Case Report

Explicit categorization goals affect attention-related processing of race and gender during person construal☆

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ABSTRACT

Faces are categorized by gender and race very quickly, seemingly without regard to perceivers' goals or motivations, suggesting an automaticity to these judgments that has downstream consequences for evaluations, stereotypes, and social interactions. The current study investigated the extent to which early neurocognitive processes involved in the categorization of faces vary when participants' tasks goals were to categorize faces by race or by gender. In contrast to previous findings, task-related differences were found, such that differentiation in the P2 event-related potential (ERP) according to perceived gender was facilitated by having an explicit task goal of categorizing faces by gender; however, the P2 was sensitive to race regardless of task goals. Use of principal components analysis (PCA) revealed two underlying components that comprised the P2 and that were differentially sensitive to the gender and race of the faces, depending on participants' top-down task goals. Results suggest that top-down task demands facilitate discrimination of faces along the attended dimension within < 200 ms, but that the effect of top-down task demands may not be evident when examining early ERP components that reflect more than one distinct underlying process.

Faces convey information critical to effective social interactions (see Hugenberg & Wilson, 2013). To facilitate efficient use of the complex information they convey, humans separate variation in faces into distinct social categories (see Levin, 1996). The processes by which faces are categorized arise spontaneously (e.g., Fiske, 1993; Macrae & Bodenhausen, 2000) and unfold so quickly (Ito & Urland, 2003, 2005; Zarate & Smith, 1990) that assignment of faces to categories can seem invariable. However, research increasingly suggests that the cognitive mechanisms that categorize faces into meaningful social groups—a phenomenon known as *person construal*—are sensitive to both stimulus-driven or "bottom-up" attributes gleaned from faces and goal-directed or "top-down" factors specific to the perceiver or context (Kawakami, Amodio, & Hugenberg, 2017).

To account for the joint influences of bottom-up and top-down factors in face categorization, Freeman and Ambady (2011, 2014) proposed the Dynamic Interactive theory of person construal (DI model). The DI model proposes that low-level perception and higher-order cognition interact over iterative cycles to produce a stable representation of the social groups or categories to which a face belongs. Initially, bottom-up perceptual cues provide a "gist" level of information that is partially consistent with multiple categories (e.g., a feminine

man's face shares features with male and female categories). Over repeated iterations, additional bottom-up cues are integrated with top-down information (e.g., memory representations; processing goals) to refine the representation and arrive at a stable categorization (e.g., "this is a man's face").

Consistent with other neural network models (Rolls, 2001; Wyatte, Herd, Mingus, & O'Reilly, 2012), the DI model assumes that such iterations cycle very rapidly (on the order of tens of milliseconds). Hence, characterizing the processes underlying construal requires measures with very high temporal sensitivity, such as event-related brain potentials (ERPs). Ito and colleagues have used ERPs to show that faces of different races (for reviews, see Ito & Bartholow, 2009; Ito & Senholzi, 2013) and genders (e.g., Ito & Urland, 2003, 2005) are differentiated within 120–300 ms. In particular, the fronto-centrally distributed P2 component of the ERP, peaking 150–250 ms after face onset, is highly sensitive to social categories and readily differentiates outgroup from ingroup faces (e.g., Amodio, 2009; Correll, Urland, & Ito, 2006; Dickter & Bartholow, 2007; Dickter & Kittel, 2012; Ito & Tomelleri, 2017; Ito & Urland, 2003, 2005; Kubota & Ito, 2017, 2007; Willadsen-Jensen & Ito, 2006, 2015). Such findings suggest that early neurocognitive processes supporting social categorization are reflected

in the P2.

To date, however, ERP studies have failed to support the DI model prediction that top-down goals bias the competition among representations activated by bottom-up facial features (Freeman & Ambady, 2011, 2014). In several previous studies, the face-elicited P2 has been equally sensitive to race regardless of whether participants were instructed to attend to race (e.g., Ito & Tomelleri, 2017; Ito & Urland, 2003, 2005; Kubota & Ito, 2007). Although supportive of the idea that social categories are spontaneously differentiated even when task-irrelevant (Brewer, 1988; Fiske & Neuberg, 1990), this finding is at odds with the notion that top-down goals alter early iterations of processing during categorization.

This inconsistency may be the result of measuring the P2 using mean amplitude across a window that incorporates activity from separable construal-related processes. Despite its emergence at the scalp as a single deflection in the waveform, the P2 (like other ERPs) is comprised of multiple underlying components differentially sensitive to stimulus features and task goals. To address this problem, Volpert-Esmond, Merkle, and Bartholow (2017) subjected face-elicited ERP waveforms to a temporospatial principal components analysis (PCA; see Chapman & McCrary, 1995; Dien & Frishkoff, 2005; Pourtois, Delplanque, Michel, & Vuilleumier, 2008). PCA is an atheoretical data reduction method that decomposes the scalp-recorded waveform into unique clusters of variance or components reflecting distinct, underlying psychological processes (Dien & Frishkoff, 2005). Using this technique, Volpert-Esmond et al. discovered that the earliest portion of the face-elicited ERP waveform is composed of three principal components, the second and third of which (PC-2 and PC-3) directly underlie the P2. Consistent with the iterative nature of construal posited by the DI model, the race of the faces affected PC-3 but neither of the earlier components.

The design of Volpert-Esmond et al.'s (2017) study limits the extent to which their findings provide direct tests of key DI model predictions, however. For one, only male faces were presented, and race was the only social category manipulated. Thus, it remains unclear whether the pattern of effects they observed is representative of social categorization generally or merely characterizes the construal of race from men's faces. In addition, Volpert-Esmond et al. failed to examine effects of perceived race in a task where faces were categorized along a different dimension, such as gender. Directly testing the DI model's prediction that top-down task goals bias processing of goal-relevant bottom-up features requires comparison of neurophysiological responses elicited by the same faces under differing top-down categorization instructions.

Finally, Volpert-Esmond et al.'s (2017) study was limited in that nearly all of the participants were White. Although use of majority-White samples is commonplace in studies of this kind (e.g., Amodio, 2009; Dickter & Kittel, 2012; Ito & Tomelleri, 2017; Ito & Urland, 2003, 2005; but see Dickter & Bartholow, 2007; Willadsen-Jensen & Ito, 2008), this practice places obvious limitations on the generalizability of conclusions that can be drawn about race categorization to non-White perceivers. Previous research has shown opposing patterns of activation depending on the match between the perceived face and the race of the perceiver, such that racial outgroup faces elicited larger P2 amplitude than racial ingroup faces (Dickter & Bartholow, 2007; Willadsen-Jensen & Ito, 2008). In the context of the DI model, perceivers' own racial categories may function as top-down influences that facilitate refinement of bottom-up cues related to race, particularly when race is task-relevant. Studying this process in perceivers from diverse racial groups is critical to more comprehensive tests of the DI model.

1. Current study

To address the limitations of previous research, both White and Black participants categorized faces by race (White or Black) and gender (male or female) while the EEG signal was recorded. Orthogonal manipulation of bottom-up features associated with race and gender and the top-down goal to categorize faces along these dimensions, combined with a PCA approach, allows for direct tests of whether task demands bias the competition among race and gender representations in early neurophysiological responses to faces as the DI model predicts.

Based on previous findings (Volpert-Esmond et al., 2017), we expected PCA to reveal three principal components underlying early neural responses to faces, the first largely reflecting differences in low-level visual input (i.e., manipulation of visual fixation), and the second and third reflecting categorization-related processes contributing to the P2. Following Volpert-Esmond et al., we predicted that the manipulated race of the faces would have little effect on earlier PCA components but would emerge in PC-3. To the extent that this pattern reflects a general differentiation of social categories, the effect of gender was also expected to emerge in PC-3 but not in earlier components. However, following the DI model idea that top-down goals facilitate discrimination of faces along the attended dimension (Freeman & Ambady, 2011, 2014), we expected race and gender effects to emerge more quickly, and to increase over iterations to the greatest degree, when participants explicitly categorized by the dimension in question.

Finally, based on the idea that one's race might function as a top-down influence facilitating construal of race from others' faces, and on previous work showing differential P2 responses to racial outgroup and ingroup faces (Dickter & Bartholow, 2007; Willadsen-Jensen & Ito, 2008), we predicted that, for both White and Black participants, racial outgroup faces would elicit larger P2 and PCA component amplitudes than racial ingroup faces.

2. Method

2.1. Participants

Sixty-six men ranging in age from 18 to 28 years old (*M* = 19.8) in Columbia, Missouri participated in exchange for credit towards a course requirement, or for monetary compensation.[1] Thirty-two participants self-identified as White and 34 self-identified as African-American or Black. None of the participants self-identified as Hispanic.

2.2. Measures and procedure

Two computer tasks were administered using *E*-Prime (Psychology Software Tools, Inc., USA). Participants were seated ~50 in. from a 19-in. monitor refreshing at 60 Hz. EEG data were recorded while each participant completed both a race-categorization task and a gender-categorization task. Task order was randomly assigned across subjects.

In both tasks, participants viewed photographs of Black and White male and female faces with neutral expressions (taken from Ma, Correll, & Wittenbrink, 2015). To reduce differences in low-level perceptual features across faces, the photographs were converted to grayscale and brightness and contrast were adjusted to be equivalent across stimuli using the SHINEd toolkit in Matlab (Willenbockel et al., 2010). Depending on the task, participants categorized each face either by gender (male or female) or race (Black or White) using one of two buttons on a game controller (button mapping was randomly assigned across participants).[2] During each trial, a central fixation cross (jittered: 500, 650, or 800 ms) was followed by a face (270 ms), which was then replaced by a visual mask (530 ms). Failure to respond within 800 ms following face onset elicited a "TOO SLOW" warning, displayed for 1000 ms. Trials were separated by a 600 ms inter-trial interval. Replicating Volpert-Esmond et al. (2017), fixation on either the forehead or the

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[1] The sample size was chosen a priori to replicate Volpert-Esmond et al. (2017). Data analysis was not conducted until the final sample was collected.

[2] Reaction time was not of interest for testing the current hypotheses. However, means and statistical analyses of reaction time data are available in the online Supplementary Material.

nasion (located between the eyes) was manipulated by varying the location where each face appeared relative to the fixation cross. On *forehead-fixation* trials, faces were located so that the middle of the forehead appeared where the fixation cross had been; on *eyes-fixation* trials, faces were located so that the nasion appeared where the fixation cross had been. Each face was presented once in each fixation position.

In each task, participants completed eight practice trials followed by 256 experimental trials. Trial type (e.g., Black female, eyes fixation; Black male, eyes fixation; etc.) varied randomly, with 32 trials of each type in total. Thirty-two faces of each race and gender combination were used in the experimental trials; different faces were used in the practice trials.

2.3. Electrophysiological recording and processing

EEG was recorded using 35 tin electrodes[3] embedded in a stretch-lycra cap (Electro-Cap, International, Eaton, OH) and placed according to the expanded 10–10 placement system (American Clinical Neurophysiology Society, 2006). All scalp electrodes were referenced online to the right mastoid; an average mastoid reference was derived offline. Signals were amplified with a Neuroscan Synamps2 amplifier (Compumedics, Charlotte, NC), sampled at 500 Hz and filtered on-line at 0.10–0.40 Hz. Impedances at all channels were kept below 10 KΩ. Blinks were corrected from the EEG signal using a regression-based procedure (Semlitsch, Anderer, Schuster, & Presslich, 1986). Face-locked epochs (1100 ms, including 100 ms pre-stimulus baseline) were created, excluding epochs containing voltage deflections of ± 75 microvolts (μV).

2.3.1. P2 quantification

ERP waveforms are shown in Fig. 1. Grand averages revealed a positive-going deflection peaking 160 ms following face onset and maximal at electrode CP4. The P2 was quantified in both tasks as the mean amplitude from 130 to 190 ms following face onset at 11 electrode locations (Cz, C1, C2, C3, C4, CPz, CP1, CP2, CP3, CP4, and Pz). The time window and scalp locations were chosen a priori to replicate Volpert-Esmond et al. (2017), with the addition of four electrodes to increase the density of measurement. Trials rejected during processing and trials where participants did not respond correctly were discarded from analysis. Because multilevel models can accommodate low numbers of trials per condition, we did not use minimum number of trials per condition as an exclusionary criterion. However, participants with fewer than 50% of trials accepted in a particular task were excluded because of concerns about data quality. This resulted in the exclusion of three participants' data (two Black and one White) in the gender-categorization task and three participants' data (one Black and two White) in the race-categorization task. The median number of trials included in each of the eight unique conditions for each participant in the gender- and race-categorization tasks was 26 (min: 11; max: 32) and 27 (min: 10; max: 32), respectively.

2.4. Model specification

Cross-classified multilevel models were fitted to trial-level data using the R package 'lme4' (Bates, Mächler, Bolker, & Walker, 2015). The random effects structure for all models allowed covariance between random slopes and intercepts; in each model, as in Volpert-Esmond et al. (2017), we used the most complex random effects structures supported by the data. This most often resulted in random slopes of each predictor (but not their interactions) by subject and a random

intercept by subject and by electrode. Satterthwaite approximations were used to estimate degrees of freedom and to obtain two-tailed *p*-values; in situations where the degrees of freedom exceeded 200, we report the results as *z* statistics.

2.5. Principal component analysis (PCA)

Averaged ERP waveforms were created for each trial type for each individual and subjected to a sequential temporospatial PCA (Dien & Frishkoff, 2005), using the Matlab PCA ERP Toolbox (Dien, 2010). Using data from both tasks, we first conducted a temporal PCA (promax rotation) to reduce the temporal dimension, and then a spatial PCA on each of the temporal components (infomax rotation) to reduce the spatial dimension. In each case, we used a Horn procedure (Horn, 1965) to determine the number of components to extract from the data. This resulted in 15 temporal components, each of which was then separated into 2 spatial components. To facilitate interpretation, the portion of the original dataset represented by each temporospatial factor combination was reconstructed into factor waveforms (i.e., in microvolts) by multiplying factor scores by their corresponding loadings and *SD*s. Because we were interested in early processes related to person construal, we selected all PCA components that peaked < 200 ms after face onset and named them in order of temporal occurrence (PC-1, PC-2, and PC-3).

Because averaged waveforms were used as input for the PCA, participants with fewer than 15 accepted trials for any given trial type were excluded. Only participants with data for both tasks were included (n = 52; 25 Black participants, 27 White participants). We report all measures, manipulations, and exclusions in this study.[4] Stimuli, data, and code for analyses are available online at https://github.com/hiv8r3/Race-Gen.

3. Results

3.1. P2 amplitude

3.1.1. Comparison of tasks

To directly compare the effects of top-down task goals on the variables of interest, P2 amplitude data from both tasks were submitted to a multilevel model with target race (Black = −1, White = 1), target gender (female = −1, male = 1), and task (Gender = −1, Race = 1) included as effect-coded predictors, along with the Target race × Task and Target gender × Task interactions.[5] The main effect of target race was significant, $b = -0.25$, $t(63.0) = -4.41$, p < .001, and not qualified by an Target race × Task interaction, $b = -0.02$, $z = -1.21$, p = .228, indicating similar effects of target race on the P2 in both tasks. However, both the main effect of target gender, $b = 0.15$, $t(63.0) = 2.88$, p = .005, and the Target gender × Task interaction, $b = -0.03$, $z = -2.17$, p = .030, were significant, such that the effect of target gender on P2 amplitude was larger when the task demanded gender categorization compared to race categorization. The main effect of task was not significant, $b = -0.03$, $t(61.0) = -0.25$, p = .801. Because of the significant interaction with task, we then examined the effect of target race, target gender, fixation, and participant race on each task separately.

3.1.2. Gender-categorization task

Target race (Black = −1, White = 1), target gender (female = −1,

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[3] Electrodes included FP1, FP2, Fz, F1, F2, F3, F4, FCz, FC3, FC4, C1, Cz, C2, C3, C4, CPz, CP1, CP2, CP3, CP4, Pz, P3, P4, POz, PO3, PO4, PO5, PO6, Oz, O1, O2, TP7, TP8, T5, T6. Additional electrodes were placed above and below the left eye and ~2 cm external to the outer canthi to record vertical and horizontal eye movements, respectively.

[4] Participants additionally completed the Existential Isolation Scale (Pinel, Long, Murdoch, & Helm, 2017) and the UCLA loneliness scale (Russell, 1996), along with judgments of attractiveness and age for each face stimulus included in the categorization tasks. These measures were unrelated to the study hypotheses and were not analyzed.

[5] Wilkinson notation: `P2amplitude ~ TarGender * Task + TarRace * Task + (TarGender + TarRace + Task | Subject) + (1 | Electrode)`
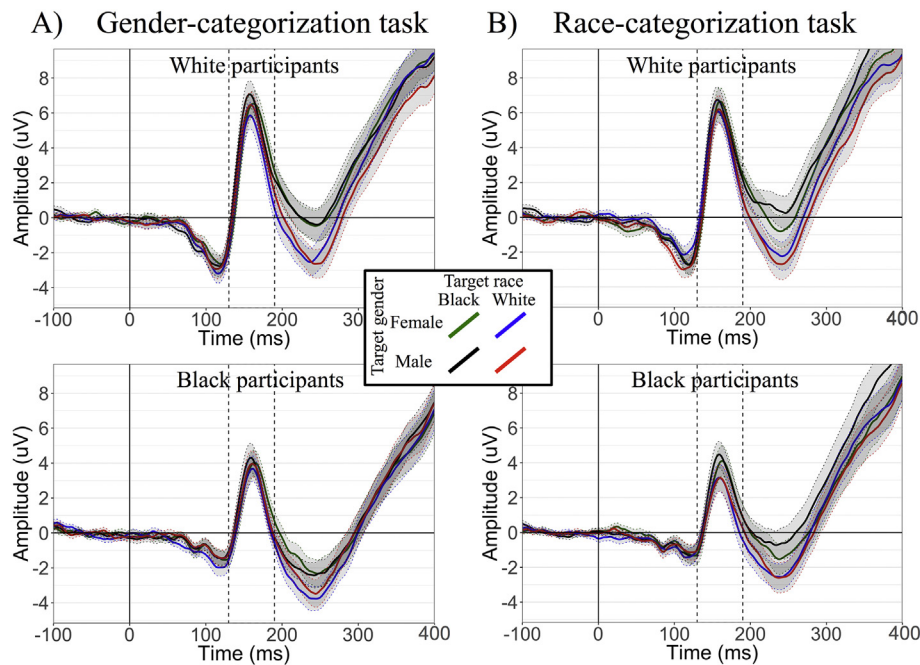
Fig. 1. ERP waveforms elicited by target faces as a function of target race and target gender, separately for each task and participant race. Waveforms are plotted at CPZ. Mean amplitude of the P2 was quantified between 130 and 190 ms after face onset. Shaded areas indicate the standard error for each waveform.

Table 1
Effects of target race, target gender, fixation, and participant race on P2 amplitude in both tasks.

	Gender-categorization Task		Race-categorization Task	
	b	p	b	p
Intercept	**2.91**	**< 0.001**	**2.84**	**< 0.001**
Target race	**−0.22**	**0.001**	**−0.28**	**0.002**
Target gender	**0.19**	**0.012**	0.11	0.104
Fixation	**−0.30**	**< 0.001**	**−0.32**	**< 0.001**
Participant race	**0.93**	**0.008**	**0.80**	**0.028**
TarRace × TarGender	0.03	0.151	**−0.08**	**< 0.001**
TarRace × Fix	**0.07**	**0.002**	**0.12**	**< 0.001**
TarGender × Fix	0.00	0.939	−0.01	0.631
TarRace × ParRace	−0.09	0.146	0.01	0.923
TarGender × ParRace	0.09	0.246	0.01	0.928
Fix × ParRace	**−0.09**	**< 0.001**	−0.02	0.449
TarRace × TarGender × Fix	**−0.08**	**0.001**	**0.15**	**< 0.001**
TarRace × TarGender × ParRace	−0.01	0.779	−0.02	0.362
TarRace × Fix × ParRace	**−0.06**	**0.004**	**0.06**	**0.007**
TarGender × Fix × ParRace	0.02	0.402	0.036	0.091
TarRace × TarGender × Fix × ParRace	−0.02	0.330	−0.04	0.052

Note. Unstandardized betas and p-values from two multilevel models (one for each task). Wilkinson notation: `P2amplitude ~ TarGender * Task + TarRace * Task + (TarGender + TarRace + Task | Subject) + (1 | Electrode)`. Values in boldface are significant ($p < .05$); Satterthwaite approximations were used to estimate degrees of freedom to calculate p-values. All predictors were effect coded. TarRace = Target Race; TarGender = Target Gender; Fix = Fixation; ParRace = Participant Race.

male = 1), fixation (eyes = −1, forehead = 1) and participant race (Black = −1, White = 1) were included as effect-coded predictors in a cross-classified multilevel model. All results are presented in Table 1. The model showed significant main effects for each of these predictors. Specifically, an effect of target race, $b = -0.22$, $t(61.3) = -3.57$, $p = .001$, indicated that Black faces elicited larger P2s ($M = 3.14 \, \mu V$) than White faces ($M = 2.71 \, \mu V$); an effect of target gender, $b = 0.19$, $t(59.9) = 2.59$, $p = .012$, indicated that male faces elicited larger P2s ($M = 3.10 \, \mu V$) than female faces ($M = 2.75 \, \mu V$); an effect of fixation, $b = -0.30$, $z = -13.6$, $p < .001$, indicated that fixating between the eyes elicited a larger P2 ($M = 3.24 \, \mu V$) than fixating on the forehead ($M = 2.61 \, \mu V$); and an effect of participant race, $b = 0.93$, $t(61.0) = 2.75$, $p = .008$, indicated that White participants exhibited larger P2s ($M = 3.85 \, \mu V$) than Black participants ($M = 1.97 \, \mu V$).

The predicted Target race × Participant race interaction was not significant, $b = -0.09$, $t(61.3) = -1.47$, $p = .146$. Although the Target race × Participant race × Fixation interaction was significant, $b = -0.06$, $z = -2.90$, $p = .004$, White faces did not elicit larger P2s than Black faces for Black participants in either fixation condition, as hypothesized. More discussion of the three-way interaction is included in the Supplementary Material.

Several interactions with fixation also emerged. Because none of these interactions changed the interpretation of the main effects (all effects were of the same form but larger when fixating between the eyes), these interactions are not discussed further.

3.1.3. Race-categorization task

To examine P2 amplitudes elicited during the race-categorization

task, we used the same predictors, coding scheme, and random effects structure as for the gender-categorization task. Main effects of target race, $b = -0.28$, $t(60.4) = -3.33$, p = .002, such that Black faces elicited larger P2s ($M = 3.13\,\mu V$) than White faces ($M = 2.54\,\mu V$), fixation, $b = -0.32$, $z = -15.0$, p < .001, such that fixating between the eyes elicited a larger P2 ($M = 3.17\,\mu V$) than fixating on the forehead ($M = 2.49\,\mu V$), and participant race, $b = 0.80$, $t(61.0) = 2.25$, p = .028, such that White participants ($M = 3.66\,\mu V$) demonstrated larger P2s than Black participants ($M = 2.01\,\mu V$), were all significant. However, the effect of target gender was not significant, $b = 0.11$, $t(60.5) = 1.65$, p = .104, though inspection of the means showed a pattern similar to that observed in the gender-categorization task (i.e., larger P2 to male than female faces). Additionally, a significant Target race × Target gender interaction emerged, $b = -0.08$, $z = -3.72$, p < .001, such that the effect of target race was larger for male faces, $b = -0.38$, $t(61.2) = -3.65$, p < .001, than for female faces, $b = -0.19$, $t(61.1) = -1.79$, p = .079.

As in the gender-categorization task, the Target race × Participant race interaction was not significant, $b = 0.01$, $t(60.4) = 0.10$, p = .923, and although the Target race × Participant race × Fixation interaction was significant, $b = 0.06$, $z = 2.68$, p = .007, White faces did not elicit larger P2s than Black faces for Black participants in either fixation condition, as hypothesized. More discussion of the three-way interaction is included in the Supplementary Material.

Also similar to the gender-categorization task, several interactions with fixation also emerged but did not change the interpretation of the main effects (all effects were in the same direction but larger when perceivers fixated between the eyes).

3.2. PCA

A PCA was conducted to extract unique components from overlapping activity in the ERP waveform. Data from both tasks were used as input to ensure correspondence in extracted components across tasks. Peak latencies and scalp distributions for the three PCA components of interest are shown in Fig. 2. The first component (PC-1) was negative-going and maximal at POz, peaking 116 ms after face onset. The second component (PC-2) was positive-going and maximal at CPz, peaking 148 ms after face onset. The third component (PC-3) also was positive-going and maximal at CPz, peaking 174 ms after face onset. Peak latencies and scalp distributions were almost identical to those observed in Volpert-Esmond et al. (2017) during a similar race-categorization task.[6] Amplitude of each component was quantified as the mean value from a set of electrodes at which the component was maximal,[7] within epochs capturing the breadth of each component: 80–140 ms for PC-1, 115–180 ms for PC-2, and 145–230 ms for PC-3.

The most critical test of DI model predictions is whether the effects of the manipulated race and gender of the faces emerged more quickly, or to a greater degree, when participants were explicitly categorizing along those dimensions. To visualize the effects of target race, target gender, and target fixation across the three PCs, we first estimated the effects of each predictor on the mean amplitude of each principal component, using separate multilevel models for each PC, separately for each task. Unique effects of each predictor in each model are given in Table 2; the changing influence of each predictor across the three components (i.e., across time) is depicted in Fig. 3.

Inspection of the patterns of these effects shows that fixation had a relatively large effect on PC-1 in both tasks, and that its effect decreased

across PC-2 and PC-3. Of greater interest, target gender and target race appeared to have differential effects on PC-2 and PC-3, which appeared to depend on the task. Specifically, the largest effect of target gender occurred during the gender-categorization task and emerged in PC-2, whereas the largest effect of target race occurred during the race-categorization task and emerged in PC-3.

To directly test the modulation of the effects of manipulated race and gender by top-down task goals, and given that effects of these features were most evident in PC-2 and PC-3, we combined data from both tasks and included task, PC, and either target race or target gender as within-subject effect-coded predictors in two separate models.[8] Both the Target race × Task × PC interaction, $b = -0.05$, $z = -4.76$, p < .001, and the Target gender × Task × PC interaction, $b = 0.03$, $z = -3.19$, p = .001, were significant, suggesting the influence of task on the effects of target race and gender differed by PC. To breakdown the interactions, we then examined each PC separately, including target race, target gender, and task as predictors.[9] When examining PC-2 amplitude, we found a significant Target gender × Task interaction, $b = -0.06$, $z = -4.41$, p < .001, such that target gender had a larger effect on PC-2 amplitude in the gender-categorization task ($f^2 = 0.031$) than in the race-categorization task ($f^2 = 0.004$).[10] Additionally, the Target race × Task interaction was significant, $b = 0.03$, $z = 2.24$, p = .025; however, the effect sizes associated with target race were extremely small and virtually equivalent in both tasks ($f^2 = 0.000$).

When examining PC-3 amplitude, we found a significant Target race × Task interaction, $b = -0.06$, $z = -5.52$, p < .001, indicating a larger effect of target race on PC-3 amplitude during the race-categorization task ($f^2 = 0.069$) compared to the gender-categorization task ($f^2 = 0.017$). However, the Target gender × Task interaction was nonsignificant, $b = 0.00$, $z = 0.53$, p = .595; the effect of target gender on PC-3 amplitude was small in both the gender-categorization task ($f^2 = 0.006$) and the race-categorization task ($f^2 = 0.004$). Plots showing individual variation in task differences for the effect of target race and gender on both PCs are available in the Supplementary Material.

3.3. Participant race

Given that PC-2 and PC-3 together give rise to the P2 observed in the averaged waveform, we additionally tested the effect of participant race and its interaction with target race in predicting PC-2 and PC-3 amplitude.[11] Target race and participant race did not significantly interact in predicting PC-2 amplitude in the gender-categorization task, $b = -0.01$, $t(50.0) = -0.21$, p = .836, nor the race-categorization task, $b = 0.06$, $t(50.0) = 0.66$, p = .514. Additionally, target race and participant race did not significantly interact in predicting PC-3 amplitude in the gender-categorization task, $b = -0.09$, $t(50.0) = -1.04$, p = .305, nor the race-categorization task, $b = -0.10$, $t(50.0) = -0.83$, p = .412.

4. Discussion

Construal of social categories from faces has long been assumed to occur very rapidly and with little effort or intention (Cloutier, Mason, & Macrae, 2005; Macrae, Quinn, Mason, & Quadflieg, 2005). ERP studies

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[6] In Volpert-Esmond et al. (2017), these principal components were referred to as VF-1, VF-2, and VF-3, respectively.

[7] Electrodes were selected based on scree plots of their eigenvalues. PC-1 was quantified at POZ, PO3, PO4, CPz, CP1, CP2, and Pz. PC-2 was quantified at CPz, CP1, CP2, Cz, C1, C2, and Pz. PC-3 was quantified at CPz, CP1, CP2, Cz, C1, C2, and Pz.

[8] Wilkinson notation: `P2amplitude ~ TarGender * Task + TarRace * Task + (TarGender + TarRace + Task | Subject) + (1 | Electrode)`

[9] Wilkinson notation: `P2amplitude ~ TarGender * Task + TarRace * Task + (TarGender + TarRace + Task | Subject) + (1 | Electrode)`

[10] As suggested in Lorah (2018), Cohen's f^2 was used as a measure of effect size for fixed effects estimated by multilevel models. Cohen's f^2 was calculated using conditional R^2 (Nakagawa & Schielzeth, 2013) using the MuMIn package in R.

[11] Wilkinson notation: `PCamplitude ~ TarRace * ParRace + (TarRace | Subject) + (1 | Electrode)`
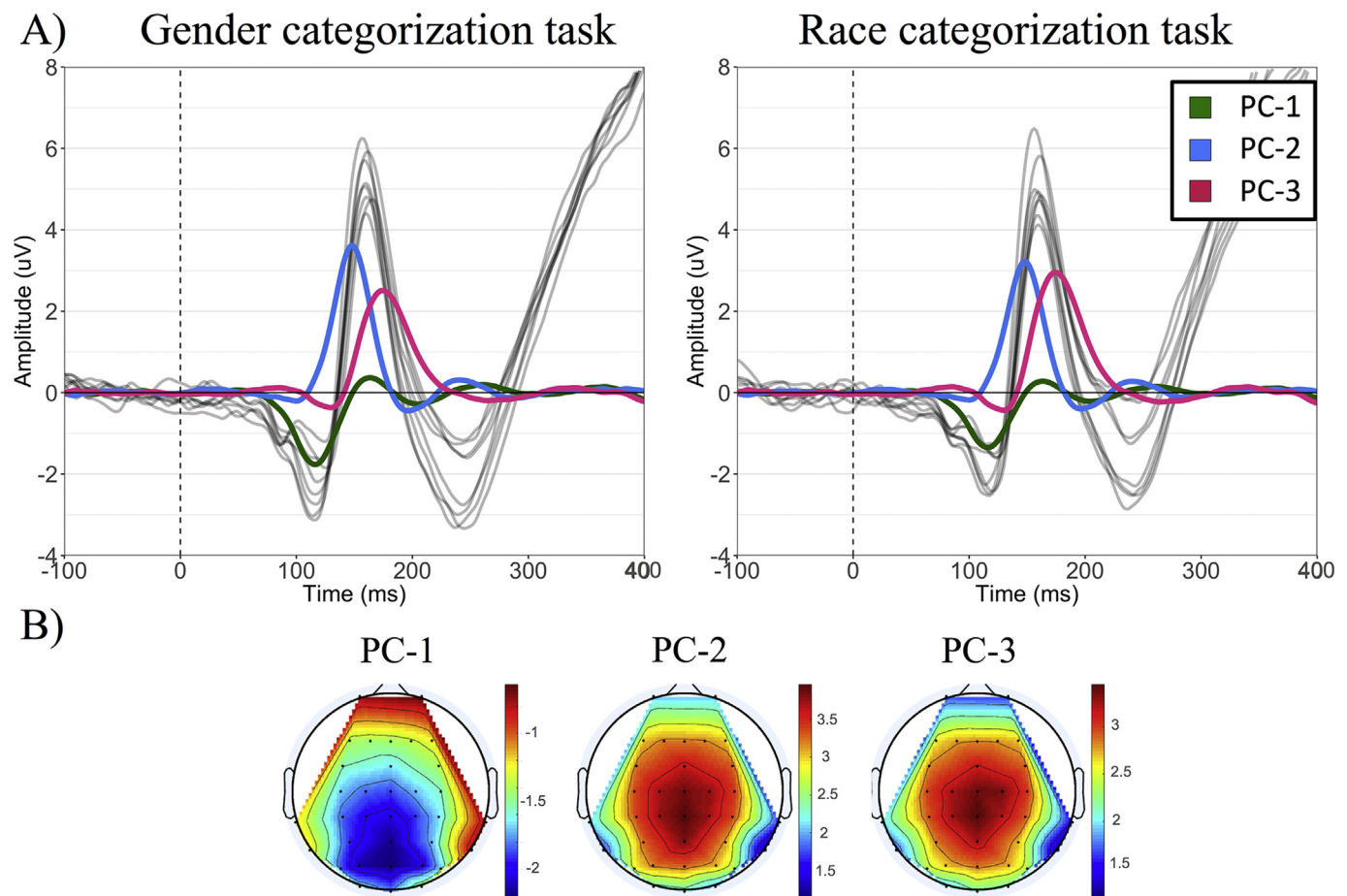
Fig. 2. (A) Grand average waveforms elicited during the gender-categorization task and race-categorization task are depicted in gray, overlaid with PCA-derived waveforms depicting PC-1 through PC-3, collapsed across conditions. The dashed vertical line indicates onset of the face. (B) Scalp topographies of each PCA component at its peak latency, collapsing across participant race.

Table 2
Effects of fixation, target gender, and target race on each of three principal components associated with face processing in both tasks.

	PC-1	PC-2	PC-3
Gender-categorization task			
Fixation	**0.39 [0.24, 0.54]**	**−0.32 [−0.45, −0.19]**	−0.02 [−0.13, 0.09]
Target gender	−0.02 [−0.12, 0.08]	**0.18 [0.09, 0.26]**	−0.07 [−0.16, 0.02]
Target race	0.03 [−0.07, 0.13]	0.03 [−0.06, 0.12]	**−0.12 [−0.21, −0.03]**
Race-categorization task			
Fixation	**0.35 [0.21, 0.49]**	**−0.35 [−0.47, −0.23]**	−0.06 [−0.16, 0.04]
Target gender	**−0.12 [−0.21, −0.03]**	0.06 [−0.03, 0.15]	−0.06 [−0.16, 0.04]
Target race	0.04 [−0.07, 0.15]	0.02 [−0.08, 0.12]	**−0.25 [−0.37, −0.13]**

Note. Values are unstandardized betas taken from six separate multilevel models (one for each principal component in both tasks). Wilkinson notation: `P2amplitude ~ TarGender * Task + TarRace * Task + (TarGender + TarRace + Task | Subject) + (1 | Electrode)`. Values in boldface are significant (p < .05); Satterthwaite approximations were used to estimate degrees of freedom to calculate p-values. Numbers in brackets represent lower and upper bounds of the 95% confidence intervals around each estimate. All predictors were effect coded.

provide evidence that social categories are distinguished as early as 100–200 ms after a face appears (e.g., Ito & Senholzi, 2013; Mouchetant-Rostaing & Giard, 2003; Zhang, Li, Sun, & Zuo, 2018). In the current study, mean P2 amplitude was larger to Black than White faces regardless of participants' categorization goals, consistent with previous research (Dickter & Bartholow, 2007; He, Johnson, Dovidio, & McCarthy, 2009; Ito & Tomelleri, 2017; Ito & Urland, 2003, 2005; Kubota & Ito, 2007). This finding is consistent with the more general notion that while top-down goals may affect the downstream consequences of categorization, they do not affect categorization itself, as measured by early electrophysiological responses (e.g., Ito & Tomelleri, 2017).

Examining the underlying component structure of the P2 encourages re-consideration of this conclusion, however. As in previous work (Volpert-Esmond et al., 2017), face-elicited P2 amplitude in the current study was comprised of two PCA components (PC-2 and PC-3), each of which was sensitive to perceivers' categorization goals. Specifically, target gender had a larger influence on the principal components when gender was task-relevant, whereas target race had a larger influence when race was task-relevant. This pattern is consistent with domain-general theories positing that perceivers tune attention control settings according to salient goals (e.g., Folk, Remington, & Johnston, 1992; Lien, Ruthruff, Goodin, & Remington, 2008). In the present context, top-down goals apparently facilitated differentiation between
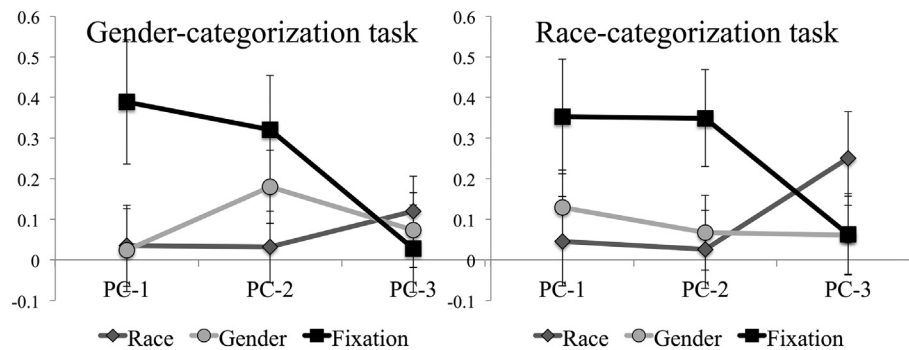
Fig. 3. Absolute values of unstandardized beta estimates for effects of fixation, target gender, and target race from the models predicting mean amplitudes of each of the three PCA-derived components. Error bars depict 95% confidence intervals. Corresponds to values in Table 2.

faces by gender or race, according to which was task-relevant. Thus, if increased PC-2 and PC-3 amplitude reflect increased attention allocation as the P2 is theorized to do, the increase in attention to Black faces compared to White faces was larger during race categorization, whereas the increase in attention to male faces compared to female faces was larger in the gender categorization task, suggesting faces are construed differently according to race vs. gender categorization goals. This is additionally consistent with recent accounts of goal-related effects on activity in occipito-temporal areas that transform high dimensional perceptual information into abstract representations through categorization (e.g., Braunlich, Liu, & Seger, 2017; Braunlich & Love, 2018; Myers et al., 2015). In this sense, categorization of faces is similar to categorization of other complex objects and similarly subject to task demands. Alternatively, this pattern may reflect differences in the facial features that are extracted as diagnostic (i.e., visual information that is deemed relevant to the categorization response), which has implications for what information is forwarded from occipital to temporal cortex for further processing (e.g., Zhan, Ince, van Rijsbergen, & Schyns, 2019). Future research is needed to localize the P2 and its underlying components to integrate these results with ongoing research in cognitive neuroscience on how top-down effects influence the selection and processing of visual information during categorization.

Interestingly, PC-2 and PC-3 appear differentially sensitive to the effects of race and gender. As shown in Fig. 3, the effect of gender in the gender-categorization task and the effect of race in the race-categorization task were most prominent on PC-2 and PC-3, respectively. As predicted by the DI model, the effect of target gender emerged earlier (on PC-2) and to a greater degree during the gender-categorization task compared to the race-categorization task. However, the temporal precedence of the task-relevant category was not observed for the effect of race, which did not emerge on the earlier PC-2 component. Instead, the effect of race was absent on PC-2 in both tasks, but was larger on PC-3 in the race-categorization task compared to the gender-categorization task. This pattern contrasts with the expectation that sensitivity to a particular category should emerge earlier when that category is task relevant, which theoretically should happen similarly for race and gender. Instead, these patterns suggest the possibility that task-relevant gender information might be extracted somewhat earlier than task-relevant race information, at least among male participants. Given evidence that salient identities facilitate processing of faces within a particular group (Bernstein, Young, & Hugenberg, 2007; Herlitz & Lovén, 2013; Meissner & Brigham, 2001), a more salient gender identity than race identity among male participants (Jones & McEwen, 2000) may facilitate extraction of gender-related cues before race-related cues. Alternatively, our use of grayscale images may have eliminated a dominant cue individuals typically use to determine race (skin tone; Stepanova & Strube, 2009), possibly delaying differentiation of faces by race relative to gender. However, it is not yet clear why categorizing by gender and race affects distinct neurophysiological responses in different time courses, and therefore any conclusions regarding the

meaning of these patterns are tentative until additional research is conducted.

Surprisingly, we did not find evidence of opposing patterns of P2 or principal component amplitudes to White and Black faces as a function of participants' race, as observed in previous research (Dickter & Bartholow, 2007; Willadsen-Jensen & Ito, 2006, 2008). Larger P2 amplitudes to White faces among Black/Asian participants and Black/Asian faces among White participants has been interpreted as evidence that other-race faces elicit early attention due to the threat associated with racial outgroups (see also Correll et al., 2006). Here, patterns in P2 amplitude were remarkably consistent across White and Black participants, such that both White and Black participants demonstrated larger P2s when viewing Black compared to White faces. It is unclear why the current results failed to replicate those of previous studies in this regard. One possibility is that previous studies were underpowered and thus vulnerable to Type 1 error (15 Black participants in Dickter & Bartholow, 2007; 21 Asian participants in Willadsen-Jensen & Ito, 2008). Additional research is required to investigate the sensitivity of the P2 and its underlying components to own and other-group distinctions among racial minority participants.

Future research also should test the replicability of the PCA structure elicited during face processing (see also Volpert-Esmond et al., 2017) and continue to assess its functional significance for person construal. For instance, questions remain regarding the generalizability of the current findings to other social categories, and whether the earlier emergence of gender compared to race differentiation is consistent across different participant populations. In addition, although participant race had few effects in the current study, additional research should strive to identify individual differences that might modulate the timing and/or structure of face-elicited neurophysiological responses (e.g., Amodio, 2010), which could provide insights into the effects of trait-level top-down influences on construal.

Another important direction for future research would be to directly compare the P2 elicited by faces in person perception tasks like the one used here with the N170 ERP component and its inversion, the vertex positive potential (VPP), which also are elicited by faces (Joyce & Rossion, 2005). The N170/VPP is larger to face stimuli compared to non-face stimuli and has been proposed to index structural encoding of faces, which is theorized to precede subsequent identification or categorization processes (Bruce & Young, 1986). This hypothesis is consistent with studies that do not show a difference in N170/VPP amplitude to other-race compared to same-race faces (e.g., Caldara et al., 2003; Caldara, Rossion, Bovet, & Hauert, 2004; Chen, Pan, Wang, Xiao, & Zhao, 2013; Ito, Thompson, & Cacioppo, 2004; Ofan, Rubin, & Amodio, 2011). However, N170/VPP amplitude also varies according to the degree to which the face is processed holistically (for reviews see Eimer, 2011; Rossion & Gauthier, 2002). This finding is consistent with a number of studies that show increased N170/VPP amplitude to outgroup faces compared to ingroup faces due to more holistic and configural processing of ingroup faces and more featural processing of

outgroup faces (Brebner, Krigolson, Handy, Quadflieg, & Turk, 2011; He et al., 2009; Herrmann et al., 2007; Stahl, Wiese, & Schweinberger, 2008, 2010; Volpert-Esmond, Merkle, Levsen, Ito, & Bartholow, 2018; Walker, Silvert, Hewstone, & Nobre, 2008; Wiese, Kaufmann, & Schweinberger, 2014).

Surprisingly, literature on the face-elicited P2 thus far has not been integrated with the N170/VPP (e.g., Bartholow & Dickter, 2011; Ito & Bartholow, 2009), instead connecting the face-elicited P2 with a centro-parietal P2 elicited in attention paradigms that is larger to attended compared to non-attended stimuli (e.g., Hillyard & Münte, 1984; Luck & Hillyard, 1994; Ritter, Simson, & Vaughan, 1983; Wijers, Mulder, Okita, Mulder, & Scheffers, 1989). However, given that the time course of the face-elicited P2 is typically earlier than the P2 found in selective attention paradigms, it is possible that what has traditionally been called the P2 in the race-perception literature is in fact the VPP, the inversion of the N170. In addition to both components being elicited by faces, the time window in which we measured the P2—130-190 ms with a peak latency of 160 ms—is consistent with previous descriptions of the VPP, which typically peaks between 140 and 180 ms following the presentation of a face at fronto-central electrodes (see Joyce & Rossion, 2005). The face-elicited P2 and the N170/VPP additionally show similar responsiveness to perceived race, such that amplitude of both the P2 and the N170 are typically larger to other-race faces (Ito & Bartholow, 2009).

However, the conclusion that what we called the P2 is in fact the VPP should be viewed with caution, for several reasons. First, the P2 measured here was maximal at centro-parietal electrodes, which is more posterior than where the VPP is typically observed (Joyce & Rossion, 2005) and corresponds with other studies that describe the P2 with a maximal amplitude at CPz (e.g., Dickter & Bartholow, 2007) or Pz (e.g., Ito & Urland, 2003, 2005). Second, while a number of studies using an average mastoid reference have reported the P2 peaking within a range that overlaps with the VPP (140–180 ms) (e.g., Dickter & Bartholow, 2007; Ito & Tomelleri, 2017; Ito & Urland, 2003, 2005; Kubota & Ito, 2017, 2007; Schutter, de Haan, & van Honk, 2004; Willadsen-Jensen & Ito, 2006, 2008, 2015), some studies have reported a similar P2 that peaks slightly later than the VPP (e.g., Correll et al., 2006; C. Dickter & Gyurovski, 2012). Third, and perhaps most importantly, the P2 measured in the current study was composed of two separate PCA components, which contrasts with previous research extracting the VPP as a single PCA component (Ito et al., 2004) and other work demonstrating a single neural generator of the VPP/N170 (Deffke et al., 2007; Rossion, Joyce, Cottrell, & Tarr, 2003). Unfortunately, we could not verify correspondence between the P2 we measured and the N170, which would strengthen the evidence that the P2 we measured is in fact the VPP, because the N170 is typically measured using a nose reference, which we did not record. Additionally, we did not measure non-face stimuli to verify a larger P2 response to face compared to non-face stimuli, which primarily identifies both the N170 and VPP (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Joyce & Rossion, 2005). Future research should incorporate these features in order to determine whether the P2 elicited in social categorization studies and the VPP typically observed in face processing studies are, in fact, the same component, reflecting similar underlying neurophysiological activity. Such work would be of considerable value in terms of bringing together two thus far disparate literatures on aspects of social categorization from faces.

In conclusion, the current study provides evidence that task demands affect electrophysiological processes related race and gender categorization during person construal, consistent with hypotheses proposed by the DI model. This top-down facilitation of discrimination between faces along particular dimensions was only apparent when stimulus-locked EEG was decomposed using spatiotemporal PCA, which revealed two distinct processes that contribute to the P2 and are differentially affected by task demand. Thus, using the temporal resolution afforded by ERPs and the statistical power of PCA to separate

overlapping components provides a more nuanced picture of activity related to person construal within 200 ms of perceiving a face.

Acknowledgement

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jesp.2019.103839.

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