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Context Influences Holistic Processing of Non-face Objects in the Composite Task

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Abstract

We explore whether holistic-like effects can be observed for non-face objects in novices as a result of the task context. We measure contextually-induced congruency effects for novel objects (Greebles) in a sequential matching selective attention task (composite task). When format at study was blocked, congruency effects were observed for study-misaligned, but not study-aligned, conditions (Experiment 1). However, congruency effects were observed in all conditions when study formats were randomized (Experiment 2), revealing that the presence of certain trial types (study-misaligned) in an experiment can induce congruency effects. In a dual task, a congruency effect for Greebles was induced in trials where a face was first encoded, only if it was aligned (Experiment 3). Thus, congruency effects can be induced by context that operates at the scale of the entire experiment or within a single trial. Implications for using the composite task to measure holistic processing are discussed.

It is generally accepted that faces are processed differently than other objects (Farah, Wilson, Drain & Tanaka, 1998; Yin, 1969; Ge, Wang, McCleery & Lee, 2006; Maurer, Le Grand & Mondloch, 2002). More specifically, face processing is believed to be “holistic”, in that faces are processed as unified wholes rather than in terms of parts or features. A holistic processing strategy for faces is highly adaptive: since all faces are made up of the same features in the same configuration, it is the subtle differences in the spatial relations between these features which is diagnostic of identity (Diamond & Carey, 1986; Le Grand, Mondloch, Maurer, & Brent, 2004; Leder & Bruce, 1998; 2000; Mondloch, Le Grand, & Maurer, 2002; Searcy & Bartlett, 1996). However, one negative consequence of this holistic processing strategy is that participants are unable to selectively attend to one part of a face, even when a failure to do so negatively impacts their performance in an experimental task (e.g., Farah, Wilson, Drain & Tanaka, 1998; Richler, Tanaka, Brown & Gauthier, in press). While evidence that suggests holistic processing of faces is relatively robust, here we investigate the possibility that similar effects can also be found with non face objects due to contextual influences. First, we describe the measure of holistic processing used in our studies, and then outline what motivated us in searching for contextually-induced effects that would resemble hallmarks of holistic processing.

One paradigm that is used to assess failures of selective attention due to holistic processing is the composite task. In this task, participants are asked to match one half of a study face composite, made of the top of one face and the bottom of another, to second subsequently presented test face composite. On *congruent trials*, both the relevant and irrelevant part of

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the test face are the same or both are different; on *incongruent trials* one part is the same and the other part is different. Holistic processing is inferred from a *congruency effect*, where performance is impaired on incongruent trials relative to congruent trials – the information in the irrelevant face half interferes with performance despite instructions to selectively attend (Cheung, Richler, Palmeri & Gauthier, in press; Farah et al., 1998; Gauthier, Curran, Curby & Collins, 2003; Richler, Gauthier, Wenger & Palmeri, 2008; Richler et al., in press). Importantly, the congruency effect is larger for faces than other objects (Farah et al., 1998) and increases with perceptual expertise (Gauthier & Tarr, 2002).

Often, studies using the composite task also use an alignment manipulation. The standard finding is that the congruency effect is reduced when the face halves are misaligned at test – when the face halves are no longer presented in the meaningful arrangement, holistic processing is attenuated (Cheung et al., in press; Richler et al., 2008; Richler et al., in press). A recent study also manipulated the arrangement of face halves at study and found that the magnitude of the congruency effect was unaffected by whether the study face was aligned or misaligned (Richler et al., in press).

Critically, in Richler et al. (in press) both parts of the study face had to be encoded because participants did not know which part they would have to respond to until the test face was presented. Observing evidence for holistic processing following encoding of an aligned face is consistent with any model of face processing, regardless of whether they posit that holistic effects are perceptual in nature (e.g., Farah et al., 1998) or that these effects arise due to decisional factors (e.g., Wenger & Ingvalson, 2002). However, holistic processing following study of a misaligned face is more surprising, and would in fact go against the predictions of a strong perceptual hypothesis, which suggests that faces are encoded to fit a face template (Tanaka & Farah, 1993) and that holistic processing occurs during the retrieval of a face gestalt from memory (Boutet, Gentes-Hawn & Chaudhuri, 2002).

The current work is aimed at exploring the possibility that some of the holistic effects observed in Richler et al. (in press) following a misaligned study face are due to contextually-induced strategies, as opposed to a holistic processing mechanism specific to faces and other objects of expertise. For example, when both parts of a misaligned face must be encoded, attention is required to parts that are further apart in space than when the face is aligned. This difference in the attentional requirements of the task may create an experimental context that influences participants' strategy. If some aspects of the failures of selective attention in the composite paradigm are due to such strategies that are influenced by the constraints of the task, then it may be possible to modulate such effects even with objects.

The holistic effects measured with the composite task are generally not found with familiar objects (Robbins & McKone, 2007) or novel objects (Gauthier & Tarr, 2002) in novices. However, these studies with objects used a version of the composite task where the irrelevant halves of the composites were always different. In this so-called "partial" design, same trials are always incongruent whereas different trials are always congruent, and holistic processing is inferred from an alignment effect that is unrelated to congruency. Although this partial variant of the composite task has also been used with faces (e.g., Goffaux & Rossion, 2006; Hole, 1994; Le Grand, Mondloch, Maurer & Brent, 2004; Michel, Rossion, Han, Chung, & Caldara, 2006; Young, Hellawell & Hay, 1987), recent work has shown that it comes with serious limitations (see Cheung et al., in press; Gauthier & Bukach, 2007). Critically, in this version of the task only performance on "same" trials is considered. Thus, differences in response bias between aligned vs. misaligned trials (see Cheung et al., in press) could be misinterpreted as true discriminability differences. Moreover, "same" trials are always incongruent, and congruency itself has been shown to affect response biases as well (Cheung et al., in press; Farah et al., 1998)

Only one study using objects has used the variant of the composite task described earlier, where holistic processing is measured in terms of congruency effects. This study found that although car experts showed a larger congruency effect than car novices, consistent with the suggestion that holistic processing emerges with perceptual expertise (Gauthier & Tarr, 2002), car novices did show a small congruency effect (Gauthier et al., 2003). This may not be surprising, as the composite task is similar to other selective attention paradigms such as the Stroop task – on incongruent trials participants need to ignore information that leads to a conflicting response (Macleod, 1991). Indeed, with faces the congruency effect has been mainly attributed to interference on incongruent trials (Richler et al., in press). Moreover, the car novices in Gauthier et al. (2003) would still have had some visual experience with cars, albeit not to the same extent as the car experts. Perhaps the small congruency effect observed for novices in this case reflects this basic knowledge and experience. Thus, a secondary goal of the present work is to examine congruency effects for novel objects in true novices, using completely novel objects.

Experiment 1

Method

Participants—Forty-two participants completed the experiment. Twenty-one were assigned to each condition (study aligned vs. study misaligned). One participant's data were discarded from the "study aligned" condition due to a failure to respond on more than 10% of the trials, and two more participants' data (one from each condition) were discarded for below chance performance.

Stimuli—Stimuli were made from images of 16 asymmetrical computer-generated novel objects (Greebles) made up of four Greebles from four different families (the families are defined by common central shapes). Asymmetrical Greebles (Rossion, Kung & Tarr, 2004) were created by transforming all the original symmetrical Greebles (Gauthier & Tarr, 1997) in the same manner, to produce an asymmetrical configuration of parts common to all objects (see Figure 1). Greebles were divided into top and bottom parts and combined to make 32 composites. Tops and bottoms were always combined within the same family. Each composite Greeble was approximately 200 × 160 pixels in size. A black line 3 pixels thick separated top and bottom halves.

Misaligned Greebles were made by moving the bottom parts of each composite 70 pixels to the right, such that the edge of the bottom half of the Greeble fell on the center of the top half.

Procedure—The experiment was conducted on Mac OS9 computers using RSVP software (Williams & Tarr, no date). Participants were seated approximately 60cm from the monitor, although head position was not fixed. On each trial a study stimulus was shown for 700 ms followed by a flashing mask (four identical random pattern masks shown each for 120 ms alternating with a 50 ms blank screen for a total of 630 ms). Participants assigned to the "study aligned" condition saw an aligned Greeble composite as the study stimulus, while participants assigned to the "study misaligned" condition always saw a misaligned Greeble composite as the study stimulus. Next a rectangular bracket cueing top or bottom judgments was shown for 300 ms and remained on the screen when the test stimulus appeared. The test stimulus was displayed until the participant responded or for 4000 ms if no response was given. Participants were instructed to indicate by button press whether the cued part was the same or different at study and test. Participants were instructed to attend to both parts of the study stimulus and to ignore the uncued part (if any) of the test stimulus. No feedback was given.

There were 240 experimental trials. On 48 trials an isolated part was shown at test (12 trials for each combination of top/bottom and same/different). The remaining trials (192) included 12 trials in each combination of test configuration (aligned vs. misaligned), congruency (congruent vs. incongruent), cued part (top vs. bottom) and correct response (same vs. different). Trial types were randomized foreach participant. The experimental trials were preceded by ten practice trials.

Results

Performance (2AFC d′ calculated for each participant) on congruent and incongruent trials when the study and test Greebles were aligned or misaligned is plotted in Figure 2. Although not reported in full here, response bias (c) was also analyzed. The results of analyses on response bias (c) for all the experiments presented here are summarized in Appendix A. As can be appreciated from the figure, congruency effects were only observed when the study Greeble was misaligned, and were not affected by the format of the test Greeble.

These observations are confirmed by inferential statistics. A 2 × 2 × 2 mixed factorial ANOVA was conducted on sensitivity (d′) with test Greeble format (aligned vs. misaligned) and congruency (congruent vs. incongruent) as repeated measures factors and study Greeble format (aligned vs. misaligned) as a between subjects factor. There was a significant main effect of congruency, such that performance was better on congruent trials compared to incongruent trials ($F_{1, 37} = 6.999$, $MSE = 147$, $p < .05$). Critically, there was a significant congruency x study Greeble format interaction ($F_{1, 37} = 4.701$, $MSE = 147$, $p < .05$), such that there was only a congruency effect when the study Greeble was misaligned ($F_{1,18} = 5.182$, $MSE = 174$, $p < .05$).

Bonferroni-corrected paired-sample *t*-tests (alpha = .00625) for each condition with its test-isolated baseline revealed no significant facilitation or interference.

Discussion

In Experiment 1 we showed that it is possible to see a congruency effect with a non-face novice category, however this effect was only observed when the study Greeble was misaligned, suggesting that the arrangement of parts at study is critical for producing a congruency effect with a completely unfamiliar object category. That congruency effects can arise with objects when the study item is misaligned raises the possibility that the congruency effects observed in Richler et al. (in press) when a study face was misaligned may be at least partly induced by the context created by the study-misaligned trials, rather than a mechanism that is specialized for face processing. For example, it may be that the attentional demands of a misaligned study item, where parts are more spread in space, change the way selective attention operates at test

In Experiment 1 study Greeble formats were manipulated between participants. Therefore, it is unknown whether the context created by the study-misaligned trials operated within a single trial, or over the entire experiment. In Experiment 2 study Greeble formats were randomized within subjects. If the study misaligned Greebles induce a context for a single trial, we would only expect to see congruency effects for study-misaligned trials and not study-aligned trials. If, on the other hand, the mere presence of the study misaligned trials causes a change in context that affects the entire experiment, then we would expect to see congruency effects in both study conditions when these trial types are randomized.

Experiment 2

Method

Participants—Thirty-seven participants completed the experiment. Data from six participants were discarded due to below chance performance.

Stimuli—Stimuli were the same as in Experiment 1.

Procedure—Each trial unfolded in the same manner as in Experiments 1.

There were 480 experimental trials. On 96 trials an isolated part was shown at test (12 trials for each combination of study aligned/misaligned, same/different and top/bottom). The remaining trials (382) included 12 trials in each combination of study configuration (aligned vs. misaligned), test configuration (aligned vs. misaligned), congruency (congruent vs. incongruent), cued part (top vs. bottom) and correct response (same vs. different). Trial types were randomized for each participant. Twelve practice trials preceded the experimental trials.

Results

Performance (d′) on congruent and incongruent trials as a function of study and test Greeble configuration is plotted in Figure 3. As can be appreciated from the figure, a congruency effect was observed in all conditions.

A 2 × 2 × 2 repeated measures ANOVA was conducted, with factors study Greeble format (aligned vs. misaligned), test Greeble format (aligned vs. misaligned), and congruency (congruent vs. incongruent). There was a significant main effect of congruency, such that performance was greater on congruent trials compared with incongruent trials ($F_{1, 30}$ = 14.701, MSE = 1.138, $p < .01$). Critically, congruency did not interact with either test or study format, indicating comparable congruency effects across all conditions

There was a significant study format x test format interaction ($F_{1, 30}$ = 5.770, MSE = .122, $p < .05$), such that the average performance was better when both the study and test Greeble were aligned compared with when the study Greeble was misaligned and the test Greeble was aligned ($F_{1, 30}$ = 6.513, MSE = .107, $p < .05$).

Bonferroni-correct paired-sample *t*-tests (alpha = .00625) for each condition with its test-isolated baseline revealed no significant facilitation or interference. Because congruency effects can only arise from facilitation and/or interference, this pattern is likely obtained because there is both a small amount of interference and of facilitation.

Discussion

In Experiment 1, congruency effects were only observed for misaligned-study items when study conditions were blocked. However, when study formats were randomized within the experiment in Experiment 2, equivalent congruency effects were observed in all conditions. This suggests that misaligned study items do not simply influence processing of the test item within the context of a single trial, but rather induce a context that influences all the trials in the experiment. Thus, we have shown that whether stimulus conditions are blocked or randomized changes the context of the experiment, and these different experimental contexts can affect whether congruency effects are observed.

In Experiments 1 and 2 we showed that contexts created by a misaligned study Greeble can influence congruency effects for Greebles in novices. One question is whether contextual influences can occur across object categories. For example, faces are processed more holistically than non-face objects, and this occurs automatically, without any inducing context and despite instructions to attend selectively to parts. Could processing faces within an experiment create a context that induces congruency effects for Greebles? Indeed, aligned face and car stimuli were interleaved in Gauthier et al. (2003). Perhaps car novices showed small congruency effects for cars because of the context of the experiment created by the presence of the face stimuli.

Several studies have shown that engaging a local or global processing strategy in one task can influence processing in a subsequent task. Macrae & Lewis (2002) had participants perform a letter identification task with Navon letters (Navon, 1977), in which large letters are made up of smaller letters (e.g., an X composed of Ys). Half the participants were asked to identify the large letter (i.e. a global processing task) and half the participants were asked to identify the small letters (i.e. a local processing task). The results showed that, relative to a control group, face recognition performance was impaired when participants completed the local processing task, and face recognition performance was enhanced when participants completed the global processing task (see also Perfect, 2003). A similar contextual effect has also been observed for recognition performance for halves of composite faces (Weston & Perfect, 2005). In Ge, Wang, McLeery and Lee (2006), simultaneous matching of ambiguous figures (similar to both faces and Chinese characters) led to an inversion effect only when primed with a different task with faces and not Chinese Characters. These results suggest that the context prior to which a recognition or a matching task is completed can affect performance by inducing a certain processing strategy. However, the temporal dynamics of these effects are not known (whether, for instance, context could vary from one trial to another).

In Experiment 3 we examined whether congruency effects for Greebles could be contextually induced across object categories, within a single trial. We used a dual task in which a face composite task and a Greeble composite task were interleaved (see Figure 4). Will the processing-style for the study – face which appears before the test Greeble – affect processing of the test Greeble and induce congruency effects? Critically, the study face was aligned or misaligned. Aligned faces are processed more holistically than misaligned faces (Cheung et al., in press; Richler et al., 2008; Young, Hellawell & Hay, 1987). Thus we predict that the trial context in the aligned face condition should induce more of a congruency effect for interleaved Greeble trials than the misaligned face condition.

Experiment 3

Method

Participants—Twenty participants completed this study in exchange for course credit or $6.00. Data from two participants were discarded due to below chance performance on the Greeble task.

Stimuli—Greeble stimuli were made in the same manner as Experiment 1.

Face Stimuli were created from twelve digital images of similar male faces taken from the face database developed by the Max-Planck Institute (MPI) for Biological Cybernetics in Tuebingen, Germany (Troje & Bulthoff, 1996). These faces did not have hair, beards or other salient diagnostic features. Each face was approximately 200 × 160 pixels in size and was converted to grayscale. Faces were divided into top and bottom halves, which were reorganized to create 24 composite faces. A black line 3-pixels thick separated the two face parts.

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Misaligned face composites were created by moving the bottom parts of each composite 70 pixels to the right, such that the edge of the bottom half of the face fell on the center of the top half.

Procedure—Two composite tasks, one with Greebles and one with faces, were interleaved (see Figure 4). Participants were instructed to judge whether the cued part of the test stimulus was the same or different as the study stimulus while ignoring the irrelevant part.

At the beginning of each trial, the study Greeble was presented for 1500ms, followed by the study face, which was presented for 1500ms. We refer to the study face as the inducing face, because we are interested in whether it can create a context that will lead to congruency effects for Greebles. The inducing face was either aligned or misaligned. Following the inducing face a square bracket was presented for 500ms, cueing participants as to which part of the test Greeble they would be asked to respond to, followed by the test Greeble, which remained on the screen for a maximum of 3000ms or until participants made a response. Then another square bracket, cueing which part of the face they would have to respond to, was presented for 500ms, followed by the test face, which remained on the screen for a maximum of 3000ms or until a response was made.

Several things were kept constant in the experiment. The study and test Greebles were always aligned, because this condition did not lead to congruency effects in Experiment 1; if we see congruency effects for Greebles in this experiment, this ensures that they will depend on the context created by the preceding face, not because of the format of the study and test Greebles. The test face was always misaligned, because we did not want an aligned face at test to potentially induce holistic processing for the study Greeble on the next trial. These factors result in a situation where we expect no measurable difference in holistic processing for the aligned vs. misaligned study face conditions, because these conditions result in comparable congruency effects at test when the test face is misaligned (Richler et al., in press). Nonetheless, we predict that aligned and misaligned study faces are perceived differently, and any difference obtained with Greebles between the two face contexts will be evidence to that effect. Trials where the inducing face was aligned or misaligned were randomized because we wanted to detect effects that could occur within a trial; if trials were blocked, we would not know whether the effect occurred within the trial, or was due to a general strategic effect of context as we saw in Experiment 2. Finally, the study Greeble was always presented first, so that only the study face would be seen before the test Greeble; if the study face was presented first, then both the study and test face would be presented before the test Greeble, so it would be unclear what effect the alignment of the study face has on the congruency effect for the test Greeble.

There were 192 experimental trials, with 12 trials for each combination of cued part (top/bottom), congruency (congruent/incongruent), correct response (same/different) and inducing face format (aligned/misaligned) for the Greeble composite task. A practice block of 4 trials preceded the experimental block. For the face task, there were 12 trials for each combination of part, congruency, correct response and study face format for the Greeble composite task and each trial type was randomly paired with a face trial-type (in terms of congruency and correct response). Face trial-types were randomly paired with Greeble trial-types.

Results

As predicted and replicating prior results (Richler et al. in press), there was no difference in the congruency effect for misaligned test faces obtained in trials with aligned vs. misaligned study faces (alignment x congruent interaction: $p = .975$). However, we nonetheless find evidence that the aligned and misaligned faces are processed differently, in that they produce different contexts for the Greeble composite task. Performance on congruent and incongruent trials for the Greeble composite task as a function of whether the inducing face was aligned or misaligned is plotted in Figure 5. As can be appreciated from the figure, a congruency effect for Greebles was only observed when the Greeble was preceded by an aligned face.

A 2 × 2 repeated-measures ANOVA with factors congruency (congruent vs. incongruent) and format of the inducing face (aligned vs. misaligned) revealed a significant main effect of congruency, with better performance on congruent than incongruent trials ($F_{1,17} = 7.596$, $MSE = .110$, $p < .05$). Critically, there was a congruency x face format interaction ($F_{1,17} = 4.496$, $MSE = .088$, $p < .05$). Post-hoc *t*-tests (Bonferroni-corrected for multiple comparisons, alpha = .25) revealed that there was only a congruency effect when the inducing face was aligned.

Discussion

In Experiment 3 we found that contextually induced congruency effects can occur within a trial when the context is created by an object from a different category. Specifically, trials that contained aligned faces led to congruency effects for Greebles. One explanation of this finding is that it results from hysteresis in terms of the processing strategy engaged by the inducing face: because participants would have perceived the aligned face holistically, they also process the following Greeble more holistically. This could occur because of a cost in switching between holistic and analytical strategies (Hubner, 2000; Hubner, Futterer & Steinhauser, 2001). While the context effect must be caused by the change in face alignment (the only difference between conditions), it is possible that the effect depends on an interaction with the Greeble that is always presented at trial outset (for instance, a certain load in visual short term memory could be necessary). Further experiments could investigate the necessary and sufficient conditions for this contextual effect. However, here we are primarily concerned with the demonstration that encoding of aligned and misaligned faces produce different contexts which influence congruency effects for novel objects, with the context rapidly changing from one trial to the next.

Indeed, there are several reports where processing style recruited by one task influences processing on a subsequent task (e.g., Macrae & Lewis, 2002; Perfect, 2003; Weston & Perfect, 2005; but see Lawson, 2007) or in which presentation of an unambiguous stimulus influences the interpretation and processing of similar shapes that are more ambiguous (Ge et al., 2006; Bentin, Sagiv, Mecklinger, Friederici & von Cramon, 2002). In addition to revealing contextual effects at the scale of single trials, our findings extend this prior work, because here context is not created by requiring participants to first perform a task with a specific strategy and the processing of faces influences that of asymmetrical Greebles despite clear differences in their geometry.

In Experiment 1 and 2 we suggested that misaligned study Greebles led to congruency effects because misaligned study Greebles must influence the strategy with which participants process other objects in the experiments, possibly due to the attentional demands of encoding parts that are spread further in space. Although misaligned Greebles are arguably perceptually more similar to misaligned faces than to aligned faces, it is nonetheless the aligned faces that induced a congruency effect in Experiment 3. However, there were several differences between the tasks used in Experiment 1 and 2 and Experiment 3, such as differences in timing and working memory demands. These results are consistent with the notion that the contextual effects are not perceptual (as in Ge et al., 2006) but rather are strategic in nature.

General Discussion

In Experiment 1, when study formats were blocked, a congruency effect was observed for novel objects (Greebles), but only when the study Greeble was misaligned. In Experiment 2, when study formats were randomized, congruency effects for Greebles were observed in all conditions of the experiment, irrespective of study format. These results suggest that the presence of certain trial types can create a context that leads to congruency effects throughout an experiment, and that changing the experimental context by blocking vs. randomizing conditions can change whether congruency effects are observed. In Experiment 3, we found that contextual effects can occur across object categories and within a trial.

Together, our results suggest that congruency effects can be influenced by context. It is interesting to speculate why faces and objects may have induced context effects on different temporal scales. Misaligned Greebles induced congruency effects on the scale of the whole experiment (Experiments 1 and 2); aligned faces induced congruency effects across categories within the context of a single trial (Experiment 3). One important difference between aligned faces and misaligned objects is that faces are processed holistically in an automatic fashion-that is, the effect occurs naturally outside of any inducing context and despite instructions to attend to face parts. In contrast, misaligned objects are not processed holistically and in fact it may require considerable effort to encode both parts of a complex object and bind them despite interference from similar objects in the same experiment. It is possible that effortful strategies are more long-lasting because of the likely costs in engaging and inhibiting them. In contrast, a perceptual strategy that is more automatic, such as holistic processing of faces, may have much faster temporal dynamics. In our experiment, it is possible that faces influence Greebles only because of the need to keep the inducing face in working memory during the Greeble decision. Clearly, future work is required to uncover the mechanism underlying these two kinds of contextual effects and compare them to other similar types of influences in the literature. What is critical here is the fact that different contexts can lead to different congruency effects that would not be predicted if congruency effects arise solely due to holistic processing

Thus, our findings have important implications for measures of holistic processing. Holistic processing in the version of the composite task used here is measured in terms of congruency – participants cannot selectively attend and so are affected by information in the irrelevant half of the image. Although it could be argued that congruency effects arise due to response conflict, analogous to the effects seen in the Stroop literature (Macleod, 1991), recent work suggests that this is not the case (Richler, Cheung, Wong & Gauthier, submitted). Moreover, response conflict by itself would not account for the fact that congruency effects are larger for faces compared with other objects (Farah et al., 1998; Gauthier et al., 2003) and increase with expertise for objects (Gauthier et al., 2003; Gauthier & Tarr, 2002). Consistent with these reports, outside of an inducing context, our experiments find no holistic processing for Greebles in novices (when study format is aligned in a blocked design)

However, in Experiments 1 and 2 we were able to show that congruency effects for novel objects in novices arise in certain contexts, such as when study items are misaligned and when study-misaligned items are randomized with study-aligned items. Is it possible to distinguish between congruency effects that are due to contextual strategy from those that arise due to holistic processing as a result of expertise? In studies with faces, the congruency effect is modulated by the alignment of the test face (Cheung et al., in press; Richler et al., 2008; Richler et al., in press), and mainly consists of interference on incongruent trials (Richler et al., in press). For novel objects in Experiments 1 and 2, there was no significant interference with respect to baseline, and alignment at test did not impact the congruency effect. This suggests that although congruency effects for faces and objects of expertise are larger than the effects presented here, the congruency effect on its own may not be a sufficient index of face-like holistic processing. Rather, the comparisons of congruent and incongruent trials with a baseline and the interaction between congruency and alignment may be more indicative of holistic processing driven by the stimulus, as opposed to congruency effects that arise due to the context of the task. Indeed, once participants become experts at individuating objects from a novel category, they show a congruency effect that is modulated by alignment, just as is found with faces (Wong, Palmeri & Gauthier, submitted).

This distinction between congruency effects that arise due to holistic processing and contextually-induced congruency effects is relevant to recent work with individuals with Autism. Deficits in face processing are well-documented in Autism, however whether these deficits are due to a deficit in holistic processing is still a source of debate. A recent study found that although individuals with Autism show a congruency effect for faces, this congruency effect is not affected by misalignment (Gauthier, Klaiman & Schultz, submitted). Critically, in this experiment study items were aligned or misaligned and these conditions were randomized. Thus, congruency effects for faces in individuals with Autism may have been observed due to context, analogous to the congruency effects observed with novel Greebles in Experiment 2, as opposed to arising due to holistic processing. This would be consistent with the notion that individuals with Autism process faces like typical participants process objects that they are not expert with. While this interpretation remains to be tested, this illustrates the usefulness of a framework that can distinguish face-like and contextual congruency effects.

There are many factors that potentially contribute to performance in the composite task, including possible strategy shifts for different experimental contexts (e.g. blocked vs. randomized design) as demonstrated here, and response biases (e.g., Cheung et al., in press), that have nothing to do with whether the stimuli are being processed “holistically”. Moreover, it has been shown that the results from the composite task cannot distinguish between holism in the perceptual representation and holism in the decisional process (Richler et al., 2008). Despite all of these limitations, however, variants of the composite task are widely used in the literature to assess holistic processing (e.g., Diamond & Carey, 1986; Farah et al., 1998; Gauthier et al., 2003; Goffaux & Rossion, 2006; Hole, 1994; Hole, George, & Dunsmore, 1999; Le Grand, Mondloch, Maurer & Brent, 2004; Michel, Rossion, Han, Chung, & Caldara, 2006; Robbins & McKone, 2007; Wenger & Ingvalson, 2002; Young, Hellawell & Hay, 1987). One challenge for future work is to disentangle all these sources of influence in the composite task, and relate them to other face processing paradigms so we can better understand what makes processing faces and objects of expertise unique.

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References

Bentin S, Sagiv N, Mecklinger A, Friederici A, von Cramon DY. Priming visual face-processing mechanisms: Electrophysiological evidence. Psychological Science. 2002; 13:190–193. [PubMed: 11934007]

Boutet I, Gentes-Hawn A, Chaudhuri A. The influence of attention on holistic face encoding. Cognition. 2002; 84:321–341. [PubMed: 12044738]

Cheung OS, Richler JJ, Palmeri TJ, Gauthier I. Revisiting the role of spatial frequencies in the holistic processing of faces. Journal of Experimental Psychology: Human Perception & Performance. in press.

Diamond R, Carey S. Why faces are and are not special: An effect of expertise. Journal of Experimental Psychology: General. 1986; 115:107–117. [PubMed: 2940312]

Farah MJ, Wilson KD, Drain M, Tanaka JW. What is "special" about face perception? Psychological Review. 1998; 105:482–498. [PubMed: 9697428]

Gauthier I, Bukach C. Should we reject the expertise hypothesis? Cognition. 2007; 103:322–330. [PubMed: 16780825]

Gauthier I, Curran T, Curby KM, Collins D. Perceptual interference supports a non-modular account of face processing. Nature Neuroscience. 2003; 6:428–432.

Gauthier I, Klaiman C, Schultz RT. Face composite effects reveal abnormal face processing in autism. submitted.

Gauthier I, Tarr MJ. Becoming a "Greeble" expert: Exploring mechanisms for face recognition. Vision Research. 1997; 37:1673–1682. [PubMed: 9231232]

Gauthier I, Tarr MJ. Unraveling mechanisms for expert object recognition: Bridging brain activity and behavior. Journal of Experimental Psychology: Human Perception and Performance. 2002; 28:431–446. [PubMed: 11999864]

Goffaux V, Rossion B. Faces are "spatial"--holistic face perception is supported by low spatial frequencies. Journal of Experimental Psychology: Human Perception and Performance. 2006; 32:1023–1039. [PubMed: 16846295]

Ge L, Wang Z, McCleery JP, Lee K. Activation of face expertise and the inversion effect. Psychological Science. 2006; 17:12–16. [PubMed: 16371138]

Hole GJ. Configurational factors in the perception of unfamiliar faces. Perception. 1994; 23:65–74. [PubMed: 7936977]

Hole GJ, George PA, Dunsmore V. Evidence for holistic processing of faces viewed as photographic negatives. Perception. 1999; 28:341–359. [PubMed: 10615472]

Hubner R. Attention shifting between global and local target levels: The persistence of level-repetition effects. Visual Cognition. 2000; 7:465–484.

Hubner R, Futterer T, Steinhauser M. On attentional control as a source of residual shift costs: Evidence from two-component task shifts. Journal of Experimental Psychology: Learning, Memory and Cognition. 2001; 27:640–653.

Lawson R. Local and global processing biases fail to influence face, object and word recognition. Visual Cognition. 2007; 15:710–740.

Le Grand R, Mondloch CJ, Maurer D, Brent HP. Impairment in holistic face processing following early visual deprivation. Psychological Science. 2004; 15:762–768. [PubMed: 15482448]

Leder H, Bruce V. Local and relational aspects of face distinctiveness. The Quarterly Journal of Experimental Psychology: Human Experimental Psychology. 1998; 51A:449–473.

Leder H, Bruce V. When inverted faces are recognized: The role of configural information in face recognition. The Quarterly Journal of Experimental Psychology: Human Experimental Psychology. 2000; 53A:513–536.

MacLeod CM. Half a century of research on the Stroop effect: an integrative review. Psychololological Bulletin. 1991; 109:163–203.

Macrae CN, Lewis HL. Do I know you?: Processing orientation and face recognition. Psychological Science. 2002; 13:194–196. [PubMed: 11934008]

Maurer D, Le Grand R, Mondlock CJ. The many faces of configural processing. Trends in Cognitive Science. 2002; 6:255–260.

Michel C, Rossion B, Han J, Chung CS, Caldara R. Holistic processing is finely tuned for faces of one's own race. Psychological Science. 2006; 17:608–615. [PubMed: 16866747]

Mondloch CJ, Le Grand R, Maurer D. Configural face processing develops more slowly than featural face processing. Perception. 2002; 31:553–566. [PubMed: 12044096]

Navon D. Forest before trees: The precedence of global features in visual perception. Cognitive Psychology. 1977; 9:353–383.

Perfect TJ. Local processing bias impairs line-up performance. Psychological Reports. 2003; 93:393–394. [PubMed: 14650660]

Richler JJ, Cheung OS, Wong AC-N, Gauthier I. Does response interference contribute to face composite effects? submitted.

Richler JJ, Gauthier I, Wenger MJ, Palmeri TJ. Holistic processing of faces: Perceptual and decisional components. Journal of Experimental Psychology: Learning, Memory and Cognition. 2008; 34:328–342.

Richler JJ, Tanaka JW, Brown DD, Gauthier I. Why does selective attention to parts fail in face processing? Journal of Experimental Psychology: Learning, Memory and Cognition. in press.

Robbins R, McKone E. No face-like processing for objects-of-expertise in three behavioral tasks. Cognition. 2007; 103:34–79. [PubMed: 16616910]

Rossion B, Kung CC, Tarr MJ. Visual expertise with non-face objects leads to competition with the early perceptual processing of faces in the human occipitotemporal cortex. Proceedings of the National Academy of Science. 2004; 101:14521–14526.

Searcy JH, Bartlett JC. Inversion and processing of component and spatial-relational information in faces. Journal of Experimental Psychology: Human Perception and Performance. 1996; 22:904–915. [PubMed: 8756958]

Tanaka JW, Farah MJ. Parts and wholes in face recognition. The Quarterly Journal of Experimental Psychology. 1993; 46:225–245. [PubMed: 8316637]

Troje N, Bulthoff HH. Face recognition under varying poses: The role of texture and shape. Vision Research. 1996; 36:1761–1771. [PubMed: 8759445]

Wenger MJ, Ingvalson EM. A decisional component of holistic encoding. Journal of Experimental Psychology: Learning, Memory and Cognition. 2002; 28:872–892.

Weston NJ, Perfect TJ. Effects of processing bias on the recognition of composite face halves. Psychonomic Bulletin & Review. 2005; 12:1038–1042. [PubMed: 16615325]

Williams P, Tarr MJ. Rsvp: Experimental control software for macOS9 [online]. no date. Retrieved June 22, 1998.

Wong AC-N, Palmeri TJ, Gauthier I. Conditions for face-like expertise with objects: Becoming a Ziggerin expert but – which type? submitted.

Young A, Hellawell D, Hay D. Configurational information in face perception. Perception. 1987; 16:747–759. [PubMed: 3454432]

Appendix A: Results of ANOVA on response Bias (c) in Experiments 1–3

Experiment	Conditions in which participants were more likely to respond "same"	*p*-value
1	study misaligned	.040
	study misaligned & test misaligned	.001
2	study aligned	.017
	study & test aligned and study & test misaligned	< .0001
3	no significant main effects or interactions	

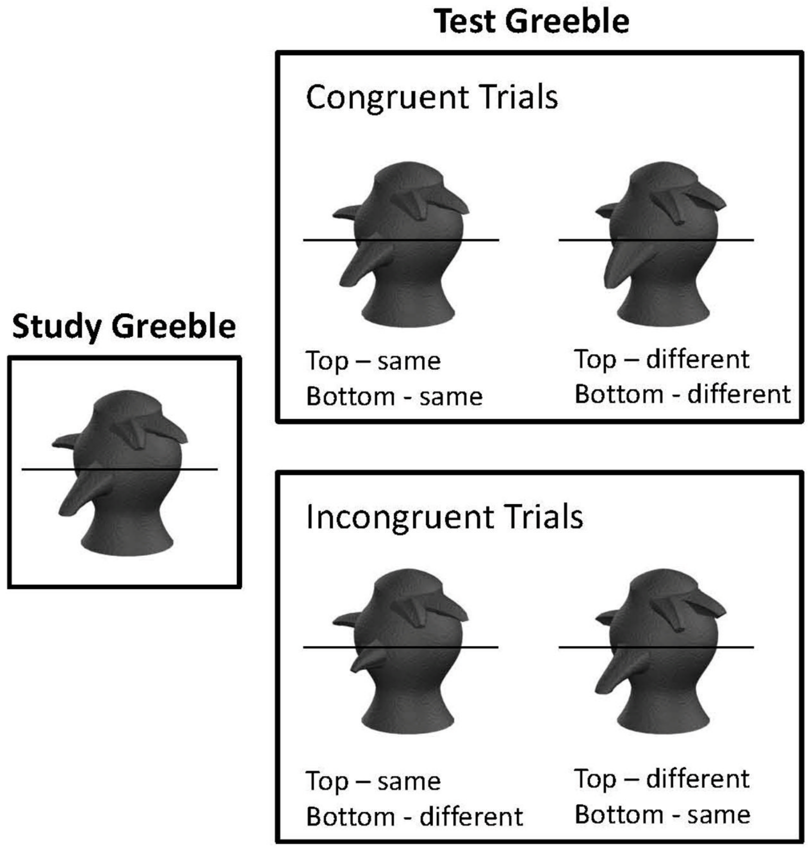

Figure 1.
Illustration of the trial types in the composite task. On congruent trials, both the top and bottom of the test Greeble are the same or both are different than the study Greeble. On incongruent trials, one part is the same and the other part is different than the study Greeble.

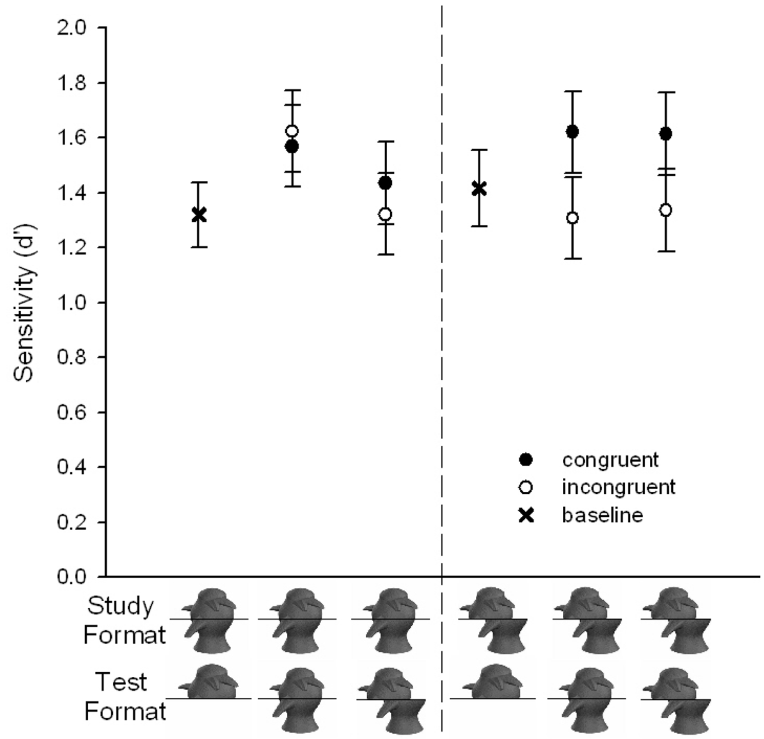

Figure 2.
Performance (d′) on congruent and incongruent trials in Experiment 1 for all combinations of aligned and misaligned study and test Greebles. Study format was blocked between participants. Error bars show 95% confidence intervals for within-subjects effects.

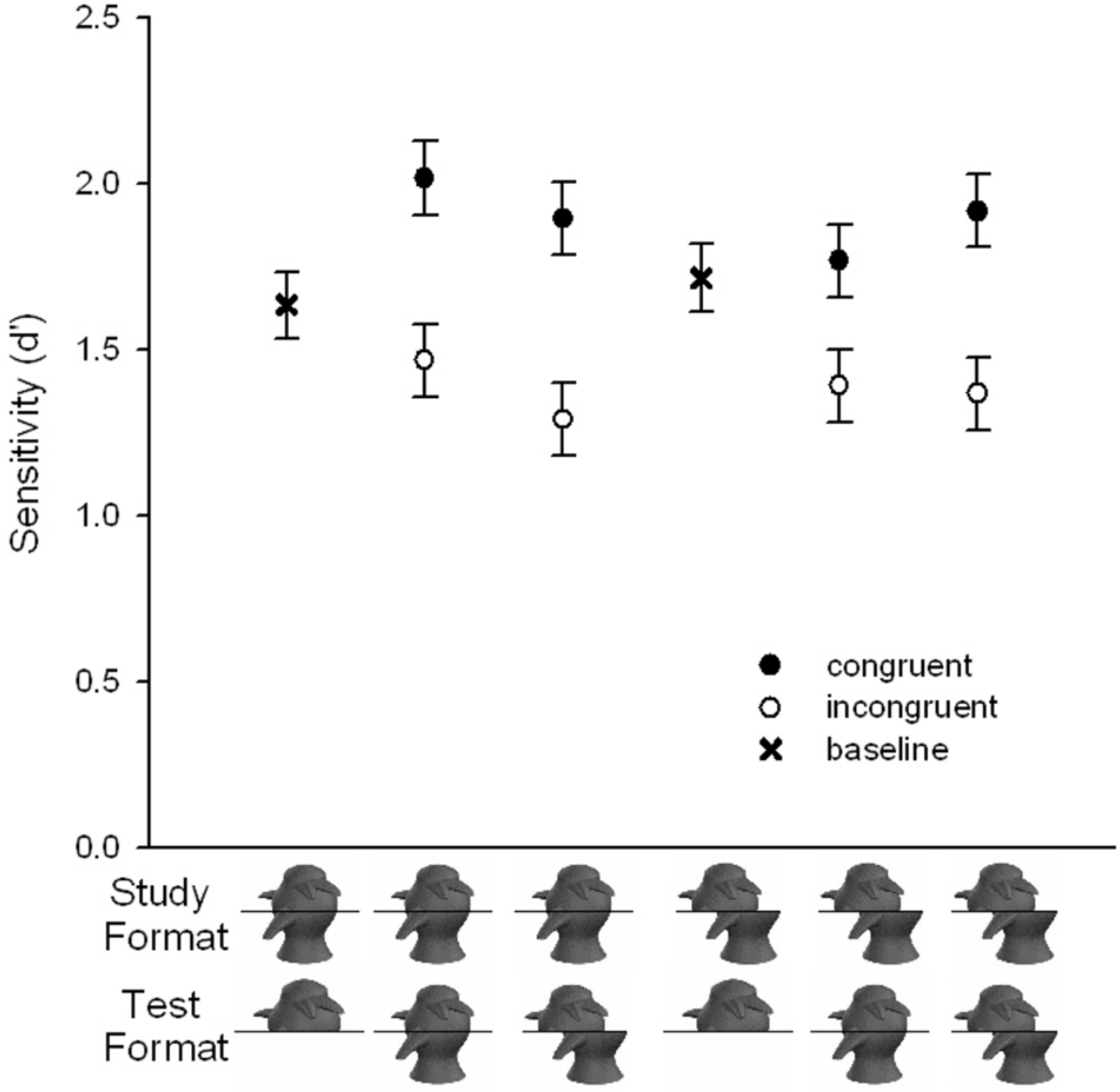

Figure 3.
Performance (d′) on congruent and incongruent trials in Experiment 2 for all combinations of aligned and misaligned study and test Greebles. Study format was randomized for all participants. Error bars show 95% confidence intervals for within-subjects effects.

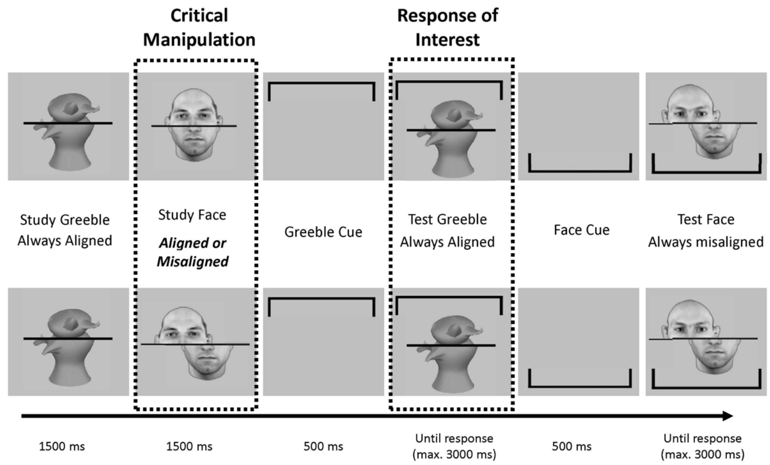

Figure 4.

Schematic of two trials in the interleaved composite task used in Experiment 3. A composite task with Greebles, where the study and test Greebles are always aligned, is interleaved with a composite task with faces, where the study face is either aligned or misaligned and the test face is always misaligned. The critical manipulation is whether face which precedes the test Greeble is aligned or misaligned. The response of interest is the response to the test Greeble: will this be affected by whether the preceding face is aligned or misaligned?

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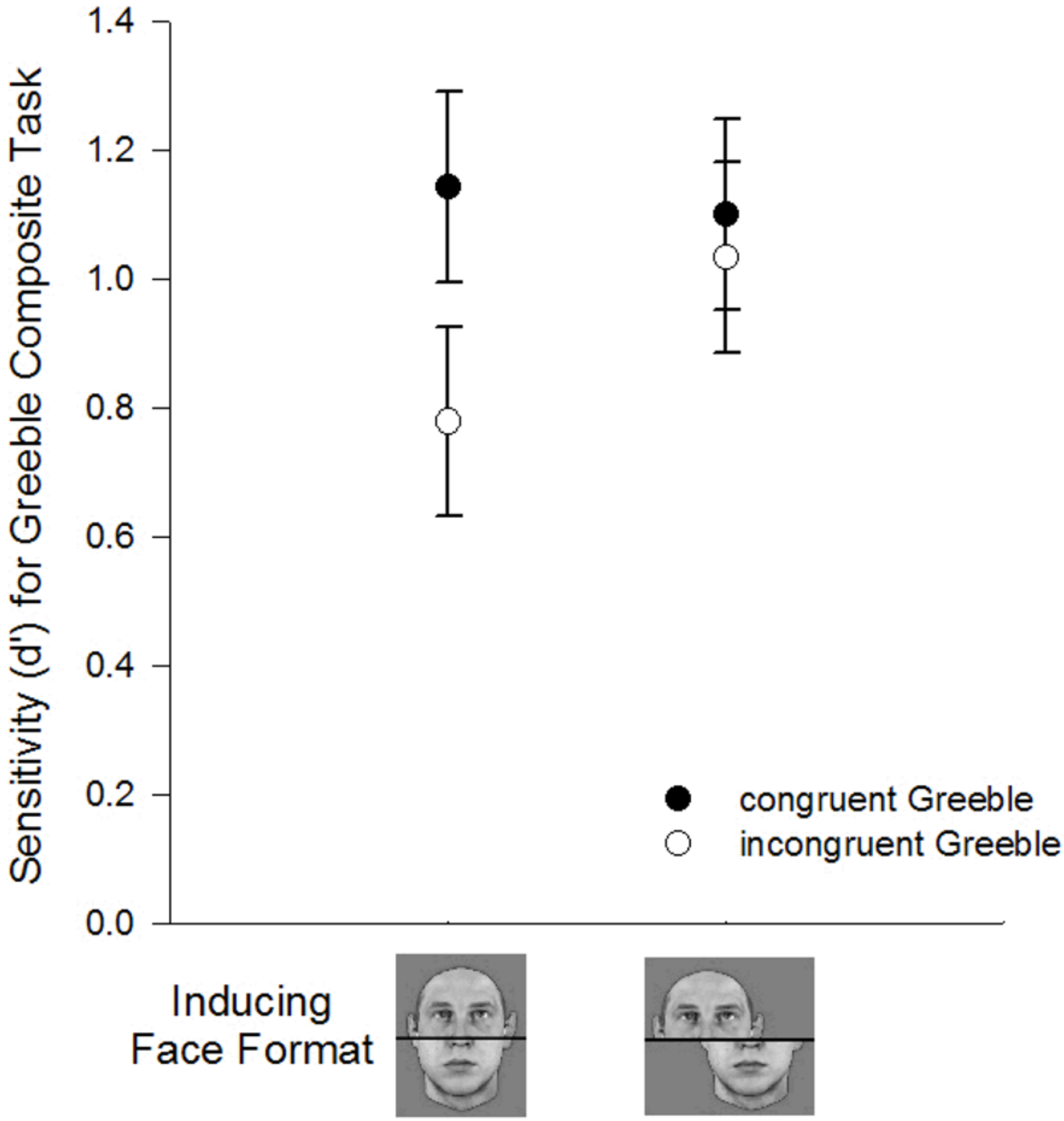

Figure 5.
Performance (d′) on the Greeble composite task in Experiment 3 when the Greeble trial was congruent and incongruent as a function of whether the preceding face was aligned or misaligned. Error bars show 95% confidence intervals of within-subjects effects.