Names and faces: The role of name labels in the formation of face representations

by

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Abstract

Although previous research in event-related potentials (ERPs) has focused on the conditions under which faces are recognized, less research has focused on the process by which face representations are acquired and maintained. In Experiment 1, participants were required to monitor for a target "Joe" face that was shown amongst a series of distractor "Other" faces. At the half-way point, participants were instructed to switch targets from the Joe face to a previous distractor face that is now labeled "Bob". The ERP analysis focused on the posterior N250 component known to index face familiarity and the P300 component associated with context updating and response decision. Results showed that the N250 increased in negativity to target Joe face compared to the Bob face and a designated Other face. In the second half of the experiment, a more negative N250 was produced to the now target Bob face compared to the Other face. Critically, the more negative N250 to the Joe face was maintained even though Joe was no longer the target. The P300 component followed a similar pattern of brain response where the Joe face elicited a significantly larger P300 amplitude than the Other and Bob face. In the Bob half of the experiment, the Bob face elicited a reliably larger P300 than the Other faces and the heightened P300 to the Joe face was sustained.

In Experiment 2, we examined whether the increased N250 negativity and enhanced P300 to Joe was due to simple naming effects. Participants were introduced to both Joe and Bob faces and names at the beginning of the experiment. During the first half of the experiment, participants were to monitor for the Joe face and at the half-way point, they were instructed to switch targets to the Bob face. Findings show that N250 negativity significantly increased to the Joe face relative to the Bob and Other faces in the first half of the experiment and an increased N250 negativity was found for target Bob face and the non-target Joe face in the second half. An increased P300 amplitude was demonstrated to the target Joe and Bob faces in the first and second halves of the experiment, respectively. Importantly, the P300 amplitude elicited by the Joe face equaled the P300 amplitude to the Bob face even though it was no longer the target face. The findings from Experiment 1 and 2 suggest that the N250 component is not solely determined by name labeling, exposure or task-relevancy, but it is the combination of these factors that contribute to the acquisition of enduring face representations.

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Acknowledgments

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Names and faces: The role of name labels in the formation of face representations

People are "face experts" to the extent that we can distinguish hundreds, if not thousands, of unique faces that have been learned over the course of a lifetime (Bahrick, 1975). While much of the research in event-related potentials (ERPs) has focused on neural components that index faces from non-face objects (Bentin, Allison, Puce, Perez, & McCarthy, 1996) and the recognition of previously familiar faces (Bentin & Douell, 2000; Caharel, Poiroux, Bernard, Thibaut, Lalonde, & Rebaï, 2002; Caharel, 2006; Eimer, 2000; Jacques and Rossion 2006; Schweinberger, Pickering, Jentzsch, Burton, & Kaufmann, 2002), less attention has been paid to understanding how the representations of these faces are formed, reinforced and become permanent in memory. One goal of the current study is to investigate the neurophysiological processes of face learning; that is, the changes in brain activity that occur as a novel face becomes familiar as consequence of practice and exposure.

Previous ERP studies have established a connection between the N170 posterior-occipital component and facial perception. Specifically, approximately 170 ms after stimulus onset, a larger negative deflection is generated in response to human faces relative to objects, animal faces, or body parts, (Bentin et al., 1996). While inversion has been shown to disrupt face perception (Purcell & Stewart, 1988; Lewis & Edmonds, 2003; Rousselet, Mace, & Fabre-Thorpe, 2003; Yin 1969), it does not abolish the face N170, but increases its amplitude or delays its latency (Rossion, Gauthier, Tarr, Despland, Bruyer, Linotte, & Crommelinck, 2000). Other manipulations such as priming low-level facial features (Bentin, Sagiv, Mecklinger, Friederici, & von Cramon, 2002), isolating facial features (Bentin et al., 1996) or even changing features' positions in a face (George, Evans, Fiori, Davidoff, & Renault, 1996) are sufficient to evoke a robust face N170 response.

Although the N170 component is sensitive to general category of face, it is not sensitive to distinct faces within the category. For example, no difference in N170 amplitude was observed between famous faces (such as politicians and actors) and unfamiliar faces (Bentin & Douell, 2001; Eimer, 2000). As a result of these findings, it has been suggested that the N170 component indexes the presence of a face stimulus at the category level of "face" as opposed to subordinate (individuated) categories. However, more recent work has suggested that the N170 can be responsive to individual facial identities, such as highly familiar faces (Caharel et al., 2002; Caharel et al. 2006) or after conditions of continuous habituation (Jacques & Rossion, 2006).

A more robust component of facial identity is the negative deflecting, posterior-occipital component elicited around 250 post-stimulus onset. Initially, variation in this component was observed in repetition-priming paradigms that presented target face stimuli successively, denoting the component as the N250r (repeated). Schweinberger et al. (2002) tested familiar faces (i.e. politicians and actors) and unfamiliar faces in a repetition paradigm that presented different pictures of the same face that varied randomly by perspective, age, expression, eye gaze or hairstyle. Participants were shown a prime face and a target face and were told categorize the latter as familiar or unfamiliar. The crucial trials utilized the same identity but a different picture of the target face for the prime. Results revealed a significant priming effect for the same identity trials during the 200-300 ms post-onset segments, resulting in larger, negative deflecting activation during this time epoch. The neural source of the N250r has been associated with activation in the anterior ventral temporal lobe corresponding to the fusiform gyrus (Schweinberger et al., 2002) an area that is responsive to individual faces (Gauthier, Tarr, Moylan, Skudlarski, Gore & Anderson, 2000).

One mechanism by which a face can be "learned" or familiarized is through the use of naming. The association of names and faces has a long-standing history in the literature, with many studies investigating the relation between faces and names during recognition paradigms (Burton & Bruce, 1992; Ellis, Young, Flude & Burton, 1996; Mackenzie & Donaldson, 2009), matching (Carson, Burton & Bruce, 2000; Huddy, Schweinberger, Jentzsch & Burton, 2003), in priming paradigms (Bruce & Valentine, 1985; Ellis et al., 1996; Martin-Loeches, Sommer, Hinojosa, 2005; Pickering & Schweinberger, 2003; Schweinberger, Pickering, Burton & Kaufmann, 2002) and in cognitive models (Bruce and Young, 1986; Burton, 1992; Carson et al., 2000; Ellis and Lewis, 2001; Valentine, Brennen, Bedart, 1996).

According to models of face recognition, two forms of semantic information are associated with a face. The first of these is perceptually derived and available from the face image, such as gender or age (Bruce & Young, 1986). The other kind of semantic information is abstract and associated with the person representation, such as occupations and names (Bruce & Young, 1986; Burton and Bruce, 1992; Cohen 1990). Behavioral research focusing on face recognition has revealed surprisingly poor performance in face naming. Findings have shown that names are retrieved slower than familiarity judgments (Young, Ellis & Flude, 1988) categorization by mortality or nationality (Johnston & Bruce, 1990) or occupation (Young, McWeeny, Ellis & Hay, 1986), and show an impairment in recall when compared to other semantic information such as occupation (Cohen and Faulkner, 1986). Names are also harder to learn in association with a face than other semantic information such as occupations (Cohen & Faulkner, 1986; McWeeny, Young, Hay & Ellis, 1987).

Whereas current research has focused on abstract semantics and the nature of their association with face representations, few have attempted to investigate the process by which names and face representations become associated. In a series of ERP studies by Paller and colleagues, participants were required to learn a series of unnamed faces (exposure condition), and faces which were associated with names and abstract semantic information such as hobbies (semantic condition) (Paller, Gonzalves, Grabowecky, Bozic, & Yamada, 2000; Paller, Ranganath, Gonsalves, LaBar, Parrish, Gitelman, Mesulam & Reber, 2003). During the recognition phase, changes in ERPs were observed to learned faces as opposed to novel faces, with learned faces resulting in larger posterior mid-line activation than novel faces evidencing recognition, (Paller et al., 2000; Paller et al., 2003), and the faces accompanied by vignette paragraphs eliciting larger anterior mid-line activation than unnamed faces (Paller et al., 2000; Paller et al., 2003), providing support of memory retrieval for biographical information to the vignette-faces.

A recent investigation of the neural correlates of face learning by Kaufmann, Schweinberger and Burton (2009) attempted to associate face-specific ERPs to learning processes. Participants were required to study a series of video recordings displaying faces half of which presented with no other semantic information associated (exposure condition), and half of which were presented with voice samples providing semantic information such as name and other identity-specific information (e.g., occupation, place of residence). During a subsequent recognition test, differential ERP activation was found, revealing a significant difference between learned and novel faces at posterior occipital sites with more negative N170 and N250 amplitudes as a result of face repetition. Critically, no differences were found between the semantic and non-semantic learned group, suggesting that the enhanced N250 did not occur as a result of learning abstract semantic associations, but as a result of perceptual learning.

It is important to note, however, that these experiments presented both name labels and other abstract semantic information together. In contrast, Tanaka and colleagues (2006) investigated the role of the name label uniquely, in the acquisition of representations for previously unfamiliar faces. In their "Joe/No Joe" experiment, participants' task was to monitor for an unfamiliar target face, "Joe", which was presented amongst unfamiliar faces and unbeknownst to the participant, their own face. Results showed that during the first half of the experiment, an N250 amplitude elicited to the participants' own face was significantly more negative than the response to either the Joe face or a randomly assigned "other" unfamiliar face. In the second half of the experiment, the acquired N250 negativity produced to the Joe face increased to the same magnitude as the pre-existing N250 to the participant's own face. It has been shown that highly over-learned faces develop visual representations which facilitate perceptual fluency and recognition, or "robust representations" (Tong & Nakayama, 1999), therefore the N250 amplitude elicited to the extremely familiar Own face, and subsequently familiar "Joe" face is indicative of robust memory representations for both these faces (Tanaka, Curran, Porterfield, & Collins, 2006)[1].

In addition to face familiarity effects, the N250 component has been shown to be sensitive to the acquisition of subordinate level representations. For example, an enhanced N250 negativity is produced when participants are trained to distinguish species of birds (Scott, Tanaka, Sheinberg, & Curran, 2006), models of cars (Scott, Tanaka, Sheinberg, & Curran, 2008) and other race faces (Tanaka & Pierce, 2009). These findings support the claim that the N250

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[1] It is interesting to note that the participant's own-face failed to influence the earlier N170 component (c.f., Caharel, 2002) in this experiment.

indexes a finer, subordinate level representation that is characteristic of expert object recognition and everyday face recognition (Tanaka, 2001).

In contrast to the gradually accrued N250 component to Joe face, a prominent P300 component was in evidence at the very outset of the experiment suggesting a dissociation between the posterior N250 and P300 potentials (Tanaka et al., 2006). The P300 is a central-parietal midline component occurring at 300-600 ms post-onset, and has also become associated with processes of categorization. Whereas it's elicitation in odd-ball paradigms had led to theories suggesting that activation is related the probability of a stimulus' presentation (Duncan-Johnson & Donchin, 1979; Donchin, 1981) a more complete model of P300 elicitation has attributed this component's activation to events that signal a need to change the current operations schema of the environment, such as response requirements (Donchin, 1981; Donchin & Coles 1988) and task relevancy (Donchin & Coles 1988).

The current "Joe/Bob" study investigated the role of naming in the formation and maintenance of representations for novel faces as measured by ERPs. Following the paradigm of Tanaka et al. (2006), electrophysiological activity was recorded while participants completed a Joe/No Joe task. In this task, participants were introduced to a previously unfamiliar target face (Joe) and then asked to monitor for the target "Joe" while shown a series of faces that included both target and other unfamiliar faces. Mid-way through the experiment, the target switched from "Joe" face to a new target "Bob" face. In order to examine the effects of associating a name label and face representation, perceptually derived semantic information was kept constant across faces (i.e., all faces were the same age, race and gender) and no other abstract semantic information except the name was associated with the face. We hypothesized that changes in the N250 component would be observed to "Joe" and "Bob" faces as a result of practice reflecting the acquisition of a face representation as a consequence of face-name associations. Critically, we expected that the N250 to presentation of the Joe face would be maintained even when the Bob face became the task-relevant face. Changes in P300 were also expected as a result of learned name-face representation associations, with increases in P300 activation occurring to task-relevant stimuli such that a larger P300 amplitude would occur to "Joe" when the Joe face was target, and to "Bob" when the Bob face was target. Furthermore, no significant P300 was predicted for learned faces when those faces were not target, reflecting the effects of task relevancy.

Experiment 1

Method

Participants

24 first-year students (4 males) from the University of Victoria ages 17 to 25 (M = 20.35) took part this study. All but two individuals were right handed, and all had normal or corrected-to-normal visual acuity. None had any history of brain injury or trauma. Informed consent was obtained from all participants prior to the experiment, and students were given the choice of either 2.5 credits to be put toward class requirements or 20 dollars as compensation for their time.

Materials

The stimuli comprised of images of 12 Caucasian male frontal faces with neutral expressions from the Karolinska Directed Emotional Faces database (Lundqvist, Flykt, & Ohman, 1998). Using Adobe Photoshop the images were gray-scaled and cropped to a dimension of 122 x 184 pixels around the face area allowing for a visual angle of 2.46 degrees in the horizontal field and 3.71 degrees in the vertical field while eliminating any possible clothing cues. For counterbalancing purposes, Joe, Bob, and filler faces were rotated amongst all 12 stimuli in order to ensure that detection of target faces were not due to stimulus properties.

Procedure

After the electroencephalogram (EEG) electrodes were applied, subjects were shown a face-stimulus and asked to look at Joe (the target face) until they felt confident that they could identify him. Subjects proceeded to a practice phase of twelve trials after they had pressed a button indicating that they were confident with the target's identity. Following completion of the practice phase, participants were given an opportunity to ask the experimenter any questions they may have had and proceeded to the experimental phase. Trials consisted of a blank screen with a fixation cross at the center jittered for 500-1000 ms, followed by a blank screen lasting 250 ms, followed by a face stimulus for 500 ms, and ended with a prompt screen that read "Joe?" and the key options corresponding to the two possible responses of "Joe" or "Other". Participants were instructed to select "Joe" if the target appeared or "Other" if any other face than the target appeared. The delayed-response was present in order to reduce motor-related artifacts in the ERP signal.

At the half-way point, participants were presented with one of the Other faces and were told that the face was "Bob". Participants were instructed to select the "Bob" key if they saw the target and the "Other" key if they saw any other face than Bob (including Joe). The prompt screen was altered to reflect the target change, with the prompt reading "Bob?" and the key selection marked "Bob" or "Other". All other components were exactly the same as in the first half of the experiment.

Participants completed a total of 720 trials that were divided into six 120 trial blocks, with 3 blocks in the first half of the experiment and 3 in the second half. Target switch occurred at 320 trials (half-way point), such that Joe was the target in the first half of the experiment, and Bob was target in the last half. Participants were given self-controlled breaks after each block, and an impedance check was performed at the halfway point before the introduction of Bob.

EEG/ERP methods

Scalp voltages were recorded from 41 channels using the Easy Cap configuration, and recorded using the Brain Vision Recorder software (Version 1.3, Brainproducts, GmbH, Munich, Germany). Channels were referenced to a common ground before re-referencing to an average reference online. Eye movement was accounted for by two electrodes placed on either temple, and blinking was monitored through the use of FP2 (referenced offline) and a separate electrode placed underneath the right eye. All impedances were kept below 10 k_ and sampled digitally at 250 Hz with a bandpass filter of 0.017 Hz to 67.5 Hz online (Quick Amp, BrainProducts, GmbH, Munich, Germany).

Data obtained was then subjected to several filtering and an ocular correction process offline as follows; first, EEG was filtered using a pass-band filter of 0.1 Hz – 20 Hz, thereafter each ERP segment was divided into 800 ms epochs, beginning 200 ms before stimulus onset and subsiding 600 ms after stimulus onset, thus the start of each epoch coincided with the blank screen stimulus that preceded the presentation of the face stimulus. Ocular corrections followed, using the Gratton and Coles method (Gratton, Coles and Donchin, 1983). All trials were baseline corrected on the 200 ms pre-stimulus and until stimulus presentation (0 ms). Lastly, trials were rejected if voltage changes exceeded 35 μV, or activation was less than 0.5 Hz.

Trials were divided into Joe, Bob and Other corresponding to the experimental conditions, with a minimum of 55 trials per each condition. Subsequent analysis techniques utilized these three stimulus groups.

Results

Reaction time was not analyzed as the paradigm utilized a delayed-response method and results would not be interpretable. Accuracy was at ceiling with all conditions averaging 99% correct, and all incorrect trials discarded from subsequent analysis. No decrease in accuracy was observed as a result of target switching.

Inspection of the graphed ERP components (N170, N250) revealed maximal activation at posterior-occipital channels, thus all ensuing analyses focused on these sites. All analyses made use of a 4 x 2 x 3, Location (channels P7, P8, P07, P08) by Condition (Joe, Bob, Other) by Half (first, second) repeated measures ANOVA with all variables treated as within-subjects measures. All subsequent analyses reported make use of the Greenhouse-Geiser adjustment, and Bonferonni adjustments for post-hoc comparisons. Average waveforms for channels PO7 and PO8 can be seen in Figure 2.

N170 component. A window of 140-240 ms was employed to obtain peak latency and amplitude measures. Peak latency analysis revealed a significant effect of location, F (2.01, 42.20) = 7.24, $p < 0.01$, with activation at channel P7 (M = 176.27, Se = 3.64) and P07 (M = 174.67, Se = 3.57) occurring later, than activation at channel P08 (M = 164.33, Se = 1.97). No other significant main effects of condition F (1.57, 33.13) = 0.15, $p = 0.81$, or half F (1, 21) = 1.93, $p = 0.18$, were found, and no interaction effects were revealed.

Peak amplitude analysis revealed a significant effect of location, F (1.92, 40.25) = 10.99, $p < 0.01$, such that activation at channels P7 (M = 2.04, Se = 0.52) and P8 (M = 2.73, Se = 0.54) were significantly smaller than activation at channels P07 ($M = 4.13$, $Se = 0.61$), or P08 ($M = 4.50$, $Se = 0.72$). The main effects of condition, $F(1.60, 33.58) = 0.18$, $p = 0.79$, and half $F(1, 21) = 4.39$, $p = 0.05$, did not reach reliable levels.

N250 Component. Following previous studies (Tanaka et al., 2006), a window of 230-330 ms was used to compute mean amplitude for the N250. The analysis revealed a significant effect of location, $F(1.81, 38.02) = 9.15$, $p < .01$, such that activation at channel P7 was reliably smaller than that of channel P07 ($M = 4.32$, $Se = 0.92$), and P08 ($M = 5.19$, $Se = 0.95$), as was activation at channel P8 ($M = 3.82$, $Se = 0.65$) significantly smaller than that of channels P07, and P08. In light of this finding, a subsequent 2 x 3 x 2, Hemisphere (left, right) x Condition (Joe, Bob, Other) x Half (first, second) ANOVA was carried out focusing on channels P07 and P08 were activation was maximal. No significant effect of hemisphere was found, $F(1, 21) = 3.85$, $p = 0.63$, thus further analysis collapsed across electrodes P07 and P08. A significant main effect of condition was found, $F(1.77, 76.01) = 47.77$, $p < .01$, such that all three condition differed reliably from the others, with Joe ($M = 3.48$, $Se = 0.62$) smaller than Bob ($M = 4.93$, $Se = 0.71$), and Bob smaller than Other ($M = 5.86$, $Se = 0.70$). A significant main effect of half was also found, $F(1, 43) = 61.30$, $p < 0.01$, with mean amplitude larger in the first half of the experiment ($M = 5.48$, $Se = 0.68$) than the second half ($M = 4.03$, $Se = 0.66$). A significant interaction effect of condition x half was also found, $F(1.90, 81.84) = 35.59$, $p < 0.01$.

As shown in Figure 3, a significant difference in the Bob condition between first and second halves of the experiment, $p < 0.01$, with mean amplitude larger in the Bob condition for the first half of the of the experiment ($M = 6.44$, $Se = 0.76$), than the second ($M = 3.41$, $Se = 0.66$) was found. Furthermore, a significant difference in the Other condition between first and second halves, $p < 0.01$ was also found, with mean amplitude larger in the Other condition for the first half of the experiment (*M* = 6.29, *Se* = 0.69) than the second (*M* = 5.44, *Se* = 0.72). No significant difference was found for the Joe condition between first and second halves. Scalp topographies representing differential activation between target and Other conditions show enhanced activation in the posterior-occipital regions to the Joe face during the Joe/Other condition, and no activation to the Bob face during the same task. Activation to both the Joe and Bob faces can be seen during the Bob/Other task at posterior-occipital regions. These scalp topographies can be seen in Figure 3.

P300 component. Graphed mean amplitudes for channels across the midline (Cz -> Oz) revealed larger mean amplitudes at the Pz region, thus analysis focused on this channel. A window of 400-600 ms was used to compute mean amplitude of the P300.

Mean amplitude analysis revealed a significant main effect of condition, *F* (1.40, 29.36) = 27.91, $p < 0.01$, such that all three conditions differed reliably from each other, with the Joe condition (*M* = 3.56, *Se* = 0.32) significantly larger than the Bob condition (*M* = 2.00, *Se* = 0.30), and the Bob condition reliably larger than the Other condition (*M* = 1.41, *Se* = 0.26). No significant effect of half was found, *F* (1, 21) = 3.89, $p = 0.06$. A significant interaction effect of both half x condition was also observed, *F* (1.85, 38.77) = 18.23, $p < .01$. Subsequent t-test analysis revealed a significant difference in both the Joe and Bob conditions between first and second halves of the experiment, $p < 0.01$, with mean amplitude larger in the first half of the experiment (*M* = 4.04, *Se* = 0.33) than the second half (*M* = 3.07, *Se* = 0.35) for the Joe condition, but larger mean amplitude in the second half (*M* = 2.88, *Se* = 0.43) than the first half (*M* = 1.14, *Se* = 0.26) for the Bob condition. These findings can be seen in Figure 4.

In sum, the magnitude of the N250 response was significantly more negative to the target Joe face in the first half of the experiment and to the target Bob face in the second half of the experiment. A significantly more negative N250 response was also observed for the Other condition in the second half of the experiment, though was reliably smaller than the Bob condition. Interestingly, the enhanced N250 negativity to the Joe face was maintained in the second half of the experiment, when the face was no longer target. These findings indicate that the N250 is not task dependent, but may reflect a more enduring face representation of the Joe face. P300 amplitude was significantly larger in response to the target Joe face than the Bob or Other faces during the first half of the experiment. In the second half of the experiment, P300 amplitude increased in response to the target Bob face, though a somewhat reduced yet sustained P300 was found in response to the previous target Joe face.

In Experiment 1, labels were presented when a face became target, confounding the effects of labeling and task-relevancy. Hence, it is not known whether the emergence of N250 and P300 components was due to labeling effects, task relevancy or a combination of these factors. In order to disentangle labeling and task relevancy, a second experiment was performed where the names for the Joe and Bob faces were presented at the beginning of the experiment. If the ERP effects observed in Experiment 1 were due to labeling, we would expect an enhanced N250 and P300 to the Bob face during the initial "Joe/No Joe" phase of the experiment. In contrast, if the name label and task relevancy are critical to the formation of the N250 and P300 components, we would expected an N250 and P300 to Bob face only in the second half "Bob/No Bob" phase of the experiment when this face becomes task relevant.

Experiment 2

Method

Participants

Participants were 24 first year psychology students ages 18 - 24 (M = 19.25) of which 5 were males, and none took part in the first experiment. Informed consent was obtained prior to the experiment from all participants who participated in return for course credit. All subjects had normal or corrected to normal vision, and were right handed. None had any history of brain injury or trauma.

Procedure

All procedures were the same as in experiment one, except for the presentation of the target stimuli and instructions. In this experiment, participants were shown pictures of Joe and Bob at the beginning of the experiment, and told to study both faces as they would have to identify both targets. Participants moved on to the practice phase after indicating that they were confident with the targets' identities. Subjects were told to monitor only for Joe in the first half of the experiment, whereas they were to monitor for Bob in the second half of the experiment. All other instructions, materials and EEG methods were identical to the first experiment.

Results

Accuracy was at ceiling with all conditions averaging 99% correct, and was maintained despite the switch in target. Incorrect trials were excluded from any subsequent analysis. Reaction time data was not analyzed as the delayed-response paradigm would make results uninterpretable.

Preliminary graphing revealed maximal activation at posterior-occipital channels, thus ensuing analysis focused on these channels. Data was input in a 4 x 3 x 2, Location (P7, P8, P07, P08) x Condition (Joe, Bob, Other) x Half (first half, second half) with all variables treated as within-subjects measures. All subsequent analysis makes use of the Greenhouse-Geisser adjustment, and all post-hoc analyses are Bonferonni adjusted. The average waveforms for PO7 and PO8 are shown in Figure 5.

N170 component. A window of 140-240 ms was used in peak detection in order to obtain peak latency and amplitude measures. Peak latency analysis revealed a significant effect of hemisphere, F (1, 21) = 13.67, $p < 0.05$, with activation in the right hemisphere at channel P08 (M = 164.39, Se = 1.90) occurring sooner than that of the left hemisphere at channel P07 (M = 174.27, Se = 3.1). No other significant main effects of time F (1, 21) = 1.14, p = 0.30, or condition F (2, 42) = 0.24, p = 0.78, were found.

Peak amplitude analysis revealed a significant effect of location, F (1.82, 38.23) = 13.17, $p < 0.01$, such that activation at channel P7 was smaller than that at channel P07 (M = 3.64, Se = 0.72), and P08 (M = 3.38, Se = 0.72), as was activation at channel P8 (M = 1.51, Se = 0.64) smaller than that of channel P07 and P08. As a result, subsequent analysis focused on channel P07 and P08 where activation was maximal. Another 2 x 3 x 2, Hemisphere (left, right) x Condition (Joe, Bob, Other) x Half (first half, second half) ANOVA was carried out, and no significant effect of hemisphere F (1, 21) = 0.33, p = 0.57, condition, F (1.99, 41.75) = 0.81, p = 0.45, or half F (1, 21) = 1.96, p = 0.18, were found, and no interaction effects were revealed.

N250 Component. Following the convention established in Experiment 1, a window of 230-330 ms was used to compute mean amplitude for the N250. The analysis revealed a significant effect of location, F (1.59, 33.48) = 4.75, $p < .05$, such that activation at channel P7 (M = 2.56, Se = 0.39) was significantly smaller than activation at channel P07 (M = 3.99, Se = 0.48), and activation at channel P8 (M = 3.01, Se = 0.50) was reliably different than that at channel P08 ($M = 3.91$, $Se = 0.42$). A subsequent 2 x 3 x 2, hemisphere (left, right) x condition (Joe, Bob, Other) x half (first half, second half) ANOVA was carried out focusing on channels P07 and P08 where activation was maximal. No significant effect of hemisphere was found, F (1, 21) = 0.39, $p = 0.84$, thus channels P07 and P08 were collapsed, and a 3 x 2, condition x half ANOVA was calculated. A significant effect of condition, F (1.89, 81.37) = 37.67, $p < .01$, such that all three condition differed reliably from the others, with Joe ($M = 2.88$, $Se = 0.41$) smaller than Bob ($M = 4.01$, $Se = 0.37$), and Bob smaller than Other ($M = 4.97$, $Se = 0.40$). A significant main effect of time was also found, F (1, 43) = 71.66, $p < 0.01$, with mean amplitude larger in the first half of the experiment ($M = 4.63$, $Se = 0.40$) than the second half ($M = 3.27$, $Se = 0.36$). A significant interaction effect of condition x time was also found, F (1.68, 72.31) = 11.92, $p <$ 0.01. T-test revealed a significant difference in all Joe, Bob, and Other conditions between first and second halves of the experiment, $p < 0.01$, with mean amplitude larger in the Joe ($M = 3.33$, $Se = 0.44$) Bob ($M = 5.14$, $Se = 0.40$), and Other ($M = 5.41$, $Se = 0.43$) conditions for the first half of the of the experiment than the second ($M = 2.44$, $Sd = 2.71$, $M = 2.88$, $Sd = 2.64$, and $M = 4.52$, $Se = 0.39$, respectively) as shown in the bar graph in Figure 6. Scalp topographies representing the difference between target and Other activation show enhanced activation in the posterior-occipital regions to the Joe face during the Joe/Other condition, but no activation to the Bob face during the same task. Activation to the Bob face can be seen during the Bob/Other task at posterior-occipital regions, and are also present in response to the Joe face during the same task. Scalp topographies can be seen in Figure 6.

P300 component. A window of 400-600 ms was used to compute mean amplitude and latency of the P300, as graphed midline channel amplitudes (Cz -> Oz) revealed larger mean amplitudes in this region. Mean amplitude analysis revealed a significant main effect of condition, *F* (1.87, 39.16) = 72.63, $p < 0.01$, with all three conditions differing reliably from the other such that the Joe condition (*M* = 4.08 *Se* = 0.28) was significantly larger than the Bob condition (*M* = 2.64, *Se* = 0.26), and the Bob condition reliably larger than the Other condition (*M* = 1.38, *Se* = 0.16). A reliable effect of half was found, *F* (1, 21) = 4.67, $p < 0.05$, with the first half of the experiment (*M* = 2.52, *Se* = 0.19) significantly smaller than the second half (*M* = 2.89, *Se* = 0.24). A significant interaction effect of both time x condition was also revealed, *F* (1.68, 35.37) = 30.29, $p < 0.01$. Subsequent t-test analysis revealed a significant difference in both the Joe and Bob conditions between first and second halves of the experiment, $p < 0.01$, with mean amplitude larger in the first half of the experiment (*M* = 4.36, *Se* = 0.27) than the second half (*M* = 3.80, *Se* = 0.32) for the Joe condition, yet mean amplitude larger in the second half of the experiment (*M* = 3.65, *Sd* = 0.38) than the first half (*M* = 1.64, *Se* = 0.25) for the Bob condition. Figure 7 represents these findings in bar-graph form.

In summary, both Joe and Bob faces were given name labels at the start of Experiment 2. In the first half of the experiment, only the target Joe face showed a significantly more negative N250 response. In the second half of the experiment, the target Bob face, Other face and the previously target Joe face elicited a more negative N250. These findings indicate that name labels are not sufficient for eliciting the N250 response, but that the N250 is acquired through practice and experience. P300 amplitude was significantly larger for the Joe condition during the first half of the experiment, decreasing reliably during the second half. An increase in both P300 latency and amplitude was found for the Bob condition in the second half of the experiment, resulting in amplitudes of equal magnitude for both Joe and Bob faces.

General Discussion

The current study investigated the formation of face representations by using a design meant to distinguish the effects of name labels, exposure, and task-relevancy in this process. In both Experiments 1 and 2, participants were required to monitor for a target face, "Joe," in the first half of the experiment and a target face "Bob" in the second half of the experiment. In Experiment 1, the target Bob face was introduced half-way through the experiment whereas in Experiment 2, the Bob face was previewed at the beginning of the experiment. An enhanced N250 negativity was found in response to the Joe face during the first half of the experiment when Joe was the target and an enhanced N250 negativity to the Bob face when Bob was the target. Critically, in both experiments, the increased N250 negativity to the Joe face was maintained during the Bob phase of the experiment task. A more negative N250 was also observed to the Other face in the second half of the experiment, though this change was not as large as that of the Bob condition.

These studies suggest conditions under which an enhanced N250 is and isn't elicited. The N250 may occur as a result of stimulus exposure, but exposure alone does not produce a large increase in N250 negativity; while the "Other" faces were seen an equal number of times as the target faces and the resulting N250 amplitude was larger during the second half of the experiment, this enhancement did not reach the same proportions as the target faces'. Nor is the N250 a simple labeling effect in which a face is made distinctive by assignment of a proper name. Specifically, in Experiment 2, Bob was introduced at the beginning of the experiment and hence, was distinguished from the "Other" faces by its name. However, name knowledge was not sufficient to generate an N250 response as indicated by the absence of the N250 negativity to Bob in Joe/No Joe phase the study. Only in the second half of the experiment, when the Bob face was task relevant, was a reliable N250 response produced. Thus individuating a face with a name label is not sufficient to elicit the N250.

Although task relevance appears to be critical in the formation of the N250 response, it is not necessary for maintaining the N250 component. In the Bob/No Bob phase of the Experiments 1 and 2, the Joe face continued to produce an enhanced N250 negativity even though it was no longer task relevant. These results suggest that the N250 to highly familiar faces is obligatory and independent of task demands. The automatic activation to the non-target Joe face in the Bob/No Bob phase of the experiments is similar to the enhanced N250 negativity shown to other highly familiar faces, such as one's own face (Tanaka et al., 2006) and the N250r to task-irrelevant famous faces (Neumann & Schweinberger, 2008).

Tong and Nakayama (1999) suggested that highly overlearned faces, such as one's own face, result in robust representations that are characterized by rapid recognition and reduced attentional resources. These representations are a result of excessive visual experience with a face in which the dynamic properties, such as expression, viewpoint and even lighting contribute to optimal learning conditions (Tong & Nakayama, 1999). These representations are robust in that they contain abstract and view-invariant information that facilitate visual and decisional processes that generalize across tasks and contexts (Tong & Nakayama, 1999). The current study has highlighted the qualitative difference between mere exposure and active experience and deliberate practice in facial familiarity in the form of subordinate-level categorization, or individuation. As indexed by the N250, excessive mere exposure result in changes in facial familiarity, but the process of consistently labeling a target face resulted in learning. Thus, it is possible that the excessive visual experience proscribed for robust representations mirrored the task-demands of this experiment.

It is important to note, however, that the current study made use of static images that were repeated many times during the experiment. Thus, it is possible that the enhanced N250 is the result of picture learning rather the formation of a robust representation of a familiar person. However, a study by Bindemann, Burton, Leuthold & Schweinberger (2008) demonstrated that in a priming paradigm, repeated faces of famous people that were vertically or horizontally distorted elicited the same N250r priming effects as the priming effects found for identical images. In a recent study, Kaufmann, Burton & Schweinberger (2009) showed dynamic video clips of faces from varying viewpoints. While the accuracy in identifying a newly familiarized face was far below ceiling, the N250 amplitude to the multiple views of the learned face was more negative than the response to novel faces, and the negativity of the N250 grew with increasing repetition suggesting that a more stable face representation was formed over time. These results support the idea that the N250 is an indicator of identity or memory representations for faces. In future research, it will be important to the test the robust representations of the N250 response to targets faces in the Joe/No Joe paradigm by varying their view-points of in a procedure similar to the Kaufman et al. study (2009).

The N250 findings are consistent with previous training experiments in which a more negative N250 was elicited to faces from a specific racial group that were individuated with a name label (Tanaka & Pierce, 2009). In this study, participants who were required to individuate African American or Hispanic faces at the subordinate showed an enhanced N250 negativity in response to novel exemplars from the sub-ordinate racial group (Tanaka & Pierce, 2009). Importantly, participants demonstrated better recognition performance to faces from the subordinate level race suggesting that the N250 might index a more durable memory representation that facilitates recognition. Further evidence indicating a connection between this

ERP component and recognition, comes from object training studies where the enhancement of the N250 and recognition advantage are still present one week following training (Scott et al., 2006).

One difference between this experiment and the original Tanaka et al. (2006) study is the immediate N250 response to the Joe face, as opposed to the accrued N250 findings of the original study. Whereas in the original Tanaka et al. (2006) experiment participants may have been anticipating their own faces and hindered learning because of expectancies, the current paradigm did not afford any distractions in task-relevant learning, resulting in a reliable N250 effect to the target sooner. In Experiment 2 however, N250 activation to the Joe condition was reliable in the first half of the experiment, though continued to increase in negativity significantly throughout the second half. Presentation of Bob's name could have acted as a distractor in the learning process similar to the Own face in the original Tanaka et al. (2006) experiment in that participants may have generated expectancies with regards to Bob's appearance. Perhaps because Bob was less surprising than the unforeseen "Own" condition and less self- relevant, the condition did not impede target learning as greatly.

In Experiments 1 and 2, the P300 amplitude was consistently larger to task –relevant, target faces than distractor faces, a finding that is congruent with those of the previous Joe/No-Joe experiment (Tanaka et al., 2006). In the second half of the experiment where the target face switched to Bob, the increased P300 to the target Bob face was offset by small, but reliable decrease in P300 amplitude to the Joe face. The net result was that the Joe and Bob faces produced a P300 of equivalent magnitude in the second half of the experiment even though the Joe face was no longer task relevant. This finding is supported by research showing that exemplars of the same category will elicit the P300 jointly (Johnson & Donchin, 1980; Kutas &

Donchin, 1979). Despite requiring two distinct responses in the second half of the experiment (i.e., "No Bob" to Joe face and "Bob" to the Bob face), participants may have grouped the Joe face and Bob face together as a special category that is distinct from the "other" distractor faces. Because the magnitude of the P300 is inversely proportional to the probability of the stimulus (Donchin, 1979; Johnson & Donchin, 1980), the reduced amplitudes to the Bob and Joe faces can be explained by the increase in probability from a 10% (e.g., Joe face) to 20% (i.e., Joe or Bob face) chance of occurrence in the second half of the experiment.

So what's in a name? Previous research investigating the neural correlates of face recognition did not find any significant contribution of abstract semantic associations when compared to mere repetition with regards to face-specific markers of recognition (Kaufmann et al., 2009). In contrast, the current study had found reliable changes in the N250 as a result of name-face associations. One factor that may have influenced the importance of the name in the learning process was the way in which names were used to familiarize a face; whereas the previous experiments required participants to identify named faces as familiar or unfamiliar, the current experiment required the participants to use the name label to categorize a face. Using the name-label in the categorization process required participants to individuate faces, while categorizing faces as familiar or unfamiliar remains a super-ordinate distinction. As a result, the name-label in the current study may have anchored the acquisition of a face representation by facilitating the individuation process, comparable to the N250 findings in training expert object recognition (Scott et al., 2006; Scott et al., 2008) and other-race face recognition (Tanaka & Pierce, 2009).

Changes in midline activity have been observed in response to abstract semantic associations with face stimuli (Paller et al., 2000: Paller et al., 2005) and were replicated in the current experiment, with P300 activation to named faces larger than those of unnamed faces. Unlike previous studies that have confounded names with other abstract semantic information and perceptual derived semantics, the current study did not present any abstract semantic associations asides from the name label and held all low-level perceptual semantics constant. Thus, present findings extend previous research, suggesting that mid-line activation reflecting exemplar differentiation and identification are not only functions of abstract semantics such as occupations, but also include name labels.

In summary, the reported findings reveal that the process of acquiring robust face representations is not passive but an active association between percept and practice in subordinate level categorization. Essentially, the N250 component showed no changes to the simple act of labeling and minor enhancements as a result of mere exposure, but when combined with task relevancy produce alterations that persist even beyond task-relevancy. These findings reinforce the notion that the N250 component is as a result of a persistent change in brain function due to an active process of learning that combines all three factors; name labels, exposure, and task relevancy. The acquisition of face representations are also corroborated by reliable changes in the P300 component that were evident even after the active learning process when faces were no longer task-relevant. Future research may investigate the permanence of these changes using paradigms that test for face familiarity across longer retention interval (days, weeks) in order to fully understand the robustness of face representations and their manifestation in ERPs. Other research may also look to compare the acquisition of face representations using stimuli from both static and varying view-points and its effects on long-term retention.

References

Bahrick, H. P., Bahrick, P. O., & Wittlinger, R. P. (1975). 50 years of memory for names and faces - cross-sectional approach. *Journal of Experimental Psychology-General, 104*, 54-75.

Bentin, S., Sagiv, N., Mecklinger, A., Friederici, A., & von Cramon, Y.D. (2002). Priming visual face-processing mechansims: electrophysiological evidence, *Psychological Science, 13*, 190-193.

Bentin, S., Allison, T., Puce, A., Perez, E., & McCarthy, G. (1996). Electrophysiological studies of face perception in humans. *Journal of Cognitive Neuroscience, 8*, 551–565.

Bentin, S., & Deouell, L. (2000). Structural encoding and identification in face processing: ERP evidence for separate mechanism. *Cognitive Neuropsychology, 17*, 35–54.

Bindemann, M., Burton, A.M., Leuthold, H., & Schweinberger, S.R. (2008) Brain potential correlates of face recognition: geometric distortions and the N250r brain response to stimulus repetitions. *Psychophysiology, 45*, 535-544.

Bruce, V., & Valentine, T. (1985). Identity priming in the recognition of familiar faces. *British Journal of Psychology, 76*, 373-383.

Bruce, V., & Young, A. (1986). Understanding face recognition. *British Journal of Psychology, 77*, 305-327.

Burton, A.M., & Bruce, V. (1992). I recognize your face but I can't remember your name: a simple explanation? *British journal of Psychology, 83*, 45-60.

Caharel, S., Poiroux, S., Bernard, C., Thibaut, F., Lalonde, R., & Rebaï, M., (2002).

ERPs associated with familiarity and degree of familiarity during face recognition. *International Journal of Neuroscience, 112*, 1499–1512.

Caharel, S., Fiori, N., Bernard, C., Lalonde, R., & Rebaï, M., (2006). The effects of inversion and eye displacements of familiar and unknown faces on early and late stage ERPs. *International Journal of Psychophysiology, 62*, 141-151.

Carson, D.R., Burton, A.M., & Bruce, V. (2000). Putting names to faces. *Pragmatics & Cognition, 8*, 9-62.

Cohen, G. (1990). Why is it difficult to put names to faces? *British Journal of Psychology, 81*, 287-297.

Cohen, G., & Faulkner, D. (1986). Memory for proper names: age differences in retrieval. *British Journal of Developmental Psychology, 4*, 187-197.

Donchin, E. (1981). Surprise! . . . Surprise? *Psychophysiology, 18,* 493–513.

Donchin, E., & Coles, M. G. H. (1988). Is the P300 component a manifestation of context updating? *Behavioral and Brain Sciences, 11,* 357–374.

Duncan-Johnson, C. C., & Donchin, E. (1979). The time constant in P300 recording. *Psychophysiology*, *16*, 53-55.

Eimer, M. (2000). Event-related brain potentials distinguish processing stages involved in face perception and recognition. *Clinical Neurophysiology*, *111*, 694–705.

Ellis, H.D., & Lewis, J.B. (2001). Capgras delusion; a window on face recognition. *Trends in Cognitive Sciences, 5,* 149-156.

Ellis, A.W., Young, A., Flude, B.M., & Burton, A.M. (1996) Two loci of repetition priming in the recognition of familiar faces. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*, 295-308.

Gauthier, I., Tarr, M. J., Moylan, J., Skudlarski, P., Gore, J. C., & Anderson, A. W. (2000). The fusiform 'face area' is part of a network that processes faces at the individual level. *Journal of Cognitive Neuroscience, 12*, 495-504.

George, N., Evans, J., Fiori, N., Davidoff, J., & Renault, B. (1996). Brain events related to normal and moderately scrambled faces. *Cognitive Brain Research, 4*, 65-76.

Gratton, G., Coles, M.G.H., & Donchin, E., (1983). A new method for off-line removal of ocular artifacts. *Electroenchephalography and Clinical Neuropsychology, 55*, 468-484.

Huddy, V., Schweinberger, S.R., Jentzsch, I., & Burton, A.M. (2003). Matching faces for semantic information and names: an event-related brain potentials study. *Cognitive Brain Research, 17*, 314-326.

Jacques, C., & Rossion, B. (2006). The time course of visual competition to the presentation of centrally fixated faces. *Journal of Vision, 6*, 154-162.

Johnson, R., & Donchin, E. (1980). P300 and stimulus categorization: two plus one is not so different from one plus one. *Psychophysiology, 17*, 167-178.

Johnston, R. A., and Bruce, V. (1990). Lost properties? Retrieval differences between name codes and semantic codes for familiar people. *Psychological Research, 52,* 62–68.

Kaufmann, J.M., Schweinberger, S. R., & Burton, A. M. (2009). N250 ERP correlates of the acquisition of face representations across different images. *Journal of Cognitive Neuroscience, 21*, 625-641.

Kutas, M., & Donchin, E. (1979). Variations in the latency of the P300 as a function of variations in semantic categorization. In D. Otto (Ed.) *Multidisciplinary perspectives in event-related brain potential research.* Washington, D.C.: U.S. Government Printing Office, 198-201

Kutas, M., McCarthy, G., & Donchin, E. (1977). Augmenting mental chronometry: The P300 as a measure of stimulus evaluation time. *Science, 197,* 792–795

Lewis, M. B., & Edmonds, A. J. (2003). Face detection: Mapping human performance. *Perception, 32,* 903-920.

Lundqvist, D., Flykt, A., & .O¨ hman, A. (1998). The Karolinska Directed Emotional Faces (KDEF). Stockholm: Department of Neurosciences Karolinska Hospital.

MacKenzie, G., & Donaldson, D., I. (2009). Examining the neural basis of episodic memory: ERP evidnce that faces are recollected differently from names. *Neuropsychologia, 47*, 2756-2765.

Martin-Loeches, M., Sommer, W., & Hinojosa, J.A. (2005) ERP components reflecting stimulus identification: contrasting the recognition potential and the early repetition effect (N250r). *International Journal of Psychophysiology, 55,* 113-125.

McCarthy, G., & Donchin, E. (1981). A metric for thought: A comparison of P300 latency and reaction time. *Science, 211,* 77–80.

McWeeny, K. H., Young, A.W., Hay, D. C., and Ellis, A.W. (1987). Putting names to faces. *British Journal of Psychology, 78*, 143–149.

Mecklinger, A., & Ullsperger, P. (1993). P3 varies with stimulus categorization rather than probability. *Electroencephalography & Clinical Neurophysiology*, *86*, 395-407.

Neumann, M.F., & Schweinberger, S.R. (2008). N250r and N400 correlates of immediate famous face repetition are independent of perceptual load. *Brain Research, 1239*, 181-190.

Paller, K.A., Gonzalves, B., Grabowecky, M., Bozic, V.S., & Yamada, S. (2000).

Electrophysiological correlates of recollecting faces of known and unknown individuals. *Neuroimage, 11*, 98-110.

Paller, K.A., Ranganath, C., Gonsalves, B., LaBar, K.S., Parrish, T.B., Gitelman, D.R., Mesulam, M.M., & Reber, P.J. (2003). Neural correlates of person recognition. *Learning and Memory, 10*, 253-260.

Pickering, E.C., & Schweinberger, S.R. (2003) N200, N250r, and N400 event-related brain potentials reveal three loci of repetition priming for familiar faces. *Journal of experimental psychology: Learning. Memory, and Cognition, 29*, 1298-1311.

Purcell, Dean G. & Stewart, Alan L., (1988). The face-detection effect: Configuration enhances detection *Perception & Psychophysics*, *43*, 355-366.

Rossion, B., Gauthier, I., Tarr, M. J., Despland, P., Bruyer, R., Linotte, & S., Crommelinck, M. (2000). The N170 occipito-temporal component is delayed and enhanced to inverted faces but not to inverted objects: an electrophysiological account of face-specific processes in the human brain. *Neuroreport*, *11*, 69-74.

Rousselet, G. A., Mace, M. J. M., & Fabre-Thorpe, M. (2003). Is it an animal? Is it a human face? Fast processing in upright and inverted natural scenes. *Journal of Vision*, *3*, 440-455.

Schweinberger, S. R., Pickering, E. C., Jentzsch, I., Burton, A. M., & Kaufmann, J. M. (2002). Event-related brain potential evidence for a response of inferior temporal cortex to familiar face repetitions. *Cognitive Brain Research*, *14*, 398–409.

Scott, L., S., Tanaka, J. W., Sheinberg, D. L., & Curran, T. (2006). A Reevaluation of the Electrophysiological Correlates of Expert Object Processing. *Journal of Cognitive Neuroscience*, *18*, 1453-1465.

Scott, L. S., Tanaka, J. W., Sheinberg, D. L., & Curran, T. (2008). The role of category learning in the acquisition and retention of perceptual expertise: A behavioral and neurophysiological study. *Brain Research, 12*, 204-215.

Tanaka, J.W. (2001). The entry point of face recognition: Evidence for face expertise. *Journal of Experimental Psychology: General, 130*, 534-543.

Tanaka, J. W., & Pierce, L. J. (2009). The neural plasticity of other-race face training. *Journal of Cognitive and Behavioral Neuroscience*, *9*, 122-131.

Tanaka, J. W., Curran, T., Porterfield, A. L., & Collins, D. (2006). Activation of Preexisting and Acquired Face Representations: The N250 Event-related Potential as an Index of Face Familiarity *Journal of Cognitive Neuroscience*, *18*, 1-10

Tong, F., & Nakayama, K., (1999). Robust representations for faces: evidence from visual search. *Journal of Experimental Psychology, Human Perception and Performance 25*, 1016–1035.

Valentine, T., Brennen, T., & Bredart, S. (1996) The cognitive psychology of proper names. On the importance of being Ernest. London:Routledge.

Yin, R. (1969). Looking at upside-down faces. *Journal of Experimental Psychology, 81*, 141-145.

Young, A.W., Ellis, A.W., and Flude, B. (1988). Accessing stored information about familiar people. *Psychological Research, 50*, 111–115.

Young, A.W., McWeeny, K. H., Ellis, A.W., and Hay, D.C. (1986). Naming and categorizing faces and written names. *Quarterly Journal of Experimental Psychology, 38A*, 297–318.

Figure Captions

Figure 1. Procedure of Experiment 1 and 2. In Experiment 1, the Joe face is first presented to the participant (1.a), and subjects are required to monitor for the face. At the half-way point, the Bob face is introduced as target (1.b) and participants are to monitor for Bob, while the Joe face becomes an Other. In Experiment 2, the Joe and Bob faces are introduced (2.a), but the participants are required to monitor for the Joe face. At the half-way point, the target switches (2.b) and subjects are now monitoring for Bob.

Figure 2. Grand average ERPs averaged across channel used in N170, and N250 analysis. Left hemisphere, P07, right hemisphere, P08. Experiment 1.

Figure 3. **a)** Top and back-view scalp topography represents activation calculated using the difference between target and Other conditions, for both Joe and Bob conditions. **b)** Bar-graph of 230-330 ms window representing the N250 collapsed across channels P08 and P07 for the Joe, Bob, and Other conditions during first and second halves in Experiment 1. Asterisk represents significant difference between first and second halves, $p < 0.01$.

Figure 4. - Bar-graph of 400-600 ms window representing the P300 at channel Pz for the Joe, Bob, and Other conditions during first and second halves in Experiment 1. Asterisk represents significant difference between first and second halves, $p < 0.01$.

Figure 5. Grand average ERPs averaged across channel used in N170, and N250 analysis. Left hemisphere, P07, right hemisphere, P08. Experiment 2.

Figure 6. **a)** Scalp topography represents activation calculated using the difference between target and Other conditions, for both Joe and Bob conditions. **b)** Bar-graph of 230-330 ms window representing the N250 collapsed across channels P08 and P07 for the Joe, Bob, and Other conditions during first and second halves in Experiment 2. Asterisk represents significant difference between first and second halves, $p < 0.01$.

Figure 7. Bar-graph of 400-600 ms window representing the P300 at channel Pz for the Joe, Bob, and Other conditions during first and second halves in Experiment 1. Asterisk represents significant difference between first and second halves, $p < 0.01$.

Figure 1.

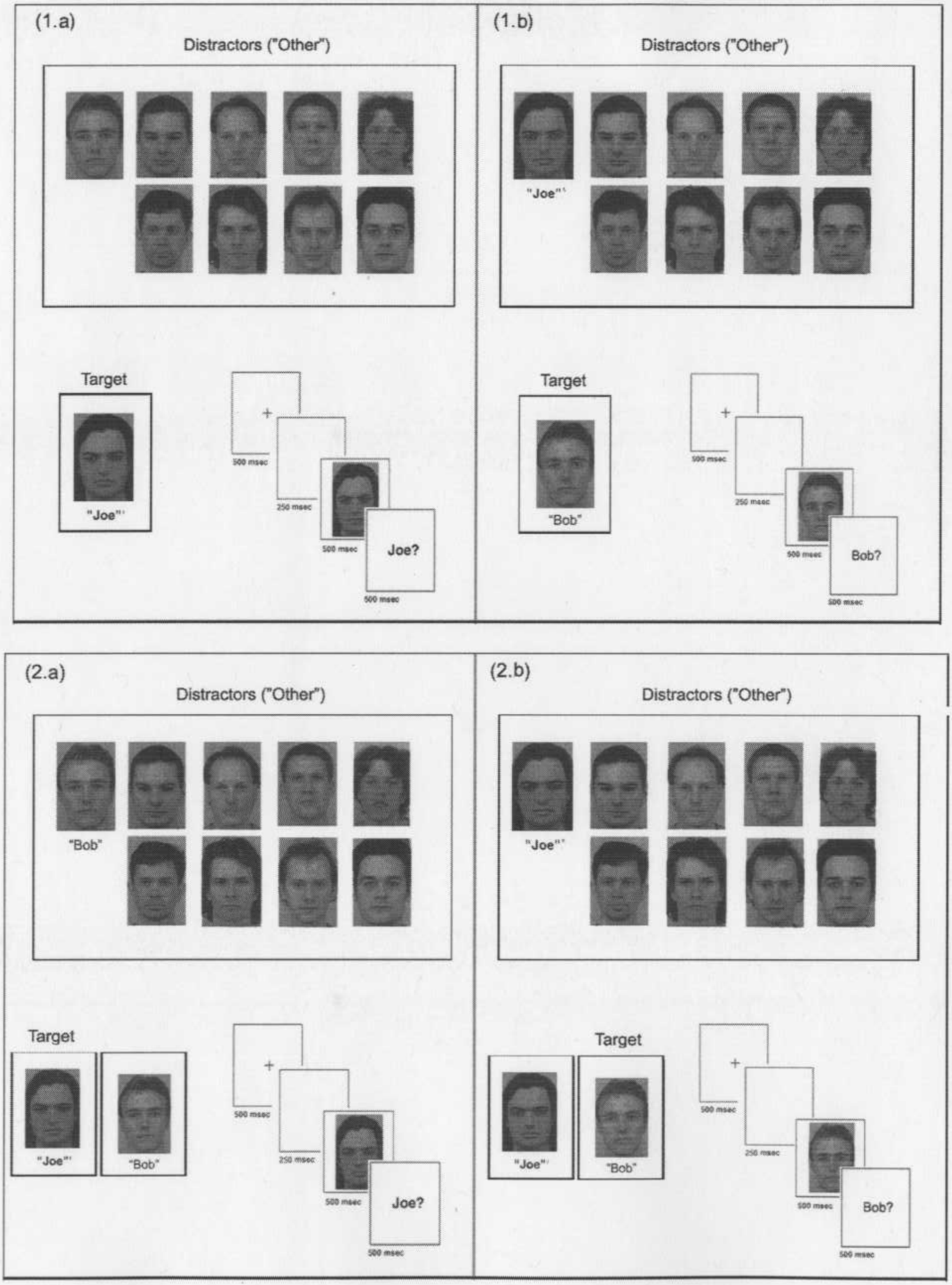
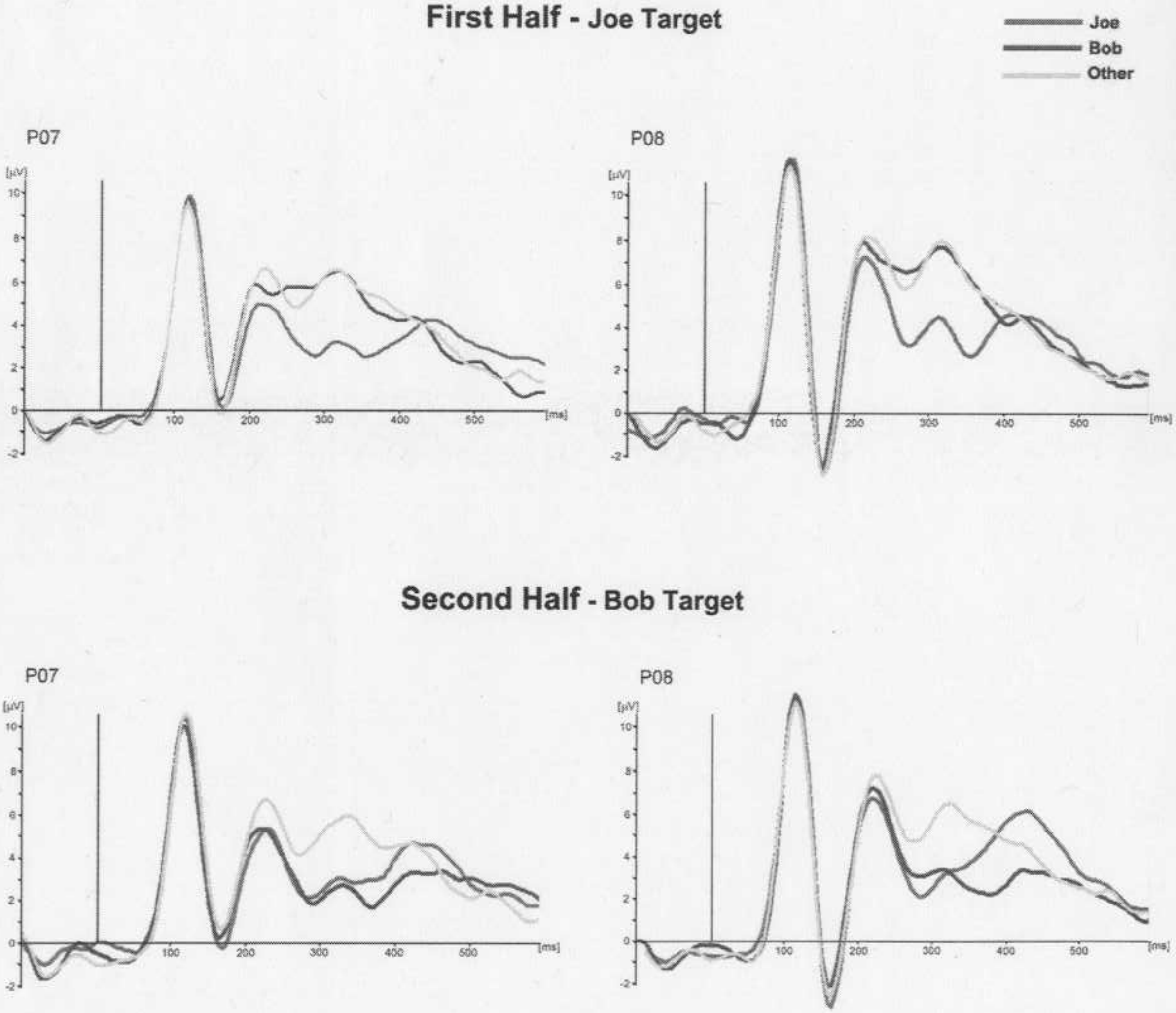

(1.a)
Distractors ("Other")
Target
"Joe"
500 msec
250 msec
500 msec
Joe?
500 msec
(1.b)
Distractors ("Other")
"Joe"
Target
"Bob"
500 msec
250 msec
500 msec
Bob?
500 msec
(2.a)
Distractors ("Other")
"Bob"
Target
"Joe"
"Bob"
500 msec
250 msec
500 msec
Joe?
500 msec
(2.b)
Distractors ("Other")
"Joe"
Target
"Joe"
"Bob"
500 msec
250 msec
500 msec
Bob?
500 msec

Figure 2.



First Half - Joe Target

Second Half - Bob Target

Figure 3. a)

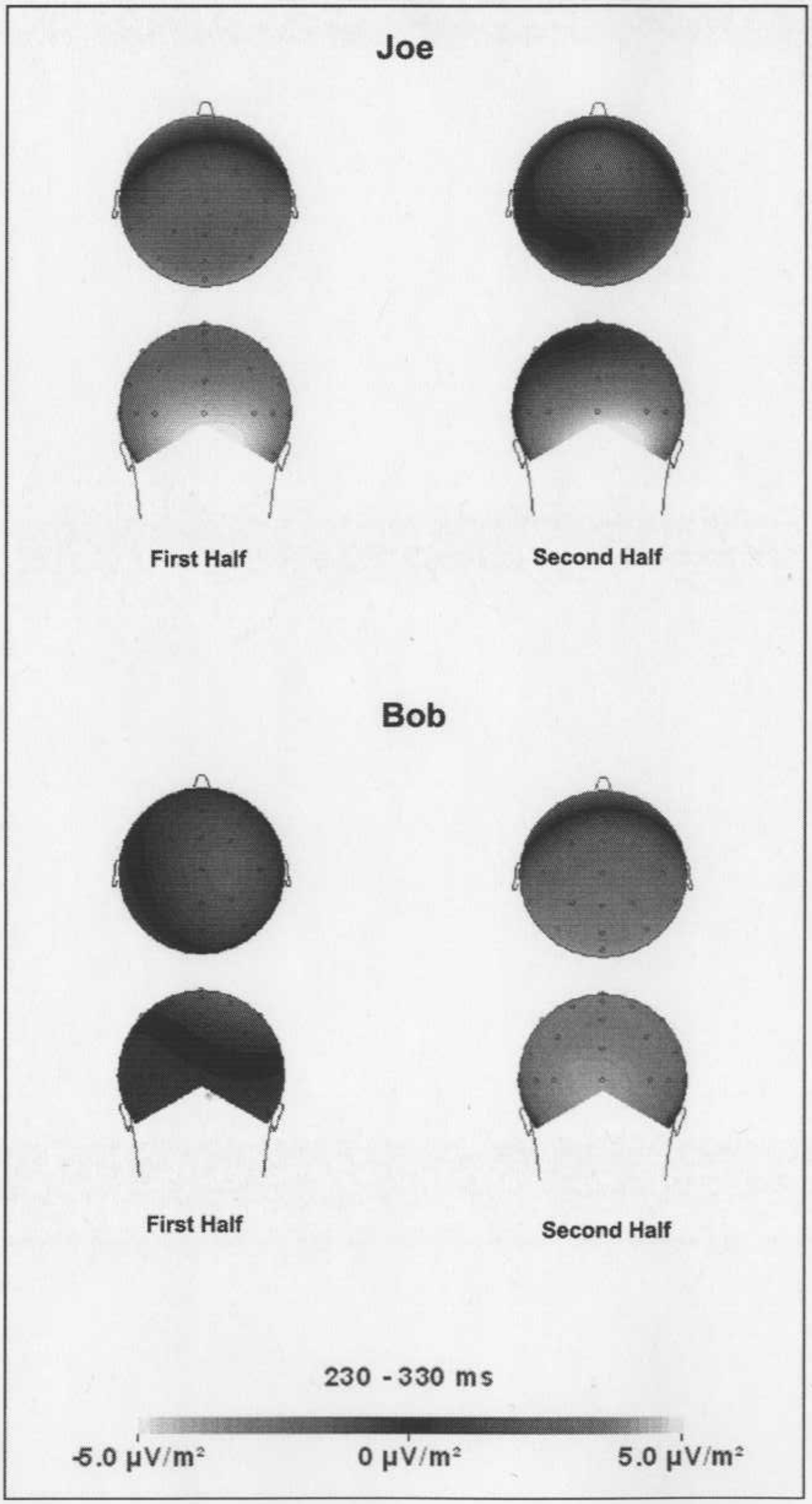

Joe
First Half
Second Half
Bob
First Half
Second Half
230 - 330 ms
-5.0 µV/m²
0 µV/m²
5.0 µV/m²

Figure 3. b)

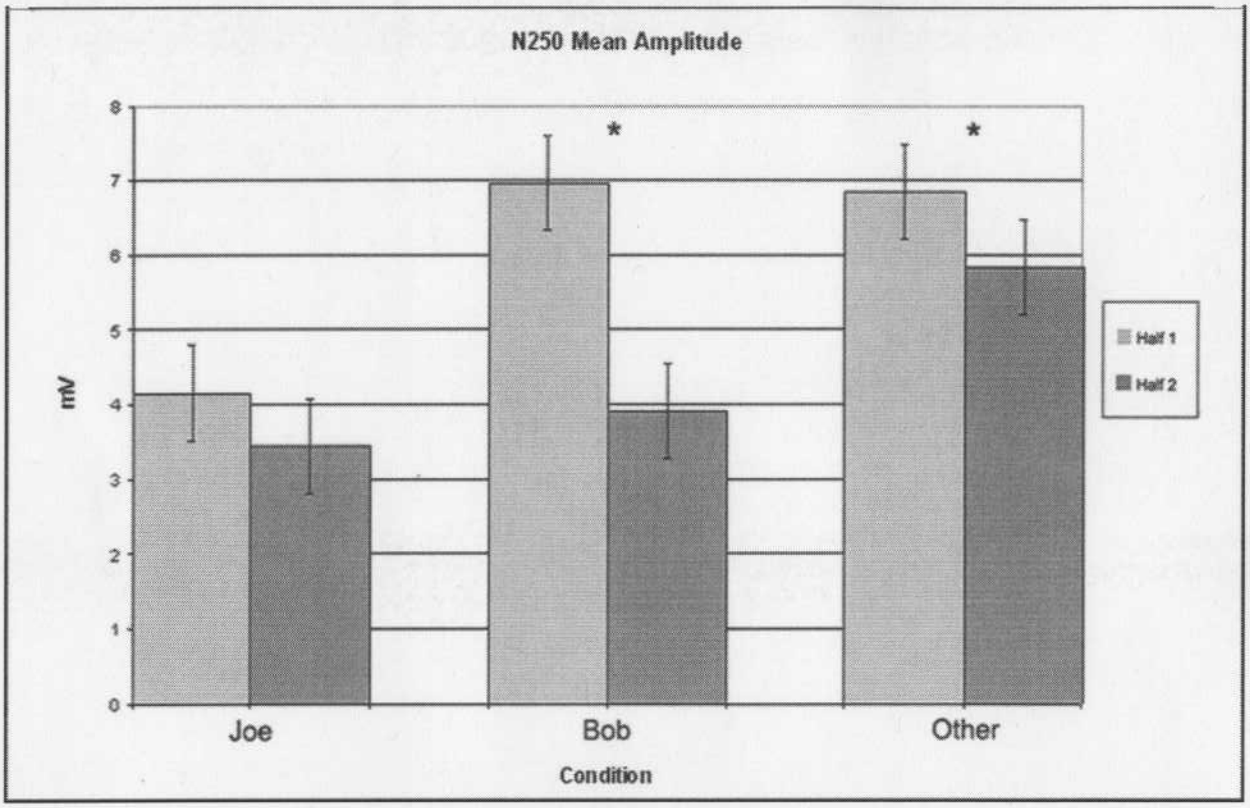

N250 Mean Amplitude
8
7
6
5
4
3
2
1
0
mV
*
*
Half 1
Half 2
Joe
Bob
Other
Condition

Figure 4.

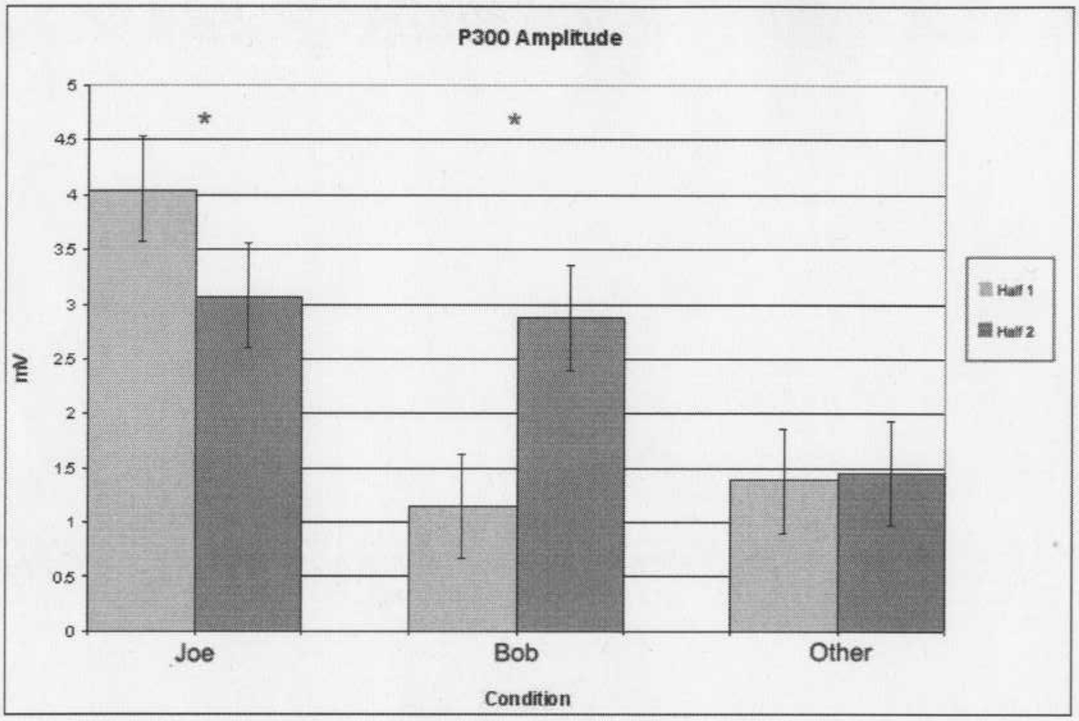
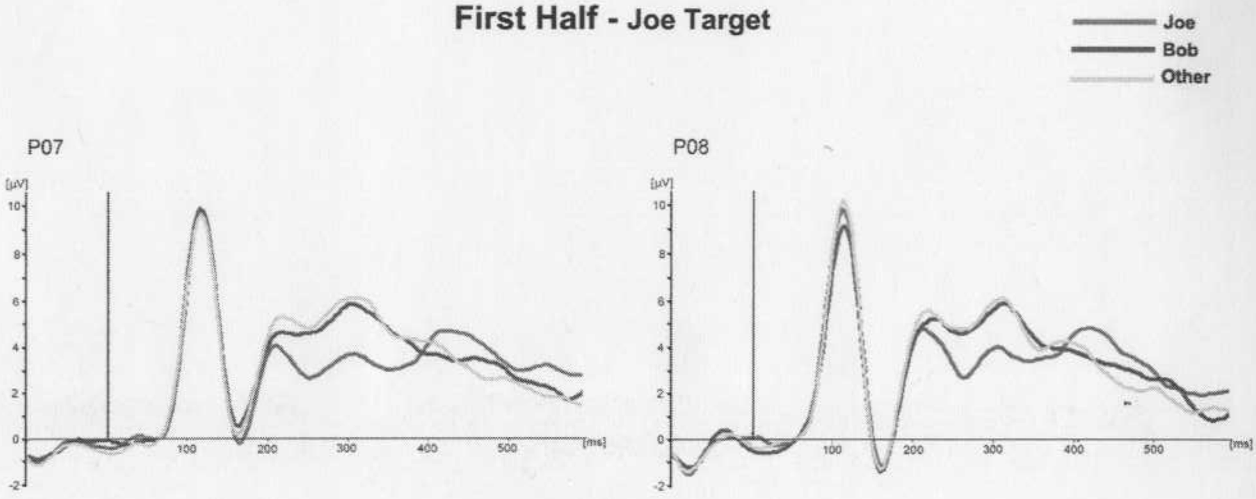
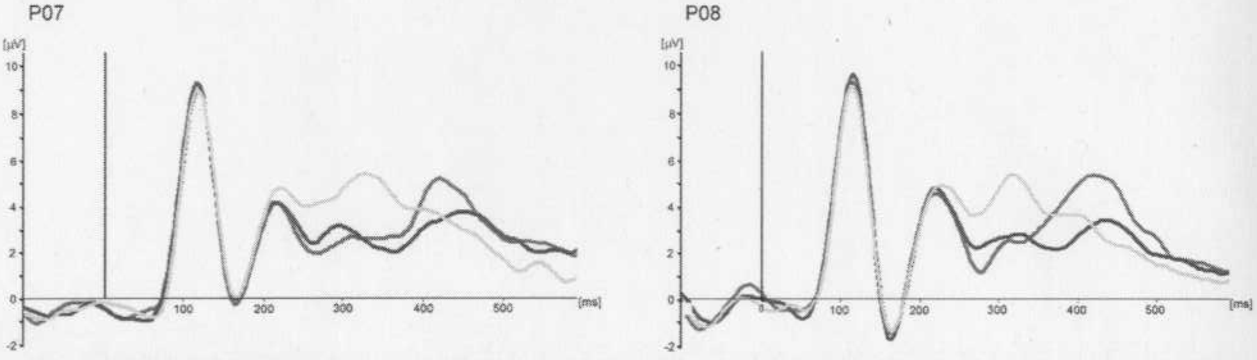

P300 Amplitude
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
mV
*
*
Joe
Bob
Other
Condition
Half 1
Half 2

Figure 5.



First Half - Joe Target



Second Half - Bob Target

Figure 6. a)

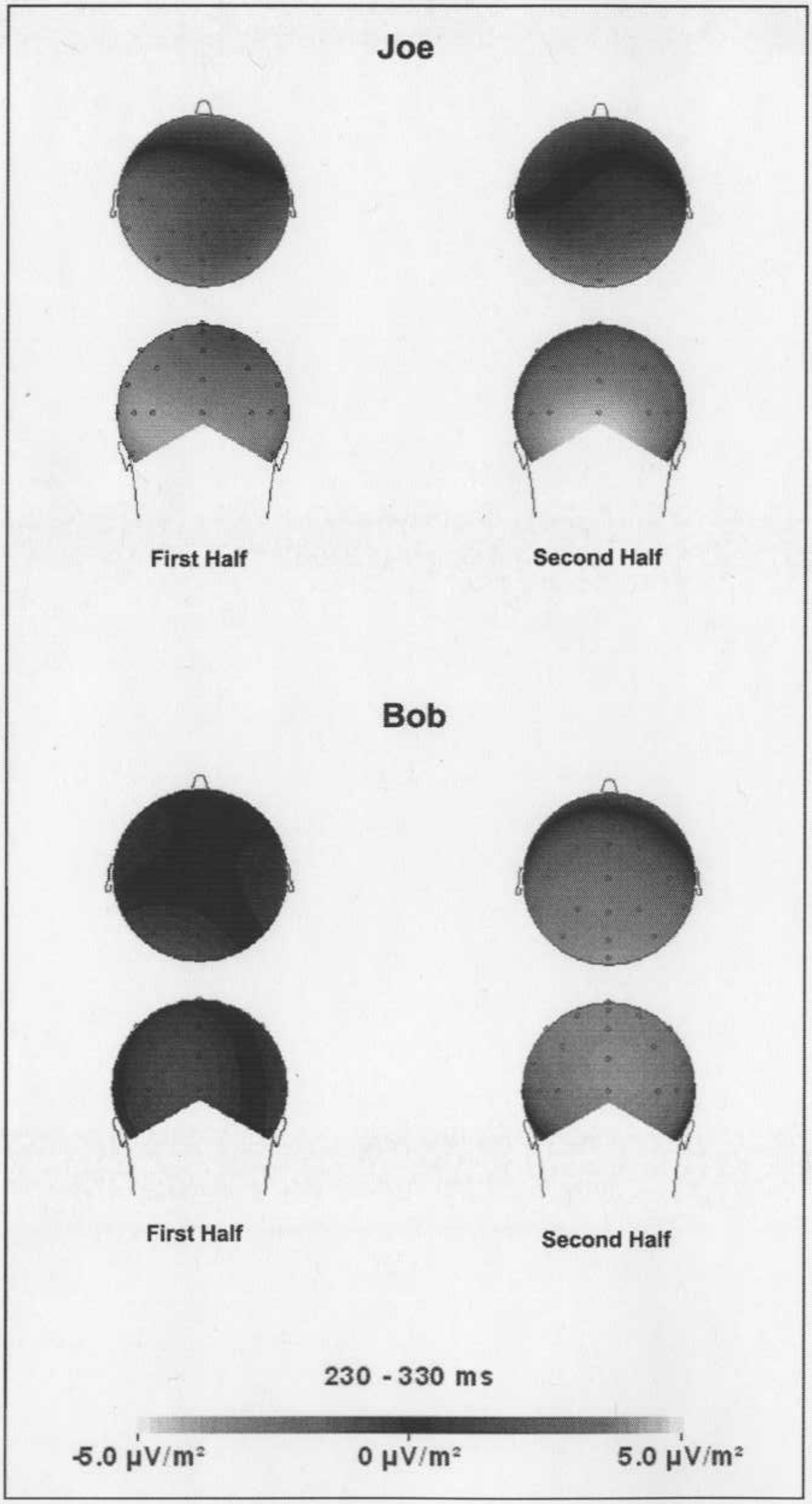

Joe
First Half
Second Half
Bob
First Half
Second Half
230 - 330 ms
-5.0 µV/m²
0 µV/m²
5.0 µV/m²

Figure 6. b)

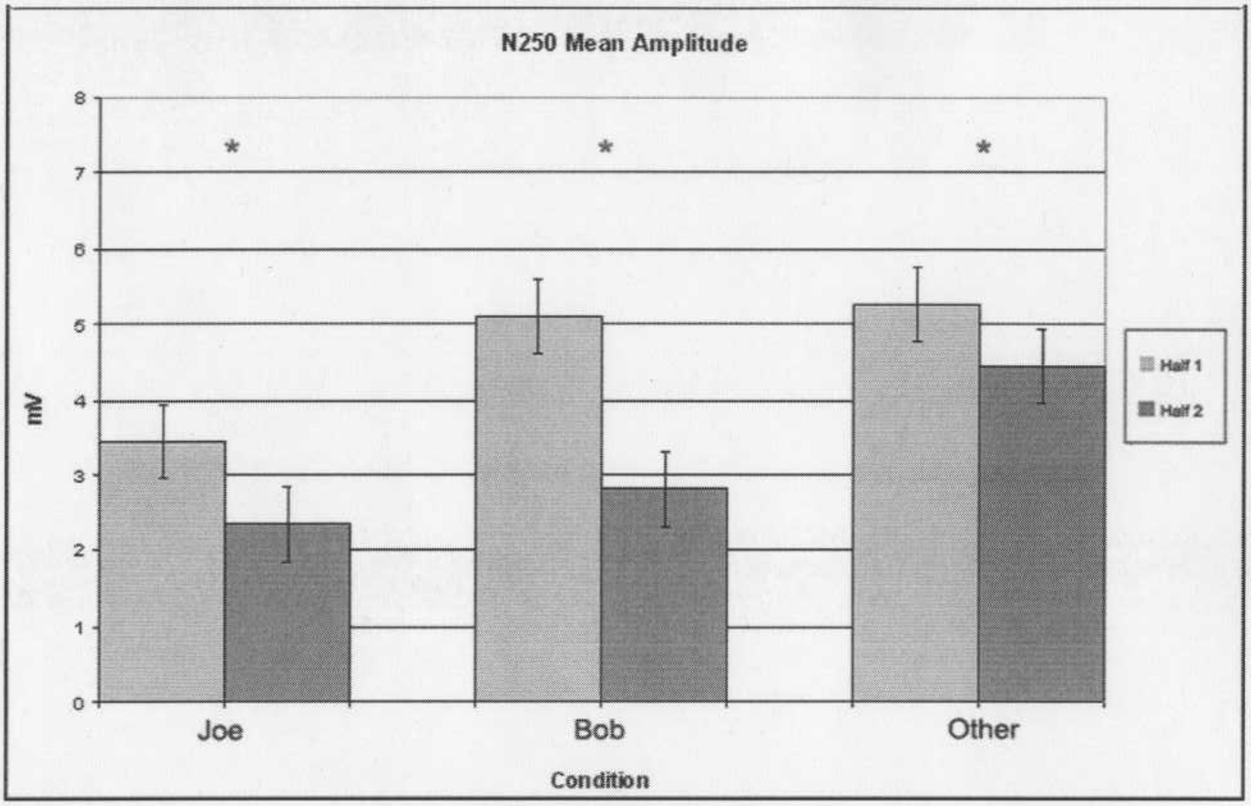
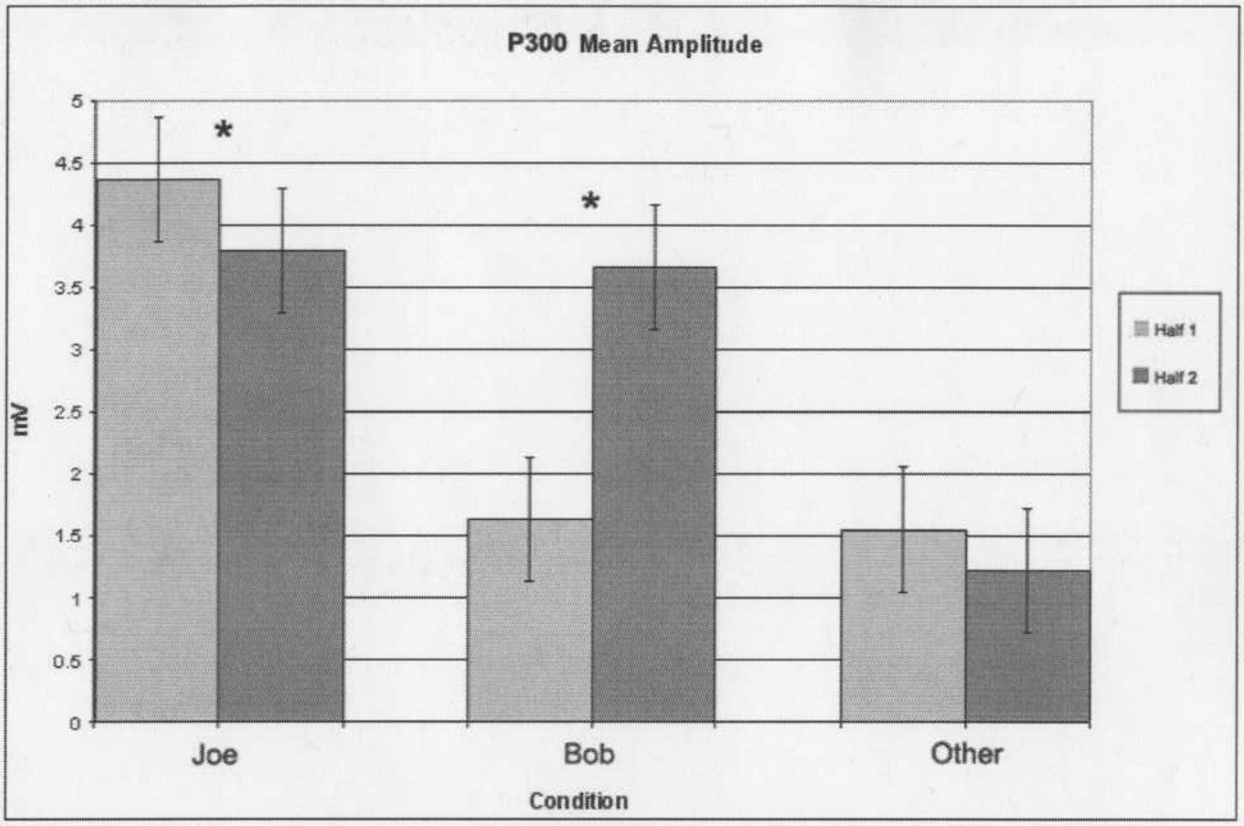
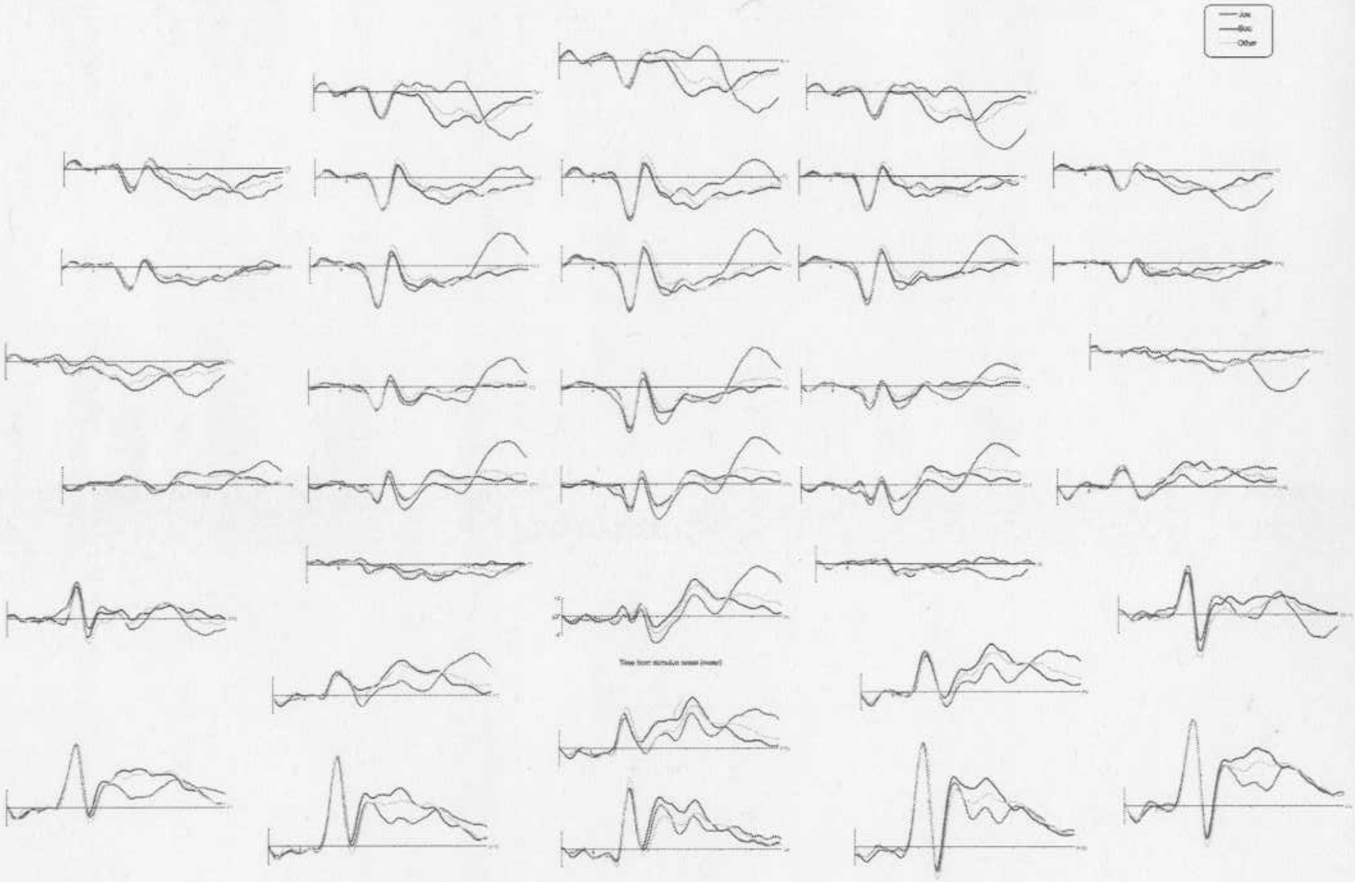

N250 Mean Amplitude
mV
0
1
2
3
4
5
6
7
8
*
*
*
Joe
Bob
Other
Condition
Half 1
Half 2

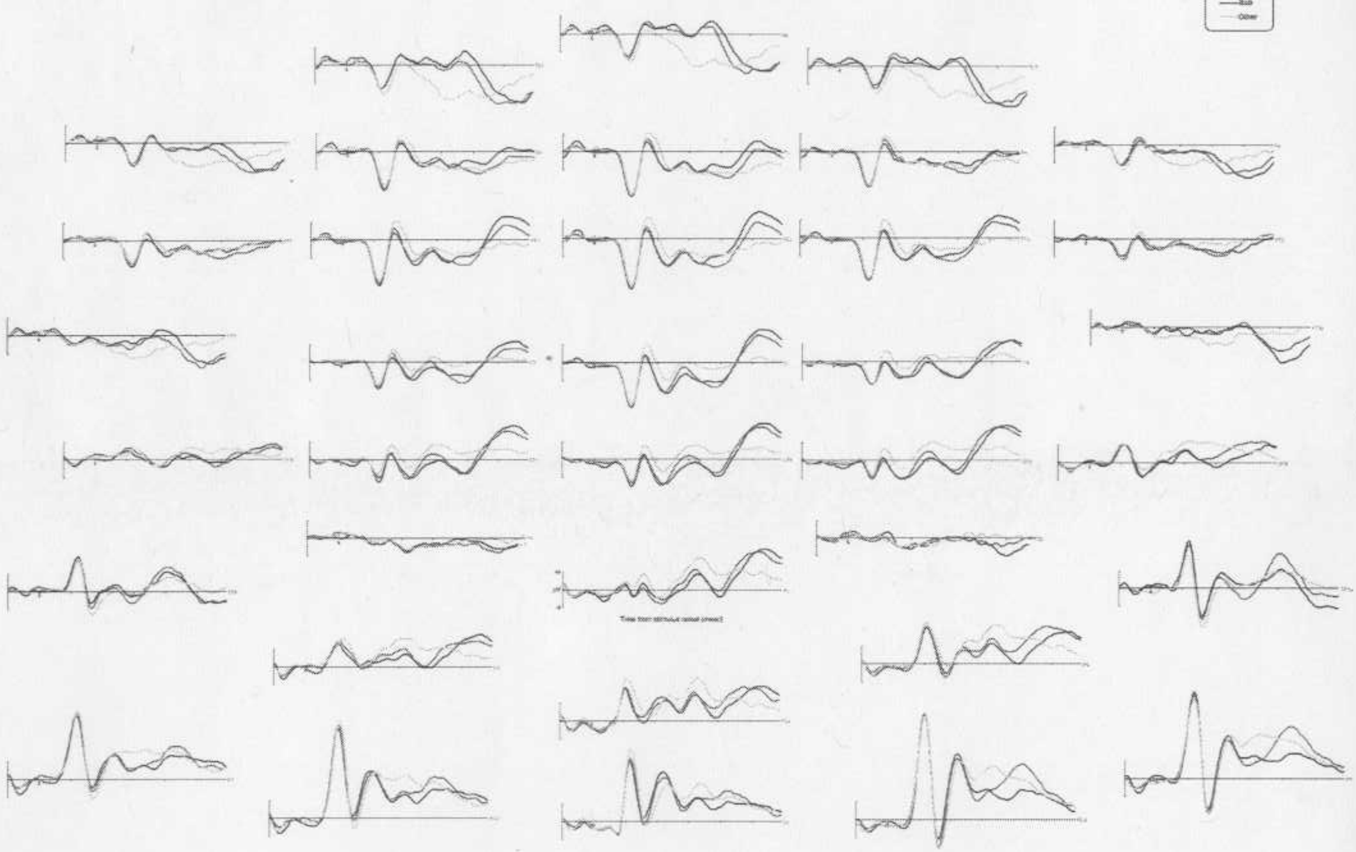
Figure 7.


P300 Mean Amplitude
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
mV
*
*
Half 1
Half 2
Joe
Bob
Other
Condition

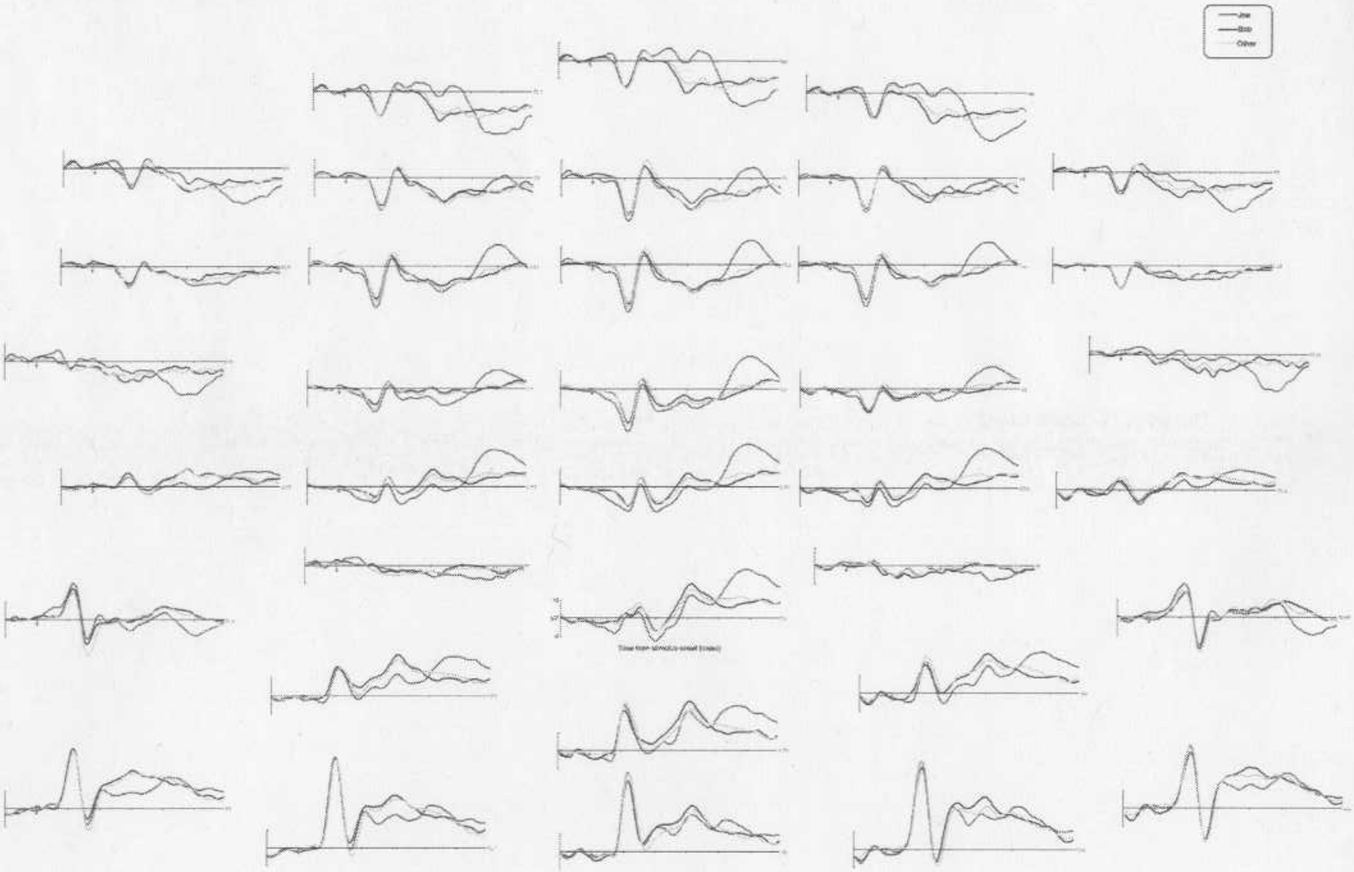
Appendix A
Waveforms of all 41 channels, Experiment 1, first half



Appendix B
Waveforms of all 41 channels, Experiment 1, second half



Appendix C
Waveforms of all 41 channels, Experiment 2, first half



Appendix D
Waveforms of all 41 channels, Experiment 2, second half