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Categorization and Holistic Perception

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CATEGORIZATION AND HOLISTIC PERCEPTION

By

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Introduction

Does expertise change perception? McKone, Kanwisher and Duchaine (2007) argued that it is an "…uncontroversial fact that experience influences perception" (p. 8). A more controversial question though, is "…whether the processes of face recognition and expert object recognition are mediated by the same or different mechanisms?" A popular topic in the domain of expertise is the face recognition process. Faces are interesting because "most adults are considered experts in the identification of faces (Tanaka & Curran, 2001), while according to Diamond and Carey (1986) "most individuals do not have representations of even 10 dog faces or airplanes or stick figures, let alone hundreds of thousands." At the base of face-recognition research is the idea of holistic processing (Richler, Cheung & Gauthier, 2011).

Research findings support the claim that faces are processed holistically (see Farah, Tanaka & Drain, 1995). Furthermore, other findings show that holistic processing can inform us on the mechanisms of object recognition. Holistic processing is defined by Richler and Gauthier (2014) as "…the tendency to process all parts together" (p. 1282). McKone, Kanwisher and Duchaine (2007, p. 10) reported that, "more direct measures of holistic processing confirm face-like holistic processing does not occur for objects of expertise," and argued against the expertise hypothesis in support of domain-specificity instead. Domain specificity argues that "face recognition involve[s] face-specific cognitive and neural processes" (McKone, Kanwisher, & Duchaine, 2007). While a contrasting study reported that "holistic processing predicts expertise for both face and non-face objects," however, "face perception relies on holistic processing more than object perception to maximize configural information" (Richler, Cheung, & Gauthier, 2011, p. 4 & 5). In this study, Richler et al. (2011) used a combination of the Cambridge Face Memory Test, the complete design of the composite task, and a face identification task. Tanaka and

Gauthier (1997) in a study testing the expertise hypothesis, came to similar conclusions. The expertise hypothesis claims that face recognition is not special in a biological or computational sense, but like other forms of object expertise, is acquired through extensive training and experience (Tanaka & Gauthier, 1997). Their first study, which tested three groups of experts against novices in a two-choice recognition test, did not find any evidence to support the influence of expertise on holistic recognition of non-face objects. However, they found that "holistic processing is not exclusive to faces, but that recognition of other objects can rely on holistic representations, albeit to a lesser extent than faces" (Tanaka & Gauthier, 1997, p. 113). Holistic processing might be a face-specific mechanism with biological explanations or a mechanism developed from learning over time. If it is the latter, then using perceptual training to develop experts of non-face object classes should result in the use of holistic processing in those experts for their objects of expertise. This study was interested in using training to induce holistic processing for a specific stimulus set created in the lab. We included an inversion manipulation as it is indicative of holistic perception in experts. It will also allow us to observe if training with this stimulus set leads to perceptual expertise.

Inversion

The face inversion effect is important because it can tell us whether the underlying mechanisms of face and object recognition are similar. The face inversion effect is defined as severely impaired recognition of inverted faces compared to upright faces (Farah, Tanaka & Drain, 1995), and other inverted non-face objects of expertise (Diamond & Carey, 1986). Farah et al. (1995) asked why face recognition is so sensitive to orientation, and pointed out that answering that question would allow us to understand how visual information for face recognition differs from that of other objects. Are faces orientation sensitive because of face-specific mechanisms or mechanisms related to experience? If experience is the key factor, then non-face objects of expertise should result in similar inversion effects seen in faces. The inversion effect could be caused by perceptual sensitivity to second-order relational properties or holistic perception. Diamond and Carey (1986) suggested that second-order relational properties are especially important for, but not confined to, the face inversion effect. Second-order relational properties are used to individuate members of a class with a shared configuration (Diamond & Carey, 1986). They “refer to the spatial configuration between the parts of a stimulus on the one hand and the central tendency or prototypical spatial configuration of its parts on the other” (Tanaka & Farah, 1991, p. 368).

Holistic Processing

Farah et al. (1995, p. 629) tested the hypothesis that face recognition is different from other familiar object categories because faces are recognized as relatively undifferentiated wholes. The first experiment used dot patterns and color manipulations sub-patterns. They taught people to identify [upright] dot patterns that either shared or did not share a common configuration. Results showed inversion effects, such as those found in faces, when participants were induced to represent the patterns as wholes. In their second experiment, face stimuli were used to portray that the face inversion effect could be eliminated when faces were represented in terms of their constituent parts by participants (Farah, Tanaka & Drain, 1995). Their results showed that faces failed to produce an inversion effect when they had initially been studied as separate parts.

Richler and Gauthier (2014) were also interested in the relevance of holistic processing regarding the difference between faces and objects. They cited many studies in which holistic processing was achieved for some categories of objects of expertise and concluded that the mechanism of holistic processing is not special to faces but occurs because of one’s expertise with faces. Richler and Gauthier (2014) also discussed findings of expert holistic processing and Fusiform Face Area (FFA) activity summarizing that some categories of expert object can recruit the FFA.

Finally, Richler, Cheung and Gauthier (2011) pointed out that face recognition and holistic processing had never been linked empirically. They used the complete design of the composite task to reevaluate the finding from Konar, Bennett and Sekuler (2010) that suggested no relationship between face recognition and holistic processing. They found that holistic processing predicted individual differences in face recognition, with the larger effect of holistic processing correlating with better face recognition performance" (Richler, Cheung & Gauthier, 2011).

Purpose of the Study

Ultimately, we aimed to study the neural mechanisms of perceptual expertise with a new stimulus set created in the lab. First, this experiment was conducted to explore if perceptual training results in perceptual expertise in this new stimulus set. Using inversion and the composite effect as a measure of holistic and configural processing, the results of some studies have suggested that training increases holistic and configural processing. Gauthier and Tarr, (1997) tested training effects on sensitivity to configural manipulations (in Tanaka and Farah, 1993) in novices and experts using the Greeble stimulus set. One of their findings implied that expertise training increased sensitivity to configuration in experts. Gauthier et al. (1998) also studied expertise training. Their results suggested that Greeble experts used holistic and configural processing. In both Gauthier and Tarr (1997) and Gauthier, Williams and Tanaka (1998) studies, the stimulus set consisted of Greebles. In the present study, we trained participants to name exemplars in this new stimulus set. This was done to enable comparison in the magnitude of the inversion effect in the trained set to a similar set of untrained stimuli.

Method

Participants

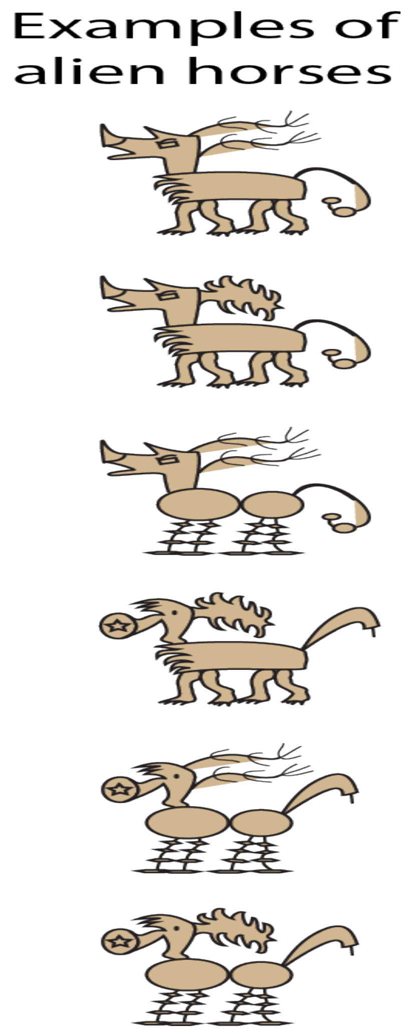
Participants were 3 female undergraduate students from Florida State University. They were paid $10 per hour.

Measures

Dependent measures were accuracy and reaction time (RT). Accuracy in the naming task was the proportion of trials with correctly named stimuli. Reaction time was how long it took the participant to press the key corresponding to the first letter in the name of the displayed alien. Accuracy in the sequential matching task, was the subject’s ability to correctly differentiate between a pair of successively presented stimuli. Calculation of the participant’s reaction time began after the display of the second alien in the pair.

Stimuli and Design

The experiment used two-stimuli sets, consisting of cartoon animals created in the lab. One of the sets contained “alien horses” and the other contained “alien fish”. There were 32 horses and 32 fish. Each stimulus had five discrete features, each with two possible values (two kinds of head, body, tail, feet, mane, eyes, and nose). The members of the categories (horses and fish) shared many features with the other members of their category, and were very dissimilar from members of the other category. Examples of the horses are shown below.



Procedure

Training

Training was comprised of a naming task, with a verification task following each level. Twenty aliens were presented in groups of four over the course of five levels. In each level, they saw four new aliens along with their labels first and then naming practice occurred. During naming practice, the participant was presented with one of the aliens they had just learned which remained on the screen until the participant pressed the key corresponding to the first letter of the alien's name. Feedback was displayed for 700ms, and subjects did not move on to the verification task until they had received 100% accuracy on the naming task. Next, in the verification task, the name of an alien was presented for 400ms followed by an alien until the participant responded. They had to decide if the name displayed matched the alien presented by pressing the S key for 'Yes' and the L key for 'No'. After all twenty names had been learned, the participants continued to practice naming and verification with all twenty stimuli but were instructed to focus on speed and accuracy. Training consisted of six sessions over a period of six days, each lasting about 1 – 2 hours. Participants were put in either a condition where they learned only about horses or a condition where they learned only about fish.

Perceptual Task

Subjects were then tested on the effects of training via a sequential matching task in which they had to judge whether stimuli were the same or different. They were tested on both the trained and untrained stimulus sets. Within a trial, participants were briefly exposed to a stimulus for 80ms, which was immediately followed by a mask for 500ms., then the second stimulus until they responded. Subjects responded same or different by pressing the S key and L key respectively. Testing also included a manipulation of inversion in which both the stimuli in the trial were either upright or inverted. The task included sixteen blocks of twenty trials each. Each block included twenty randomly selected "different" stimulus pairs and ten "same" pairs, half upright and half inverted, in random order. Half of the blocks consisted of trained stimuli and half of untrained stimuli.

Results

Training Performance

Two participants reached level six of the naming task. Although the remaining participant completed the tasks, long periods of time between sessions in addition to too many breaks resulted in overall low accuracy. On the sixth day of training, average accuracy for subjects 1 & 2 on trial blocks one through six was 89%, 90%, 88%, 90% and 91% respectively. The corresponding verification tasks had an average accuracy of about 80%. The RT ranged between .88 – 3.3s. The corresponding average reaction time for the verification task was approximately .8s. In the naming task, subject two was more accurate while subject one was faster. In the verification task, subject two was both more accurate and faster.

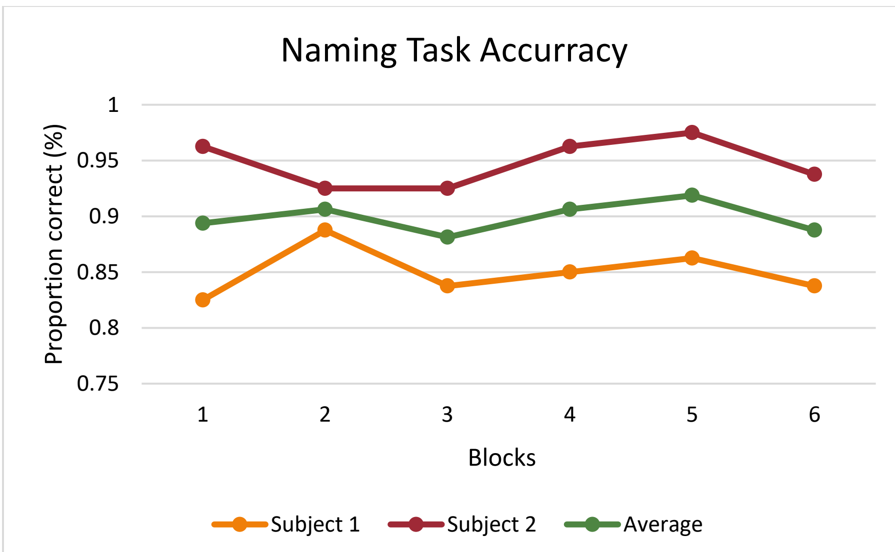


Figure 1. Both subjects followed a similar accuracy trend throughout the task except for during block two when subject 2 decreased while subject three increased in accuracy. Overall, subject 2 performed better.

Perceptual Task

Only one of the two individuals who reached level six (i.e. learned all the names) finished the perceptual task. The data from the subject who did not do well on the naming task, was included because he/she the only other person to complete the perceptual task. On average for all conditions – inverted trained, inverted untrained, upright trained, upright untrained – distinguishing between aliens with four features in common was the most difficult with regards to accuracy. Focusing in on the most difficult four-feature condition, the following pattern was observed. The trained conditions were more accurate at around 60% than the untrained conditions which were about 40%. For the trained condition alone, neither inverted nor upright were significantly more accurate than the other. This trend in the average data was mostly driven by subject two, while subject three was generally lower than average except for in the upright condition. RT averages did not differ significantly for either condition or category.

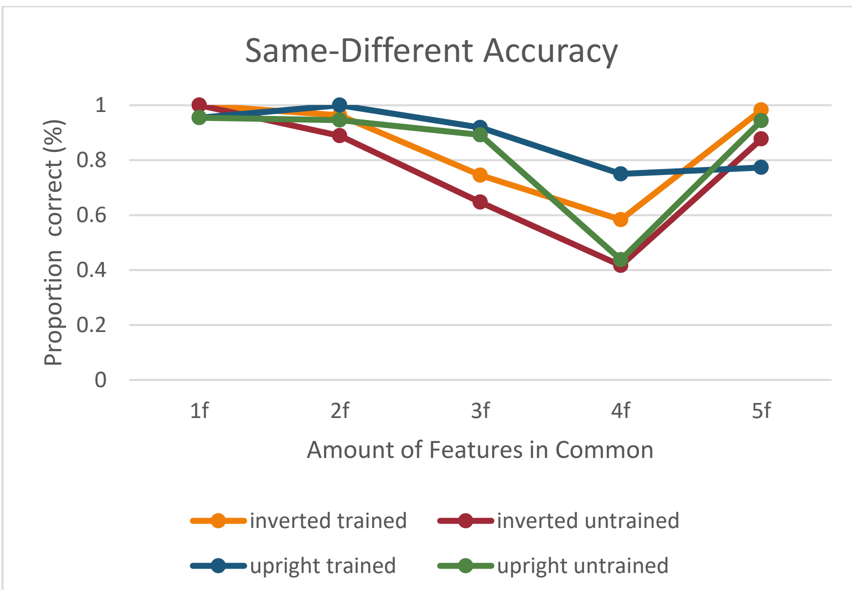


Figure 2. Accuracy in the Perceptual Task for subject 2, who completed training with high accuracy. The untrained conditions have the lowest accuracy when aliens have four features in common. All conditions performed well with one and all features in common.

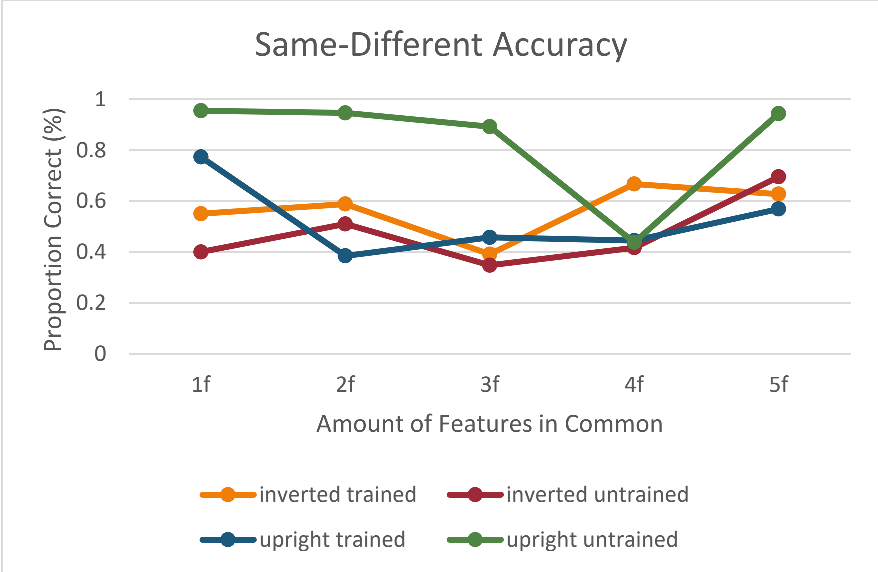


Figure 2. Accuracy in the Perceptual Task for subject 3.

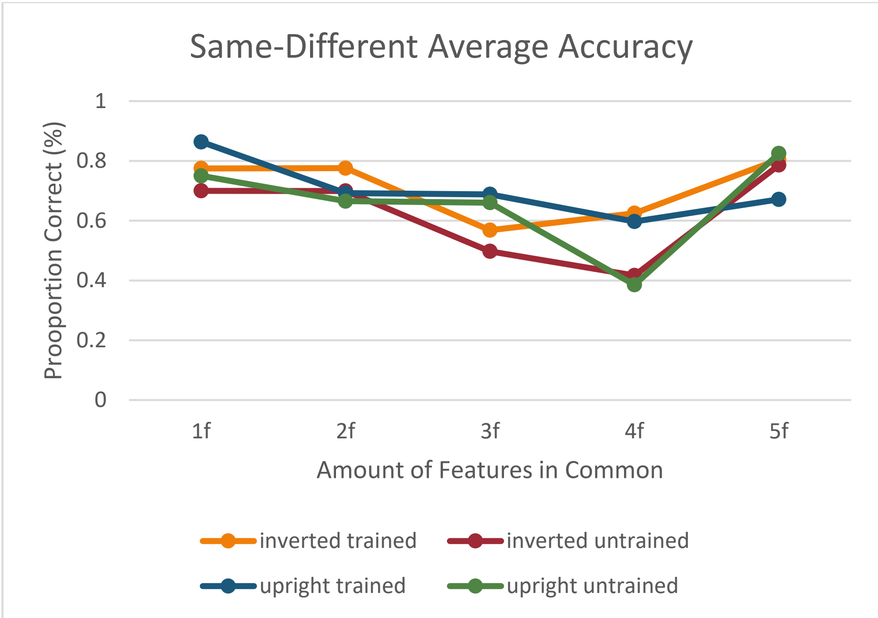


Figure 3. Trained conditions are more accurate than the untrained condition.

Discussion

Our results show that two of the three subjects learned the names of all twenty aliens, while the third failed, probably due to inconsistent attendance. For the subject that learned the names and performed the perceptual task, a training effect provides evidence that the learning that took place during training changed the subject's perception of the aliens. A training effect can be observed when the trained condition performs more accurately than the untrained condition (see Figure 4.). This occurred in the most difficult condition in the perceptual task – when aliens in the stimulus pair had four features that were the same and only one that was different. Accuracy for both upright trained and inverted trained was around 60%, while accuracy for both untrained conditions was around 40%.

Finally, in the experiment we were looking for evidence that training lead to holistic perception. We found some evidence to support this while looking at the four-feature condition for the upright trained condition. Subject 2 was more accurate for the upright than in the inverted trained condition, whereas the untrained conditions did not differ.

This observation provides evidence that training leads to holistic processing because the results indicate that with training, accuracy decreases in the inverted condition – except for when all five features were identical. The implication here is that holistic processing developed but was disrupted in the inverted condition. As mentioned before, studies have demonstrated that training increases holistic processing and configural processing, and Richler, Cheung and Gauthier (2011) suggested that "[t]o facilitate extraction of configural information, people process faces holistically…" (p. 1). Configural processing is defined by Gauthier et al. (1998) as "the ability to take into account the precise relations between different parts of objects as well as the parts themselves" (p. 2413). Gauthier and Tarr (1997) studied how changes in configuration affected processing by using stimuli, known as Greebles, created to be similar to faces. They trained participants on what they called a Studied—configuration condition and tested them on that condition in addition to a Transformed-configuration and an Isolated-parts condition. They expected comparable performance in the three conditions if it was the case that subjects processed Greeble parts separately (Gauthier & Tarr, 1997). However, they believed performance would be better in the Studied-configuration condition for experts in the upright orientation if configural processing for the stimulus set occurred (Gauthier & Tarr, 1997). They found that they could train novices into experts, who were not only faster and more accurate but displayed a greater sensitivity to configural changes, and that sensitivity occurred with experts even when this change was performed on a part that they were instructed to ignore (Gauthier & Tarr, 1997). When comparing the Studied-configuration to the Transformed configuration, experts were faster in the studied condition for the upright orientation. This implies that inversion caused differentiation of Greeble parts. In a multi-experiment study on whether faces are special, Diamond and Carey (1986) used experiment three to test dog experts and novices on their sensitivity to orientation of dogs and faces. For faces, both experts and novices performed better when the stimulus was upright. For dogs, experts were extremely more sensitive to inversion compared to novices who were equally accurate in the upright and inverted conditions.

In this experiment, not only was the stimulus set learnable but training seemed to lead to expertise because of the observed inversion effect for Subject 2. The fact that subjects could learn the alien names is pertinent to our ultimate goal of studying the neural mechanisms of perceptual expertise. Observation of the inversion effect was important for this experiment because it indicated that subjects were practicing holistic and configural processing – which are processes characteristic of experts of faces *and* other non-face objects. The observed inversion effect was not large; however, a bigger sample size could be used to test this experiment again.

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