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EXPLORATION OF THE OTHER-RACE RECOGNITION DEFICIT

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF PSYCHOLOGY

BY

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This dissertation is dedicated to my parents Randy and Andrea Wetmore.

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Abstract

Existing research regarding the Other-Race Bias (ORB), a phenomenon in which faces of the same race are more accurately recognized than of another race, primarily focuses on when the recognition deficit occurs and not why it occurs. The current research was designed to investigate what processing components are responsible for the ORB through the use of a sequential sampling model, the EZ diffusion model. Accuracy and reaction time were jointly considered, in addition to traditional measures of performance, to evaluate recognition decisions made about same race and other race faces. Emotion and face orientation were also manipulated to differentiate what type of processing, configural or featural, is recruited. The results indicated that recognition differences occur because of the quality of information available in memory and not a response bias. Furthermore, the use of configural or featural processing may not be able to explain the differences in processing for SR and OR faces. Research needs to continue to seek explanations of the ORB.

Introduction

People are natural experts at recognizing faces, with the ability to discriminate thousands of individuals, recognize hundreds, in poor lighting, after many years, and even when encountering a novel viewpoint (Bahrick, Bahrick, & Wittlinger, 1975). Furthermore, neural circuits have been identified that support the expertise of processing faces (Kanwisher, McDermott, & Chun, 1997; Haxby, Hoffman, & Gobbini, 2000; Caldara & Seghier, 2009). These studies suggest that there is an area in the fusiform gyrus, the fusiform face area (FFA), which is highly responsive to faces. Neuroimaging in normal subjects has confirmed and refined the role of the occipito-temporal regions and the superior sulcus in face and non-face object processing (Kanwisher et al., 1997; McCarthy, Puce, Gore & Allison, 1997; Gauthier, Behrmann, & Tarr, 1999, Haxby et al., 2000). Unlike other objects, faces tend to be processed in a configural manner, where the components of the face are united into a Gestalt-like representation (Tanaka & Farah, 1993). This Gestalt-like representation makes the processing of individual features difficult, although individuals can be attuned to feature cues (e.g., nose shape or eye color; Freire, Lee, & Symons, 2000; Mondloch, Le Grand, & Maurer, 2002) and the relationship between features (i.e., second-order relation cues; Diamond & Carey, 1986; Freire et al., 2000; Mondloch et al., 2002).

Expert face processing, however, does have limitations. For instance, the other-race bias (ORB, also known as the own-race bias or cross-race effect) is a well-known phenomenon in which people are more accurate at recognizing faces of individuals of the same-race (SR) as opposed to those of the other race (OR) (Chance & Goldstein, 1981; Malpass & Kravitz, 1969; Meissner & Brigham, 2001). The lower discriminability (i.e., ability to distinguish old from new faces) for OR faces is generally indicated by increased false alarms (i.e., selecting a new face as old) and occasionally by a reduced hit rate (e.g., incorrectly rejecting an old face) (Meissner et al., 2001). The ORB is a robust finding that has been replicated across a variety of conditions and for a variety of races, including Asian and White (Ng, & Lindsay, 1994), Germans viewing Turkish faces (Sporer, 1999), Mexican American, White, and Black (Platz & Hosch, 1988), Hispanic and Black (MacLin et al., 2001), Whites and Blacks from South Africa and England (Wright, Boyd, & Tredoux, 2001; Chiroro, Tredoux, Radaelli, & Meissner, 2008), and Jewish and Arab (Weimann, Fishman, & Rattner, 1986; Rattner & Fishman, 1998). Although support for the general effect is robust, attempts at explaining the underlying mechanisms of the ORB across racial groups are limited, and have not resulted in much consensus (Meissner et al., 2001; Teitelbaum & Geiselman, 1997).

The purpose of the current experiments was to examine potential processes underlying the other-race recognition deficit. Most prior research on the ORB examines only accuracy as a dependent measure. However, process explanations of memory phenomena require consideration of more than just accuracy (e.g., Ratcliff, 1978), more specifically, a theory that ties reaction time and accuracy together. Evaluating accuracy and reaction time together is necessary, as these decisions develop over time. Furthermore, the relationship between accuracy and reaction time is not fixed, but rather is dependent on whether a particular task emphasizes speed or accuracy, and whether one response is more likely than another. A simplified version of Ratcliff's diffusion model (the EZ diffusion model) will be used to tease apart component processes affecting SR and OR recognition through the joint assessment of accuracy and reaction time.

In addition to the EZ diffusion model, two manipulations were introduced to more closely examine the processes underlying the ORB: emotion and face inversion. First, emotion is a socially important attribute (Fox et al., 2000). There is a clear evolutionary advantage to being able to rapidly respond to the presence of a potential threat that can be signaled by the emotion on an individual's face (e.g., angry attacker). Recent research has found that OR faces with angry expressions can reduce the ORB (Ackerman et al, 2006). However, it is unclear if the angry expression is providing a better memory cue or whether it alters the willingness to select these faces. Second, face inversion (turning faces upside down) disrupts the eyes-over-nose-over-mouth configuration shared by all human faces and hinders face recognition (Yin, 1969). The inverted orientation of the faces is thought to disrupt the configural processing that generally aids facial recognition. Inversion paradigms are used as a test of the relative contributions of configural versus featural processing, and the current experiment will do so with SR and OR faces for both neutral and angry expressions. One social-cognitive theory, the Ingroup/Outgroup Model (IOM) of face processing, makes specific predictions regarding the contributions of configural and featural processing for OR and SR faces, discussed next.

Ingroup/Outrgroup Model of Face Processing

Deficits in recognition of OR faces have been attributed to many different factors, including differential amounts of contact (Malpass & Kravitz, 1969), quality of contact (Brigham & Malpass, 1985; Lavrakas, Buri, & Mayzner, 1976), differential development of the perceptual system (Chance, Turner, & Goldstein, 1982; MacLin & Malpass, 2001; O'Toole, Abdi, Deffenbacher, & Valentine, 1995), rapid categorization (Bernstein, Young, & Hugenberg, 2007) and prejudiced social attitudes (Secord, Bevan, & Katz, 1959; Seelman, 1940). But none of these hypotheses have been able to explain all the results regarding the ORB (Young, Hugenberg, Bernstein, & Sacco, 2012), which is why recent theories have begun to incorporate both social and cognitive components. This includes the In-group/Out-group model (IOM) of face processing (Sporer, 2001).

According to the IOM model, in-group (SR) and out-group (OR) face processing occurs through two separate routes (Sporer, 2001). When confronted with a SR face, automatic processing commences with configural coding, which is characteristic of expert processing of upright faces. Conversely, perception of an OR face triggers categorization prior to face-processing strategies (which might be either configural or featural). An initial reliance on categorization can result in cognitive disregard (individuals are disregarded because of the focus on categorical characteristics (e.g., female, black; Malpass, 1990), differential depth of processing (shallow processing generally used for OR faces; Chance & Goldstein, 1981), or poor activation of salient features (see Sporer, 2001). In other words, because categorization precedes face processing in OR faces due to the existence of an obvious out-group cue (e.g., skin color), dimensions along which SR and OR members differ do not become salient and recognition suffers (e.g., Levin, 1996). In addition, the IOM predicts that this initial categorization of out-group faces shifts participants to a more liberal response bias because the number of out-group (OR) faces that are activated in memory is greater than the individuated faces of those automatically processed as in-group (SR). In sum, the categorization of OR faces results in poorer encoding of those faces. Given the automatic categorization of other race individuals based on an out-group cue predicted by the IOM, it is difficult to imagine how the theory would be able to identify situations in which performance for OR faces may be similar to that of SR faces. However, one such feature that may override initial categorization and result in enhanced encoding is emotion.

Anger and Face Processing

Outgroup (OR) members might become salient to perceivers when those outgroup members are angry. Research has shown that angry facial expressions capture and hold attention (e.g., Fox et al., 2000; Ohman, Flykt, Esteves, 2001). Recall that the IOM predicts that the categorization of OR faces leads to poor encoding of OR faces through cognitive disregard, shallow processing, or more generally because the dimensions salient for individuation are not being activated. However, there are two considerations that suggest that the perception of anger may lead perceivers to allocate more resources to angry faces. First, anger is an interpersonal emotion. It implies threatening intent by an individual, the person expressing anger, toward another individual, the person perceiving the expression (Knutson, 1996). Second, angry expressions may not be held for long, in that the angry expression may disappear even though the threat persists. Therefore, just as it is functional to attend to people with angry facial expressions (to detect and avoid), it is also functional to encode individuating features of those individuals to remember to avoid them in the future (Keltner & Haidt, 1999). This reasoning suggests that angry individuals are likely to command a greater proportion of cognitive resources, and potentially lead to greater attention to angry OR faces and a reduced ORB. In fact, Ackerman et al. (2006) found that angry expressions enhanced recognition performance for OR faces. Participants not only exhibited increased accuracy for OR faces with an angry expression compared to OR faces with a neutral expression, they also found that OR accuracy exceeded that for SR faces when cognitive resources were limited.

Although anger resulted in a reduction of the ORB, it is not clear how the processes that underlie the ORB were affected. The changes in accuracy may be the product of a better memory for those angry faces. However, it may also be the result of people being more conservative in their responding, resulting in slower but more accurate decisions. The relationship between reaction time and accuracy needs to be evaluated to reveal the underlying processes, and the EZ diffusion model can provide estimates of the quality of information and response bias. But the EZ diffusion model is silent regarding whether configural or featural processing supports the differences that may occur in the quality of information. It is possible that the same processing mechanisms that are used for SR faces are not recruited for OR faces (e.g., categorization as proposed by the IOM). However, because emotion provides important interpersonal information and captures attention, it may promote the use of the same processing mechanisms regardless of race. Face inversion paradigms are one way to gain additional insight into the specific type of face processing (configural or featural) underlying the ORB, and the potential impact of emotion.

Face Inversion

Face inversion studies have exhibited differences in the processing of SR and

OR faces. Rhodes, Brake, Taylor, and Tan (1989) hypothesized that SR faces are processed more configurally, which meant that inversion should harm SR but not OR recognition. As predicted, when inverted, SR recognition dropped to that of OR recognition levels. Inverting OR faces, however, had relatively little influence on OR recognition. These results support the idea that SR faces are processed in a configural manner, whereas OR faces are processed in a more featural manner. More recently, Vizioli, Foreman, Rousselet, and Caldera (2010) demonstrated differences in the processing of SR and OR faces with a face inversion paradigm using EEG. The results indicated that OR faces and inverted SR faces produced greater amplitudes, whereas the SR faces were processed with smaller amplitudes. The authors argued that the smaller amplitudes indicated that the SR faces were processed more configurally compared to OR faces or inverted SR faces. Although it is difficult to determine the specific type of processing that occurred, the EEG does demonstrate that there is a difference in the processing of upright and inverted faces, and that OR faces were processed differently than SR faces.

If the configural processing of SR faces is responsible for better recognition, it is possible that anger leads OR faces to be processed in a configural manner. According to the IOM, an OR face is categorized before a specific processing strategy is recruited. Therefore, if configural processing is recruited for angry OR faces, then inverting those faces should hinder recognition performance in a manner similar to SR faces. However, if featural processing still occurs for these faces because they are OR, then recognition performance should not be affected. In order to evaluate whether configural or featural processing is recruited, both angry and neutral expressions were tested in a face inversion paradigm where both accuracy and response latency were examined.

EZ Diffusion Model

To date, few studies have considered the reaction time of SR and OR recognition decisions (Caldara, Rossion, Bovet, & Hauert, 2004; Tower, 2013). These studies generally have found that responses to OR faces are slower than to SR faces, although not significantly slower. One possibility suggested by the IOM is that differences in the quality of memory may be responsible for the recognition deficit (featural versus configural processing). However, the IOM also proposes that there is a response bias to OR faces that also could be a factor in the ORB. In order to assess whether the memory evidence, or some other factor, is responsible for the differences in reaction time, a cognitive model must be utilized.

Sequential sampling models for two-choice decisions, such as recognition decisions, jointly consider assessments of accuracy and reaction time. The premise of these models is that the representation of an item in memory is noisy; therefore, there is a noisy accumulation of information that occurs over time before a decision can be reached regarding whether an item has been previously studied (Ratcliff & Smith, 2004; Ratcliff, 1978). The EZ Diffusion model is a member of this class of sequential sampling models, and is a simplified version of Ratcliff's complex diffusion model (Wagenmakers, Van der Maas, & Grasman, 2007).

In the EZ diffusion model, memory evidence is assumed to accumulate over time and a response is given when enough evidence has accumulated towards one of the response boundaries (‘‘old’’ or ‘‘new’’; see Figure 1). The model takes summary measures from the data as input (mean reaction time, the variance of the reaction time, and accuracy) and outputs parameter estimates that reflect the quality of memory evidence (v), response bias (a), and the non-decision time (T_{er}). The v can be thought of as an index of the quality of the evidence that is being retrieved from memory after viewing a test face. If the test face matches a studied face that was well encoded, the v is strongly positive; conversely, if the test face does not easily retrieve a studied face (or that face is weakly encoded), then v will be smaller or even negative. The memory evidence accumulates over time between two boundaries that represent old and new responses. The separation of the two boundaries represents the response bias (a). A small value of a indicates that the boundaries are close together. Conversely, a larger value of a would signal greater response conservatism (require more evidence before responding). The distance between the boundaries reflects how the model trades off response speed for accuracy. An assumption of the EZ diffusion model is that the starting point of the accumulating information falls equidistant between the two boundaries ($a/2$). If the proportion of old and new tests is equal, this is a reasonable assumption. Lastly, there is a parameter that accounts for the non-decision aspects of the recognition task, reflecting the time to encode the test stimulus and to execute the response (T_{er}). If OR faces are responded to more slowly, it could be because they provide a poorer quality of evidence (lower v), induce a more conservative response bias (larger a), or are due to differences in non-decision time (T_{er} greater for OR faces).

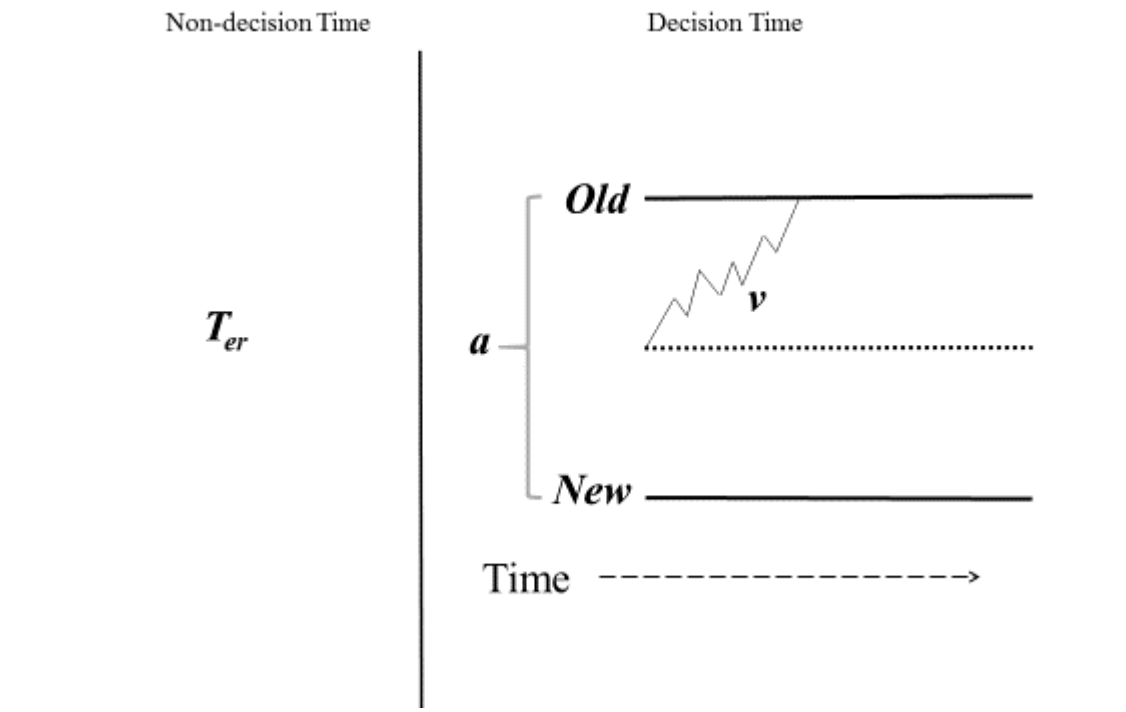

Figure 1. The EZ Diffusion model depiction of evidence accumulation (see Wagenmakers et al., 2007).

Previous ORB research using the EZ diffusion model has found differences in these parameters. Tower (2013) examined the reaction time of recognition decisions of SR and OR in an inversion experiment. The results of an ANOVA on mean reaction times found no significant differences between SR and OR faces. However, the analysis using the parameters of the EZ diffusion model indicated significant differences in processing. When upright, there was a significant difference in *v* between SR and OR race faces, indicating that the quality of evidence was better from SR than OR faces. When inverted, however, there was no significant difference. In addition, as predicted by Sporer (2001), upright OR faces had a more liberal response bias (greater *a*) compared to SR faces. As this analysis indicates, reaction time data can reveal more detailed information when assessed using the EZ diffusion model than when only mean reaction times are assessed.

Within the framework of the EZ diffusion model, specific predictions can be made regarding what differences in parameter values may arise as a function of SR and OR faces, as well as what impact emotion, specifically anger, may have on these parameters. (Predictions concerning how inversion will affect recognition and parameters of the EZ Diffusion model are discussed prior to Experiment 2.) First, the IOM predicts that the configural processing of SR faces is responsible for better recognition performance. Therefore, configural processing is responsible for the better quality of evidence, which should be reflected in a greater value of the *v* parameter for SR faces. Conversely, because OR faces are categorized first, this should result in poorer quality of evidence because individuating features are not encoded. Additionally, the IOM predicts a liberal response bias for OR faces, although this prediction may only be true for neutral faces. Larger values of *a* should occur in SR conditions, whereas OR conditions should have smaller values. Lastly, as there is additional processing for OR faces (i.e., categorization), T_{er} (the non-decision time parameter) should be greater for OR than for SR faces.

Experiment 1 was designed to assess the processing differences that occur in recognition decisions involving SR and OR faces with neutral and angry expressions. Experiment 2 will introduce a face inversion paradigm to determine if configural or featural processing is utilized with OR angry faces.

Experiment 1

Participants and Design

A total of 66 participants were recruited from the University of Oklahoma. The sample consisted of Caucasian/White (n = 50), Black/African American (n = 6), Middle

Eastern (n = 2), Asian (n = 7), and one person who did not indicate their ethnicity. The sample was predominantly female (n = 45, 68%) with a mean age of 20 years. Although no participants were excluded from participation on the basis of race or ethnicity, due to the constraints of the experiment and the demographic make-up of the student population at the University of Oklahoma (62.5% of the students are White non-Hispanic), analysis of the data was restricted to White participants only. One participant was excluded on the basis of their performance, which was below chance in all conditions. Therefore, a total of 49 participants were included in the current experiment. Participants received course credit for their participation. All guidelines set forth by the American Psychological Association and the Institutional Review Board were followed.

The experiment employed a 2 (Target Race: Other, Same) X 2 (Target Emotion: Neutral, Angry) repeated-measures design. The dependent variables include accuracy and response bias as assessed by signal detection measures (sensitivity, d' and bias, β), and reaction time. Reaction times were evaluated using the EZ Diffusion Model parameters, v (drift rate), a (response bias), and T_{er} (non-decision time).

Materials

Photographic Stimuli

Participants viewed a total of 320 photographs of college-age White (160) and Other Race (160) males and females. All photographs excluded any individuals with facial hair, glasses, or visible tattoos. All photographs were grayscale, displayed head and shoulders only, and scaled to 768 x 576 pixels. Eighty White and Other Race (40 Black and 40 Asian) face photographs were of individuals with neutral facial expressions. The other eighty photographs were of individuals with angry facial expressions. The White and Black stimulus images were courtesy of Dr. Chris Meissner (Investigative Interviewing Research Laboratory, University of Texas at El Paso, http://iilab.utep.edu/stimuli.htm) and Dr. A. Martinez and Dr. R. Benavente. (*The AR Face Database*. CVC Technical Report #24, June 1998). The Asian faces were from the CAS-PEAL-R1 face database collected under the sponsor of the Chinese National Hi-Tech Program and ISVISION Tech. Co. Ltd.

Equipment and Software

The photographs were presented via computer, utilizing E-prime software (Psychology Software Tools).

Procedure

After reading the consent form, participants were asked to read brief instructions about studying the stimuli and the subsequent recognition test that would follow. In total, each participant completed a single practice trial and six study/test blocks.

Study Phase

The study phase presented 24 faces (6 Other Race-Neutral, 6 Other Race-Angry, 6 White-Neutral, 6 White-Angry). Each trial began with a 500ms fixation point (+) followed by the presentation of a face for 2s, with a 500ms inter-trial interval (following Ackerman et al., 2006). The study faces were presented in blocked order, such that participants studied all of the White faces followed by the Other Races faces, or vice versa (counterbalanced between participants)[1]. Which faces were presented at study and test, or used as distractors, was randomized between subjects.

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[1] The blocked presentation of faces at encoding produces stronger effects of ORB (Meissner et al., 2001).

Filler Task

After the study phase**,** participants completed a filler task wherein they were given 1 min to solve a series of simple math problems.

Test Phase

In the recognition test phase, participants were first instructed to respond as quickly yet accurately as they could to avoid biasing them toward any response. Participants were tested on the original 24 faces as well as 24 distractor faces that were not previously seen (6 Other Race-Neutral, 6 Other Race-Angry, 6 White-Neutral, 6 White-Angry). These 48 faces were presented sequentially, in a different random order for each participant. Participants indicated whether the test face was ‘old’ (studied item) or ‘new’ (not previously studied), and reaction times were recorded.

Results

In order to examine recognition memory for OR faces with neutral and angry expressions, an analysis of accuracy using traditional measures (sensitivity, d' and bias, β) was conducted (see Table 1 for Means and SDs). In addition, the EZ Diffusion model was utilized for its capability to jointly assess both the accuracy and reaction time of responses, and extract latent measures of the quality of memory evidence, response bias, and non-decision time (see Table 2 for Means and SDs). Prior to any analyses, contaminant responses were trimmed from the data. Contaminant responses, responses that do not derive directly from the processes under study (e.g., anticipations, lapses of attention, spurious responses), can result in very fast responses. However, very slow contaminant responses may also occur in the positive tail of the reaction time distribution (Ratcliff, 2008). Therefore, any responses below 200 ms or above 2604 ms

(5 standard deviations above the mean) were excluded from further analysis. In total, 422 responses (3% of the overall data) were excluded. However, it is important to note that analyses including all the data do not differ from those reported here.

Table 1. Recognition Performance and EZ Diffusion Parameter Means for Target Faces as a Function of Race and Expression**.**

	Other Angry	**Other Neutral**	**Same Angry**	**Same Neutral**
Hits	.76 (.12)	.72 (14)	.77 (.12)	.71 (.14)
False Alarms	.27 (.12)	.30 (.16)	.29 (.13)	.22 (.12)
d'	1.42 (.45)	1.23 (.50)	1.39 (.55)	1.45 (.43)
B	1.11 (.95)	1.15 (.82)	1.05 (.73)	1.49 (1.26)
Drift Rate (*v)*	.082 (.03)	.065 (.02)	.078 (.03)	.082 (.03)
Boundary Separation (*a*)	.137 (.02)	.140 (.02)	.140 (.02)	.139 (.02)
Non-Decision Time (T_{er})	.573 (.12)	.572 (.12)	.581 (.12)	.587 (.13)

Note: Standard deviations in parentheses.

Performance

Discriminability is assessed by the signal detection parameter *d′*. Separate *d′* scores were obtained by first calculating separate hit and false-alarm rates for each condition for each participant. After converting all hit and false-alarm rates to *z*-scores, *d′* scores were calculated by subtracting the false-alarm score from the hit score within each condition[2]. The *d′* scores were then submitted to a 2 (Race: same, other) x 2 (Expression: angry, neutral) repeated-measures analysis of variance (ANOVA; see Figure 2). There was a significant main effect of race ($F(1,48) = 3.80$, $p < .05$, $\eta_p^2 =$

[2] Any hit rates of 1.0 or false-alarm rates of 0.0 were adjusted by 1-(1/2*N*) or 1/2*N*, respectively, where *N* is equal to the total number of trials for that condition (Snodgrass & Corwin, 1988).

.07), replicating the ORB. No significant main effect of expression emerged ($F(1,48) = 2.48$, $p = .12$). Critically, the interaction between race and expression, ($F(1,48) = 5.17$, $p = .01$, $\eta_p^2 = .09$), was significant. Paired-samples *t*-tests[3] revealed results consistent with previous research; discriminability was similar between the OR face with an angry expression ($M = 1.42$) and the SR faces with either a neutral ($M = 1.45$) or angry ($M = 1.39$) expression ($t(48) = .45$, $p = .65$, and $t(48) = .28$, $p = .78$, respectively). The worst discriminability occurred for OR faces with a neutral expression ($M = 1.23$) which was significantly different from the OR angry and SR neutral ($t(48) = 3.06$, $p = .004$, $d = .41$ and $t(48) = 3.17$, $p = .003$, $d = .49$ respectively), and SR angry faces nearly reached significance ($t(48) = 2.50$, $p = .01$).

The IOM theory predicts that one of the contributors to an ORB should be a liberal response bias for OR faces. Therefore, a 2(Race: same, other) x 2 (Expression: angry, neutral) repeated-measures ANOVA was conducted on the response bias measure β. The analysis revealed an interaction of race and expression $F(1,48) = 2.02$, $p < .01$, $\eta_p^2 = .16$. Consistent with the IOM, the SR faces with the neutral expression had the most conservative response bias ($M = 1.50$), whereas the neutral and angry OR conditions were more liberal ($M = 1.15$ and $M = 1.11$, respectively). Interestingly, the SR angry response bias ($M = 1.05$) was more liberal than either of the OR conditions. However, the only significant difference for response bias was between angry and neutral SR faces ($t(48) = 3.07$, $p = .004$, $d = .43$). There was a main effect of expression $F(1,48) = 2.76$, $p < .05$, $\eta_p^2 = .13$, indicating a more liberal response bias for angry ($M =$

[3] Bonferroni adjustment was applied to all *t*-tests reported in this paper, and all reported *p*-values are two-tailed. In addition, following Dunlap, Coritna, Vaslow, and Burke, (1996), the original standard deviations (rather than the paired *t*-test value) were used to calculate the effect size for paired-samples *t*-tests to prevent overestimated effect sizes.

1.08) than neutral (M = 1.32) faces). There was no main effect of race $F(1,48) = 2.10$, $p = .15$.

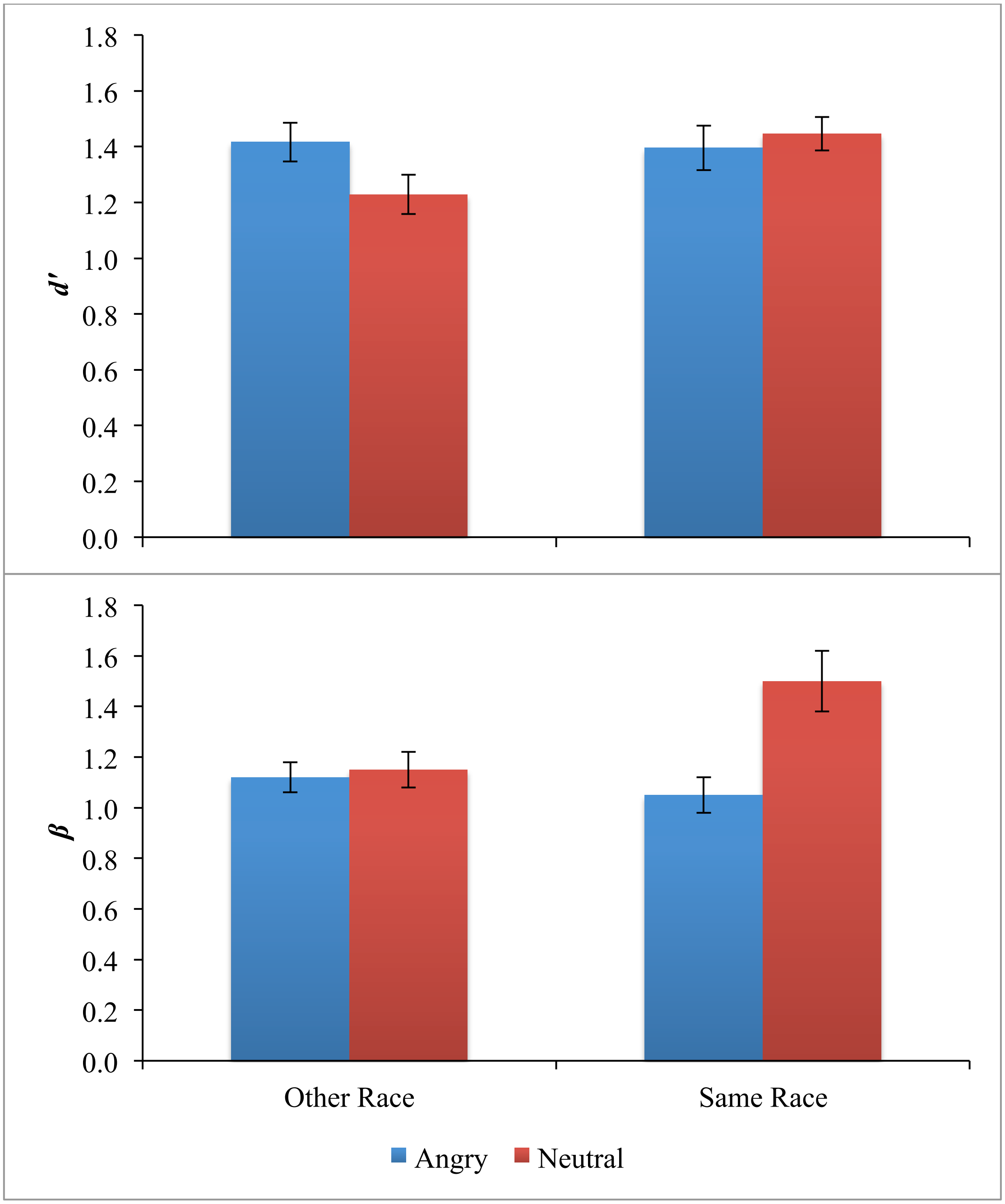

Figure 2. Performance differences for d' (top panel) and β (bottom panel). Bars represent standard error.

EZ Diffusion Model

For each condition, each participant's proportion correct (hits and correct rejections), mean reaction time, and variance of reaction time, were input to estimate values of quality of memory evidence (v), response bias (a), and non-decision time (T_{er}) (R code provided by Wagenmakers, van der Maas, & Grasman, 2007). The estimated parameter values were each submitted to a 2 (Race: same, other) x 2 (Expression: angry, neutral) repeated-measures ANOVA (see Figure 3). Consistent with the d' analysis, the interaction between race and expression was significant for v ($F(1,48) = 14.041$, p .01, $\eta_p^2 = .23$). The main effects mirrored the d' findings: a significant main effect of expression ($F(1,48) = 6.544$, $p = .014$, $\eta_p^2 = .12$); the main effect for race neared significant $F(1,48) = 3.531$, $p = .06$). Most importantly, v indicated that the weakest evidence was for OR neutral expression ($M = .065$), which was significant less than OR angry ($M = .082$), SR neutral ($M = .081$), and SR angry ($M = .078$; $t(48) = 4.81$, $p = .001$, $d = .67$, $t(48) = -4.07$, $p = .001$, $d = .67$, and $t(48) = -3.013$, $p = .004$, $d = .66$, respectively). The performance for the OR angry expressions was not significantly different from either the neutral or angry SR expressions ($t(48) = .04$, $p = .96$ and $t(48) = .85$, $p = .40$, respectively). In contrast to the predictions of the IOM, response bias (a) yielded no significant results (main effect race: $F(1,48) = 1.31$, $p = .26$, main effect expression: $F(1,48) = .90$, $p = .35$, and interaction $F(1,48) = 1.18$, $p = .28$). Lastly, contrary to predictions of the IOM model, there does not seem to be any extra processing time for OR faces due to categorization; the non-decision time parameter, $T_{er,}$ did not yield significant main effects of race nor expression, nor an interaction ($F(1,48) = 3.789$, $p = .06$, $F(1,48) = .104$, $p = .71$, $F(1,48) = .38$, $p = .54$, respectively).

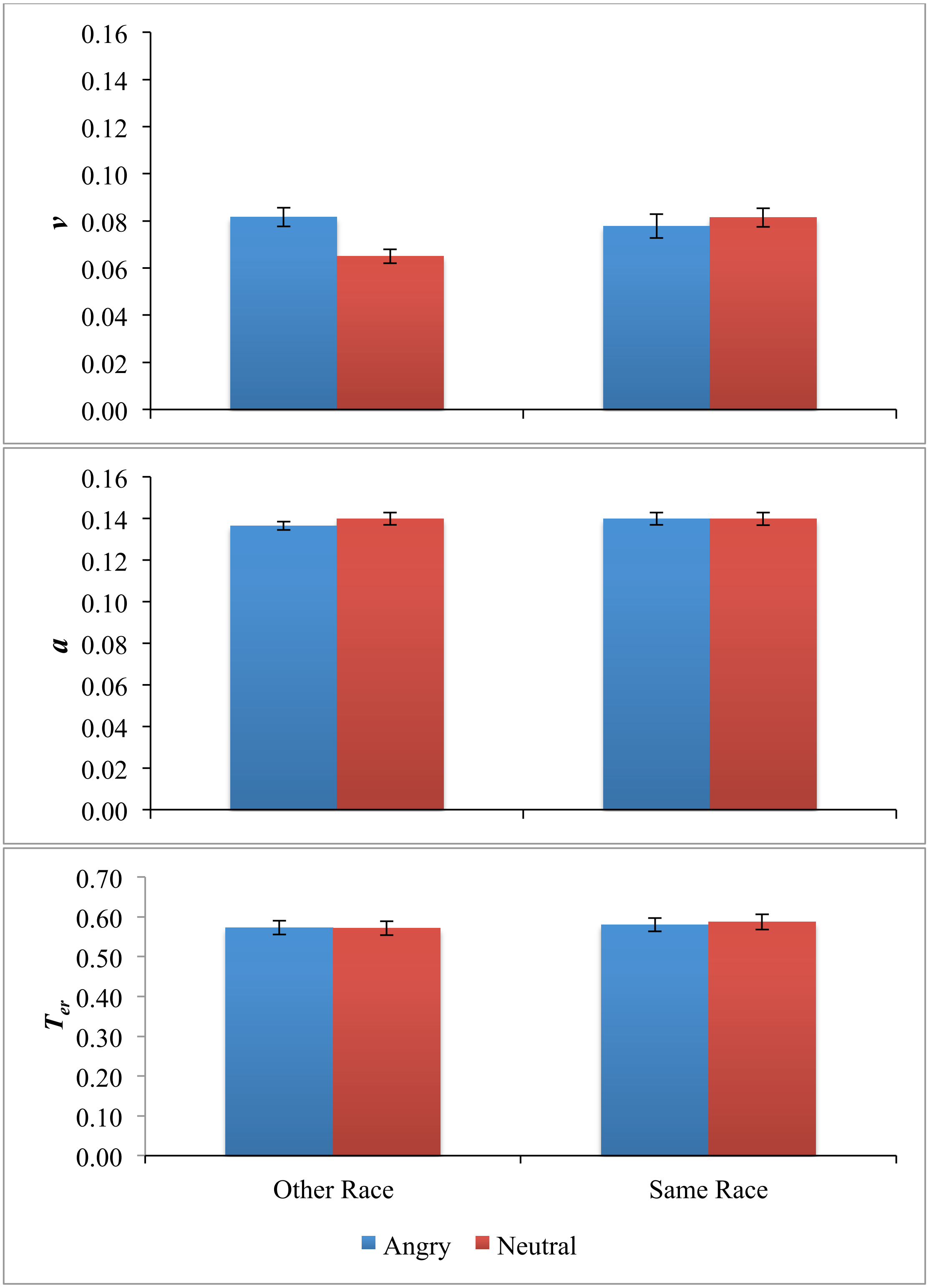

Figure 3. EZ Diffusion model parameters, v (top panel), a (middle panel), and T_{er} (bottom panel). Bars represent standard error.

Discussion

Consistent with previous research, an ORB was found, in which participants had better performance (i.e., *d′*, generally higher hit rate and lower false alarm rate) in SR than OR conditions. Additionally, replicating Ackerman et al. (2006), participants recognized angry OR as well as they recognized SR angry and neural faces. As predicted by the IOM, OR faces tended to promote a more liberal response bias; however, angry SR faces produced the most liberal response bias. The EZ diffusion model results are generally consistent with those found in the accuracy measures. As predicted, the v parameter demonstrated superior quality of information for SR and angry OR faces compared to OR faces with neutral expressions. However, neither the a nor T_{er} parameters were significantly different across conditions. Therefore, the quality of information (encoding), not a response bias, appears to be responsible for the ORB.

Performance was increased for OR faces with angry expressions; however, it is unclear whether the type of processing that occurs with angry OR faces is the same type of processing that occurs for SR faces. Experiment 2 was designed to explore how configural or featural processing in an inversion paradigm may affect performance for OR and SR faces with angry and neutral expressions.

Experiment 2

Previous research has suggested that configural processing is responsible for the superior performance in SR faces, and inversion of SR faces disrupts that processing, resulting in a performance deficit. In contrast, OR face performance does not decrease with inversion because featural processing, thought to be supporting OR face processing, is more resistant to inversion (Rhodes et al., 1989). Therefore, the current experiment was designed to assess whether angry OR faces are processed configurally, like SR faces, or featurally as neutral OR faces. The upright conditions should replicate the results of Experiment 1. When inverted, however, the SR neutral and angry faces should both suffer if configural processing is responsible for their superior processing.

For the EZ Diffusion model, race differences due to inversion should arise in v if configural processing is utilized for SR and OR angry faces. This is because the configural processing should be disrupted when inverted. However, if featural processing is utilized for OR faces, regardless of expression or orientation, v should be unaffected by inversion. Because the IOM predicts that OR faces are categorized first, it implies that recognition decisions should take longer because additional processing is necessary. This likely would slow T_{er}, although no such slowing was found in Experiment 1. Additionally, inversion itself should slow T_{er} because the test orientation differs from what was encoded.

Participants and Design

A total of 177 participants were recruited from the University of Oklahoma. The sample consisted of Caucasian/White (n = 126), Black/African American (n = 22), Asian (n = 14), American Indian/Alaskan Native (n = 7), Middle Eastern (n = 2), Native Hawaiian or Pacific Islander (n = 2), and four participants who did not indicate their ethnicity. Consistent with Experiment 1, the sample was predominantly female (n = 132), with a mean age of 20 years. Again, analysis of the data was restricted to White participants only. Three participants were excluded on the basis of their performance, which was below chance in all conditions. Therefore, a total of 110 participants were retained for analysis. Participants received course credit for their participation. All guidelines set forth by the American Psychological Association and the Institutional Review Board were followed.

The experiment employed a 2 (Target Race: other, same) X 2 (Target Emotion: neutral, angry) X 2 (Orientation at Test: upright, inverted) within-subjects design. The primary dependent variables are the same as Experiment 1.

Materials

Photographic Stimuli

The stimuli are the same as described in Experiment 1.

Equipment and Software

The photographs were presented via computer, utilizing the same experimental program described in Experiment 1.

Procedure

After reading the consent form, participants read brief instructions about studying the stimuli and the subsequent recognition test. In total, each participant completed a single practice trial and eight study/test blocks.

Study Phase

The study phase presented 24 faces (6 Other Race-Neutral, 6 Other Race-Angry, 6 White-Neutral, 6 White-Angry). All study faces were presented upright because the interest was in how normal upright faces are encoded (Rhodes et al., 1989). Each trial began with a 500ms fixation point (+) followed by the presentation of a face for 2s, with a 500-ms inter-trial interval. The study faces were presented in a blocked order such that participants studied all of the White faces followed by the Other Race faces, or vice versa (counterbalanced between participants). The individual faces, neutral or angry, presented as study and test items, and those used as distractors were randomized between subjects.

Filler Task

After the study phase, participants completed a filler task wherein they were given 1 min to solve simple math problems.

Test Phase

All participants completed the recognition test phase in which they were presented the 24 previously studied faces and an additional 24 distractor faces (6 Other Race-Neutral, 6 Other Race-Angry, 6 White-Neutral, 6 White-Angry). Half of the blocks were tested upright and the other half were tested inverted, in a blocked format (e.g., upright then inverted, or vice versa, counterbalanced across participants). The upright and inverted presentations were blocked at test so that the constant switching of the orientation of the faces would not influence participant response times. Within a test block, the angry and neutral expressions were presented in a different random order for each participant. Participants indicated whether the test face was ‘old’ (studied item) or ‘new’ (not previously studied) and reaction times were recorded.

Results

As in Experiment 1, an analysis of accuracy using traditional measures (d' and β) and the EZ Diffusion model were conducted (see Table 1 and 2 for Means and SDs). Prior to any analyses, contaminant responses were trimmed from the data so that any responses below 200 ms or above 2442 ms (five standard deviations above the mean) were excluded from further analysis. In total, 1,852 responses (4.3% of the overall data) were excluded. The analyses including all the data are consistent with those reported.

Table 2. Recognition Performance and EZ Diffusion Parameter Means for Target Faces as a Function of Race, Expression, and Orientation.

	Other Angry	**Other Neutral**	**Same Angry**	**Same Neutral**
Upright				
Hits	.75 (.16)	.71 (.18)	.75 (.16)	.74 (.15)
False Alarms	.29 (.16)	.32 (.17)	.29 (.17)	.23 (.14)
d'	1.40 (.66)	1.18 (.67)	1.43 (.72)	1.57 (.62)
β	1.16 (1.01)	1.04 (.64)	1.14 (.98)	1.56 (1.64)
Drift Rate (*v*)	.078 (.04)	.067 (.04)	.079 (.04)	.087 (.04)
Boundary Separation (*a*)	.136 (.02)	.133 (.02)	.135 (.02)	.137 (.02)
Non-Decision Time (T_{er})	.549 (.10)	.559 (.10)	.560 (.10)	.545 (.10)
Inverted				
Hit	.71 (.16)	.71 (.16)	.71 (.17)	.69 (.17)
False Alarm	.44 (.17)	.49 (.19)	.45 (.20)	.40 (.18)
d'	.77 (.54)	.65 (.45)	.78 (.57)	.82 (.55)
β	.89 (.34)	.88 (.31)	.98 (.64)	.97 (.39)
Drift Rate (*v*)	.045 (.03)	.034 (.02)	.040 (.03)	.046 (.03)
Boundary Separation (*a*)	.136 (.02)	.135 (.02)	.139 (.02)	.136 (.02)
Non-Decision Time (T_{er})	.592 (.14)	.602 (.14)	.597 (.15)	.624 (.12)

Note: Standard deviations in parentheses.

Performance

Consistent with Experiment 1, *d'* and β scores were computed for each participant for each of the conditions (see Figure 4). These scores were then each submitted to a 2 (Race: other, same) x 2 (Expression: angry, neutral) x 2 (Orientation:

upright, inverted) repeated-measures ANOVA. For *d'*, a main effect of orientation, $F(1,109) = 247.33$, $p < .001$, $\eta_p^2 = .69$, indicated that recognition of upright faces (M = 1.39) was superior to inverted faces ($M = .76$), consistent with previous research indicating decreased recognition performance for faces when inverted (Yin, 1969). Additionally, a main effect of race, $F(1,109) = 21.14$, $p < .001$, $\eta_p^2 = .16$, demonstrated that participants recognized SR faces ($M = 1.15$) better than OR faces ($M = 1.00$), consistent with the ORB. There were two significant interactions, race x orientation and race x expression ($F(1,109) = 4.04$, $p < .05$, $\eta_p^2 = .04$ and $F(1,109) = 21.17$, $p < .001$, η_p^2 = .16, respectively). No other interaction terms were significant (all F's < 3.06 and p's > .09).

Paired-samples *t*-test were conducted separately for the upright and inverted conditions in order to further explore the significant interactions. First, when tested upright, *d'* demonstrated that OR neutral ($M = 1.18$) resulted in significantly worse performance than the OR angry ($M = 1.40$), SR neutral ($M = 1.57$), and SR angry (M = 1.43; $t(109) = 4.01$, $p = .001$, $d = .33$, $t(109) = -2.75$, $p = .007$, $d = .61$, and $t(109)$ = -3.52, $p = .001$, $d = .36$, respectively), consistent with Experiment 1. When faces were inverted at test, only the OR neutral and SR neutral expressions were significantly different, $t(109) = -3.28$, $p = .007$, $d = .34$). However, the means create the same pattern when inverted as upright, with SR neutral with the best performance ($M = .82$) followed by SR angry ($M = .78$) and OR angry ($M = .77$), with the worst performance for OR neutral faces ($M = .65$).

Evaluating β revealed a significant three-way interaction (race x expression x Orientation $F(1,109) = 11.391$, $p < .001$), and one significant two-way interaction (race x expression $F(1,109) = 7.23$, $p < .01$, $\eta_p^2 = .06$). Neither of the other two-way interactions was significant (F's all < 7.23 and p's > .07). Both the main effects for orientation and race were significant ($F(1,109) = 26.27$, $p < .001$, $\eta_p^2 = .19$ and $F(1,109) = 7.40$, $p < .01$, η_p^2 .06, respectively). The response bias for upright faces ($M = 1.23$) was more conservative than inverted faces ($M = .93$). The main effect for race indicated that the response bias for SR ($M = 1.61$) was more conservative than for OR faces ($M = .99$), consistent with the IOM.

To further examine the interactions, paired-samples t-tests were conducted. When faces were tested upright, the most conservative condition was the SR neutral ($M = 1.56$), which was significantly different from SR angry ($M = 1.14$) and OR neutral ($M = 1.04$; $t(109) = -2.77$, $p = .007$, $d = .31$ and $t(109) = -3.12$, $p = .001$, $d = .42$, respectively). But SR neutral was not significantly different from OR angry ($M = 1.16$; $t(109) = -2.32$, $p = .02$). In contrast, when inverted, there were no significant differences in response bias (t's range from -2.06 to .24, p's > .045).

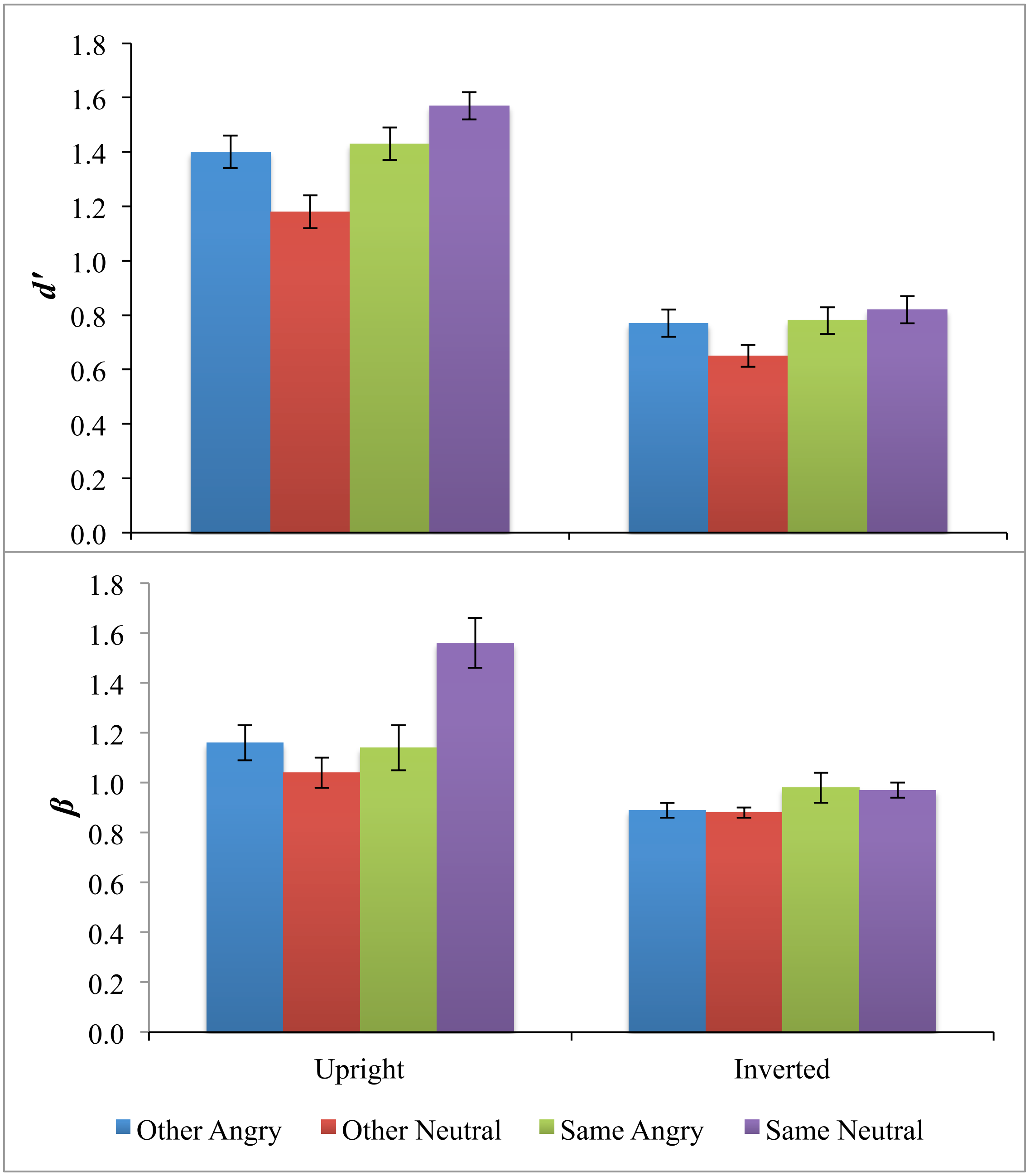

Figure 4. Performance differences for *d′* (top panel) and *β* (bottom panel). Bars represent standard error.

EZ Diffusion Model

As in Experiment 1, the estimated parameter values were each submitted to a 2 (Race: same, other) x 2 (Expression: angry, neutral) x 2 (Orientation: upright, inverted) repeated-measures ANOVA (see Figure 5). For the *v* parameter, the interaction between race and expression was significant, $F(1,109) = 26.17$, $p < .001$, $\eta_p^2 = .19$. The main effects of orientation and race were also significant ($F(1,109) = 269.15$, $p < .001$, $\eta_p^2 = .71$ and $F(1,109) = 20.50$, $p < .001$, $\eta_p^2 = .16$, respectively). Paired-samples *t*-tests were conducted to explore the interaction. The *v* parameter results match the pattern of results found for *d'* in both orientations. The OR neutral ($M = .067$) provided significantly poorer quality of evidence than the OR angry ($M = .078$), SR neutral ($M = .087$), and SR angry ($M = .079$) conditions ($t(109) =3.66$, $p = .001$, $d = .30$, $t(109) = -5.54$, $p = .001$, $d = .53$, and $t(109) = -3.14$, $p = .002$, $d = 30$, respectively). When faces were inverted at test, only the OR neutral and SR neutral expressions were significantly different, $t(109) = -4.20$, $p = .001$, $d = .52$). The inverted SR neutral ($M = .046$) provided the best quality of evidence, followed by OR angry faces ($M = .045$), SR angry ($M = .040$), and OR neutral ($M = .034$).

There was a three-way interaction between race, expression, and orientation for the *a* parameter, $F(1,109) = 6.81$, $p < .01$, $\eta_p^2 = .06$. No other interactions were significant (*F*'s all < .70 and *p*'s > .41). However, the means were so similar across conditions (ranging from .133 to .139), it seems prudent to not explore this particular three-way interaction. The main effect of race was significant $F(1,109) = 4.62$, $p < .05$, $\eta_p^2 = .04$, supporting the IOM; participants had a slightly more liberal response bias with OR ($M = .135$) than SR ($M = .137$) faces.

Lastly, for the T_{er} parameter, there was a significant three-way interaction, and one significant two-way interaction between race and orientation ($F(1,109) = 11.10$, $p < .01$, $\eta_p^2 = .09$ and $F(1,109) = 3.95$, $p < .05$, $\eta_p^2 = .04$, respectively). There were also two main effects. For expression, the neutral expression (.58) required more non-decision time than the angry expression (.57), $F(1,109) = 4.95$, $p = .03$, $\eta_p^2 = .04$, respectively. The main effect of orientation indicated that the inverted test ($M = .60$) required significantly more non-decision time than the upright test ($M = .55$), $F(1,109) = 32.55$, $p < .01$, $\eta_p^2 = .23$.

Paired-samples *t*-tests were conducted to further investigate the interactions. There were no significant differences in T_{er} for the upright test (*t*'s ranging from -1.77 to -.242, *p*'s > .017). However, in the inverted test, the SR neutral had significantly greater T_{er} than all other conditions (SR angry: $t(109) = -3.54$, $p = .001$, $d = .19$; OR neutral: $t(109) = -2.73$, $p = .007$, $d = .19$, and OR angry: $t(109) = -4.03$, $p = .001$, $d = .28$).

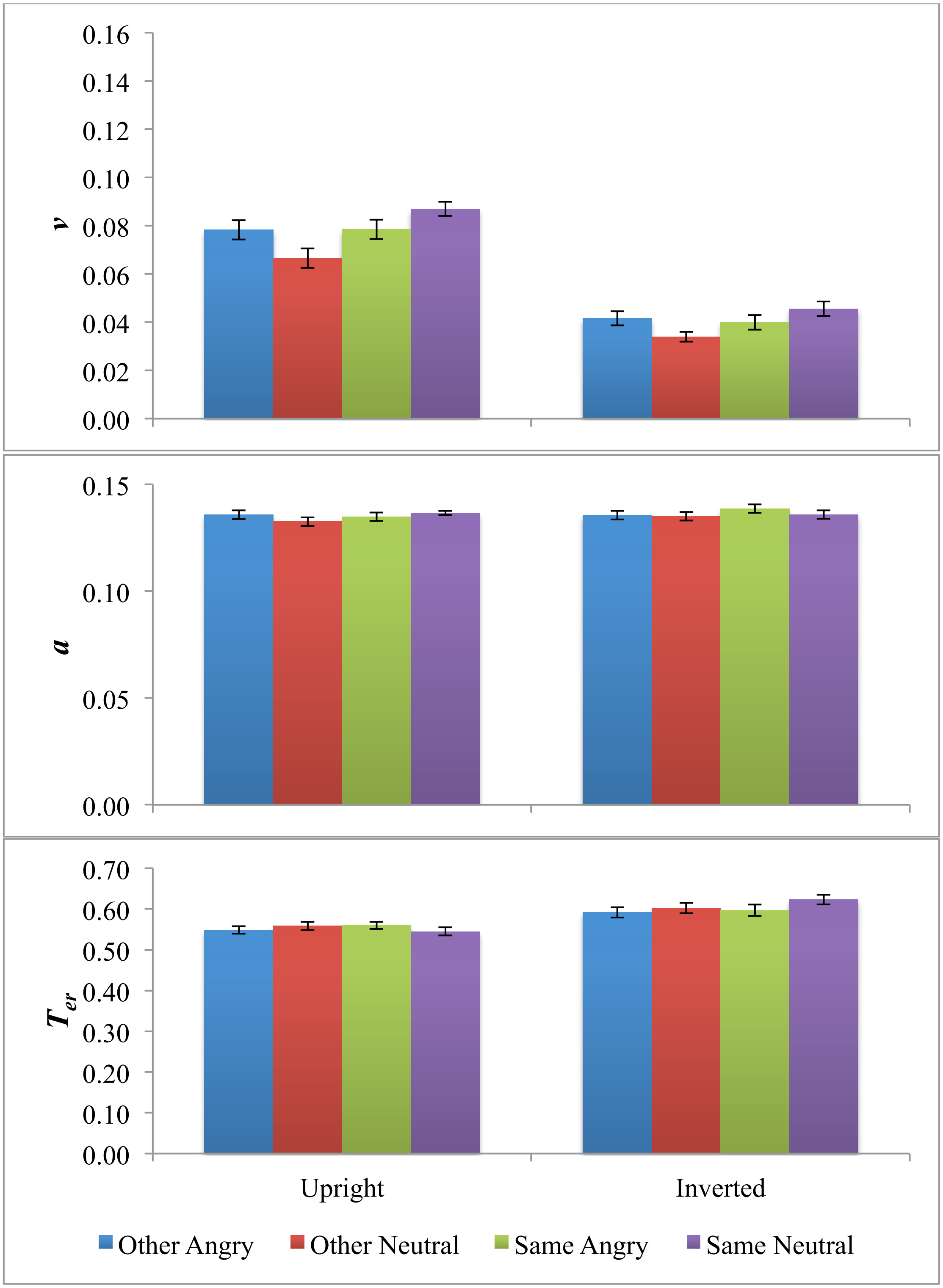

Figure 5. EZ Diffusion model parameters, *v* (top panel), *a* (middle panel), and T_{er} (bottom panel). Bars represent standard error.

Discussion

Consistent with the results of Experiment 1, OR faces with angry expressions were recognized as well as SR faces with neutral or angry expressions (when measured by *d'* and *v*). The same pattern was evident in both the upright and inverted conditions. The inversion of faces at test diminished performance overall. This was contrary to the results of Rhodes et al. (1989) who found only a decrease in performance of SR faces, which they attributed to disrupted configural processing. However, the inverted test did induce differences in the T_{er} parameter. Beyond, the quality of information and response bias, an increase in the non-decision time for SR neutral faces occurred, indicating that other aspects of processing were affected by inversion.

General Discussion

In order to investigate the underlying processes of the ORB, emotion and orientation were manipulated, through facial expression and inversion, to determine if differences in discriminability or response bias were responsible for poorer performance in recognizing OR faces. In addition to traditional measures of accuracy, the EZ diffusion model was used to assess the accuracy and reaction time of these decisions within the context of the IOM theory of face recognition, and extract estimates of latent variables that assess the quality of information, response bias, and non-decision time.

Consistent with previous research, the ORB was found when SR and OR faces were tested with neutral expressions. However, angry OR faces did not suffer from the same recognition deficit as neutral OR faces, consistent with Ackerman et al. (2006). Both Experiment 1 and 2 demonstrated that the recognition of angry OR faces was similar to SR faces (be they angry or neutral). When the quality of information was assessed by the v parameter, results were very similar to that of d'; the quality of information was best for the SR and angry OR faces compared to the neutral OR faces. This suggests that anger overrides the OR bias by inducing better encoding of these faces. If emotion (i.e., anger) recruits configural processing for OR faces, it can be used to explain the superior performance for OR angry faces over neutral faces. More specifically, when OR angry faces are presented, configural processing may be recruited in a manner similar to the automatic configural processing that results in superior recognition for SR faces. Rhodes et al. (1989) argued that evidence of configural processing was the decrease in performance with SR faces and equivalent performance in OR faces. In Experiment 2, the angry faces and SR neutral all had greater decreases in performance than the OR neutral, therefore, configural processing may be responsible for the decreased performance in the former conditions. Featural processing may have been recruited for the OR neutral faces as the decrement was not as severe for this condition.

Different conclusions arose between the assessment of response bias measures using β versus a. When only response proportions were assessed, a more liberal response criterion was evident for OR faces (Experiments 1 and 2), and the neutral SR face condition had the most conservative responding when tested upright (Exp. 1 and 2). However, with the inclusion of reaction time data, the response bias differences are nearly non-existent. Consequently, the differences in performance between SR and OR faces arise from the quality of information that exists in memory, consistent with the IOM. Although the pattern of results for a was not completely consistent between Experiment 1 and the upright conditions of Experiment 2, it is interesting to note that the angry expressions (SR and OR) tended to induce more liberal response biases. Because emotion is processed earlier than other more deliberative processes, it may be advantageous to respond to a potential threat more liberally. More specifically, recognizing the face as a threat provides protection even if the identified face is not actually a threat or was not encountered previously.

Although the IOM was able to account for the traditional performance results, it is unclear how the IOM can account for the EZ diffusion model results in its current state. For instance, the IOM states that OR faces are first categorized, which should require extra processing above and beyond that done with SR faces. If this categorization takes place, differences in T_{er} should have been found. However, the only significant differences that occurred in T_{er} were due to the inversion test of Experiment 2 and not race itself. Additionally, there were no significant differences in response bias as measured by *a,* between OR and SR faces. Differences in *a* only occurred between the upright and inverted test conditions of Experiment 2; increased caution is reasonable given the difficulty of recognizing inverted faces. Although the IOM has the means of predicting differences between the OR neutral and angry expressions, the model is noncommittal regarding whether configural or featural processing is recruited for the angry OR faces. Further investigation will be necessary to identify when configural versus featural processing occurs, and why different strategies are potentially recruited.

Future Directions

The use of the EZ diffusion model is a first step toward a clearer understanding of the underlying processes contributing to the ORB. From the current results, it is clear that the differences in processing stem from the quality of evidence that can be initially encoded. Although Experiment 2 attempted to discern whether featural or configural processing differences are responsible for the ORB, it is possible that an inversion test may not have been the best approach to disrupt configural processing, especially with an emotion manipulation. When the angry faces were inverted (SR and OR) at test, they may no longer have been perceived as angry faces. However, it is interesting to note that the OR angry face was similar to the SR faces when inverted. Regardless, a better test of whether configural or featural processing can account for differences in performance might involve a composite face paradigm. In this task, participants are shown two faces in quick succession and are asked to determine whether the top halves of the two faces are identical or different. In each case, the second face always appears with a new bottom half, but only sometimes with a new top half. If the faces are processed configurally, then the top half of a face will be difficult to process without processing the bottom half. This will cause the matching eyes and nose to appear different when joined with a different mouth and chin because the spatial relationship that is initially encoded will differ. In addition, this task either aligns or misaligns the faces. In the aligned condition, the familiar top half and novel bottom half are arranged like a normal face. In the misaligned condition, the bottom half of the face is laterally offset from the top half of the face. Greater configural processing is evident in the aligned than misaligned conditions. Recent work has found that the composite face effect occurs more strongly for SR than OR faces, indicating that SR faces are processed more configurally. Because the performance for OR angry faces is similar to that of SR faces, it is possible that the composite face task may allow for emotion to be perceived better in the upright orientation. The composite face paradigm could then be used to determine if the angry OR faces are processed configurally, like SR faces.

In addition, future research should continue to use methods that do not rely solely on measures of accuracy. The speed-accuracy trade-off (SAT) procedure, or response signal paradigm, is another method that could provide further understanding of the underlying process. The SAT traces the full time-course of retrieval and yields independent assessments of accuracy and speed of processing; in contrast to traditional reaction time measures, which are subject to speed-accuracy trade-offs (see McElree, 2006 for an overview). In SAT procedure, participants are cued to respond when a response signal (generally a tone) is presented. Although the diffusion model can account for the speed-accuracy tradeoff through the boundary separation parameter, the experimental manipulation of response deadline has the additional advantage of mapping out the full time course of retrieval for each experimental condition. Although the EZ diffusion model was able to demonstrate that the difference between OR angry faces and SR angry and neutral faces is due to a difference in the quality of information available, it is not clear when this information becomes available. It is possible that the information from SR faces may be retrieved sooner than OR faces because it is processed automatically. However, it may be that the information from angry expressions, regardless of race, are processed more quickly as the brain areas known for processing emotion are sensory (e.g., amygdala) and therefore this information may be relayed more quickly. Applying methods such as these can aid in the search for *why* the ORB occurs.

Conclusion

Overall, the studies here demonstrate that the ORB is a product of differences from the quality of information available in memory. Emotion, in this case anger, can provide a superior retrieval cue to OR faces. Existing theories regarding the ORB, including the IOM, need to be able to account not only for instances in which the bias occurs but also when factors inhibit it. Ultimately, utilizing cognitive models and paradigms such as the composite face and response signal, promise to reveal more about the processes that underlie the ORB.

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