INVESTIGATING THE EARLY PROCESSES OF PERSON CONSTRUAL USING ERPS

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The undersigned, appointed by the dean of the Graduate School, have examined the thesis entitled

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ABSTRACT

According to the dynamic interactive theory of person construal (Freeman & Ambady, 2011), upon perception of a person, multiple social categories become simultaneously active and are refined through the integration of bottom up and top down processes over iterations to arrive at a stable person construal (e.g. set of social categories that apply to the perceived person). In the current study, sixty-five participants viewed Black and White male faces during two behavioral tasks while EEG was recorded. Participants fixated either between the eyes or on the forehead. The amplitude of early ERP components involved in face processing (N170) and early allocation of attention (P2) were both sensitive to the race of the face, demonstrating the encoding of race within 165 millisecond of seeing a face. Importantly, a PCA approach revealed three early components during person construal. Examination of the changing effect of race (a top down variable) and fixation (a bottom up variable) over this sequence of components revealed an initially large but decreasing effect of fixation and an initially small but increasing effect of race. This pattern emerged, regardless of whether participants intentionally categorized faces by race or if faces were task-irrelevant. These results provide support for the DI model using a methodology that has not previous been used to investigate processes of person construal and suggest that perceived bottom up perceptual cues are integrated with top down cues to arrive at a stable social categorization of the

face within 230 ms, and that this occurs relatively automatically, regardless of whether social categorization is goal-relevant.

Introduction

Much research in social cognition and psychology has investigated the cognitive, affective, and behavioral consequences of social categorization (e.g. Brewer, 1988; Devine, 1989; Fiske & Neuberg, 1990). Traditional models hold that, upon perception of a person, perceivers first spontaneously place him or her into a relevant social category (e.g., male or female), which then activates related stereotypic traits or evaluations (e.g., aggressive or docile) (Bodenhausen & Macrae, 1998; Fiske & Neuberg, 1990). Recently, this traditional model in which perception, categorization, and evaluation happen sequentially has been challenged by data suggesting stereotypic evaluations can be activated directly from the perception of facial features, independently from any categorization processes (e.g., Blair, Judd, & Fallman, 2004; Maddox, 2004) and that stereotypic information associated with a category can be activated before categorization processes are fully finished (Freeman & Ambady, 2009; Freeman, Ambady, Midgley, & Holcomb, 2011). In other words, these data suggest that perception, categorization, and cognitive or affective consequences may not have to occur sequentially and that the processes leading up to categorization (alternatively called “person construal”) are more complex than previously assumed. The current study employs the temporal specificity of event-related potentials (ERPs) to investigate the quickly occurring processes of person construal.

The assumption that the activation of social categories is spontaneous and unavoidable has largely been supported by evidence derived from methodology in cognitive psychology (Brewer, 1988; Devine, 1989; Macrae & Bodenhausen, 2000). Behavioral studies have used a variety of paradigms (e.g., semantic and evaluative priming tasks, lexical decision tasks, word completion tasks, etc.) in which the activation of a category is presumed from the enhanced accessibility of category-related concepts (as measured by response latency or accuracy) (Dovidio, Evans, & Tyler, 1986; for a review see Macrae & Bodenhausen, 2000). Many of these studies show that the activation of category-related information occurs even when perceivers are motivated to produce non-prejudiced responses (Devine, 1989); are under cognitive load (Macrae, Milne, & Bodenhausen, 1994); when racial categories are irrelevant to the task (Dovidio et al., 1997; Fazio, Jackson, Dunton, & Williams, 1995); and when primes are presented subliminally (Devine, 1989; Dovidio et al., 1997; Lepore & Brown, 1997).

Only recently have researchers attempted to directly observe "person construal", or the processes by which individuals are placed into social categories such as gender, race, and sexual orientation (e.g. Eberhardt, Dasgupta, & Banaszynski, 2003; Macrae & Bodenhausen, 2000; Freeman & Ambady, 2011). Instead of presuming that categorization simply *happens*, researchers investigating person construal have proposed a more complex process that integrates bottom up and top down information and allows for the interaction of multiple dimensions, such as gender, race, and emotion (Freeman & Ambady, 2011; Freeman et al., 2011). This model (called the dynamic interactive theory of person construal, shortened here to the "DI model") draws heavily from cognitive psychology and neuroscience and suggests that multiple categories are partially activated in parallel by perceptual cues in a face. Information from partially active categories cascades to other higher order systems, resulting in downstream cognitive, affective, and behavioral consequences, even before categorization is finished (Freeman et al., 2011; Freeman, Johnson, Adams, & Ambady, 2012). Through iteration, information from these higher order systems is continuously fed back to lower order systems, integrating bottom up and top down influences to alter the active representation and eventually arrive at a stable person construal (Stolier & Freeman, 2016).

The predictions of the DI model are consistent with reports that stereotypes and evaluations can follow directly from the perception of individual facial features, reflecting within-category variation in physiognomy (Blair, Judd, Sadler, & Jenkins, 2002; Livingston & Brewer, 2002; Maddox, 2004). Studies have found direct behavioral and psychological consequences of the degree to which a person's features are more or less racially prototypical (such as how dark their skin tone is, or how wide their nose or lips are), including stereotypic trait judgments (Blair et al., 2002; Blair, Judd, & Fallman, 2004; Maddox & Gray, 2002), how likely they are to be shot in a computerized shoot/don't shoot task (Kahn & Davies, 2011; Ma & Correll, 2011), how negatively they are evaluated (Livingston & Brewer, 2002; Stepanova & Strube, 2012; Uhlmann et al., 2002), and the harshness of their criminal sentence (Blair, Judd, & Chapleau, 2004; Eberhardt, Davies, Purdie-Vaughns, & Johnson, 2006). These results can be interpreted within the DI model, which suggests that faces that are less racially typical activate competing categories simultaneously within the same dimension (i.e. activation of White and Black categories at the same time). These partially active categories then activate corresponding competing evaluations or stereotypic judgments (Freeman & Ambady, 2009; Freeman et al., 2011). Freeman and colleagues investigated this within the context of gender categorization and found evidence of more parallel activation of the opposite sex category for sex-atypical faces than sex-typical faces (Freeman, Ambady, Rule, &

Johnson, 2008) as well as more parallel activation of opposite sex stereotypes for sex-atypical faces before categorization is complete (Freeman & Ambady, 2009).

The current study expands on existing research in several ways. Thus far, research has investigated the role facial features play in social categorization and processing by manipulating the prototypicality of facial features that indicate category membership, including race (Freeman, Pauker, Apfelbaum, & Ambady, 2010; Livingston & Brewer, 2002), age (Friedman & Zebrowitz, 1992) and gender (Freeman et al., 2008; Ko, Judd, & Blair, 2006). Here, instead of varying the prototypicality of the face, a fixation manipulation was used to examine how attention to different features may affect person construal and related evaluations. Research in other areas has provided evidence that fixation manipulations are effective in changing facial processing. Hills and Lewis (2011) used a fixation manipulation to investigate the *own-race bias* (ORB) in face recognition, which refers to the tendency for perceivers to remember faces of their own race better than faces of other races (Itier & Batty, 2009; Meissner & Brigham, 2001). They showed that forcing White European perceivers to use an atypical fixation on the lower half of the face (e.g., nose and lips) causes the ORB to flip, such that memory for African faces was better than for European faces, compared to typical fixations on the upper half of the face (i.e. between the eyes). In the current context, using a fixation manipulation allowed us to manipulate the bottom up sensory information being perceived and attended to without changing any visual aspects of the stimuli. Separately manipulating sensory information perceived and the race of the face avoids confounds in manipulations of bottom up and top down contributions to more effectively pull apart the influences integrated in person construal.

Second, the current study used event-related brain potentials (ERPs) to examine quickly unfolding processes related to social perception before any behavior can be measured. The ERP signal (i.e., waveform) is composed of a series of positive and negative voltage deflections measured on the scalp that unfold over time following discrete stimuli or responses. Physiologically, these deflections represent the summation of post-synaptic potentials generated by synchronously active neurons (primarily pyramidal cortical neurons) whose electrical fields (i.e., dipoles) are oriented in the same direction toward the scalp. Psychologically, the ERP signal reflects the activity of distinct and overlapping information-processing operations that occur at different times and are generated in different combinations of neural structures (Luck, 2005). Scalp-recorded voltage deflections in the ERP are often confused with the underlying component structure of the information processing operations they are presumed to reflect but are theoretically distinct (see Luck, 2005; Makeig et al., 1997). For example, the summation of activity from two separate operations can result in a peak with latencies and amplitudes that do not reflect either of the separate underlying processes. However, because of our ability to measure and quantify the amplitude and latency of these deflections they often are used as a proxy for underlying operations. To be consistent with the extant literature (see Fabiani, Gratton, & Federmeier, 2007), I will continue to refer to both deflections in the waveform and underlying psychological operations as "components," despite the theoretical distinction.

Third, the current study employed two different tasks to examine the impact of task-relevancy on person construal. Participants completed two computer-administered tasks while EEG was recorded. The first task was based on traditional evaluative priming paradigms (e.g. Fazio et al., 1995; Livingston & Brewer, 2002), in which the speed of responding to positive or negative target words serves as an implicit measure of evaluations activated by previously presented prime stimuli (in this case, faces of difference races). The prime stimuli were presented so that participants fixated either between the eyes or on the forehead of the face. Importantly, since participants are only responding to the words, the faces are task-irrelevant and any processing of the faces is presumed to be fairly automatic and unintentional. In the second task, participants saw the same face stimuli as in the first task (also presented in both fixation locations) and were asked to simply categorize each face as Black or White, one at a time. In this task, since participants are explicitly attending to and categorizing the faces, the faces are task-relevant. Looking at differences in the processes of construal (of the same faces) in these two tasks allows us to make inferences about how automatic and task-independent these processes are. The use of an evaluative priming task also allowed us to investigate downstream affective consequences of person construal.

Hypotheses

ERPs. Two ERP components were examined that have been used previously in the context of social categorization: the P2 (or P200) component and the N170 component. The P2 generally peaks 150-250 milliseconds post-stimulus along midline scalp sites and has been associated with early orienting of attention to threatening or distinctive stimuli with evolutionary significance (Correll, Urland, & Ito, 2006; Kubota & Ito, 2007; Schutter, de Haan, & van Honk, 2004). One of the most consistent findings in the social categorization literature is that outgroup faces elicit larger P2s than ingroup faces (e.g. Dickter & Bartholow, 2007, 2010; Dickter & Kittel, 2012; He, Johnson, Dovdio, & McCarthy, 2009; Ito & Urland, 2003, 2005; Kubota & Ito, 2007; Willadsen-Jensen & Ito, 2006, 2008), suggesting outgroup faces attract attention, possibly because of the greater possibility of threat from outgroup members. This differentiation between races is found regardless of task relevance (He et al., 2009; Ito & Urland, 2003, 2005; Kubota & Ito, 2007) or context (Correll, Urland, & Ito, 2006; Dickter & Bartholow, 2007; Willadsen-Jensen & Ito, 2008), suggesting that this attentional bias happens spontaneously, regardless of motivation or task relevance. Importantly, in order to attend to one race other another, social categorization must have occurred by the time attention is allocated to one group and so the P2 has been considered an early index for social categorization processes. Similar effects have been found with age and gender (Mouchetant-Rostaing et al., 2000, 2003). Because differentiation has been robustly shown in previous literature, I hypothesized that Black faces would elicit larger P2s than White faces (in White participants), regardless of fixation.

Additionally, researchers have investigated the influence of social categories on the N170, an earlier component selective to faces ~170 ms after stimulus onset over lateral temporal areas of the scalp (Bentin et al., 1996; Eimer, 2000; Rossion & Jacques, 2011). In line with many face perception models (e.g. Bruce & Young, 1986), early N170 studies suggested the N170 reflects structural encoding of faces that distinguishes a human face from other objects or animal faces, which precedes subsequent identification and categorization processes (Bentin et al., 1996; Bentin & Deouell, 2000; Eimer, 2000). This is supported by a number of studies that fail to show a distinction in N170 amplitude according to race (Caldara et al., 2003, 2004; Chen et al., 2013; James, Johnstone, & Hayward, 2001; Wiese, Stahl, & Schweinberger, 2009) and is similar to the perception-categorization-evaluation sequential models proposed in social psychology (e.g. Brewer, 1988).

Other studies investigating the N170, however, have reported differentiation in the N170 due to gender (Freeman, Ambady, & Holcomb, 2010; Wolff, Kempter, Schweinberger, & Wiese, 2013), race (Brebner et al., 2011; Gajewski, Schlegel, & Stoerig, 2008; He et al., 2009; Herrmann et al., 2007; Senholzi & Ito, 2013; Stahl, Wiese, & Schweinberger, 2008; Walker et al., 2008) and even membership in arbitrarily created “minimal” groups (Ratner & Amodio, 2013). These results are consistent with the DI model, which suggests relevant social categories are partially activated very early on by relevant facial cues (e.g. “This person has dark skin and is therefore [tentatively] Black”). This partial activation occurs even while structural encoding is occurring and later becomes refined through additional iterative processes. Together, these studies suggest that initial structural face encoding and the processing of social category cues can happen simultaneously rather than sequentially as previously suggested and are both reflected in the N170 (Freeman, Ambady, & Holcomb, 2010; see also Ito & Senholzi, 2013).

Considering the iterative integration of top down and bottom up information proposed in the DI model may help to explain the inconsistency in the N170 literature but consistent evidence of differentiation in the P2 literature. Early activation of social categories via top down influences may only occur when the bottom up visual cues that are being immediately attended to trigger the partial activation of those cue-related categories. In situations when category-related visual cues are not being attended to (or are not salient), the activation of social categories may be delayed until attention, whether overt or covert, is redirected or peripheral cues are incorporated into the active representation. This framework would predict a differentiation in the N170 due to race when the perceiver fixates on the eyes, but less differentiation in the N170 due to race when the perceiver fixates on the forehead, which was expected in the current study. This is consistent with evidence that differentiation in the N170 by race is contingent on the perceiver's goal state (Senholzi & Ito, 2013). As processes of person construal continue, more information (including non-obvious cues about race) is incorporated in the active representation. This differentiation by social category may then be reflected in P2 amplitude, which has consistently been found to be sensitive to racial categories and may not depend on where the perceiver is fixating. The current study tested this framework in a novel way, which may shed light on inconsistent effects of race on the N170 in existing literature but a consistent differentiation by race in the P2.

Behavioral. In addition to investigating early processes of person construal, I was interested in the downstream affective consequences. The evaluative priming task was useful in this regard. In this task, a typical pattern of racial bias emerges when participants respond more quickly to negative words than positive words following Black faces and vice versa following White faces (e.g. Fazio et al., 1995). This is interpreted as evidence that Black and White faces automatically activate negative and positive evaluations, respectively, which facilitate responses to valence-congruent words. This response facilitation manifests as faster RTs in congruent trials compared to incongruent trials (Fazio et al., 1995; Willadsen-Jensen & Ito, 2015). I expected this typical pattern to emerge when participants' attention was directed between the eyes of the face prime, since this is generally the default fixation area for White perceivers (Kawakami et al., 2014). However, the results from previous studies using a fixation manipulation (Hills and Lewis, 2011) suggest this pattern may not hold when participants are direct to fixate elsewhere. As such, I expected no race-related priming effects to emerge when participants fixated on the forehead.

Preliminary support for these hypotheses was obtained in a recent pilot study using a protocol similar to that employed here, although three fixation locations were used instead of two: the middle of the forehead, between the eyes, and the tip of the nose. Data from 27 undergraduate volunteers revealed a typical priming effect in the eye-fixation condition, such that people were faster to categorize the targets on congruent trials (Black-negative and White-positive pairings) compared to incongruent trials (Black-positive and White-negative pairings), although this difference was not statistically significant, likely due to a large standard error (see Figure 1). In the forehead-fixation condition, however, reaction times were similar, regardless of congruency, suggesting the faces did not prime stereotypic evaluations on those trials. In the nose-fixation condition, the priming effect reversed such that people were faster to respond on incongruent relative to congruent trials, which was an unexpected outcome for which we have no theory-derived explanation.

Despite the lack of statistical significance, the pattern of responses in the eyes- and forehead-fixation conditions suggests the typical race priming effect is disrupted when the perceiver fixates on an unusual location (the forehead). This could be attributed to the disruption of the processes leading up to categorization, so that no category is available to activate related evaluations. Alternatively, categorization processes could be operating normally but the activation of category-related content may be disrupted. Interestingly, there is evidence that racial differentiation in the P2 is not always reflected in behavioral outcomes. Ito (2011) reported a study in which typical behavioral race priming effects are elicited during a sequential priming task when participants are instructed to categorize the prime faces by race but not elicited when participants are instructed to search for the presence of a white dot superimposed on the prime face. Examination of the P2, however, revealed differentiation between races in both tasks, regardless of instructions, suggesting ERPs and related behaviors can dissociate based on task demands and that the P2 can reveal social categorization processes, even when not reflected in behavior. In the forehead condition, dissociation in the P2 by race that is not reflected in typical priming behavior would suggest that categorization by race is occurring but that the priming effect of that category is somehow modified or interrupted.

Examining the RTs in the categorization task can further contribute to understanding of these processes. Slower RTs in categorizing faces when fixating on the forehead compared to the eyes would suggest that fixation modifies the person construal processes that lead to explicit categorization. Alternatively, no difference in RTs between fixation conditions would suggest person construal processes do not differ according to fixation and that differences in priming are instead attributable to disruption of the activation of category-related content rather than categorization itself.

Summary

Through the integration of behavioral and electrophysiological measures, the current study investigated the contributions of top down and bottom up influences on category activation and race-related evaluations within the framework of the dynamic interactive (DI) model of person construal (Freeman & Ambady, 2011). I expected to see a larger impact of bottom up influences (fixation) in earlier components (the N170), such that differentiation by race is evident only when perceivers fixated between the eyes and not when perceivers fixated on the forehead, but a decrease in the impact of fixation over time as top down information regarding race was integrated in the person construal. Thus, I expected differentiation by race in the P2, a later component, regardless of fixation.

Together, these results would provide novel evidence for the DI model (Freeman & Ambady, 2011), showing initial race-related information being incorporated in early face processing according to which features are being attended to (represented in the N170), with additional iterations of processing leading to subsequent categorization by race, regardless of fixation (represented in the P2). This model would provide a frame in which to understand consistent findings of race-related differentiation in the P2 but inconsistent differentiation in the N170 across studies.

Method

Participants

Sixty-five community members and undergraduates (34 women, 31 men) from Introductory Psychology courses participated in exchange for credit towards a research requirement or monetary compensation. 60 identified as White, 2 identified as Asian, and 3 identified as more than one race. None identified as African-American.

Measures and Materials

Two computer tasks were administered during an experimental session using E-Prime (Psychology Software Tools, Inc., USA). Participants were seated ~40 inches from a 20 inch CRT monitor refreshing at 60 Hz. Each participant first completed the evaluative priming task and then the categorization task. During each task, EEG data were recorded. Then, each participant completed the Internal and External Motivation to be Unprejudiced Scale (Plant & Devine, 1998). These data were not analyzed and will not be discussed further.

Evaluative priming task. The evaluative priming task was modified from tasks used previously in the literature (e.g. Fazio et al., 1995) and is designed to measure bias in evaluative (positive and negative) associations with African-American and European-American men. Prime stimuli consisted of grayscale photographs of Black and White male faces with neutral expressions. Target stimuli consisted of positive and negative words that were slightly visually degraded. During each trial, a fixation cross was presented in the same location for every trial (jittered: either 500, 700, or 900 ms), followed by a prime (Black or White face; 310 ms), then a blank screen (50 ms), and then a target (positive or negative word; 200 ms), followed by a visual mask (600 ms). The location of the face prime varied so that the fixation cross preceded either the middle of the forehead or between the eyes (each face stimulus was presented once in each fixation position). Participants were asked to identify the valence of the target word using two keys on a keyboard. If the participant failed to respond within 800 ms of the target onset, red text saying, “TOO SLOW,” was displayed on the screen (1000 ms). The ITI was 600 ms.

Participants completed 16 practice trials, followed by 512 experimental trials separated into 4 blocks. 64 trials were presented for each condition (race of the face, fixation location, and word valence were fully crossed). The same 8 positive words and 8 negative words were used in the practice and experimental trials. Thirty-two Black face stimuli and 32 White face stimuli were used in the experimental trials. A different set of face was used in the practice trials.

Race categorization task. In the race categorization task, participants viewed the same faces as in the evaluative priming task, again presented in both fixation positions. Participants were asked to simply categorize the faces by race using two buttons on a keyboard. During each trial, a fixation cross was presented (jittered: 500, 700, or 900 ms), followed by a Black or White male face (270 ms) presented either in the eyes or forehead position, which was then masked (530 ms). If participants did not respond within 800 ms following the onset of the target face, text saying, “TOO SLOW,” was displayed (1000 ms). The ITI was 600 ms.

Participants completed 8 practice trials followed by 256 experimental trials, separated into two blocks. 64 trials were presented for each condition (Black-eyes, Black-forehead, White-eyes, White-forehead). The same set of faces was used for the experimental trials of both tasks.

Electrophysiological Recording and Reduction

EEG data were collected during both tasks using 20 tin electrodes in a stretch-lycra cap and placed in standard 10-20 locations (American Encephalographic Society, 1994). The electrodes included FP1, FP2, Fz, FCz, FC3, FC4, Cz, C3, C4, CPz, CP3, CP4, TP7, TP8, Pz, P3, P4, T5/P7, T6/P8, and Oz, plus four electrodes placed above and below the left eye and on the outer canthi of each eye. Electrodes were additionally placed on each mastoid and the tip of the nose. All scalp electrodes were referenced online to the right mastoid. All signals were amplified with a Neuroscan Synamps amplifier (Compumedics, Charlotte, NC) and filtered on-line at .10–40 Hz at a sampling rate of 1000 Hz. Impedances were kept below 15 K**Ω**. Ocular artifacts (i.e., blinks) were corrected from the EEG signal using a regression-based procedure off-line (Semlitsch, Anderer, Schuster, & Presslich, 1986). Trials containing voltage deflections of ±75 microvolts were discarded, as well as trials undetected by the automatic artifact rejection procedure that contained large muscle artifacts, as determined by visual inspection.

P2 quantification. To quantify the P2, data were re-referenced offline to an average mastoids reference before artifact rejection. Grand averages revealed a positive-going deflection peaking around 160 ms following the presentation of a face and maximal at CPZ, consistent with previous characterizations of the P2 (Dickter & Bartholow, 2007; Ito & Urland, 2005). The P2 was quantified as the mean amplitude from 130-190 ms post stimulus onset (30 ms before and after the peak at CPZ) at CZ, C3, C4, CPZ, CP3, CP4, and PZ. The same approach was used to quantify the P2 in both tasks.

N170 quantification. To quantify the N170, data were re-referenced to an electrode on the tip of the nose, as has been done previously (e.g. Eimer, 2000; Caldara et al., 2003; Senholzi & Ito, 2013). Grand averages revealed a negative deflection peaking around 165 ms and maximal at P8/T6, consistent with previous characterizations of the N170 (Rossion & Jacques, 2011). The mean amplitude was quantified for each trial at P8/T6, P7/T5, TP7, and TP8 between 135 ms and 195 ms post stimulus onset (30 ms before and after the peak at P8). The same approach was used to quantify the N170 in both tasks.

Statistical Approach

Quantified P2 and N170 components were analyzed separately with multilevel models (MLMs). Instead of the typical approach of quantifying the P2 from waveforms created by averaging all the epochs for each condition separately for each subject, each component was quantified for every trial separately. Averaging across trials increases the signal-to-noise ratio by retaining information about processes that are locked to the stimulus of interest but eliminating (random) noise that is unrelated to the processes of interest (Luck, 2005). These quantified averages are then analyzed using repeated measures ANOVA (rANOVA) with one data point per condition per subject. When using multilevel models, averaging over potentially useful data is not necessary because the model can correctly account for multiple sources of variance, including subjects and electrodes, as well as separately partition these sources of variance from the error term (Gelman & Hill, 2006; Vossen et al., 2011). Recently, MLMs have been advocated as a more appropriate approach for psychophysiological data (Bagiella et al., 2000; Kristjansson, Kircher, & Webb, 2007; Tibon & Levy, 2015; Tremblay & Newman, 2015; Vossen et al., 2011) for a number of reasons: 1) MLMs do not have the stringent assumption of sphericity that univariate rANOVA does, which psychophysiological data often violates; 2) MLMs are particularly appropriate for hierarchical data (such as data collected from electrodes within subjects) and can account for clustering of observations via several different sources of variance (subject, electrodes, stimulus items); 3) MLMs are very robust in dealing with missing data and do not require list-wise deletion or mean imputation to balance data; 4) MLMs model inter-individual variability separately from the error variance, allowing researchers to examine individual differences in within-subject effects; and lastly, 5) MLMs can simultaneously examine trial-level effects and categorical or continuous predictors related to subjects. Accordingly, trial by trial data for each component of interest and reaction times in each task were analyzed with multilevel models.

Results

Reaction time and ERP data from the evaluative priming task for two subjects was discarded because behavioral accuracy was more than 3 SDs below the mean (65.6% and 50.2% accurate). Data from the categorization task for one subject was similarly discarded (60.9% accurate).

Behavioral results

Only reaction times from correct trials were included in these analyses.

Evaluative priming task. Mean RTs and accuracy rates are presented in Table 1. A multilevel model was fitted to the data with race of the face prime, valence of the target word, and fixation included as predictors. Model-specification procedures (Barr, 2013) determined the most appropriate random-effects structure to be one where the effect (slope) of word valence was allowed to vary by subject and the intercept was allowed to vary by word stimulus (see Table 2 for full model results). A Race x Word Valence interaction did emerge as significant, $b = 5.86$, $p = .018$, but the pattern of the interaction was very different from the pattern of racial bias typically found—participants were faster to respond to positive words than negative words, following both Black and White faces (see Figure 2). In fact, there was a larger facilitation of positive words compared to negative words following Black faces ($M = 502$ ms and 519 ms), compared to White faces ($M = 505$ ms and 517 ms). A main effect of Fixation also emerged, $b = -3.89$, $p = .026$, such that words were evaluated faster following a forehead fixation than an eyes fixation.

Race categorization task. Mean RTs and accuracy rates are presented in Table 2. Model specification procedures (Barr et al., 2013) determined the most appropriate random effects structure to be one where the slopes of Race and Fixation (but not their interaction) varied by subject and the intercept varied by face stimulus (see Table 3 for full model results). The model estimated a main effect of Fixation, $b = 5.78$, $p = .004$, a marginal effect of Race, $b = 5.68$, $p = .074$, and no effect of their interaction, $b = -.38$, $p = .886$ (see Figure 3).

ERP Results

ERP components were locked to the presentation of the face in both tasks. Model specification procedures (Barr et al., 2013) determined the most appropriate random effects structure for both components to be one where the slopes of Race, Fixation, and their interaction varied by subject and the intercept varied by electrode nested within subject. The same model was applied to analyze P2 and N170 amplitude within each task separately, as well as across both tasks.

N170. The multilevel model predicting N170 peak amplitude estimated a significant main effect of Race in both the evaluative priming task, $b = .52$, $p = .006$, and the categorization task, $b = .72$, $p = .002$, such that Black faces elicited larger (more negative) N170s than White faces (see Figure 4 and Table 4). Neither the main effect of Fixation nor the Race x Fixation interaction were significant in either task, *p*s > .25.

When data from both tasks were included in the model and Task was added as a predictor, the predicted Fixation x Race was marginally significant, $b = -.27$, $p = .090$, such that the effect of race was larger in the eyes-fixation condition than the forehead-fixation condition. Additionally, the main effect of Task was significant, such that N170s elicited in the categorization task were larger (more negative) than in the evaluative priming task, *b* = .47, *p* < .001. A marginal Race x Task interaction also emerged, *b* = -.41, *p* = .093, such that the effect of Race was larger in the categorization task.

P2. The multilevel model predicting P2 mean amplitude estimated a significant main effect of Race in both the evaluative priming task, *b* = -.79, *p* < .001, and the categorization task, *b* = -1.2, *p* < .001, such that Black faces elicited larger (more positive) P2s than White faces (see Figure 5 and Table 5). A significant main effect of Fixation also emerged in both tasks, *b*s = -.39 and -.69, *p*s = .047 and .005, such that larger P2s were elicited when fixating on the eyes than the forehead. The Race x Fixation interaction was not significant in either task, *p*s > .34.

When data from both tasks were included in the model and Task was added as a predictor, a significant effect of Task emerged, *b* = -2.2, *p* < .001, such that P2s were larger in the categorization task. Additionally, a Task x Race interaction, *b* = .31, *p* = .001, and a Task x Fixation interaction, *b* = .23, *p* = .019, both emerged, such that the effects of Race and Fixation were in the same direction but larger in the categorization task.

As expected, Black faces elicited a larger P2 than White faces, as found previously in the literature (Dickter & Bartholow, 2007, 2010; Dickter & Kittel, 2012; He et al., 2009; Ito & Urland, 2003, 2005; Kubota & Ito, 2007; Willadsen-Jensen & Ito, 2006, 2008), regardless of where participants fixated. Additionally, a main effect of fixation was found, such that fixating on the eyes elicited a larger P2 than fixating on the forehead. Although unexpected, this main effect is consistent with evidence that faces with direct gazes are more arousing and capture more attention (Gale, Kingsley, Brookes,

& Smith, 1978; Senju & Hasegawa, 2005). Given the P2's sensitivity to threat and arousal, this result, while not anticipated, is unsurprising.

The expected pattern in the N170 was not as clearly supported. Larger N170s were found in response to Black faces than White faces, replicating previous literature showing differentiation in the N170 by race (Brebner et al., 2011; Caharel et al., 2011; Gajewski et al., 2008, Study 2; Walker et al., 2008). However, the expected interaction, such that the effect of fixation is larger when fixating between the eyes than on the forehead, was not significant in either task and only marginally significant when data from both tasks were combined, suggesting this effect, if it exists, is rather small.

Because of their association with social categorization in previous literature and their previously reported difference in latency, the P2 and N170 were chosen as components of interest to examine the influence of bottom up and top down variables over time. Using the DI model, we hypothesized that later components in the person construal process (i.e. the P2) would show an effect of race, but not necessarily of fixation, while earlier components (i.e. the N170) would show a smaller effect of race but a bigger effect of fixation. However, in the current data the peak latency of the N170 was about the same as the P2 (160-165 ms) and so analysis of these components did not directly test this hypothesis. To further pursue this line of inquiry, a temporo-spatial PCA (Dien and Frishkoff, 2005) was used to isolate unique psychological processes that occur close together in time or space and examine change in the effect of race and fixation over a sequence of different early components in an exploratory way. PCA allows ERP researchers to decompose a waveform, which represents the summation of several different components that overlap in time and space, into unique clusters of variance that meaningfully reflect underlying psychological processes. A sequence of identified clusters or components can then be examined for the changing effect of external influences over time. To accomplish this, data were referenced to an average of the mastoids and subjected to a sequential temporospatial PCA using the Matlab PCA ERP Toolbox (Dien, 2010). The PCA was first conducted using data from the categorization task, since a) face processing was intentional and would likely elicit bigger effects and b) the ERP waveform in response to the face was not interrupted by the presentation of the following stimulus, which contaminates any face-related processing with processing of the subsequent word (in the evaluative priming task). We hypothesized that bottom up influences would have a large effect early on but then diminish in subsequent components. Conversely, we hypothesized that top down influences would have a small effect early on but then increase as the person construal became refined.

Exploratory Analyses

Data from all electrodes excluding HEOG, VEOG, and the nose electrode from the categorization task were first submitted to a temporal PCA using a Promax rotation with a covariance relationship matrix (Kayser & Tenke, 2003) and Kaiser weighting (Dien, Beal, & Berg, 2005). A parallel test (Horn, 1965) comparing the Scree plot of the factors extracted from the dataset to a Scree plot of a random dataset determined 20 temporal factors should be extracted from the data. Then, to reduce the spatial dimensions of the data set, a separate spatial PCA on each temporal factor was performed with an Infomax rotation (Dien, 2012). A similar parallel test determined that 3 spatial factors should be extracted from each temporal factor. To facilitate interpretation of the PCA results, the portion of the original data set represented by each temporospatial factor combination can be reconstructed (i.e., in microvolts) into factor waveforms by multiplying factor scores by their corresponding loadings and standard deviations. This allows both the time course and scalp topography of the electrocortical activity captured by that temporospatial factor combination to be directly assessed. These reconstructed factor waveforms were then viewed in comparison with the raw grand averages. The first spatial factor of temporal factors 1, 3, 5, 6, 7, 9, and 10 were determined to correspond meaningfully to areas of the grand averaged waveform and were ordered temporally (henceforth referred to as Virtual Factor 1, or VF 1, for the factor occurring earliest in the time, VF 2 for the second, etc.).

Categorization task. We focused on the first three components, which were identified to be relevant and occur during the person construal process. The first (VF 1) peaked at 113 ms following stimulus onset and was maximal at Pz. The second (VF 2) peaked at 143 ms and was maximal at FCz. The third (VF 3) peaked at 172 ms and was maximal at Cz.

As evident in Figure 6, the positive deflection previously characterized and quantified as the P2 was separated into two separate temporo-spatial PCA components (VF 2 and VF 3), corresponding to the ascending and descending portions of the deflection. This is one demonstration of the utility of using PCA to separate closely occurring but distinct sources of variation. To investigate the effects of race and fixation on each virtual factor, the mean amplitude of each factor was calculated separately for each condition for each individual. VF 1 was quantified as the mean amplitude between 80-140 ms, VF 2 was quantified between 115-180 ms, and VF 3 was quantified between 145-230 ms. Each VF was quantified at the electrode it was maximal at, plus surrounding electrodes (VF 1: PZ, CPZ, CZ, P3, P4, CP3, CP4, C3; VF 2: FCZ, CZ, FZ, CPZ, FC4, FC3; VF 3: CZ, FCZ, CPZ, C3, FC3, FZ, PZ, CPZ, FC4, C4). Mean amplitudes were subjected to MLMs where the intercept and slopes of all effects (including the interaction) were allowed to vary by individual and the intercept was allowed to vary by electrode. Results across the three models revealed an increase in the (absolute value) effect of Race across the three virtual factors, while the effect of Fixation decreased across the three virtual factors (see Table 6, Figure 7).

Evaluative priming task. To confirm a similar pattern in the evaluative priming task, the same analyses were conducted on the evaluative priming task data. A temporo-spatial PCA revealed three PCA components that matched VF 1, VF 2, and VF 3 from the categorization task in timing and location. VF 1 peaked at 115 ms post stimulus onset and was maximal at Pz. VF 2 peaked at 148 ms and was maximal at FCz. VF 3 peaked at 179 ms and was maximal at CPz. Because of these similarities and the fact that these components were elicited by the same face stimuli, these PCA components were assumed to represent similar processes. Mean amplitude was calculated within the same time windows as for the categorization task, separately for each condition for each individual. Analyses mirrored those conducted for the categorization task. A similar pattern was found as in the categorization data: the absolute value of the effect of race increased as processing continued, while the effect of fixation decreased (see Table 7, Figure 9).

Discussion

To investigate the integration of bottom up and top down influences on category activation and race-related evaluations, two tasks were employed while EEG data were recorded, an evaluative priming task and a race categorization task. The predicted hypotheses about the patterns of differentiation by race and fixation in the P2 and N170 were somewhat supported, such that the P2 differentiated between races in both fixation conditions. However, the predicted interaction between race and fixation on N170 amplitude was only marginally significant when both task data were included in the same model, although in the predicted direction (larger difference in amplitude between races in eyes-fixation condition than forehead-fixation condition). Because of the similarity in latency between the N170 and P2, a better test of the dynamic interactive theory of person construal (DI model) was obtained by examining a sequence of several early components identified by a spatio-temporal PCA. Although exploratory, these results provide strong evidence for the integration of bottom up and top down influences proposed by the DI model. The effect of attended bottom up sensory information was larger in early processing between 80-140 ms after the presentation of a face and decreased over the next 100 milliseconds as subsequent iterations of processing incorporated top down information about the race of the face. In contrast, the effect of top down racial categorization was small early on but increased as the person construal became refined. Additionally, this effect was confirmed in the evaluative priming task, despite differences in the task-relevancy of the face stimuli, and supports the applicability of this model, regardless of whether the perceiver is purposefully categorizing the faces or whether the faces are task-irrelevant. This is a novel demonstration using PCA and

ERP data that person construal processes integrate bottom up and top down information in an iterative way to arrive at a stable person construal and that this occurs rapidly and automatically, regardless of how goal-relevant social categorization is. The temporal sensitivity of EEG data and the ability for PCA to separate closely occurring but unique sources of variance allows us to directly measure this integration before anything is observable by behavior.

Similar conclusions came from comparisons of the N170 and P2 across tasks. N170s were larger to faces from the racial outgroup compared to racial ingroup faces in both tasks, in contrast to other studies (with much smaller sample sizes) that have not found an effect of race on the N170 when the faces are task-irrelevant (Caldara et al., 2003; Chen et al., 2013; Ito & Urland, 2005, Study 1; Vizioli et al., 2010). Overall, N170s to task-relevant faces in the categorization task were larger than N170s to task-irrelevant faces in the evaluative priming task, but the race effect was not significantly different in the two tasks. While the literature remains mixed, these results provide evidence in a much larger sample than used previously that social category information is encoded during face processing, as represented in the N170, and that this happens relatively automatically, even when faces are not task-relevant.

A similar pattern was found for the P2, which was larger to outgroup faces compared to ingroup faces in both tasks. In contrast to the N170, there was a Task x Race interaction, such that the effect of race on P2 amplitude was larger in the categorization task than the evaluative priming task, which demonstrates some effect of task-relevancy on sensitivity of the P2 to race. However, the effect of race on the P2 was still highly significant even when the faces were not task-relevant, suggesting social categorization by race does occur automatically and is reflected in P2 amplitude but that these processes may be enhanced when social categorization of the faces is the explicit goal.

Interestingly, differentiation in both the P2 and N170 according to race was not reflected in the priming behavior in the evaluative priming task. The typical pattern of response facilitation for words matching the stereotypical valence of the faces was not found, even in the eyes-fixation condition, where it was expected. Instead, participants were quicker to respond to positive words, regardless of the race of the face that preceded the word. Similar to reports of dissociation between ERPs and related behavior in Ito (2011), both the P2 and N170 differentiated by race in the evaluative priming task, suggesting faces of different races were processed differently, but those differences did not carry over into the priming behavior typically seen in these types of tasks (facilitation of valence-congruent responses, depending on the stereotypical valence of the preceding prime). This suggests that whatever is causing the typical priming effect to disappear has its effect after at least initial racial categorization processes have occurred. In the race categorization task, however, differentiation in the P2 and N170 by race did correspond to differentiation in RTs (faster reaction times to categorize Black faces than White faces). Consistent with previous research (Ito, 2011), the results provide additional evidence that ERPs and related behaviors can dissociate based on task demands and that the P2 and N170 can reveal social categorization processes, even when not reflected in behavior.

It is important to consider that although the relationship between ERPs and behavior does differ depending on the task, the comparison between the two is not direct—in one, RT is measured to the same stimulus that elicits the ERPs while in the other, RT is measured to a secondary stimulus subsequent to the stimulus eliciting the ERPs. In other words, there is simply more time between the ERP components and the measured behavior in the evaluative priming task than the categorization task, which increases the opportunity for other psychological processes to dominate the behavioral response. However, previous research has reported that P2 amplitude can predict response behavior in priming paradigms, showing that in some cases, ERPs do predict behavior that occurs in the same time frame as in the evaluative priming task used here (Amodio, 2010; Correll, Urland, & Ito, 2006; He et al., 2009; Willadsen-Jensen & Ito, 2014; but see Dickter & Bartholow, 2007; Kubota & Ito, 2007). Additionally, failure to produce the typical priming effect in the evaluative priming task, even in the eyes condition, is unexpected, and could be for several different reasons, including ineffectiveness of the priming paradigm itself, as the phenomenon of evaluative priming is sensitive to a number of parameters (Spruyt, Gast, & Moors, 2011). Importantly, although the current study cannot answer why a priming effect was not found, it provides evidence that the race of the prime was identified and processed, as measured by both the N170 and the P2, but that corresponding race-related evaluations were either not activated, or did not facilitate a valence-congruent response to the following target word.

In sum, the current data provide strong support for the DI model using a method that has not previously been used to investigate the dynamic interactive theory of person construal (DI model; Freeman & Ambady, 2011). Separation of closely occurring but distinct processes during person construal using a PCA revealed an initially large but diminishing effect of fixation and an initially small but increasing effect of race, consistent with the iterative integration of bottom up and top down processes to arrive at a stable person construal proposed by the DI model. This pattern was evident in both the word evaluative priming task and the race categorization task, demonstrating the applicability of this model, regardless of the task-relevancy of the face stimuli. Additionally, the current research replicated the well-researched phenomenon of P2 differentiation by race (with outgroup faces eliciting a much larger P2 than ingroup faces), as well as providing evidence in a much larger sample than previously used that the N170 also consistently (and regardless of task-relevance) differentiates by race, suggesting race-related cues are incorporated during initial face encoding, rather than sequentially after face encoded has been completed.

TABLES

Table 1

Mean Reaction Times (and SDs) and Accuracy Rates (and SDs) as a Function of Prime, Target, and Fixation in the Evaluative Priming Task.

	Black Primes	White Primes
Target	Eyes fixation	
Positive word	502 (84) // .91 (.06)	505 (87) // .91 (.07)
Negative word	519 (85) // .92 (.07)	517 (82) // .91 (.07)
	Forehead fixation	
Positive word	502 (86) // .92 (.06)	503 (86) // .91 (.07)
Negative word	516 (83) // .92 (.06)	515 (82) // .91 (.08)

Note. Numbers in parentheses are standard deviations. Numbers to the left of forward slashes are mean (and *SD*) reaction times in milliseconds (correct response trials only). Numbers to the right of the slashes are mean accuracy rates.

Table 2

Mean Reaction Times (and SDs) and Accuracy Rates (and SDs) as a Function of Target and Fixation in the Race Categorization Task.

	Black Targets	White Targets
Fixation		
Eyes	451 (88) // .93 (.05)	456 (92) // .93 (.05)
Forehead	456 (92) // .93 (.06)	461 (93) // .93 (.05)

Note. Numbers in parentheses are standard deviations. Numbers to the left of forward slashes are mean (and *SD*) reaction times in milliseconds (correct response trials only). Numbers to the right of the slashes are mean accuracy rates.

Table 3

Results of Multilevel Models Testing the Effect of Race, Fixation, and Word Valence (When Applicable) on Reaction Time to Targets in the Evaluation and Categorization Tasks.

	Evaluative priming task		Categorization task	
	β	*p*	β	*p*
Race	-2.8 (1.7)	.102	5.7 (.14)	.074
Fixation	-3.9 (1.7)	.026*	5.8 (.22)	.004**
Word Valence	-17.4 (5.9)	.007**	-	
Race*Fixation	3.3 (2.5)	.186	-.38 (.23)	.886
Race*Valence	5.9 (2.5)	.018*	-	
Fixation*Valence	4.3 (2.5)	.083	-	
Race*Fixation*Valence	-5.3 (3.5)	.127	-	

Note. Unstandardized betas are presented. Standard errors of estimate are in parentheses. Satterthwaite approximations were used to estimate degrees of freedom to calculate p value. Targets in the evaluative priming task were positive and negative words. Targets in the categorization task were Black and White faces.
*p < .05. **p < .01.

Table 4

Results of Multilevel Models testing the effect of Race, Fixation, and Task (When Applicable) on N170 amplitude in the Evaluation and Categorization tasks, As Well As Both Task Data Together.

	Evaluative priming task		Categorization task		Both tasks	
	β	*p*	β	*p*	β	*p*
Race	.52 (.18)	.006**	.72 (.23)	.002**	.77 (.19)	.000***
Fixation	.19 (.20)	.364	.01 (.24)	.970	.00 (.19)	.969
Task	-		-		.47 (.11)	.000***
Race*Fixation	-.27 (.25)	.287	-.40 (.35)	.255	-.43 (.25)	.093†
Race*Task	-		-		-.27 (.16)	.090†
Fixation*Task	-		-		.18 (.16)	.259
Race*Fixation*Task	-		-		.19 (.23)	.406

Note. Unstandardized betas are presented. Standard errors of estimate are in parentheses. Satterthwaite approximations were used to estimate degrees of freedom to calculate p value.
† $p < .1$. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 5

Results of Multilevel Models testing the effect of Race, Fixation, and Task (When Applicable) on P2 amplitude in the Evaluation and Categorization tasks, As Well As Both Task Data Together.

	Evaluative priming task		Categorization task		Both tasks	
	β	*p*	β	*p*	β	*p*
Race	-.79 (.14)	.000***	-1.2 (.24)	.000***	-1.2 (.15)	.000***
Fixation	-.39 (.19)	.047*	-.69 (.23)	.005**	-.68 (.19)	.001***
Task	-		-		-2.2 (.07)	.000***
Race*Fixation	.16 (.18)	.395	.33 (.35)	.350	.33 (.23)	.156
Race*Task	-		-		.31 (.10)	.001**
Fixation*Task	-		-		.23 (.10)	.019*
Race*Fixation*Task	-		-		-.06 (.14)	.689

Note. Unstandardized betas are presented. Standard errors of estimate are in parentheses. Satterthwaite approximations were used to estimate degrees of freedom to calculate p value.
**p* < .05. ***p* < .01. ****p* < .001.

Table 6

Results of Separate MLMs Examining Effects of Race, Fixation and their Interactions on VF 1, VF 2, and VF 3 Mean Amplitudes in the Categorization Task.

	VF 1	VF 2	VF 3
Race	.11	-.44**	-1.00***
Fixation	1.02***	-.72***	-.10
Race*Fixation	-.42	.47*	.14

Note. Unstandardized betas are presented. Satterthwaite approximations were used to estimate degrees of freedom to calculate p value.
*p < .05. **p < .01. ***p < .001.

Table 7

Results of Separate Multiple Regression Models Examining Effects of Race, Fixation and their Interactions on VF 1, VF 2, and VF 3 mean amplitudes in the Evaluative Priming Task.

	VF 1	VF 2	VF 3
Race	.36***	-.39***	-.67***
Fixation	1.27***	-.88***	.42***
Race*Fixation	-.40**	.42**	-.24

Note. Unstandardized betas are presented. Satterthwaite approximations were used to estimate degrees of freedom to calculate p value.
**p* < .05. ***p* < .01. ****p* < .001.

FIGURES

Figure 1. Presents reaction times (RTs) for evaluating positive and negative words following Black and White faces in three fixation conditions. Black face/negative word and White face/positive word trials were considered congruent. White/negative and Black/positive trials were considered incongruent. Error bars represent the standard error.

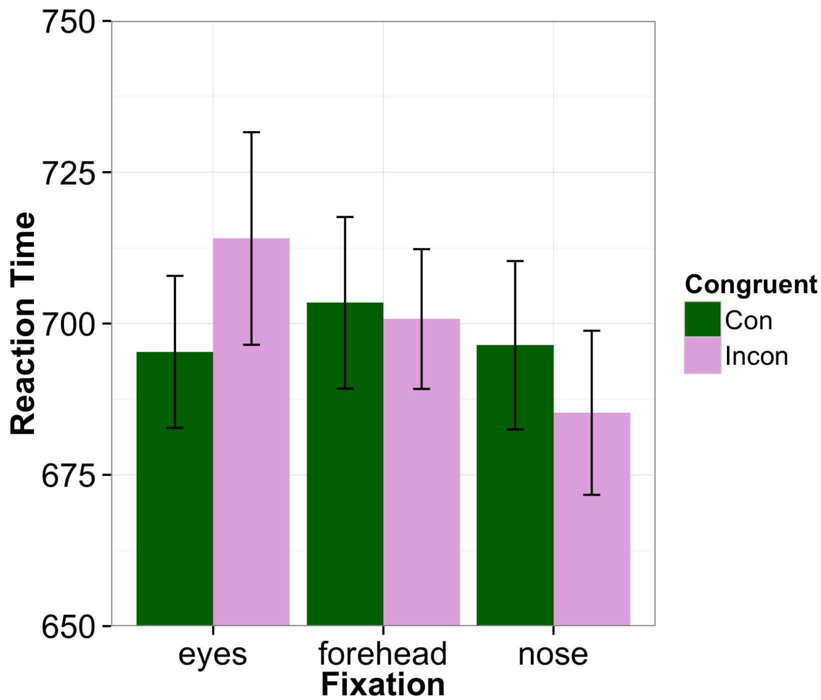


Figure 2. Displays RTs to target words in the evaluative priming task, separated by condition. Only includes correct trials. Participants' task was to categorize the word by valence. Error bars represent the standard error.

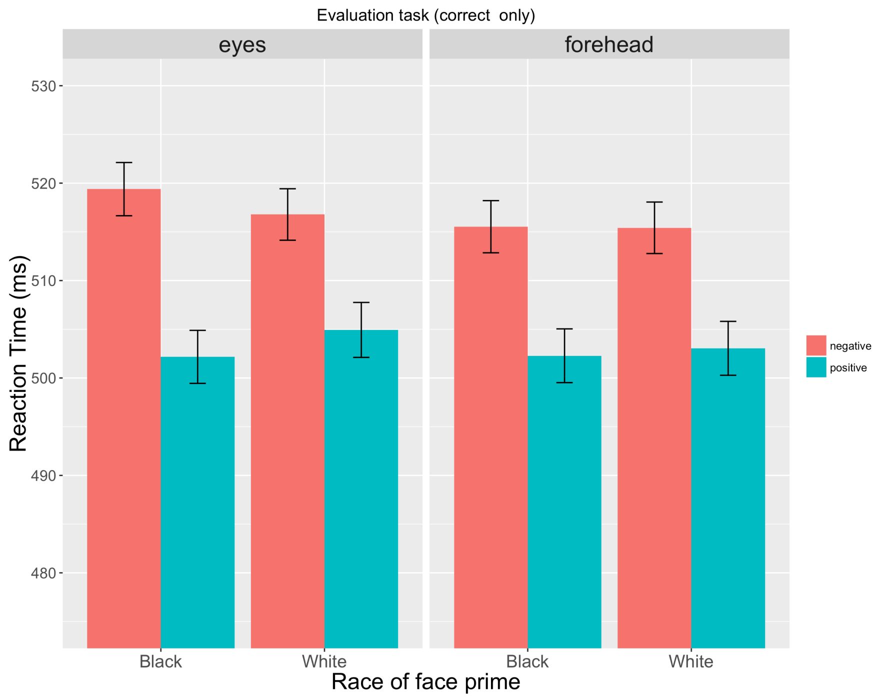


Figure 3. Displays RTs to target faces in the categorization task, separated by condition. Only includes correct trials. Participants' task was to categorize each face by race. Error bars represent the standard error.

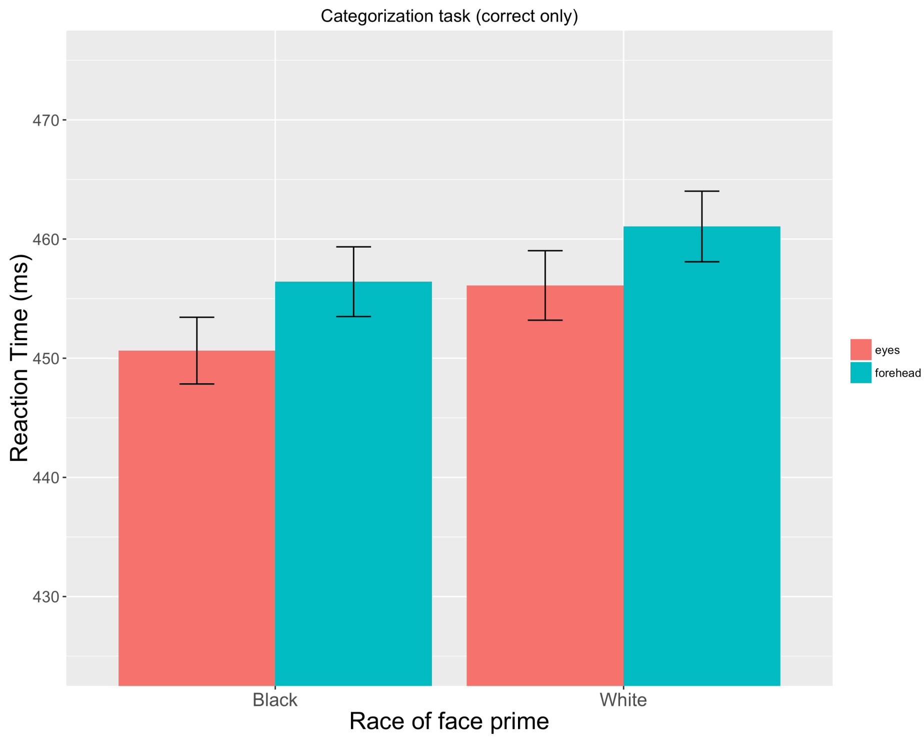


Figure 4. Displays N170 grand average waveforms for evaluation and categorization task, averaged across TP7, TP8, P7, and P8. Waveforms are locked to the presentation of the face and only include trials here the correct response was given. Positive is plotted upward.

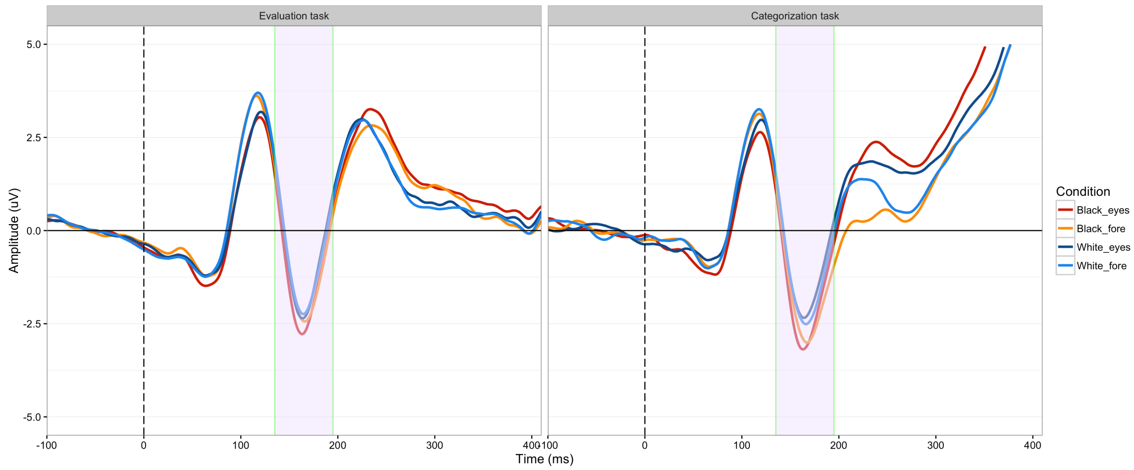


Figure 5. Displays P2 grand average waveforms for evaluation and categorization task, averaged across CZ, CPZ, PZ, C3, C4, CP3, and CP4. Waveforms are locked to the presentation of the face and only includes trials where the correct response was given. Positive is plotted upward.

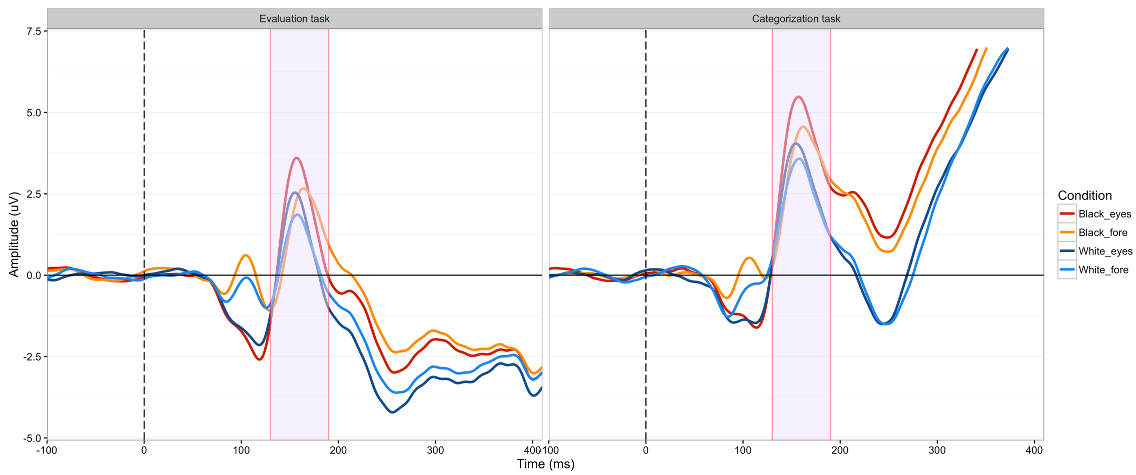


Figure 6. Displays grand average waveforms from the categorization task in grey, with factor waveforms for VF 1 (green), VF 2 (blue), and VF 3 (pink) collapsed across condition overlaid. The dotted line indicates the stimulus onset of the face. Mean response times were around 500 ms.

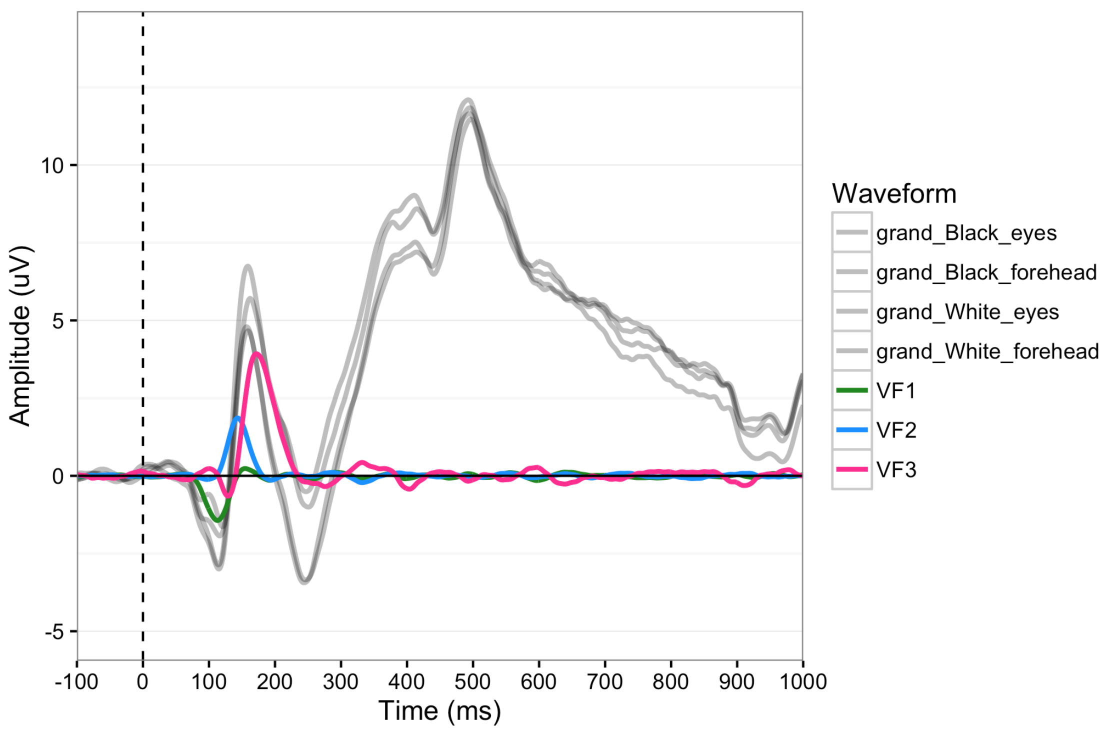


Figure 7. Displays absolute values of unstandardized beta estimates for Race and Fixation from the three models predicting mean amplitude of PCA virtual factors 1, 2, and 3 in the categorization task. Error bars depict standard error of estimate from the models.

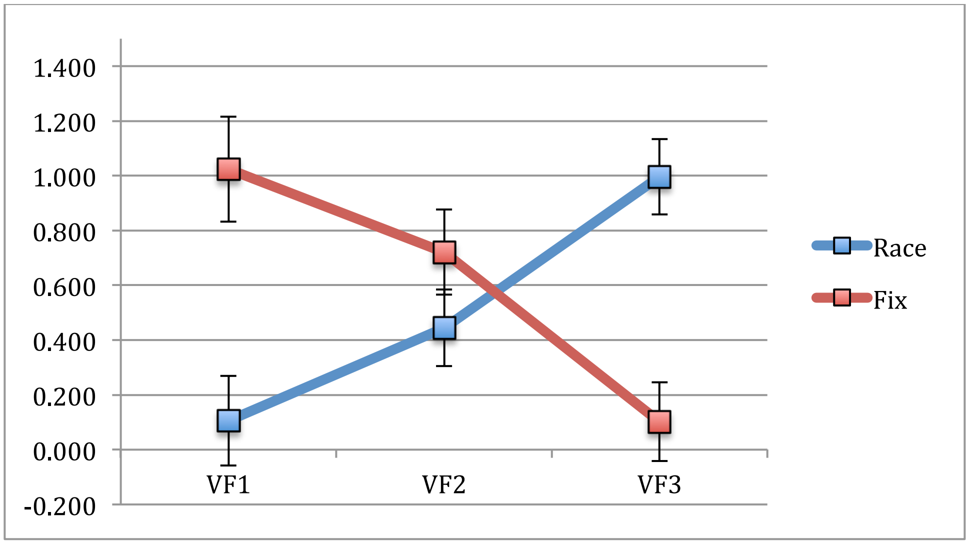


Figure 8. Displays grand average waveforms from the evaluative priming task in grey, with the factor waveforms for VF 1 (green), VF 2 (blue), and VF 3 (pink) collapsed across condition overlaid. The dotted line indicates the stimulus onset of the face. The word stimulus was presented 360 ms following the onset of the face.

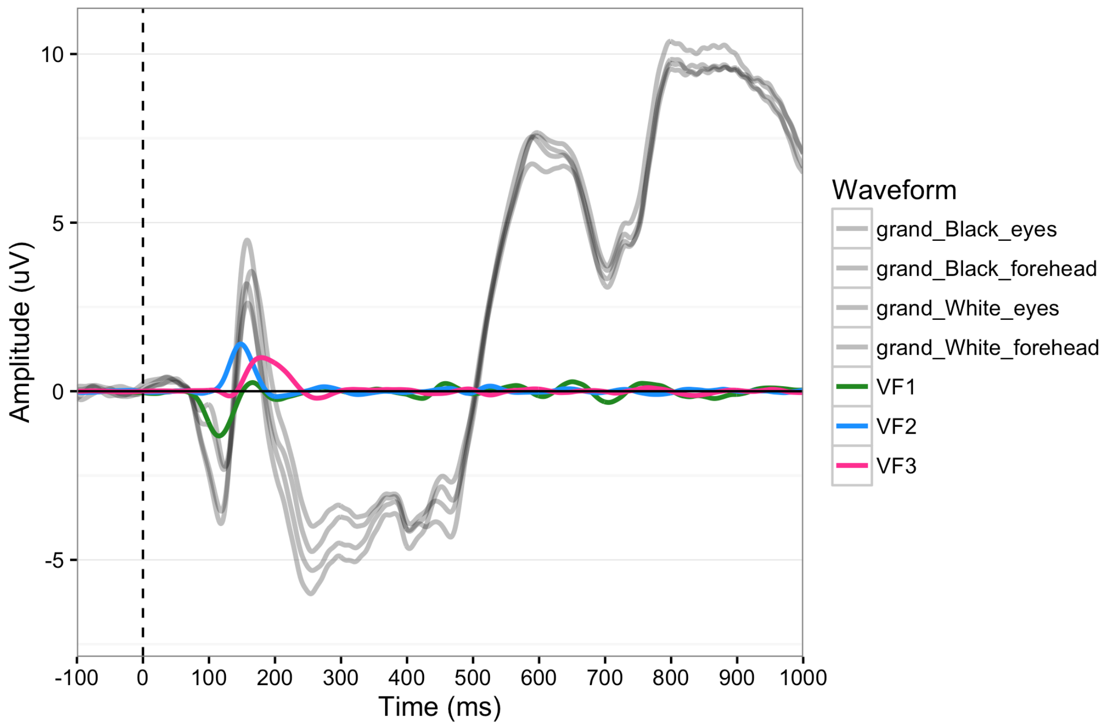
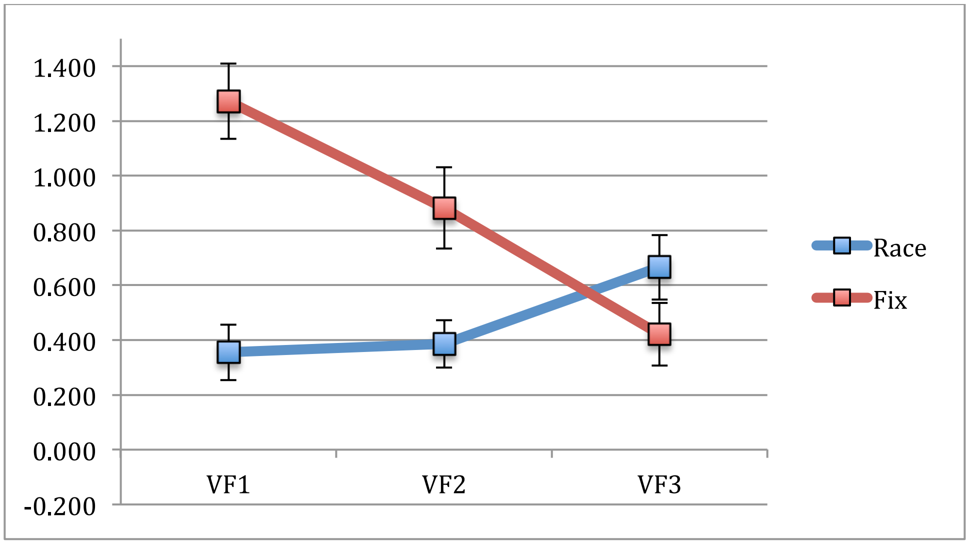


Figure 9. Displays absolute values of unstandardized beta estimates for Race and Fixation from the three models predicting mean amplitude of PCA Virtual Factors 1, 2, and 3 in the evaluative priming task. Error bars depict standard error of estimate from the models.



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