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Research Article

Conditions for Facelike Expertise With Objects

Becoming a Ziggerin Expert—but Which Type?

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ABSTRACT—*Compared with other objects, faces are processed more holistically and with a larger reliance on configural information. Such hallmarks of face processing can also be found for nonface objects as people develop expertise with them. Is this specifically a result of expertise individuating objects, or would any type of prolonged intensive experience with objects be sufficient? Two groups of participants were trained with artificial objects (Ziggerins). One group learned to rapidly individuate Ziggerins (i.e., subordinate-level training). The other group learned rapid, sequential categorizations at the basic level. Individuation experts showed a selective improvement at the subordinate level and an increase in holistic processing. Categorization experts improved only at the basic level, showing no changes in holistic processing. Attentive exposure to objects in a difficult training regimen is not sufficient to produce facelike expertise. Rather, qualitatively different types of expertise with objects of a given geometry can arise depending on the type of training.*

Debates about whether face processing is "special" or not center around whether hallmarks of face processing can also be found for processing of other objects of expertise. Generally, processing of faces and processing of nonface objects differ in two important ways: First, faces are processed more holistically than other objects, in that it is more difficult to selectively attend to a single face part than to an object part (e.g., Cheung, Richler, Palmeri, & Gauthier, 2008; Farah, Wilson, Drain, & Tanaka, 1998; Gauthier & Tarr, 2002; Richler, Gauthier, Wenger, & Palmeri, 2008; Richler, Tanaka, Brown, & Gauthier, 2008). Second, configural information about spatial relationships between parts is more important for face perception (e.g., Diamond & Carey, 1986; Gauthier & Tarr, 2002; Tanaka & Sengco, 1997). Some researchers suggest that holistic and configural processing occur because they are innate properties of face perception or reflect early developmental constraints (McKone, Kanwisher, & Duchaine, 2007). Other researchers suggest that configural and holistic processing reflect perceptual styles and attentional strategies that can be learned through expertise in discriminating between individuals within a category; this is referred to as the expertise hypothesis (Gauthier & Tarr, 2002). For example, a strategy to attend to all parts of an object (holistic processing) may be learned when configural relations between features are especially diagnostic of identity (Diamond & Carey, 1986; Le Grand, Mondloch, Maurer, & Brent, 2004; Leder & Bruce, 1998, 2000; Mondloch, Le Grand, & Maurer, 2002; Searcy & Bartlett, 1996).

As people develop expertise in nonface objects, they may exhibit holistic and configural processing of those objects as well. Participants trained with novel objects called Greebles have shown small but significant increases in both configural and holistic processing of Greebles (Gauthier & Tarr, 1997, 2002). Increases in holistic processing during the acquisition of Greeble expertise correlate with changes in the response of the fusiform face area to these objects (Gauthier & Tarr, 1997). Expertise with real-world objects also increases holistic processing: Cars in a normal configuration are processed more holistically than cars in an unfamiliar configuration, and this effect is directly related to the observer's level of car expertise (Gauthier, Curran, Curby, & Collins, 2003). These claims have not gone without debate, particularly regarding the appropriate task design and analyses for measuring holistic and configural effects (e.g., compare Robbins & McKone, 2007, and McKone & Robbins, 2007, with Cheung et al., 2008, Gauthier & Bukach, 2007, and Richler, Tanaka, et al., 2008). But putting methodological debates aside, researchers have yet to test one critical prediction of the expertise hypothesis: that expertise at individuating objects within a visually homogeneous category is

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specifically what causes participants to rely on configural information and to develop a more holistic processing strategy (Bukach, Gauthier, & Tarr, 2006; Gauthier & Tarr, 1997).

According to the expertise hypothesis, significant experience with novel objects that does not involve individuation should not produce facelike effects in configural and holistic processing. An example concerns a domain in which all literate humans acquire expertise—the orthographic characters of their language. Expertise with Roman letters or Chinese characters requires basic-level categorization, but variability due to font or handwriting should be ignored (Gauthier, Wong, Hayward, & Cheung, 2006). In the case of faces and objects in other domains in which expertise requires individuation, categorization among experts is as quick at the subordinate identity level as at the more general basic level (Tanaka, 2001; Tanaka & Taylor, 1991); for most other objects, categorization among experts is quicker at the basic than at the subordinate level (i.e., a basic-level advantage; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). The basic-level advantage for letters and characters is greater among experts than among novices (Wong & Gauthier, 2007). Configural and holistic processing have also been shown to diminish with letter and character expertise (Ge, Wang, McCleery, & Lee, 2006; Hsiao & Cottrell, 2009; van Leeuwen & Lachmann, 2004; but see Pelli & Tillman, 2007, and Simon, Petit, Bernard, & Rebai, 2007).

To date, there is little direct evidence that individuation training per se reduces the basic-level advantage and increases configural and holistic processing strategies. In fact, some evidence suggests that even mere exposure to objects can produce effects once thought to be the hallmark of facelike expertise (as reflected by, for instance, the N170 event-related potential; Peissig, Singer, Kawasaki, & Sheinberg, 2007; Scott, Tanaka, Sheinberg, & Curran, 2006, 2008). Few studies have compared effects of different training regimens using the same objects. One found that generalization of rapid individuation skills to new exemplars of a trained category follows individuation training but not basic-level categorization training (Tanaka, Curran, & Sheinberg, 2005). Another (Nishimura & Maurer, 2008) showed that individuation, but not basic-level categorization, of blob patterns resulted in higher sensitivity to metric differences in spatial relations among blobs. However, these studies compared a difficult training regimen with a far-easier training procedure that produced little evidence of learning. Also, none of these previous studies examined whether different training regimens produced differential changes in holistic processing of the learned objects.

In the study reported here, we compared the effects of individuation and categorization training with the same set of novel objects, holding object geometry and testing tasks constant. Instead of using the type of easy categorization-training procedures employed in previous studies, we aimed to train categorization experts by modeling some key components of experience with letters (Hsiao & Cottrell, 2009; Wong & Gauthier, 2007). Specifically, a large portion of categorization training was devoted to rapid, sequential basic-level categorization of objects within a spatial array. This task was designed to mirror some of people's experience with letter recognition when reading texts.

We examined holistic processing and its sensitivity to object configuration after training, using a composite task. Our primary hypothesis was that expertise at individuating objects within a visually homogeneous category is required for participants to develop a holistic processing strategy specific to the trained configuration of parts, and that experience categorizing at the basic level is insufficient.

METHOD

Participants

Participants were 52 undergraduate students, graduate students, and staff members at Vanderbilt University. Eighteen participants were assigned to the individuation-training group (12 females, 6 males; mean age = 24.06 years, $SD = 5.92$), and 18 were assigned to the categorization-training group (10 females, 8 males; mean age = 23.33 years, $SD = 5.63$). Sixteen additional participants without any prior training performed the composite task as a control group (4 females, 12 males; mean age = 27.63 years, $SD = 3.74$). All participants reported normal or corrected-to-normal vision. They were paid $12 per hour.

Stimuli and Design

Seventy-two novel objects, called Ziggerins (see Fig. 1), were created using Carrara 5 software (DAZ Productions, Inc., http://www.daz3d.com). There were six classes of Ziggerins, each defined by a unique part structure. Within each class, there were 12 styles, each defined by variations in the parts' cross-sectional shape, size, and aspect ratio. The same style variations applied across all six classes. This combination of class and style is analogous to six different letters in 12 different fonts. A pilot card-sorting study ($N = 13$) revealed that novices easily sorted the Ziggerins by class and by style.

Procedure

Training Regimens

Each participant in a training group was trained with 36 Ziggerins (selection randomized across participants); the remaining Ziggerins were reserved for the pretest and posttests. Computerized training occurred over ten 1-hr sessions. The individuation-training group learned individual names for 18 of the 36 Ziggerins, with the other 18 objects being used as distractors. The categorization-training group learned to categorize the 36 Ziggerins into the six classes. Two-syllable nonsense words (e.g., *xedo*, *kimo*) were randomly assigned as names for classes or individuals for each participant. Ziggerins were introduced progressively in Sessions 1 through 3; all 36 Ziggerins were included in Sessions 4 through 10 (see Table 1). For both

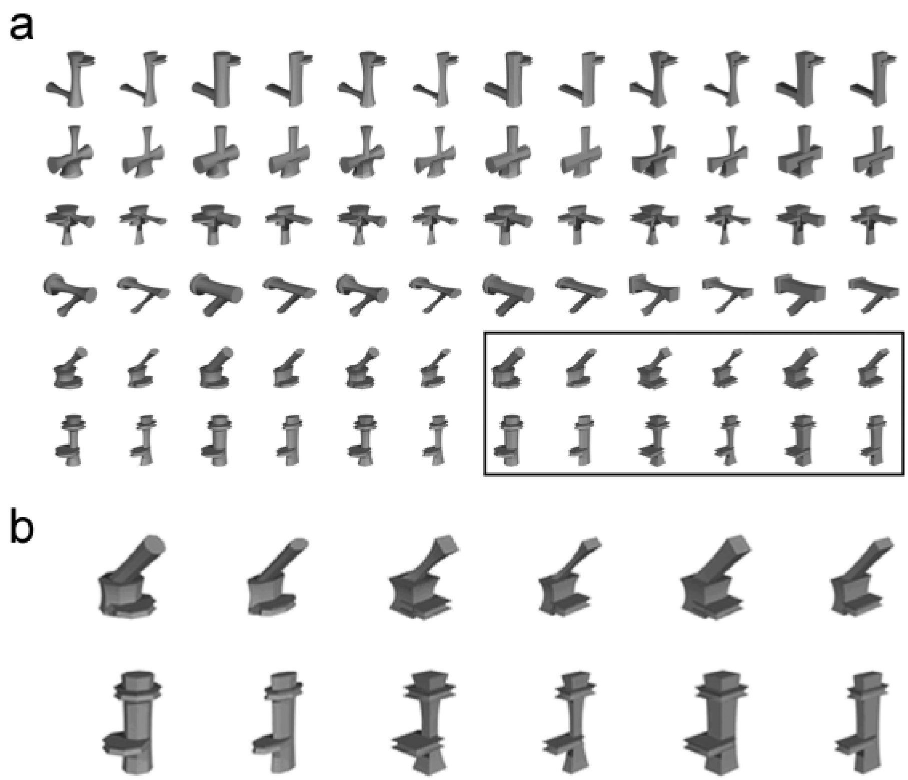

Fig. 1. The artificial objects (Ziggerins) used in the experiment. The Ziggerin set (a) consisted of six classes, shown here in separate rows. Each class had a unique set of parts and structure. The columns in (a) correspond to the 12 styles, defined by the parts' cross-sectional shapes, aspect ratios, and sizes. The subset of Ziggerins in the outline box is magnified for visualization in (b).

training regimens, each training session included three tasks (see Table 1 for the number of trials per task). In all tasks, both speed and accuracy were emphasized, and corrective feedback was provided. At the end of each training block (typically 28–36 trials), average accuracy and speed were displayed to the participant. From Session 4 onward, a rank table showed the participant's 10 best blocks, providing further motivation and encouragement for the participant to break his or her speed

TABLE 1
The Two Training Regimens

	Individuation training		Categorization training	
Session	No. of trials	Task	No. of trials	Task
Session 1 (12 Ziggerins)	360	Naming	360	Naming
	288	Verification	288	Verification
	288	Matching	84	Matrix scanning
Session 2 (24 Ziggerins)	360	Naming	360	Naming
	288	Verification	288	Verification
	288	Matching	84	Matrix scanning
Session 3 (36 Ziggerins)	360	Naming	360	Naming
	288	Verification	288	Verification
	288	Matching	84	Matrix scanning
Sessions 4–10 (36 Ziggerins)	360	Naming	216	Naming
	288	Verification	216	Verification
	288	Matching	112	Matrix scanning

Note. For individuation training, Ziggerins from two classes were presented in Session 1, exemplars from two more classes were introduced in Session 2, and exemplars from the final two classes were included from Session 3 onward. For categorization training, two styles of Ziggerins were presented in Session 1, with two more styles introduced in Session 2, and the final two styles included from Session 3 onward. Because the naming and verification tasks were relatively easy for the categorization group, the number of matrix-scanning trials was increased in Sessions 4 through 10.

record while maintaining high accuracy. In all tasks (except matrix scanning, as described later), each Ziggerin spanned a visual angle of 3.8°.

Individuation training was similar to prior Greeble training (Gauthier & Tarr, 1997; Gauthier, Williams, Tarr, & Tanaka, 1998). Each training session included three tasks: naming, verification, and matching. In *naming*, a Ziggerin was shown until the participant responded (by typing the first letter of its name). On 10% of trials, an unnamed object was shown, and the space bar was the correct response. In *verification*, an individual name appeared for 1 s; after a 200-ms blank screen, a Ziggerin was displayed until the participant responded ("match" or "nonmatch"). On nonmatch trials, the Ziggerin was another object from the same class as the named object or was a modified version of the named object (i.e., a part was altered or the object had a slight configural change). In *matching*, an individual name was shown for 1 s, followed by a blank screen for 200 ms; then, two Ziggerins appeared side by side until the participant indicated the location (left or right) of the object that matched the name. On 25% of trials, neither Ziggerin was the target, and the correct response was to press the space bar. The distractors were the same as in the verification task.

Categorization training was designed to teach participants names of Ziggerins at the class level and required them to rapidly categorize Ziggerins in the context of an array of other Ziggerins of the same style. Each training session included three tasks: naming, verification, and matrix scanning. Naming and verification were the same as in individuation training, except that (a) category names were used instead of individual names, (b) all objects were named and thus there were no unnamed objects, and (c) on nonmatch trials during verification, the distractor did not belong to the named class. In *matrix scanning*, an array of 40 Ziggerins appeared (5 rows × 8 columns), covering a visual angle of 15° × 26° (2.8° × 2.8° for each Ziggerin). Participants were told:

> The upper left object is your first target. Scan the matrix from left to right, top to bottom until you find another object identical to your target. The next object in the matrix then becomes your new target. Keep scanning the matrix until you find an object identical to this new target. Continue this process until you get to the end of the matrix. Press the space bar as soon as you get to the end. After pressing the space bar, type the first letter of the last target you were searching for.

Within each matrix, all Ziggerins had the same style, so that the task required only categorization at the class level. Matrices were carefully generated to conform to the following criteria: (a) Only five to seven target shifts occurred in each matrix, (b) each combination of two or three adjacent objects occurred as frequently as every other so that sequence learning would not come into play, (c) each Ziggerin had an equal chance of being the final target, (d) all Ziggerins occurred equally often, and (e) all styles were used equally often.

Pretest and Posttests

Participants completed one pretest session before training and four posttest sessions after training. Each session lasted for an hour. The 36 Ziggerins on which participants were not trained were used during testing. A sequential-matching task was performed at pretest and posttest. To minimize participants' initial experience with Ziggerins and maximize the difference between training groups, we had participants complete a composite task and a triplet recognition task only at posttest. The untrained control group ($n = 16$) provided a measure of baseline performance for the composite task. Practice trials were provided for each task.

The *sequential-matching* task measured the advantage of basic-level categorization over subordinate-level categorization (Gauthier & Tarr, 1997; Tanaka, 2001; Tanaka & Taylor, 1991). Participants judged if two sequentially presented Ziggerins were the same or different. On some trials, they judged whether the Ziggerins were the same or different individuals; on other trials, they judged whether the Ziggerins belonged to the same or different classes. Participants had no knowledge about the Ziggerins before training, so for the pretest they were shown a sheet with the images of all Ziggerins, and the experimenter explained that the objects within each row formed a class. Each trial began with a 500-ms fixation cross. Then, the first Ziggerin was displayed for 800 ms, followed by a pattern mask for 500 ms. Finally, the second Ziggerin was displayed until the participant responded "same" or "different," or for a maximum of 5 s. The task included 12 blocks of 72 trials each, with the type of judgment (class or individual) alternating across blocks. In the individual-judgment blocks, identical objects were presented on *same* trials, and different individuals within the same class were presented on *different* trials. In the class-judgment blocks, two different Ziggerins within the same class were presented on *same* trials, and objects (of the same or different styles) from two different classes were presented on *different* trials. To encourage matching of objects and not images, we varied the sizes of the Ziggerins within a trial such that one was always slightly larger than the other (three sizes were used: 3.2 × 3.2 cm, 4.0 × 4.0 cm, and 4.8 × 4.8 cm). Speed and accuracy were both emphasized, and no feedback was given.

A variant of the *composite task* from the face-recognition literature was used to measure holistic processing and its dependence on configuration (for procedural details, see Cheung et al., 2008; Gauthier et al., 2003; Gauthier & Tarr, 2002; Richler, Gauthier, et al., 2008; Richler, Tanaka, et al., 2008). Each composite was made from two different-style Ziggerins within the same class by combining the top half of one and the bottom half of the other.[1] A trial began with a 500-ms fixation cross (see

[1]Half of the trials in this task used composites made from two Ziggerins from different classes. These trials did not result in significant congruency effects for either training group and are not included in the analyses reported here. The large difference in shape between classes likely facilitated selective attention to the cued part on these trials.

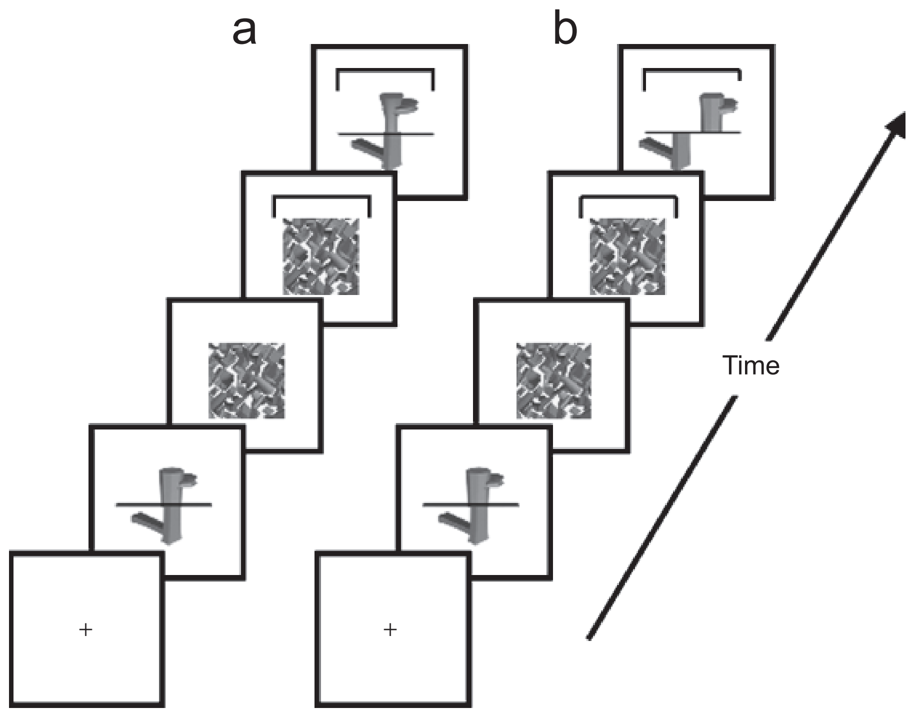

Fig. 2. Two example trials of the composite task. On each trial, two composite stimuli were presented in succession, separated by a pattern mask. The cue bracket indicated whether the top or the bottom parts of the composites should be compared. Both trials shown here required comparing the top parts. The trial illustrated in (a) is an example of a *different* trial (i.e., the cued parts of the two composites do not match) with the top and bottom halves aligned in the test display. This is an incongruent trial because the top parts of the two composites are different, but the bottom parts are the same. The trial illustrated in (b) is an example of a *same* trial (i.e., the cued parts of the two composites match) with the top and bottom halves misaligned in the test display. This is a congruent trial because both the top parts and the bottom parts of the two composites are the same.

Fig. 2). Then, the first composite was displayed for 400 ms, followed by a pattern mask for 3,000 ms. During the last 500 ms of the mask display, a bracket cued the top or bottom part of the display. Finally, the second composite appeared; its halves were either aligned or misaligned (cf. Fig. 2a and Fig. 2b). Participants indicated by key press if the cued halves of the two composites were the same or different. The maximum time allowed for response was 1,000 ms. The trials were evenly divided between *same* and *different* trials, and no feedback was given.

Two variants of the composite task have been widely used. In one, which has been called a partial design (Gauthier & Bukach, 2007), the irrelevant parts (i.e., the parts at the noncued location) are always different, only *same* trials are analyzed, and configural processing is defined as better performance matching relevant parts (i.e., the parts at the cued location) in a misaligned than in an aligned configuration. We used instead the complete design, which deconfounds congruency between the relevant and irrelevant parts by allowing the irrelevant part to be the same or different. In this design, performance on both *same* and *different* trials is examined, which allows certain measures that are not possible with the partial design (e.g., see Cheung et al., 2008; Gauthier & Bukach, 2007; Richler, Gauthier, et al., 2008; Richler, Tanaka, et al., 2008; see also Farah et al., 1998; Wenger & Ingvalson, 2002). We used the complete design because of arguments fully articulated in our previous articles.

Thus, the target parts (to which participants responded) and the distractor parts (to be ignored) of the two composites in a trial were either congruent in response (both parts the same or both different, as in Fig. 2b) or incongruent in response (one part the same and the other different, as in Fig. 2a). Either the top or the bottom parts could be targets (the order of trials with top and bottom targets was randomized). The Alignment (halves aligned vs. misaligned) × Congruency (target and distractor parts congruent vs. incongruent) × Target Parts (top vs. bottom) × Response (same vs. different) design resulted in 16 conditions, and 18 trials in each condition were presented (total of 288 trials). Trials from the various conditions were presented in random order, in four blocks of 72 trials. We expected a cost of selective attention to part of a Ziggerin, indexed by worse performance on incongruent than congruent trials. Holistic processing was defined as sensitivity to part configuration and indexed by the selectivity of the congruency effect to an aligned configuration of parts (i.e., the Alignment × Congruency effect). Following previous work, we examined costs to both discriminability and response times; costs have been previously revealed in one, the other, or both measures (Cheung et al., 2008; Gauthier et al., 2003).

We used a *triplet recognition* task to measure perceptual fluency with short sequences of Ziggerins. Prior work on expert perception of Roman letters and Chinese characters (Gauthier et al., 2006; Wong & Gauthier, 2007) revealed both rapid basic-level categorization of characters within an array and more efficient recognition of characters when they had the same font, rather than mixed fonts. We hypothesized that after categorization training, analogous rapid categorization in an array and style-regularity effects (i.e., better recognition of Ziggerins of the same, rather than different, styles) might be observed. A trial began with presentation of a pattern mask for 1 s. Then, three target Ziggerins were presented side by side for a variable duration. Following a 200-ms mask, two Ziggerins were presented, one above the other, at each of the three locations, and participants indicated the studied target at each location, from left to right. Accuracy was emphasized, and no feedback was provided. The three studied objects were always from different classes, but could be of the same or different styles; the nonstudied alternative was from a different class than the studied object with which it was paired but always matched the studied object's style. A key measure was the calibrated duration of the initial Ziggerin presentation. A staircase procedure over 10 blocks of 12 trials was used to find the presentation duration that led to 2.25 Ziggerins being recognized. Presentation duration started at 600 ms and changed according to the participant's performance after each block, with the step size changing gradually from 220 ms at 660 ms or above to 20 ms at 100 ms or below.

RESULTS

Training Performance

We cannot directly compare overall training performance between groups because the training tasks were different. These tasks were really just vehicles for encouraging differences in processing, representation, or both, and were not a focus of investigation in and of themselves. Both training groups showed accuracy near ceiling throughout training (i.e., accuracy well over 90% in all tasks and all sessions); significant increases across sessions were observed only in some of the tasks. The constant accuracy in some tasks may be surprising, especially for the early training sessions, but recall that classes and styles were added gradually over the first three sessions. Significant improvement in speed across sessions was observed in all training tasks (see Fig. 3). We do not report statistical analyses here, but Figure 3 shows the confidence intervals relevant to the significant learning effects. The fact that named Ziggerins were gradually added over the first three sessions likely contributed to the plateau apparent in the individuation-training group's response times for those sessions.

Sequential Matching: The Basic-Level Advantage

At pretest, both training groups were faster at matching by class (the basic level) than at matching by individual, but training

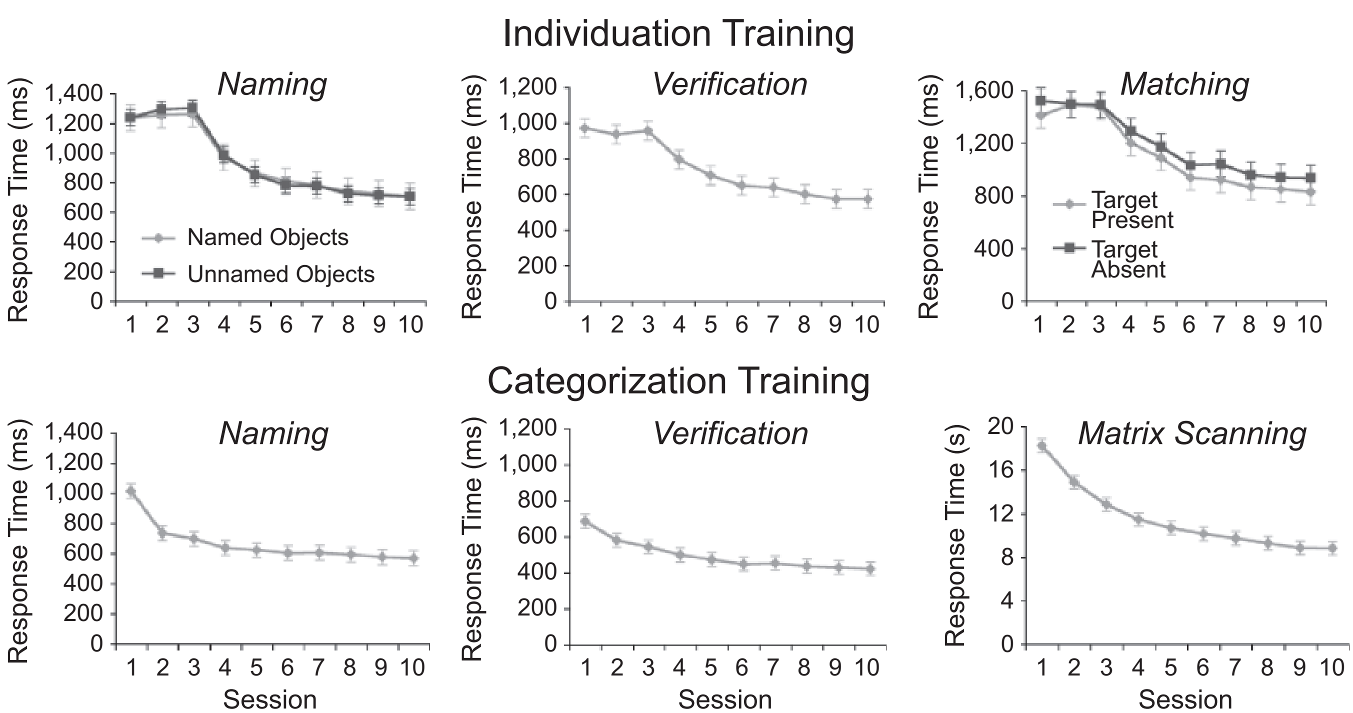

Fig. 3. Mean response times for all training tasks across sessions. Note that response times are reported in seconds for matrix scanning and in milliseconds for all other tasks. Error bars represent the 95% confidence intervals for the main effect of session.

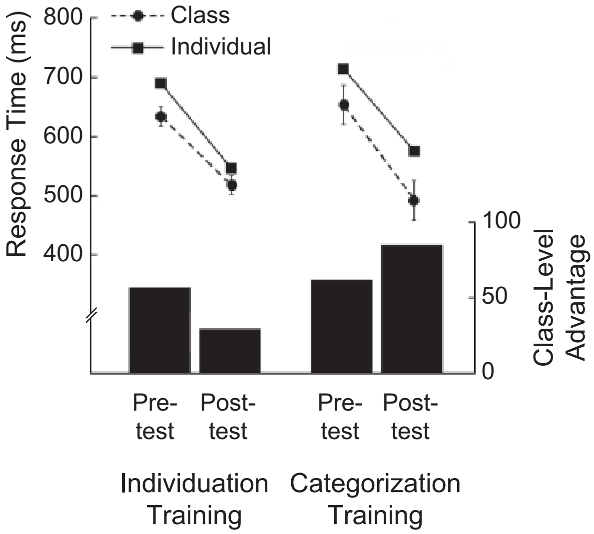

Fig. 4. **Performance in the sequential matching task as a function of training group (individuation vs. categorization), test (pretest vs. posttest), and level of judgment (class vs. individual). The graphed lines represent mean response times, and the bars represent the mean class-level advantage (response times for individual judgments minus response times for class judgments). Error bars represent the 95% confidence intervals for the effect of level of judgment.**

produced opposite effects on the two groups (see Fig. 4). Individuation training reduced the basic-level advantage, whereas categorization training increased the basic-level advantage. A Group (categorization vs. individuation training) × Testing Session (pretest vs. posttest) × Level of Categorization (class vs. individual) analysis of variance (ANOVA) showed a main effect of testing session, $F(1, 34) = 94.13, p \leq .0001$,[2] $\eta_p^2 = .734$, and a main effect of level of categorization, $F(1, 34) = 41.43$, $p \leq .0001$, $\eta_p^2 = .549$. Most important, there was a three-way interaction, confirming that differential effects of training on class-level and individual-level judgments differed between the groups, $F(1, 34) = 4.00$, $p = .054$, $\eta_p^2 = .105$. A separate ANOVA revealed that for the individuation-training group, the Testing Session × Level of Categorization interaction was significant, indicating a significant reduction of the class-level advantage after training, $F(1, 17) = 6.34, p = .022, \eta_p^2 = .272$. Despite a numerical increase in the class-level advantage for the categorization-training group, the Testing Session × Level of Categorization interaction was not statistically significant for this group, $F(1, 34) = 1.02$, $p = .326$. However, Scheffé tests ($p < .05$) showed that at the class level, the categorization-training group was faster than the individuation-training group after but not before training. Accuracy was near ceiling (> 91%) before and after training.

[2]A significance level of $p < .05$ corresponds to a probability of replication (p_{rep}) of .916 or higher (Killeen, 2005).

Composite Task: Configural and Holistic Processing

Figure 5 summarizes the three group's performance on the composite task. Data from 2 participants in the individuation-training group and 4 participants in the categorization-training group were discarded because of low accuracy (< 57%; no participants in the control group met the exclusion criterion).

Response times of the two training groups demonstrated significantly different patterns: The individuation-training group, but not the categorization-training group, showed a congruency effect for aligned stimuli only (see Fig. 5a). Response times for the two training groups were compared in a Group (categorization vs. individuation training) × Congruency (congruent vs. incongruent) × Alignment (aligned vs. misaligned) ANOVA. All two-way interactions were significant—Group × Congruency: $F(1, 28) = 3.75, p = .063, \eta_p^2 = .118$; Group × Alignment: $F(1, 28) = 4.47$, $p = .044$, $\eta_p^2 = .138$; Congruency × Alignment: $F(1, 28) = 3.90$, $p = .058$, $\eta_p^2 = .122$. The most theoretically important finding, however, was the significant three-way interaction, $F(1, 28) = 4.07$, $p = .053$, $\eta_p^2 = .127$. Separate ANOVAs revealed a significant Congruency × Alignment interaction only in the individuation-training group, $F(1, 15) = 6.12, p = .026, \eta_p^2 = .290$. Scheffé tests ($p < .05$) showed that for this group, responses were faster on congruent than on incongruent trials for aligned but not misaligned stimuli.

A Group (categorization vs. individuation training) × Congruency (congruent vs. incongruent) × Alignment (aligned vs. misaligned) ANOVA conducted on sensitivity (d') showed a significant effect of congruency, $F(1, 28) = 11.71$, $p = .002$, $\eta_p^2 = .295$. This effect did not differ significantly between the two training groups ($F < 1$ for all interactions involving group; see Fig. 5b).

The untrained control group showed no significant effects on response time or sensitivity with one exception: Sensitivity was greater on congruent than on incongruent trials, $F(1, 15) = 18.845, p = .0006, \eta_p^2 = .556$.

The interaction between alignment and congruency found after individuation training is very similar to the hallmark finding with faces (e.g., Richler, Tanaka, et al., 2008). For faces, sensitivity and response time typically show a congruency effect that interacts with alignment. Some studies have demonstrated similar interactions in participants with expertise in nonface objects. Response times of Greeble experts trained in the laboratory showed an interaction between congruency and alignment ($p = .06$; Gauthier et al., 1998), whereas sensitivity showed a similar interaction in car experts (Gauthier et al., 2003). After a limited number of sessions of laboratory training, different subjects can acquire quite different levels of expertise, so perhaps it is not surprising that the behavioral effects of Ziggerin training were weaker than what is typically observed after a lifetime of experience with faces. We obtained a significant interaction between congruency and alignment in one dependent measure, but only a nonsignificant trend in the other. Past studies have shown no interaction between congruency and

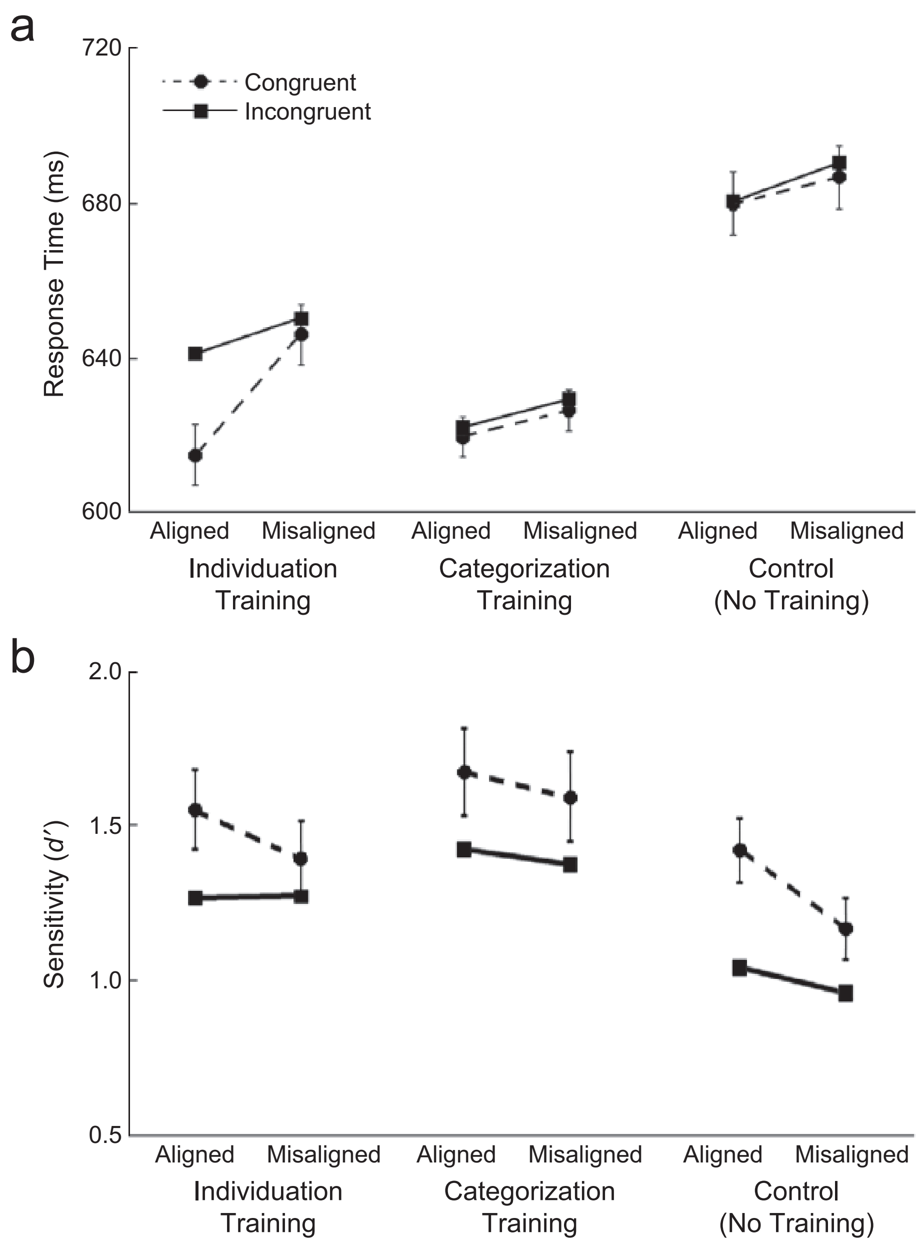

Fig. 5. Mean (a) response time and (b) sensitivity (d') in the composite task as a function of training condition, alignment, and congruency. Error bars represent the 95% confidence intervals for the effect of congruency.

alignment for nonface novel objects, and at least one study obtained a congruency effect that did not interact with alignment (Richler, Bukach, & Gauthier, in press). This is precisely what we observed after categorization training and in the untrained control group. Although congruency effects can be observed with nonface novel objects for a variety of reasons (Richler et al., in press), an interaction between alignment and congruency like that obtained after individuation training is a hallmark of face processing not found for nonface novel objects (e.g., Richler et al., in press; Robbins & McKone, 2007).

Triplet Recognition: An Advantage for Categorization Training

The duration threshold during triplet recognition is our index of perceptual fluency for rapidly categorizing objects within a short string of Ziggerins. After training, the categorization-training group required a significantly shorter presentation duration than the individuation-training group to achieve the 2.25-Ziggerin recognition level (193 ms and 294 ms, for categorization and individuation training, respectively), $F(1, 35) = 6.93, p = .013, \eta_p^2 = .165$.

DISCUSSION

It is meaningful to talk about kinds, not merely degrees, of perceptual expertise with objects (Wong & Gauthier, 2007). Two groups that underwent different training regimens, but with the same set of objects, demonstrated different hallmarks of expertise when tested on new exemplars of the trained object categories. As shown in prior work with individuation experts trained in the real world (Busey & Vanderkolk, 2005; Gauthier et al., 2003) or in the laboratory (Gauthier & Tarr, 1997; Gauthier et al., 1998; Scott et al., 2006, 2008), individuation training reduced the basic-level advantage and increased holistic processing. These effects were not observed in categorization experts, who instead became faster at basic-level judgments.

A unique feature of the current study is that factors such as mere exposure, attention, and effort are insufficient to account for the facelike expertise effects found after individuation training. Other studies have demonstrated differential effects of individuation training relative to other training equated for exposure (Nishimura & Maurer, 2008; Scott et al., 2006, 2008; Tanaka et al., 2005), but in those cases, not only was the comparison training task far easier than the individuation-training task, but there was no evidence that the control group learned anything qualitatively different from the individuation-training group. The difference between groups was only a matter of degree, and participants in the comparison training group could not be claimed to be "experts" in any way. In contrast, our categorization experts were faster than our individuation experts at basic-level categorization and showed increased perceptual fluency in the triplet recognition task. These selective advantages of categorization training could not have occurred if categorization training had recruited the same strategies as individuation training, but to a lesser degree. The requirements of guided visual search and speeded basic-level categorization in an array, unique to the categorization training in our experiment, may have caused a perceptual strategy different from that adopted after individuation training.

Our individuation and categorization training differed in multiple aspects, but surely did not differ more than the experiences that lead to acquisition of facelike and letterlike expertise. Our goal was not to make specific inferences about the particular aspect of training that produced the observed effects. To know which particular aspect of training was critical to our results, we would need to systematically examine the effects of the various training components alone and in combination. Our goal, instead, was to demonstrate that two different kinds of expertise can in fact be acquired for the same set of objects.

The training effects we observed were smaller in magnitude than those reported for other experiments with novel objects (e.g., Gauthier & Tarr, 1997) and with real-world experts (e.g., Gauthier et al., 2003). Given the differences between this experiment and earlier work, this difference in magnitude may not be surprising. Prior facelike individuation training with a homogeneous set of Greeble objects required between 7 and 10 hr for the disappearance of the basic-level advantage (Gauthier & Tarr, 1997; Gauthier et al., 1998). All Greebles share a common part configuration and constitute one basic-level class. In contrast, there were six classes of Ziggerins, which means that the 10 hr of training our participants received amounted to less than 2 hr per class. It is reasonable to expect that longer training with Ziggerins would increase the effects we obtained. More important, our results demonstrate that the qualitative markers of facelike expertise can be observed for nonface object categories that clearly do not have any face geometry, and after only about 1,500 training trials per category. Although limited laboratory training in artificial domains is unlikely to produce expertise of the same magnitude as that acquired in the real world, hallmarks of facelike expertise do not require 10 years, or even 10 hr, of experience to emerge (Gauthier & Tarr, 1997; cf. Diamond & Carey, 1986).

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