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SHIFTS IN POSTDISCRIMINATION GRADIENTS WITHIN A STIMULUS DIMENSION BASED ON FEMALE WAIST-TO-HIP RATIOS

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Fifteen participants were trained on a within-subjects basis with two discrimination training conditions and one simple generalization training (control) condition to determine whether gradient shifts can be obtained within a stimulus dimension consisting of women's waist-to-hip ratios (WHRs). In one discrimination condition, the S– consisted of the "optimal" WHR; in the other, the S– consisted of the approximate mean WHR for adult women. For all three conditions, the S+ was an intermediate value. Under both discrimination training conditions, the generalization gradient was observed to shift away from the S– and toward extreme values on the opposite end of the dimension; under the control condition, the gradient was more closely centered on the S+. The results suggest that the processes involved in gradient shifts can affect judgments of biologically significant stimuli.

Stimulus generalization describes instances in which a response appropriate to one stimulus (S+) occurs in the presence of other, similar stimuli. The degree to which generalization occurs is determined, in part, by the learning history of the organism. For example, the generalization gradient will be steeper if subjects are trained to discriminate an S+ from a similar stimulus paired with nonreinforcement (S–), rather than if subjects are given simple generalization training with an S+ (Jenkins & Harrison, 1960). Discrimination training may also cause the gradient to shift away from the S– and toward stimuli on the opposite end of the dimension. In some instances, discrimination training will lead to a kind of gradient shift known as peak shift (cf. Hanson, 1959). In the case of peak shift, subjects respond more frequently to a novel stimulus displaced away from the S– than they do to the S+; that is, the modal response (or "peak" of the gradient) shifts along with the mean response.

"Gradient shift" and "peak shift" are descriptive phenomena known

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principally through laboratory-based research on generalization within sets of unidimensional stimuli (for reviews, see Honig & Urcuioli, 1981; Rilling, 1977; Thomas, 1993). Nevertheless, a number of authors use these terms (especially *peak shift*) to describe processes involved in judgments of complex stimuli in the natural environment. For example, among infrahumans, peak shift has been invoked as a mechanism underlying the evolution of aposematism (warning coloration) among prey (Gamberale & Tullberg, 1996; Gamberale-Stille & Tullberg, 1999; Leimar, Enquist, & Sillén-Tullberg, 1986), the sexual selection among birds for elaborately plumaged males (Weary, Guilford, & Weisman, 1993), and the preference for supernormal stimuli displayed by many species (Ghirlanda & Enquist, 1998, 1999, 2003; Staddon, 1975). In a similar vein, some authors have suggested that in humans peak shift is a mechanism or principle that can affect most aesthetic judgments (Ramachandran & Hirstein, 1999; Zimmer, 2003).

Although it may not be possible to directly test claims about the role of gradient shifts in nature, recent laboratory research does suggest that the phenomenon is fairly general. For example, gradient shifts have been obtained with complex stimulus dimensions based on abstract shapes (McLaren, Bennett, Guttman-Nahir, Kim, & Mackintosh, 1995; McLaren & Mackintosh, 2002; Wills & Mackintosh, 1998), spatial location (Cheng & Spetch, 2002; Cheng, Spetch, & Johnston, 1997; Cheng, Spetch, Kelly, & Bingman, 2006), and images of human faces (Derenne & Breitstein, 2006; Lewis & Johnston, 1999; Spetch, Cheng, & Clifford, 2004). In all of these cases, however, the stimulus dimension was relatively unfamiliar and, arguably, of little importance outside the experimental setting. For example, in several studies the stimuli were constructed by morphing two faces together to create a series of intermediate images (Lewis & Johnston; Spetch et al.). Another study used "natural" images but had participants judge the faces on the basis of an arbitrary dimension: the proportion of face length that lay below the nose (Derenne & Breitstein).

The present research considers whether gradient shifts can be obtained with a familiar and biologically significant stimulus dimension. In this case, the stimulus dimension was based on variations in a woman's waist-to-hip ratio (WHR). Evolutionary theories of mate selection claim that the attractiveness of human females is determined to a large extent by physical cues such as WHR (e.g., Buss, 1987, 1989; Symons, 1995). A woman's WHR is negatively correlated with measures of health and reproductive fitness (e.g., Bray, 1992; Price, Uauy, Breeze, Bulpitt, & Fletcher, 2006; Rexrode et al., 1998; Wass, Waldenström, Rössner, & Hellberg, 1997) and ratings of physical attractiveness by both women and men (e.g., Furnham, Petrides, & Constantinides, 2005; Henss, 1995; Singh, 1993; Streeter & McBurney, 2003). Although some have questioned the universality of these findings (Marlowe & Wetsman, 2001; Yu & Shepard, 1998), at least in westernized societies, women with relatively small WHRs tend to be more desired as mates (see Weeden & Sabini, 2005, for a recent review).

Laboratory research with unidimensional stimuli has shown that a gradient shift is not an inevitable result of discrimination training. For example, a shift will not occur if the S+ and the S– are drawn from relatively different parts of the stimulus dimension (Derenne, 2006) or if the S– is introduced in such a manner as to minimize the probability of errors (Rilling, 1977). In other words, gradient shifts are most likely when the discrimination is at least "moderately difficult" and least likely when subjects can readily discern S+ from S–. It is reasonable to presuppose, then, that it should be more difficult to obtain gradient shifts with biologically significant stimuli than with other varieties. Presumably subjects' extensive preexperimental history with such stimuli improves their ability to make accurate discriminations among similar stimuli. Indeed, given that shift in the gradient generally leads to a decrease in response accuracy, it would be adaptive for organisms to be resistant to gradient shifts with familiar and important stimuli.

Even if biologically significant stimuli do not readily lend themselves to gradient shifts, judicious selection of the stimuli may still allow the effect to be observed. That is, even with familiar stimuli, there may still be a range of values at which the discrimination is at least "moderately difficult" and gradient shifts are possible. A critical question for researchers to address is whether gradient shifts can be obtained with a range of stimulus values comparable to those commonly encountered outside the laboratory. The present research was not designed to confirm that gradient shift–like phenomena occurring in nature are the result of the same processes observed in the laboratory. Rather, it was designed to begin to explore, using traditional laboratory-based methods, whether such claims are at least plausible. In this regard, we used a stimulus dimension based on two values reported in WHR-related research. One endpoint of the dimension was a WHR of 0.700, the value that men report as finding most attractive (Furnham et al., 2005; Henss, 1995; Singh, 1993; Streeter & McBurney, 2003). The other endpoint was a WHR of 0.800, a value that approximates the mean WHR of healthy adult women (e.g., Dobbelsteyn, Joffres, MacLean, & Flowerdew, 2001; Lahti-Koski, Pietinen, Männistö, & Vartiainen, 2000; Lissner et al., 1998; Seidell, Pérusse, Després, & Bouchard, 2001). The S+ was a WHR midway between these extremes (0.750). Each endpoint served as the S– in one of two discrimination training conditions. In other words, in one condition the shift would be away from the optimal ratio and toward the typical ratio, and in a second condition the shift would be away from the typical ratio and toward the optimal ratio.

Method

Participants

The participants were 15 undergraduate students (3 male, 12 female) recruited from lower-level psychology courses, a number chosen on the basis of an earlier, pilot investigation. The participants were required to achieve at least 70% accuracy in responding during the training phase of all three conditions, and several students had to be replaced for failure to meet this criterion. The participants received extra course credit in exchange for their time.

Apparatus

Participants were seated at one of three data collection stations. The stations occupied a single table but were separated by wooden dividers. Each station consisted of a computer with a 13-in. DynaFlat color monitor (Samsung). The computer was located below the table; the monitor was positioned at eye level approximately 48 cm from the participant. A keyboard and mouse were placed in front of the monitor.

Procedure

Stimuli. The stimuli were based on three pictures of women in two-piece swimsuits obtained from a retailer's Web site. The pictures were selected because they afforded a clear view of the waist and hips and because they contained minimal visual noise (the background being a clear sky in one case and an ocean view in the other two). Each of these pictures was used to create a set of images. First, the pictures were cropped so as to show the area from the top of the head to midthigh. Then the waist and hips were warped with the use of Microsoft Winmorph to create five images with WHRs of 0.700, 0.725, 0.750, 0.775, and 0.800. In other words, each of the original images served as the basis for a separate stimulus dimension. An illustration of one set of images (shown here in silhouette) appears in Figure 1.

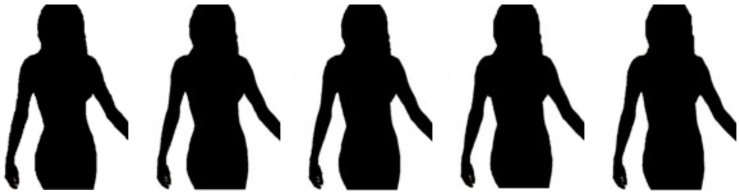

Figure 1. Illustration of one set of stimuli.

Design. The experiment followed a 1 × 3 within-subjects design. In one (control) condition, participants received simple generalization training (only the S+ was shown), and in the other two, participants received discrimination training (S+ and S– were shown). The S+ consistently was a ratio of 0.750. For one discrimination condition the S– was a relatively small ratio (0.700), and for the other it was a relatively large ratio (0.800). The image set assigned to a given condition and the order in which the conditions occurred were determined randomly for each participant.

General. Each condition consisted of 10 training trials followed by 10 test trials. At the beginning of each condition, the participant was instructed to remember the S+, which was then shown for 10 s. During training trials, the participant was prompted to indicate whether the image shown was the same as the S+. The participant chose, by using the mouse, to click on a "Yes" or "No" button below the image. The image then disappeared, and feedback ("Correct" or "Incorrect") was shown for 3 s. The subsequent trial began after a 10 s intertrial interval, during which the participant was instructed to "Please Wait." Test trials were similar to training trials, except that feedback was withheld. Under the discrimination training conditions, the S+ and S– each appeared five times; during the subsequent generalization test, each of the five images comprising the complete set was shown twice. In both cases, the images were presented in an irregular order.

Results

Figure 2 shows the generalization gradients for the three groups. The response gradient for the control condition was roughly centered on the S+, although there was a slightly greater tendency for participants to respond to larger-ratio images than smaller-ratio ones. This outcome suggests that participants were responding, as instructed, on the basis of the similarity of each test image to the S+; if participants responded instead to those images they perceived as most attractive, then the gradients most likely would have been centered on relatively small-ratio stimuli. Further evidence that participants' responding was under the appropriate stimulus control comes from the results of the two discrimination conditions. When the S– was a relatively small ratio, the gradient shifted toward relatively large ratios, and when the S– was a relatively large ratio, the gradient shifted in the opposite direction.

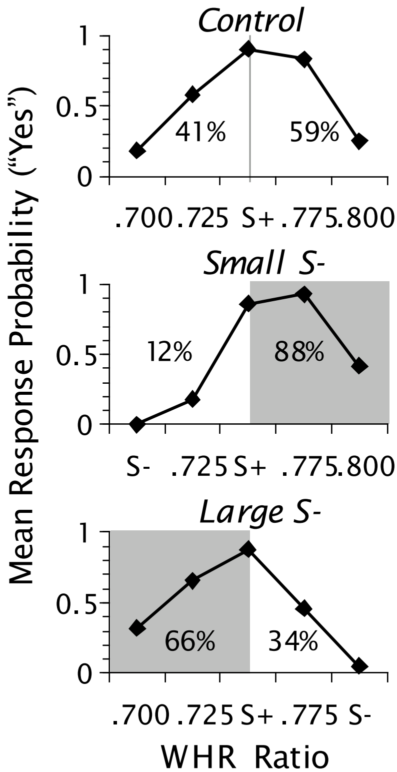

Figure 2. Generalization gradients for the three conditions. The percentages listed on each graph indicate the proportion of responses to stimuli on either side of the S+. The side of the dimension opposite the S– has been shaded gray.

The figure shows that the degree of gradient shift depended somewhat on the relative position of the S–. When the S– was a relatively small ratio, the shift in the gradient was fairly pronounced, including a shift in the modal response. By comparison, when the S– was a relatively large ratio, the shift away from the S+ was fairly modest. However, this imbalance is not unexpected, given that the results from the control condition suggest that participants had greater difficulty discriminating among the larger-ratio images than the smaller-ratio ones. A comparison of the three generalization gradients shows that the mean response under the control condition (0.754) was roughly equidistant between the means for the two discrimination training conditions (0.742 and 0.767, respectively, for the relatively large-ratio and small-ratio S–). A within-subjects analysis of variance based on the individual mean responses indicated that the differences in responding under the three conditions was reliable, $F(2, 28) = 16.25$, $p < 0.001$. Fisher's least-significant-difference test further showed that the differences among the three combinations of conditions also reached the level of statistical significance ($p = 0.01$ for control vs. small-ratio S–, $p = 0.03$ for control vs. large-ratio S–, $p < 0.001$ for small-ratio vs. large-ratio S–).

Discussion

The present research extends the finding of gradient shifts to a stimulus dimension deemed to be of biological significance. Participants were trained to respond to an S+ that consisted of an image of a woman with a moderately small WHR. When the S– was equivalent to the "optimal" WHR, participants subsequently responded with disproportionate frequency to images with relatively large ratios, and when the S– was equivalent to the approximate mean WHR for adult women, the same participants responded with disproportionate frequency to images with relatively small ratios. In other words, both discrimination-training conditions resulted in a shift in the generalization gradient away from the S–.

The repeated exposure of a single group of participants to multiple training conditions is a unique feature of the present investigation. Between-groups designs characterize both human- and nonhuman-based research on stimulus generalization, because experiences with one training condition normally may carry over and affect performances under subsequent conditions. To circumvent this problem, the present procedure included a set of images for each of the conditions that was qualitatively unique, even though some quantitative aspects of the stimuli were held constant. Judging by the consistency of the findings with precedent and the reliable differences across conditions, it would appear that the procedure has internal validity.

The degree of gradient shift that was observed in this study seems modest by comparison with the robust role ascribed to "peak shift" by some researchers (Gamberale & Tullberg, 1996; Gamberale-Stille & Tullberg, 1999; Ghirlanda & Enquist, 1998, 1999, 2003; Leimer et al., 1986; Ramachandran & Hirstein, 1999; Weary et al., 1993; Zimmer, 2003). However, the present results are consistent with other investigations of gradient shifts in humans, which have shown that it is not uncommon for the area under the gradient to shift while the modal response remains unchanged (e.g., Derenne & Breitstein, 2006; Galizio, 1985; O'Donnell, Crosbie, Williams, & Saunders, 2000; Spetch et al., 2004; Thomas, Windell, Williams, & White, 1985). The degree of shift that occurs may be affected by a number of variables not presently under consideration, such as the preexperimental learning history of the individual and the manner in which the generalization test is performed (see Thomas, 1993, for a review). Therefore, the present findings do not preclude the possibility that more dramatic effects might occur in differently designed studies or in nature.

Regardless of the magnitude of the effect, the present research suggests that the processes involved in gradient shifts may play a role in how women and men respond to cues for physical attractiveness. If correct, then a better understanding of gradient shifts may add to researchers' understanding of some problematic phenomena concerning such cues. For example, the eating disorder anorexia nervosa is characterized in part by a perceptual distortion that causes the sufferer to believe that she is overweight even when she is not (for a recent review, see Levine & Smolak, 2006). To briefly speculate on how such an effect might be related to gradient shifts, it is possible that the victim's learning history has made larger body sizes de facto negative stimuli and that the distortion is similar to the bias for stimuli displaced away from the S– found in studies of gradient shifts. Individual differences in such a learning history may also help explain why some women develop eating disorders and others do not. Findings from basic research indicate that gradient shifts are most likely to arise if the individual cannot easily discriminate the S+ from the S– (cf. Derenne, 2006); by extension, a young woman would be expected to be most at risk for developing perceptual distortions about her appearance if the body type she has been trained to avoid (S–) is minimally different from one that is healthy and normal (S+).

Considerable additional research is needed, however, to establish that gradient shift may plausibly be involved in the development of eating disorders or other perceptual biases in humans. While the present research does show gradient shifts with a biologically significant stimulus dimension, there are a number of differences between the judgments that participants were asked to make in this study and those that take place outside the lab. For example, in the present case the images were manipulated and comparisons were across different versions of the same woman rather than between different women. Also the range of WHRs (0.700 to 0.800) was narrower than that found in nature. Furthermore, basic laboratory research will also have to determine whether gradient shift–like phenomena affects not only accuracy in recognition but also preference for certain members of a stimulus class. A change in preference is of course central to the perceptual distortions accompanying anorexia nervosa. The affected woman not only misperceives her physical appearance but also wishes to change it. Presumably, gradient shifts can explain such changes. For example, herring gulls prefer unnaturally large eggs over their own brood (Baerends, 1982) because the offspring from small eggs (the "S–") have a lesser rate of survival (cf. Ghirlanda & Enquist, 1998, 2003). As for WHR, it's possible that men's preference for relatively small WHRs (Furnham et al., 2005; Henss, 1995; Singh, 1993; Streeter & McBurney, 2003; Weeden & Sabini, 2005) is the result of a shiftlike process, given that larger WHRs correlate with poorer health and reproductive fitness (e.g., Bray, 1992; Price et al., 2006; Rexrode et al., 1998; Wass et al., 1997). However, experimental demonstrations of this effect are as of yet absent from the research literature.

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