggest an indirect measure of feature use, in terms of the weight participants give to facial features and their interactions in a regression model of their face preferences. Levine et al. used the values of each of six dichotomous features to predict participants' liking of cartoon faces, as a function of concurrent introspection about their judgments (cf. Wilson, Dunn, Kraft, & Lisle, 1989). The researchers analyzed the β weights for the six features, reordered for each participant from most to least important, in an analysis of variance (ANOVA) with dimensional importance (most important, second most important, etc.) treated as a repeated measure. Only the main effects were analyzed because initial analyses indicated that feature interactions did not improve the fit of the participants' regression models.

For the present purposes, Levine et al.'s initial analysis of main effect and interaction terms provides an ideal measure of holistic processing in face preferences, which by definition would involve interactions among facial features. The current experiments examined the use of facial features and their interactions in preference judgments, as a function of practice and time pressure, two variables that appear to be associated with holistic processing (e.g., Carey & Diamond, 1994; Gauthier & Tarr, 1997; Rhodes et al., 1989; Schooler & Engstler-Schooler, 1990; Smith & Kemler Nelson, 1984). In Experiment 1, participants rated their liking for a set of cartoon faces combining all possible combinations of five dichotomous facial features (examples appear in the top panel of Fig. 1). Experiment 2 replicated Experiment 1 using morphed photographs of faces varying on three facial dimensions. In both experiments, rating blocks alternated between short and long stimulus presentations. Increases in the magnitude of the interaction terms, decreases in the magnitude of the main effects, or both, would be indicative of holistic processing.

In addition, following Levine et al.'s (1996) procedure, we reordered, in terms of decreasing magnitude, each participant's main effects and interaction weights. We thereby were able to test more precisely how participants' attention to features or interactions changed over time and time pressure, independent of their idiosyncratic use of particular features or interactions. Specifically, an increase in the weight given to important features relative to less important ones would suggest participants are focussing their attention on a few, influential features, rather than, for example, taking into account additional features that would be otherwise less important in their preferences.

Method

Participants

Seventy-eight Indiana University undergraduates participated in Experiment 1, and 72 in Experiment 2, in

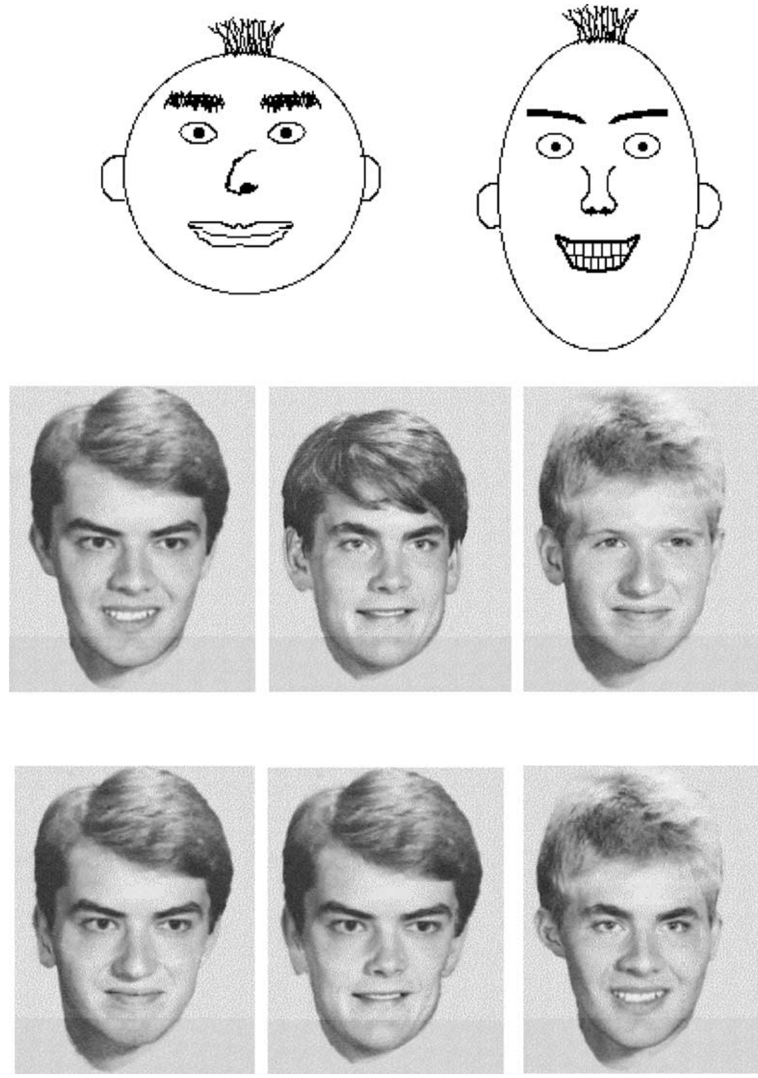

Fig. 1. Examples of faces presented to participants in Experiment 1 (first row) and Experiment 2 (second and third rows).

order to fulfill a requirement for their Introductory Psychology course.

Materials

Stimuli for Experiment 1 were 32 cartoon faces generated on a Macintosh computer. The faces varied along five binary dimensions: eyes (almond-shaped vs. oval), eye brows (thin vs. thick), mouth (smiling vs. serene), nose (front- vs. side-view), and head shape (round vs. oval). The five features were completely crossed such that each feature appeared once with every possible combination of the other four features. The distance between the five facial features remained constant regardless of the head shape. Each set of five facial features was centered on both of the two different head shapes. The faces were 3.9 cm from ear to ear, and at a 60 cm viewing distance subtended a visual angle of 3.7°. Fig. 1 shows two faces that were generated with opposite values on each of the five features.

Stimuli for Experiment 2 were 27 faces representing the factorial combination of three face dimensions (eye, mouth/nose, and hair). The faces were generated from three faces taken from a college yearbook (shown in the middle row of Fig. 1), selected so as to be approximately equally attractive as judged by a set of 10 pilot participants. Using morphing routines developed by Steyvers (1999), 60 control points were located on each of the three original faces at salient face positions such as corners of eyes, pupils, cheekbones, and the midway point of the lower lip. These 60 control points were segregated into the three spatial regions defined by the three dimensions. Hybrids of the three faces were taken by factorially combining eye, mouth, and hair regions from different faces and blending them together. The morphing algorithm developed by Steyvers automatically fades gradually between the three defined spatial regions. As such, there are no sharp discontinuities between face regions, but the internal appearance within each region is completely determined by the original photograph. Apart from some occasional morphing artifacts around the ears, the hybrid faces appeared naturalistic, and a group of 10 pilot participants were able to choose the actual face from a triad of one real face and two hybrid faces on only 40% of the trials (chance performance would be 33%). The faces were 6.0 cm wide by 8.5 cm tall, and at a 60 cm viewing distance subtended a visual angle of 5.7°. Examples of the morphed stimulus faces appear in the bottom row of Fig. 1.

Procedure

The procedure was identical in the two experiments, except where indicated. Participants were tested in groups of 1–7. Each participant sat approximately 60 cm from the 25.4 cm wide by 19.1 cm high screen of an Apple Power Macintosh 6300 computer. Each computer was isolated in its own sound-dampened cubicle, illuminated by a single 40 W bulb. Participants were shown the following instructions:

> In a moment, you will be asked to judge how much you like a number of different cartoon faces that will appear on the screen for different amounts of time. Your task is to rate how much you like each of the faces by moving a slider with the mouse (the device to the right of the keyboard). The scale goes from 1 to 100, where 1 would mean "I don't like the face at all" and 100 would mean "I like the face a lot."
>
> There are different ways to move the slider. One way is simply to click on the mouse button when the arrow is at to your desired rating. You can also drag the slider by clicking on it, pulling it somewhere else with the mouse, and then lifting off of the mouse button. The computer will constantly show you what rating you are currently giving the face. When you have moved the slider to the desired rating, press the "Done" button.

Before beginning to rate the faces, participants were first exposed to 15 randomly chosen faces. During this pre-exposure phase, participants were told to simply look at the faces so as to get an impression of the range of faces that they would see. After this pre-exposure, participants were informed that none of the faces was very attractive, but that they were still encouraged to use the entire range of the scale.

In Experiment 1 each participant rated three blocks of faces, each containing two sub-blocks defined by the presentation duration of a face. Participants were randomly assigned to one of two conditions: In the "fast first" condition, faces were shown for a brief duration (1 s, the fastest speed at which pretest participants were able to register all parts of the stimuli) in the first sub-block of each block, and for a relatively long duration (4 s, the slowest speed that prevents boredom) in the second sub-block. In the "slow first" condition, faces were first shown for a long duration, and then for a brief duration. In each sub-block, participants rated each of the 32 faces in a random order; thus, there were 192 trials in all. The procedure in Experiment 2 was identical, except that participants rated four blocks, each containing 2 sub-blocks (one fast duration and one slow duration) of all 27 faces, for a total of 216 trials.

On each individual trial, a face appeared in the middle of the screen for either 1 or 4 s, and then was immediately removed. Following the face presentation, a sliding bar labeled "attractiveness" was displayed. The participant moved the mouse, as described above, to indicate the attractiveness of the face. When satisfied with the rating, the participant clicked on a button labeled "Done." After a 1 s blank screen, the next trial began.

Results

Two types of data were derived from the raw attractiveness ratings: (1) the importance of individual features and their interactions in each sub-block, as quantified by the overall F scores associated with each type of effect; and (2) the relative importance of idiosyncratically more and less influential features and their interactions, as determined by F scores reordered in terms of magnitude (Levine et al., 1996). These data were analyzed in mixed model analyses of variance (ANOVAs), using a critical p value of .01 (unless otherwise noted) because of the large number of tests involved. Incomplete data from eight participants in each experiment were not included in the analyses.

Main effects vs. interactions

In Experiment 1 the overall importance of main effects and interactions was determined by analyzing each participant's 32 preference ratings within each sub-block of the experiment in separate five-way (corresponding to the five facial features) ANOVAs. Because of the large ratio of effects to observations (30:32) within each analysis, only the 5 main effects and 10 two-way interactions were computed. The overall F scores associated with the main effects and interactions for each participant were then analyzed in a 2 (main vs. interaction effect) × 3 (block) × 2 (time pressure: 1 s vs. 4 s) × 2 (order: fast first vs. slow first) ANOVA, with the first three factors treated as repeated measures. The results indicated that F scores in all blocks were greater for main effects than interactions, $F(1, 68) = 28.86$, $p < .001$, and increased overall in magnitude across blocks, $F(2, 136) = 6.41$, $p < .005$. The analysis also revealed an interaction between effect type and block, $F(2, 136) = 5.49$, $p = .005$, such that main effects, but not interactions, of the facial features increased in magnitude over blocks. Finally, a marginal order × effect type × speed interaction, $F(1, 68) = 5.95$, $p = .02$, was due to the fact that main effects (and not interactions) were more influential for fast than slow presentation speeds, but only in the slow first condition; in the fast first condition neither effect type differed between presentation speeds.

In Experiment 2, the F scores associated with the (three) main effects and (three) two-way interactions on each participant's judgments were analyzed in a 2 (main vs. interaction effect) × 4 (block) × 2 (time pressure: 1 s vs. 4 s) × 2 (order: fast first vs. slow first) ANOVA. The analysis revealed, as in Experiment 1, that main effects of features were stronger than interactions, $F(1, 62) = 104.80$, $p < .001$, and that F scores overall increased over blocks, $F(3, 186) = 3.93$, $p < .01$. Again, an effect type by block interaction, $F(3, 186) = 4.38$, $p = .005$, indicated that this increase was limited to main effects.

Analysis of idiosyncratic importance

In Experiment 1, to determine more specifically how participants allocated their attention to features of different idiosyncratic importance, the F values associated with each main effect and the five most influential two-way interactions in each participant's liking ratings were reordered (within each effect type) in terms of decreasing magnitude (Levine et al., 1996). These data were then analyzed in a 2 (main effect vs. interaction) × 5 (effect importance: most important, second most important, etc.) × 3 (block) × 2 (speed: 1 s vs. 4 s) × 2 (order: fast first or slow first) ANOVA, with the first four factors treated as repeated measures. This analysis revealed that, in addition to the trivial effect of importance, F scores were greater for features than their interactions, $F(1, 68) = 24.06$, $p < .001$, and overall increased over blocks, $F(2, 136) = 6.49$, $p < .005$, consistent with the analysis reported above. The higher-way effects relevant to our experimental hypotheses can be summarized as follows. First, an interaction among effect type, importance, and block, $F(8, 544) = 3.33$, $p = .001$, was due to the fact that only participants' idiosyncratically most important features increased in importance over blocks; less important features, and feature interactions, did not. Second, an interaction among effect type, importance, and speed, $F(4, 272) = 3.56$, $p < .01$, was due to the fact that the F score associated with participants' most influential feature was greater for fast than for slow stimulus presentations, but no other, less important features, and no interactions, differed between presentation speeds. Unexpectedly, this result interacted with order, $F(4, 272) = 4.54$, $p = .001$, with the three-way effect holding only for the slow first condition; in the fast first condition, time pressure did not interact with importance for either type of effect. These effects are depicted in Figs. 2 and 3, respectively.

In Experiment 2, a 2 (main vs. interaction effect) × 3 (importance) × 4 (block) × 2 (speed) × 2 (order) mixed model ANOVA conducted on idiosyncratically reordered F scores revealed, in addition to the trivial effect of importance, main effects of effect type, $F(1, 62) = 104.59$, $p < .001$, and block, $F(3, 186) = 3.95$, $p < .01$, which were consistent with the analysis on overall effects. The effect type × importance × block interaction, de-

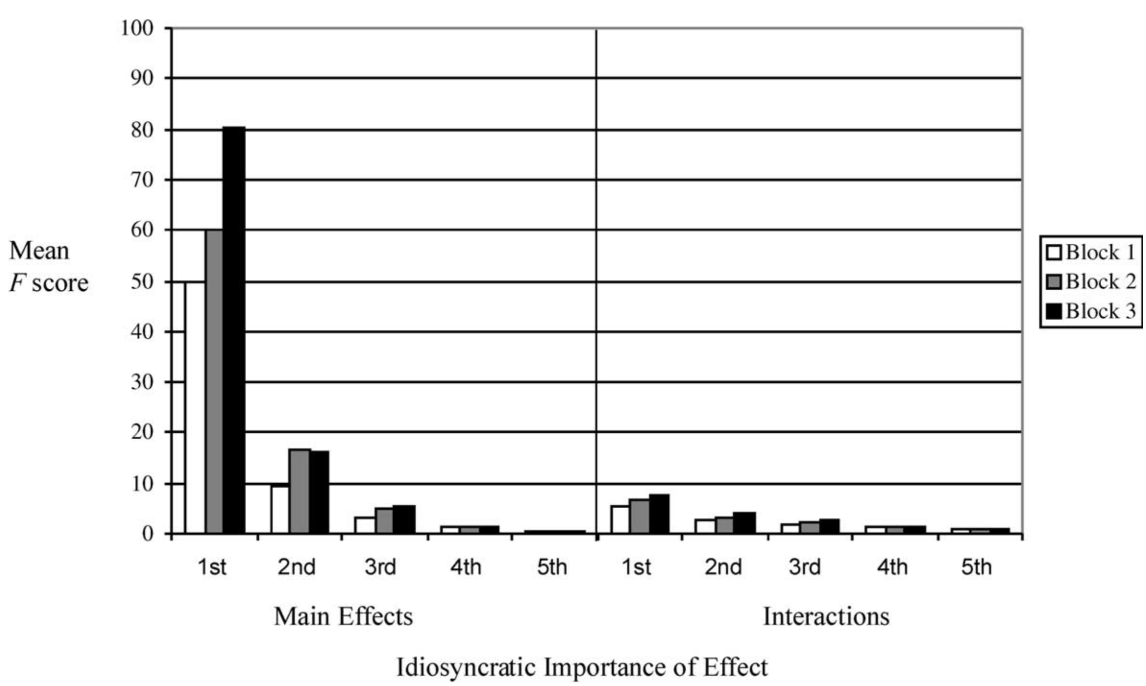

Fig. 2. F scores as a function of effect type, dimensional importance, and block, Experiment 1.

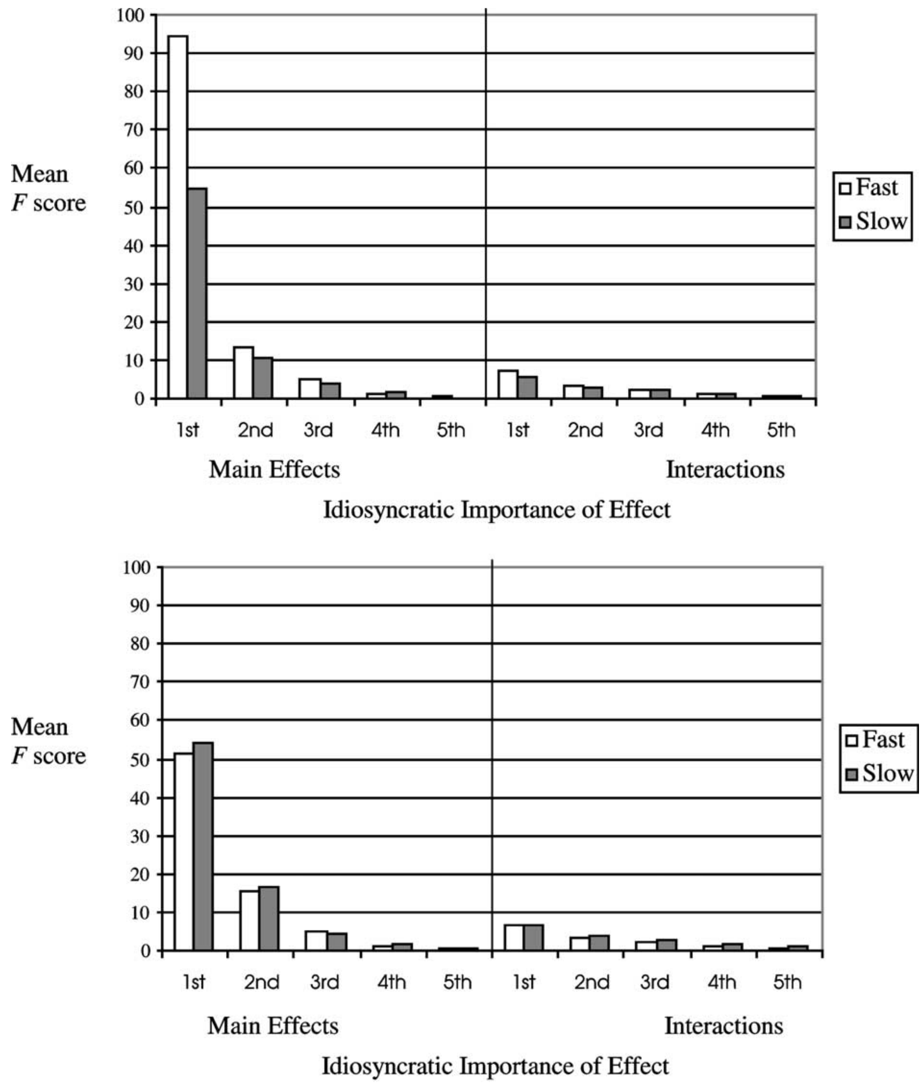

Fig. 3. *F* scores in the slow first (top frame) and fast first conditions as a function of effect type, dimensional importance, and time pressure, Experiment 1.

picted in Fig. 4, was marginally significant, $F(6, 372) = 2.37$, $p = .03$. As in Experiment 1, participants' most influential feature increased in importance over blocks to a greater extent than less important features or feature interactions. The effect type × importance × speed interaction was not significant.

Discussion

The current experiments were conducted to explore the effects of practice and time pressure on holistic processing in face preferences, operationally defined as being strongly influenced by feature interactions. Regarding the effects of practice, the two experiments tell a remarkably consistent story, despite the differences between their stimuli, and the specificity and complexity of the interactions in the data. Over blocks, independent facial features had an increasingly influential effect on attractiveness judgments, but interactions of those features—the essence of holistic processing—did not change. Analyses of idiosyncratic importance showed that the increase in feature effects was due to increasing weight over time that participants gave to the particular facial features that were most important in their judgments. Idiosyncratically important feature interactions did not similarly increase in strength. Thus, the results are clearly inconsistent with increases in holism (as defined by feature interactions) found in face recognition research using similar manipulations. Participants certainly did alter their use of stimulus information over time, but the effects of feature interactions remained constant.

The effects of time pressure were somewhat less clear. In Experiment 1, main effects—and particularly participants' most important main effects—were more

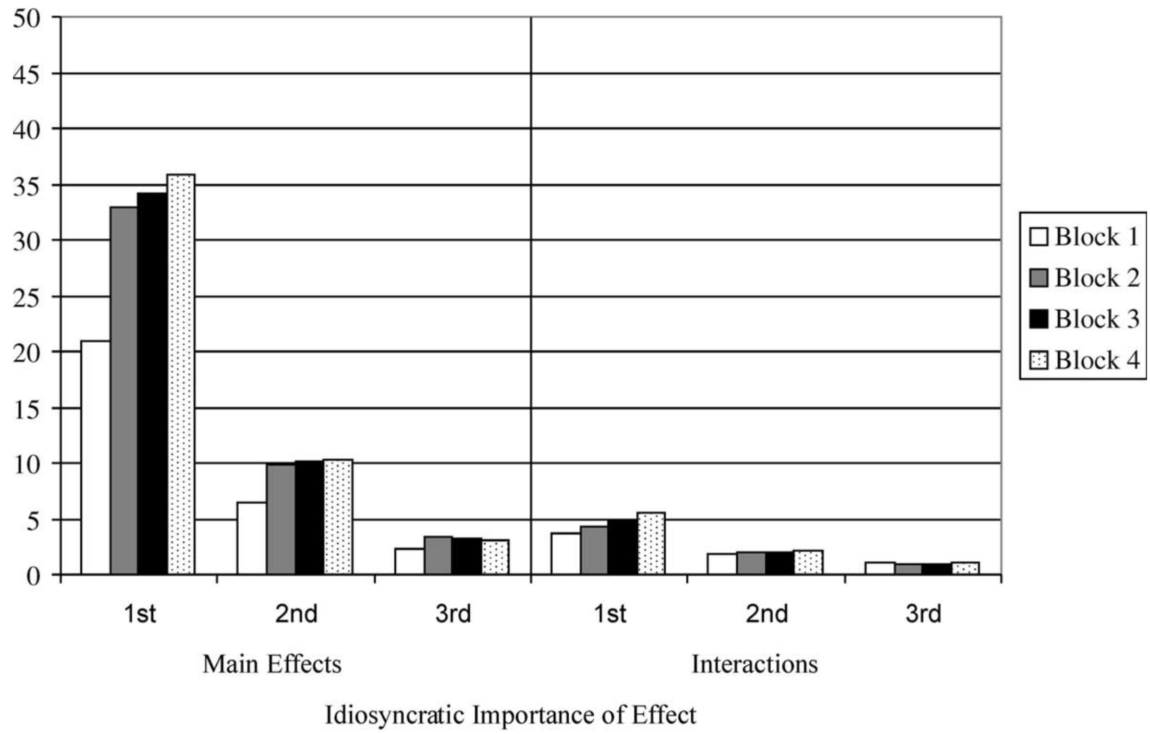

Fig. 4. *F* scores as a function of effect type, dimensional importance, and block, Experiment 2.

influential than interactions for fast than slow presentation speeds. As for the practice effects, this suggests a process of attentional isolation of particular, idiosyncratically important features, rather than an increase in holism. However the data indicate several qualifications to this conclusion. First, these effects occurred only when fast trials followed slow trials within each block. Although not predicted, this interaction with order is understandable in light of the fact that main effects increased with practice. If main effects were also greater for fast than slow trials, this effect would tend to be enhanced when fast trials occurred in the second half of each block, and inhibited when they occurred first. A more problematic qualification, however, is that the effects of speed were not replicated in Experiment 2. It is possible that this difference is due to the nature of the stimuli in the two experiments, namely, the use of cartoon vs. photographic faces. It is possible, for example, that features of cartoon faces are more easily attentionally isolated than those of "real" faces (although both types of stimuli have been used in research on face perception). Finally, even if one gives credence to the timing effects in Experiment 1, one might be reluctant to attribute them to "time pressure," because participants were not technically under time pressure to respond. Unfortunately we cannot isolate judgment time from response time with the current data, so we conclude only that fast presentation speed may encourage the perceiver to process stimulus features independently, at least when attending to relatively discrete cartoon features.

It should also be noted that feature interaction is arguably the most familiar, but not the only, definition of holistic processing. Another distinct sense of "holism" relates to the breadth rather than the independence of attention (e.g., Garner, 1974; Kemler-Nelson, 1993; Lockhead, 1972; Smith, 1981). According to this definition, stimuli are processed holistically to the extent that they are perceived and compared in terms of similarity based on linear summation from multiple features. By this definition, holistic processing would be evidenced not by feature interactions, but by attention to and use of multiple stimulus dimensions simultaneously. Thus, our idiosyncratic analyses, which essentially examine perceivers' breadth of attention, also provide a test of this second sense of holism. Clearly, then, in neither sense do preference judgments in our studies become more holistic with practice or time pressure.

Interestingly, this conclusion is not necessarily inconsistent with the perception and recognition literatures. Although much of the research on face perception suggests increased holistic processing over time and under pressure (see Introduction), the evidence is more mixed for other stimuli. Some studies on categorization in children, for example, suggest a developmental trajectory from holistic to dimensional processing. Smith and Kemler (1977) found that children younger than about age seven categorized stimuli varying in size and shade (two easily separable dimensions for adults) in terms of their overall similarity. Older children, however, were capable of attending to one of the dimensions while ignoring the other.

Some research on categorization learning in adults is also consistent with holistic primacy. Goldstone (1994) found that training subjects on a categorization task increased perceptual discrimination via selective attention to category-relevant dimensions. Even extremely integrated stimulus dimensions, such as the hue, saturation, and brightness of color, can be attended to selectively by experts (e.g., art students; Burns & Shepp, 1988). Indeed, learning to selectively attend to relevant dimensions forms the basis of several influential models of categorization (Gluck & Bower, 1988; Kruschke, 1992; Medin & Schaffer, 1978; Nosofsky, 1986; Smith & Zarate, 1992), and perceptual learning (Gibson, 1969).

Our data suggest that, in some tasks, stimulus features are increasingly unitized over time (e.g., Goldstone, 2000; Czerwinski, Lightfoot, & Shiffrin, 1992), while in other tasks (including, based on the current studies, face preference judgments), stimulus features are differentiated and selectively attended. What determines more generally whether an individual will attentionally isolate important features of a stimulus, or process those features interactively? We suggest that cognitive economy can in part account for the difference between recognition and preference judgments in faces. Similarity judgments, on which recognition is presumably based, may be biased toward the use of holistic information because, in many situations, it is in fact easier for people to base such judgments on more, rather than fewer, properties (Goldstone, 1994; Kemler, 1983). For example, Sekuler and Abrams (1968) report cases in which participants are faster to respond that two displays are identical along all their elements than that two displays have a single common element. Nickerson (1972) reviews evidence in favor of a fast "sameness detector" that allows people to quickly assess overall similarity between displays before being able to respond to particular dimensions. Brooks (1978) argued that judging category membership by overall similarity is an often-used strategy, particularly when the category members are rich and multi-dimensional and the category rules are complicated (also see Allen & Brooks, 1991). Therefore, face recognition, because it requires a similarity-based comparison to a complex representation, may depend on processing multiple facial features to a relatively large extent.

Preference judgments, however, have no criterion for accuracy, and do not require that all features be considered. Such judgments can therefore safely rely on particular features or dimensions of idiosyncratic importance to the perceiver. Learning to make preference judgments may not be a matter of learning how to process multiple dimensions interactively or simultaneously, but rather learning (consciously or unconsciously) what dimensions are most predictive of overall liking. Once the important dimensions have been identified, a sensible and functional strategy is to isolate those dimensions and attend more heavily to them.

Of course, the extent of feature-based face processing may also depend on the context in which preference and recognition judgments are made. For example, rewards and penalties associated with preference judgments (e.g., in terms of money, or self-esteem) might create pressure to incorporate more dimensions into one's judgment, and in turn a greater tendency toward holistic processing. Conversely, simpler recognition tasks may not require holistic comparisons, and may be adequately solved by attention to a single or small subset of facial features. Future research should explore these contextual influences, as well as apply the current paradigm to other stimulus classes and processing tasks within a single study to establish the generality of our functional analysis.

Acknowledgments

This research was supported by an Otago Research Grant to the first author and by a National Institute of Health Grant and Jack Gill Fellowship to the second author. The authors thank Emma Witt for help with data analysis.

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