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OBSERVATION

Training Experts: Individuation Without Naming Is Worth It

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There is growing evidence that individuation experience is necessary for development of expert object discrimination that transfers to new exemplars. Individuation training in human studies has primarily used label association tasks where labels are learned at both the individual and more abstract (basic) level, and expertise criterion requires that individual-level judgments become as fast as basic-level judgments. However, there are training situations when the use of labels is not practical (e.g., with animals or some clinical populations). Moreover, labeling itself can facilitate object discrimination, thus it is unclear what role labels play in the acquisition of expertise in such training paradigms. Here, participants completed an online game that did not require labels in which they interacted with novel objects (Greebles) or control objects (Yufos). Games either required individuation or categorization. We then assessed the impact of this exposure on an abridged Greeble training paradigm. As expected, participants who played Yufo games or Greeble categorization games showed a significant basic-level advantage for Greebles in the abridged training paradigm, typical of novices. However, participants who played the Greeble identity game showed a reduced basic-level advantage, suggesting that individuation without labels may be sufficient to acquire perceptual expertise.

Keywords: perceptual expertise; individuation; labels

Individuating objects rapidly and accurately is important to many aspects of our lives, from face perception to skilled identification of objects in our work or hobbies. Several studies have used laboratory training paradigms to model such expertise and have concluded that generalization of skilled subordinate-level discrimination to new exemplars can be obtained following practice individuating objects, but not through mere exposure or even practice categorizing at more abstract levels (Nishimura & Maurer, 2008; Scott & Monesson, 2009; Tanaka, Curran, & Sheinberg, 2005; Williams McGugin, Tanaka, Lebrecht, Tarr, & Gauthier, in press; Wong, Palmeri, & Gauthier, 2009). However, most studies that teach humans to individuate objects present two independent challenges for participants: learning to use diagnostic perceptual information to discriminate individuals, and learning to associate specific labels with objects. One example is the Greeble training paradigm that was originally developed to study the acquisition of holistic processing, an important hallmark of expertise with faces (e.g., Gauthier, Williams, Tarr, & Tanaka, 1998). In this paradigm, participants are taught to associate labels to novel objects at both family (basic) and individual (subordinate) levels. The “basic-level advantage” (faster responses to basic than subordinate labels) is a ubiquitous phenomenon that is reduced and can even disappear in real-world experts (Tanaka & Taylor, 1991). Training Greeble experts therefore involved training participants until subordinate responses were as fast as basic responses. This criterion is associated with increased holistic processing and faster learning of new exemplars at the subordinate level (Gauthier & Tarr, 2002; Gauthier et al., 1998). Because labels have played a central role in the development of such training paradigms, we ask whether the use of individuating labels during training is critical for the advantages that individuation training has shown in human studies.

Labels influence other types of learning paradigms, for instance facilitating the acquisition of new categories in adults (Lupyan, Rakison, & McClelland, 2007) and discrimination at the individual level in infants (Xu, 2002). Objects are more easily discriminated

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when they belong to different linguistic categories (Gilbert, Regier, Kay, & Ivry, 2006; Roberson & Davidoff, 2000). Thus, naming objects, rather than individuation per se, could be an essential component of training paradigms developed to study expertise in the laboratory.

We developed an online game that did not use labels. Games required either individuation (targets defined by identity), or categorization (targets defined by orientation—facing right or left). We then assessed the impact of this label-free exposure on an abridged Greeble training task. If naming is not necessary for acquisition of expertise, participants who individuated Greebles in the game should show a reduced basic-level advantage (smaller response time differences between family and individual level name verification) when learning new Greebles. To test the specificity of training without labels we included identity and categorization games using a control category (Yufos) before the abridged Greeble posttest. We expected no generalization between Yufos and Greebles, and thus no difference between the two Yufo groups for Greeble verification. Yufo training also served as a baseline to investigate whether any differences in basic-level advantage for Greeble groups was because of facilitation and/or interference.

Method

Participants

Participants ($N = 126$) were recruited using advertisements posted on academic Websites and on college campuses. Three participants were excluded for using incorrect keys, and five for chance performance, leaving 118 (59 female, mean age = 23.1; 30 in each identity condition, 29 in each orientation condition). Participant names were entered into a draw for a cash prize.

Materials

The online study was programmed in Flash and data were collected on a secure server. The game used 30 Greebles or 30 Yufos (see Figure 1), novel objects used in prior work (Gauthier, James, Curby, & Tarr, 2003; Gauthier & Tarr, 2002). For all participants, a critical test included a label-learning task using 30 previously unseen Greebles (15 from each of two families). Greebles can be identified individually by the shape of their appendages, or categorized into two families with the appendages pointing up versus down. Body shape varied, but was nondiagnostic. Phonologically plausible nonwords were used for family and individual labels as in previous studies.

Procedure

Participants were randomly assigned to one of four "preexposure" games that varied object class (Greeble or Yufo) and target criteria (identity or orientation). The games were modeled after the classic "Space Invaders" video game (see http://www.spaceinvaders.de/). Each trial consisted of nine invaders moving laterally across the screen and downward toward the participant's avatar. Initial identity and orientation (facing left vs. right) of each invader was random for all games. In the orientation condition, the avatar was a laser gun and invaders were in target status if they were facing right, regardless of identity. In the identity condition, the avatar was a Greeble or Yufo (corresponding to the participant's assigned object condition) whose orientation and identity was randomly determined for each trial; invaders were in target status if they matched the identity of the avatar, regardless of orientation. Pressing the *Z*-key produced a laser beam that changed the target status of an invader on contact. Pressing the *X*-key produced a beam that eliminated an invader in target status. After successfully completing 200 trials, participants proceeded to the expertise-training phase. Participants could pause and resume the game as often as they wished, but were required to complete the experiment in 2 weeks.

Next, participants completed an abridged version of the expertise-training paradigm (Gauthier & Tarr, 2002) in which they learned to categorize 30 unfamiliar Greebles into two families and to individuate 10 Greebles. Training consisted of label learning and verification tasks. Family categorization training consisted of two types of blocks. In viewing blocks each of the 30 Greebles were presented centrally one at a time with family labels appearing above the Greebles. The Greeble and label remained until the participant pressed the key corresponding to the first letter of the

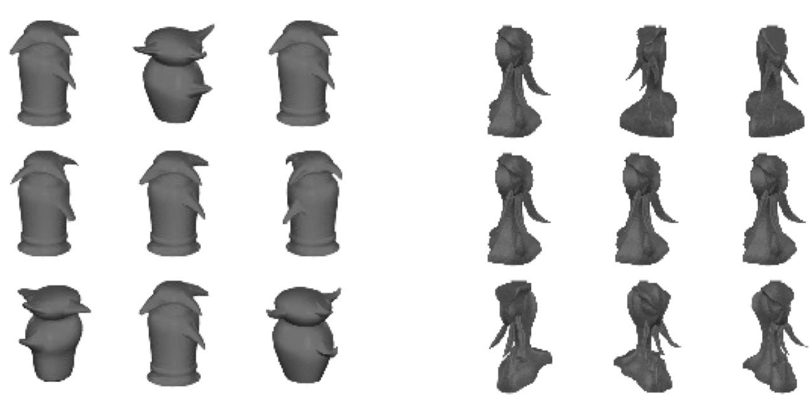

Figure 1. Sample Greebles (right) and Yufos (left) used in the invader games. In the games, targets were either defined by Greeble identity or by orientation (facing left vs. right). In the abridged expertise training paradigm, a different set of Greebles similar to those shown here were categorized by the direction of the appendages (upward vs. downward) and were individuated by the shape of the appendages.

family name. In test blocks, the 30 Greebles appeared without labels and the participant pressed the appropriate key from memory. A beep signaled an incorrect response. Training proceeded until participants reached a criterion of 27/30 correct in the test block. Identity training for the 10 critical Greebles followed with the same structure as category training except with individual labels.

Afterward, participants were instructed to complete the verification phase in one session. A label appeared centrally on the screen for 750 ms, followed by a Greeble that remained on the screen until the participant pressed a key indicating a match or mismatch. These trials included only the 10 individuated Greebles. There were 120 randomly ordered verification trials divided evenly across family and individual level, and across matching condition.

On average, participants took approximately 1.5 hr spread over 3.69 days to complete all phases of the experiment. All but one participant completed the verification task in one session, as instructed.

Results

Groups did not differ on number of trials attempted (M = 212) in the game or on number of blocks taken to learn family (M = 3.4) and individual (M = 5.3) label associations. To assess the impact of prior exposure on expertise acquisition, mean sensitivity (d') and correct response times (RTs) in the verification task were submitted to mixed factorial analyses of variance (ANOVA), with game category (Greeble, Yufo) and target criterion (individuation, orientation) as between subjects factors, and verification level (family, individual) as the within subjects factor. The ANOVA on sensitivity revealed no significant effects (M = 2.95), as expected from using an accuracy criterion in the training stage, and there was no evidence of a speed–accuracy trade-off (see Figure 2).

Correct RTs over 6,000 ms (1.84%) were excluded from analysis. The resulting mean RTs are displayed in Figure 3. Statistical analysis revealed a main effect of target criterion $F(1, 114) = 7.547$, $p = .007$, $\eta^2 = .062$, with participants in the orientation condition taking significantly longer to verify labels than participants in the identity condition. There was also a main effect of verification level, $F(1, 114) = 37.636$, $p < .001$, $\eta^2 = .248$, with verification of individual labels taking longer than verification of category labels. Importantly, there was a significant three-way interaction between game category, target criterion and verification level, $F(1, 114) = 5.166$, $p = .025$, $\eta^2 = .043$. To further investigate this interaction, we performed separate ANOVAs for each object category.

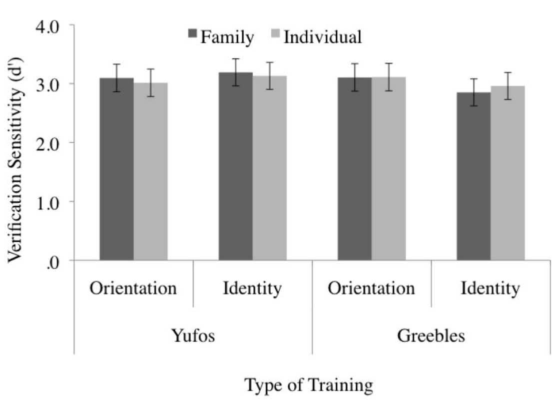

Figure 2. Mean sensitivity in the Greeble verification task as a function of prior exposure condition. Error bars represent 95% CI based on *MSE* from the three-way interaction of the omnibus ANOVA.

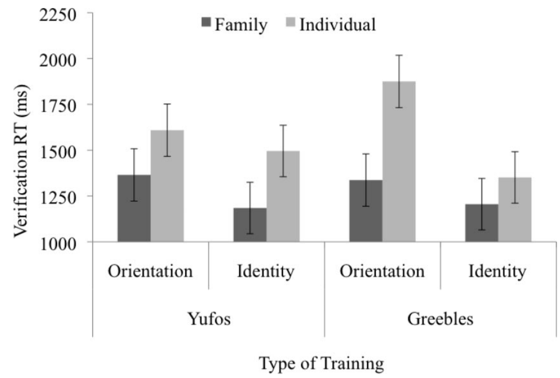

Figure 3. Mean response times in the Greeble verification task as a function of prior exposure condition. Error bars represent 95% CI based on *MSE* from the three-way interaction of the omnibus ANOVA.

Participants who played the Yufo games showed the typical novice pattern when learning to associate labels to Greebles, with faster responses to family than to individual verification trials as shown by a main effect of verification level, $F(1, 57) = 24.004$, $p < .001$, $\eta^2 = .296$. No other effects were significant. Pairwise comparisons confirmed a significant family level advantage in Greeble training for both identity $t(29) = 3.365$, $p = .002$ and orientation $t(28) = 3.796$, $p = .001$ Yufo conditions.

For participants who played the Greeble games, there was a main effect of verification level, $F(1, 57) = 16.739$, $p < .001$, $\eta^2 = .277$, and a main effect of target criterion, $F(1, 57) = 8.617$, $p = .005$, $\eta^2 = .131$. Importantly, these effects were modulated by a two-way interaction, $F(1, 57) = 5.501$, $p = .023$, $\eta^2 = .088$. Pairwise comparisons revealed that the typical RT advantage for family level verification was present only for the orientation condition, $t(28) = 3.653$, $p = .001$. In contrast, participants who individuated Greebles were on their way to expert-like performance, with statistically equivalent RTs for family and individual level judgments, $t(29) = 1.776$, $p = .086$.

To investigate whether these effects were because of facilitation versus interference, we conducted pairwise contrasts of verification RTs for Greebles versus Yufos. For family level verification, differences were small: RTs were 21 ms slower for Greeble than Yufo preexposure when identity was diagnostic, and 28 ms faster when orientation was diagnostic (ps > .82). At the individual level, differences were much larger: RTs were 144 ms faster for Greeble than Yufo preexposure when identity was diagnostic, but 266 ms slower when orientation was diagnostic. None of these contrasts were statistically significant, however, ps > .10.

Discussion

Using a gaming environment, we find that learning to discriminate individual objects without naming may be sufficient to acquire perceptual expertise. Whereas labels may give an advantage in some situations, they do not appear to be necessary. Furthermore, the effect of training without labels is specific to the class of objects trained, and appears to operate primarily on the speed at which new exemplars can be individuated, with little impact on categorization.

Comparisons with baseline, although not statistically significant, are similar to those of a previous study using label-based training (Wong et al., 2009): individuation experience facilitates individuation of new exemplars, whereas categorization experience interferes with individuation of new exemplars. Further studies with additional power and baseline conditions will be necessary to learn under what conditions experience without names can produce facilitation or interference in the acquisition of expertise but, in general, the pattern is consistent with the role of shared relevant dimensions in the transfer of learning between two tasks (Goldstone & Steyvers, 2001),

There are some caveats to our conclusions. We tested only the first stages of expertise acquisition and our data do not speak to the specific cognitive mechanisms underlying the reduced basic-level advantage. However, other recent studies showed marked improvements at the subordinate level that transfer to new exemplars with under 2 hr of training per category (McGugin & Gauthier, 2010; Wong et al., 2009). Our work and these studies suggest that some of the qualitative differences in the processing of objects and faces may arise quite early in learning the appropriate tasks for these categories. Importantly, the present work demonstrates that the interaction between individuation and categorization tasks on the basic-level advantage is found even when labels are not used. Our method can allow for meaningful contrasts of human and animal expertise. In addition, these results are promising in terms of implicit training protocols for perceptual expertise in populations with verbal or memory difficulties.

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