Feature learning during the acquisition of perceptual expertise

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Schyns, Goldstone, and Thibaut argue that new features will evolve when an object class cannot be represented using previously-developed features. We are sympathetic with the authors' point of view that the human object recognition/categorization system is plastic, without a fixed feature vocabulary. But does feature evolution necessarily stop once we have acquired sufficient features to perform a given recognition task? A novice birdwatcher may quickly develop a collection of features for distinguishing different species of hawks, but this feature set may not be ideal. With extended practice, the novice may be able to develop a more sophisticated feature space that allows her to perform more accurately and/or quickly. Our work on perceptual expertise (Gauthier & Tarr 1997; Gauthier, Williams et al. 1997) provides support for the idea that feature learning and reorganization can continue even after an initial set of features is available to represent a novel class of objects.

The stimuli we have employed, "Greebles" (Figure 1a), are easily decomposable into constituent parts. Moreover, participants unfamiliar with Greebles (novices) can learn to identify individuals without difficulty, indicating that people in our participant pool (undergraduates) either already possess the features necessary to categorize Greebles, or can develop the needed features almost immediately. According to Schyns et al., these conditions should lead to "fixed-space" learning: distinctions between different Greebles should continue to be made using the features participants use during their initial encounters with the objects.

However, when participants were trained for many hours on Greeble recognition (Gauthier, Williams et al. 1997), we found that their response times on a Greeble-naming task continued to go down even after they reached near-perfect accuracy levels (Figure 1b). Furthermore, correlational analyses of the response time data showed that the Greebles participants found easiest to recognize at the beginning of training (when they were novices) were not necessarily the easiest to recognize once they became experts. These findings indicate that perceptual learning, and possibly feature differentiation, continues even when features sufficient to recognize the Greebles have already been acquired.

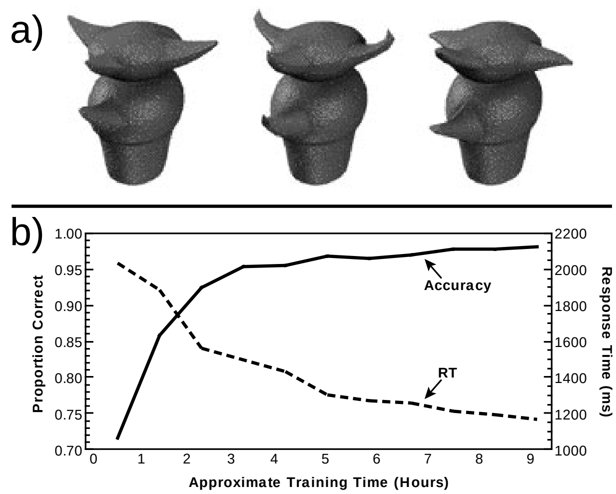

Figure 1: a) Three Greebles from our studies of perceptual expertise. All Greebles share the same part structure, but each one has uniquely-shaped appendage parts. b) Training results from a Greeble expertise experiment. The plot shows accuracy and response times for a series of tests (performed over the course of 10 one-hour training sessions) in which participants had to name up to 20 individual Greebles (Gauthier, Williams et al. 1997).

Once the training regimen was completed, these "Greeble experts" learned to name new Greebles faster than novices, and more importantly, showed qualitative differences, compared to novices, on tests such as the Tanaka and Sengco (1997) old/new configuration task. In this test, participants are asked to identify one portion of a known Greeble that is presented either in the normal (old) Greeble part-configuration or in a transformed (new) configuration, for example with the top, side-attached parts rotated fifteen degrees around the vertical axis towards the front. Experts, but not novices, were significantly impaired at recognizing parts in new configurations (Gauthier & Tarr 1997; Gauthier, Williams et al. 1997), again indicating that experts had developed qualitatively different ways of representing Greebles even though "novice features" could have provided a sufficient basis for Greeble identification.

These and other results from our studies suggest that the simple featural contrasts that may be used by perceivers when they first learn to discriminate between members of an object class may not be used by the same perceivers once they become highly familiar with the class. While broadly consistent with Schyns et al.'s feature-creation framework, our findings challenge the proposition that the feature space ever becomes fixed. In other words, an expert's feature space may become reorganized in response to environmental pressures to perform a categorization task more efficiently. Perhaps *every* encounter with an object of a class leads to a small amount of feature-space reorganization. Such a mechanism would not only lead to constant improvements in performance (as long as such improvements are possible), but would also do away with the need to "decide" when a given learning task requires fixed-space and when flexible-space learning.

If our hypothesis is correct, then at least two important questions need to be answered. First, what are the environmental pressures that cause an expert's feature space to become reorganized? In our studies, participants were explicitly instructed to perform as quickly as possible; similarly, our birdwatcher would be under similar time pressure, as she may get only a fleeting glimpse at a to-be-identified hawk. A natural history museum curator, on the other hand, would have ample time to examine birds for his exhibits, but would want to be exceedingly accurate. Still another form of expertise might be exhibited by a falconer, who needs to identify the best way to handle individual hawks. We hypothesize that these situations would all lead to different feature spaces, even though the visual stimuli would be the same in each case.

A second issue is how feature reorganization might be accomplished. Preliminary data from a longitudinal fMRI study (Gauthier, Tarr et al. 1997) indicates that a particular area in ventral temporal cortex may become increasingly important over the course of training for Greeble recognition. Neurons in this area thus appear to be particularly well-adapted for processing and encoding features that support the fine metric discriminations needed for fast and accurate identification at the individual level, but extensive training seems to be necessary to tune these neurons to the particular types of features found in a given object class.

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