The Lateralized Readiness Potential in Observed Cross-Group Task-Sharing

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Emily R. Daniels

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ABSTRACT

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By Emily R. Daniels

Past research has shown that we are more inclined to resonate on a neural level with people who are similar to us (ingroup members) compared to people who are perceived to be less similar (outgroup members) to us (e.g. Keller, Knoblich, & Repp, 2007). The aim of this study was to test if people resonate with outgroup members once that person becomes an important player in successfully completing a task. The current study examined neural activity during cross-group competition in a joint-Simon task computer game. Neural activity was measured using electroencephalography (EEG) while participants observed an ingroup member compete against or cooperate with an outgroup member. Results showed greater neural resonance activity while anticipating actions by ingroup members compared to outgroup members. The readiness potential (a negative shift in activity over frontal and central electrode just before a response is made; Luck, p. 47) was greater while viewing ingroup members versus outgroup members, independent of the goal of the task. This effect and was positively correlated with scores on the Affect Misattribution Procedure (AMP; Payne, Cheng, & Govorun, 2005), revised for race. These results suggest people simulate and anticipate ingroup members' actions, to the degree that they prefer ingroup members to outgroup members. The exception is found in biased individuals, who also anticipate the actions of threatening outgroup members.

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INTRODUCTION

Social interaction is essential to daily life. We must coordinate with others, often members outside of our normal social group, in order to complete basic tasks at work and in our personal lives. These interactions require both verbal and non-verbal communication as well as the ability to anticipate another person's intentions. This is intuitive when we are predicting the thoughts and actions of an ingroup member, but less easy when we are required to coordinate with an outgroup member. An ingroup is any group in which a person identifies as a member, such as race, gender, sports fan, Christian, etc. while an outgroup can be a "rival" such as opposing team, race, or religion, or simply a group with which a person does not identify (Tajfel, Billig, & Bundy, 2006). Research on neural activity during social interactions can provide insight into the missteps that arise in cross-group interactions and efforts.

NEURAL RESONANCE AND TASK-SHARING

Research in motor resonance suggests that there are similarities between neural activity during one's own actions and during the observation of another person's actions. It begins with action representation. When we observe an action made by another that movement is represented in similar neural activation patterns as when we make the movement ourselves (e.g. Di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Rizolatti, Fadiga, Fogassi, & Gallese, 1996). Importantly, neural motor activation is greater for our own movements in relation to our perception of others' movements (Calvo-Merino, Glaser, Grezes, Passingham, & Haggard, 2005) and explains why we are able to distinguish our actions from another person's actions (Repp & Knoblich, 2004). This extends beyond action perception and into action anticipation. People show similar neural activity in anticipation of another person's actions as they do for their own actions on the same task (Hollander, Jung, & Prinz, 2011), and this effect is present during both competitive and cooperative situations (Ruys & Aarts, 2010).

This neural motor resonance is important for coordinating one's movements with another person in order to accomplish a goal, much like rowing a boat across a lake. Successful joint action is the difference between making it across the lake and rowing in circles near the shore. Interestingly, joint action attention develops at an early age, around 12-18 months (e.g. Moore & D'Entremot, 2001; Tomasello, 2000) before theory of mind has completely developed. This suggests that joint action does not require an ability to empathize as much as an ability to infer another person's goals based on their attention to stimuli in the environment. When participants were given a task in which certain stimuli required a response from the participant, a co-player in another room, or a computer, participants anticipated the co-actor's responses (Ramnani & Miall, 2004). Further, there was activity in the motor and mentalizing areas of participants' brains while they were anticipating the moves of the other player. There is even evidence that shared representations lead us to incorporate another person's actions into our own regardless of whether or not that action impedes our own goal-pursuit (e.g. Sebanz, Knoblich, & Prinz, 2003; Sebanz, Knoblich, Stumpf, & Prinz, 2005).

Although successful joint action requires a shared action representation of the other person's movements, we tend to begin with our own expectations and movement parameters as the template for the other person's actions (Knoblich & Sebanz, 2006). A natural extension of this tendency is better performance on a joint task when one has to coordinate with a similar other rather than a very different other (Keller, Knoblich, & Repp, 2007). Unfortunately, this means we are often better at coordinating our movements with an ingroup member than with an outgroup member, because we believe we share more similarities with an ingroup member than with an outgroup member (Gutsell & Inzlicht, 2013). This asynchronous movement could potentially impair cross-group efforts to achieve a common goal.

GROUP BIASES IN MEMORY AND ATTENTION

It is possible that people show a group bias in the readiness potential because previous research has shown that people express biases in early processing (e.g. Ratner & Amodio, 2012; Zheng & Segalowitz, 2013). Group biases affect many domains of social interaction including motivational relevance (Gutsell & Inzlicht, 2013), memory (Rothbart, Evans, & Fulero, 1979), and mimicry (Leighton, Bird, Orsini, & Heyes, 2010). In fact, group membership influences perceptual processes within the first hundred milliseconds of perception of outgroup members (Ratner & Amodio, 2012).

The application of neuroscience to studies of social categorization has revealed the time course of social processing and shown a link between intergroup categorization and neural processing on unconscious and automatic levels (Cikara & Van Bavel, 2014). For instance, several fMRI studies have shown that greater amygdala activation while viewing other-race faces compared to own-race faces is correlated with other measures of racial bias like the Implicit Association Test and the startle eye blink (e.g. Hart, Whalen, Shin, McInerney, Fischer, & Rauch, 2000; Phelps, O'Connor, Cunningham, Funayama, Gatenby, & Gore, 2000). As another example, EEG studies have found that novel group membership influences early (within 200-300 milliseconds) face component processing. The event-related potential (ERP) N170 is related to encoding facial identities. There is a greater N170 response to ingroup faces than outgroup faces (Ratner & Amodio, 2012). This activation is also faster for ingroup than outgroup faces (Zheng & Segalowitz, 2013).

Group biases also affect automatic imitation of others. Achaibou, Pourtois, Schwartz, Vuilleumier (2008) recorded both EEG and EMG during spontaneous emotion imitation. The researchers recorded activity over the zygomaticus major and corrugator supercilii while participants watched short clips of people displaying happy and angry facial expressions. Participants mimicked the facial expressions of the targets in the clips and displayed smaller N170 amplitudes when the intensity of their facial mimicry was higher. The authors concluded that early face processing determines the magnitude of facial imitation. We even see differences in neural responses to emotion expressions of ingroup and outgroup members. People show similar patterns of neural activity to their own feelings of sadness and the sight of a sad expression on an ingroup member, but not an outgroup member (Gutsell & Inzlicht, 2012).

A popular measurement of shared neural activity is the lateralized readiness potential (LRP) in the motor cortex. This portion of the movement related potential is present in the anticipation of movement and is usually calculated from the centro frontal electrodes from EEG recording (C3, FC3 C4, and FC4; Hollander et al., 2011). The LRP is present a few hundred milliseconds before the actual movement and there is a positive correlation between the magnitude of the LRP at the stimulus onset and the speed at which a person responds to the stimulus (Luck, p. 48). A key characteristic of the LRP wave is that it represents prepared movement by the contralateral hand (i.e. more negative activity in the left hemisphere represents prepared movement by the right hand, and vice versa; Luck, p. 65). Most importantly, the LRP can also be found when we observe others (e.g. Gutsell & Inzlicht, 2013; Hollander et al., 2011). This means the LRP is an excellent indicator of shared motor resonance.

COMPETITION IN INTERGROUP RELATIONS

Biases are initiated when group membership is salient, such as when people are made aware of their own race or gender compared to others in the environment. These group biases are enhanced by the addition of a zero-sum relationship between group goals (Fiske & Ruscher, 1993) such as with rival sports teams. In respect to memory, students from rival universities recalled different versions of the same sports game based on their team allegiance, irrespective of the strength of that team allegiance (Hastorf & Cantril, 1954).

There has been a lot of work on the neural components of cross-group competition and cooperation. Similarly, there is greater activation in mentalizing brain regions (e.g. dorsomedial prefrontal cortex) when people observe ingroup members relative to outgroup members. It is possible that there would be greater neural activity for outgroup members versus ingroup members in a competitive context because outgroup members would be more motivationally relevant (Ackerman, Shapiro, Neuberg, Kenrick, Becker, Griskevicius, & Schaller, 2006). For instance, past research shows people exhibit more motor resonance for threatening outgroup members than for threatening ingroup members (Gutsell & Inzlicht, 2013). Further, there is support for this claim through the stereotype content model (Fiske, Cuddy, Glick, & Xu, 2002). The model suggests that people are evaluated based on perceived warmth and social status. We consider if another group is competing with us for resources (low in warmth) and if the group enjoys high social status (high in competence). An outgroup member who is competing against us for resources or a reward would be threatening already, and a high-status (relative to one's own status) outgroup member seems more competent and therefore more threatening (e.g. Cikara, Farnsworth, Harris, & Fiske, 2010; Glick, 2002; Zink, Tong, Chen, Basset, & Stein, 2008).

Past research has established our tendency for greater motor resonance with ingroup members than with outgroup members because we find it easier to coordinate with similar others than with dissimilar others (e.g. Keller, Knoblich, & Repp, 2007). Past research suggests we find competitive outgroup members more threatening than non-competitive outgroup members (Ackerman, Shapiro, Neuberg, Kenrick, Becker, Griskevicius, & Schaller, 2006), and thus we should resonate more with the competitive outgroup members than we normally would with outgroup members. The goal of the current study is to test this theory by comparing motor resonance during the observation of joint action between ingroup and outgroup members. Specifically, we predict that people would usually show less motor resonance in anticipation of the motor responses of outgroup members compared to ingroup members. However, we expect that this bias in motor resonance will disappear or even reverse in a competitive context such that people will show more resonance to outgroup competitors than ingroup competitors.

STUDY OVERVIEW

STUDY DESIGN

This was a 2(membership: ingroup, outgroup) × 2(context: cooperation, competition) mixed design, with group membership being a within-subjects factor and context being the between-subjects factor. Participants observed ingroup and outgroup members complete the Simon task together (a choice reaction time task in which the relevant and irrelevant stimuli overlap in spatial location), and then participants completed the Affect Misattribution Procedure (AMP; an implicit measure of racial bias). This was part of a larger study, in which participants at some point also completed the Simon task with other players. EEG was recorded from participants during the Simon task.

HYPOTHESES

1. Participants will show a stronger readiness potential for ingroup members than for outgroup members.
    a. Specifically, participants will show stronger activation in the C3, C4, Cz, FCz, FC3, and FC4 electrodes when anticipating the actions of ingroup versus outgroup members.
2. Participants will show a stronger readiness potential with outgroup members when they believe the outgroup member is competing against the ingroup member rather than cooperating with the ingroup member.

3. The strength of activation at electrodes C3 and FC3 will be positively correlated with scores on the Affective Misattribution Paradigm, which would indicate a relationship between the LRP and bias against outgroup members.

METHOD

PARTICIPANTS

A total of 55 participants completed the study. Twelve participants were excluded due to noisy and incomplete EEG data and 5 more were dropped due to incomplete data on the AMP. This left a total of 38 participants with data from both the Simon task and AMP task. Results are reported from the 38 valid participants. Participants were male and female (13 male and 25 female[1]) undergraduate students (mean age was 19.5 years) from the University of Toronto who participated for course credit. Participants were either White or Asian (10 identified as White, 26 identified as Asian, and 2 chose not to identify or identified as "other[2]").

PROCEDURE

As part of a larger study on social interactions, participants were connected to an EEG cap and seated in front of a computer in an individual testing room. An experimenter told the participant that they would be watching two other participants complete a Joint-Simon task online, and that those participants were seated in adjacent testing rooms. In reality, the game was computerized and there were no other participants. The participant was shown a photo of each of the other players (one racial ingroup member (Asian or White respectively), and the other a racial outgroup member (Black)) although they were not explicitly told that the players were

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[1] Gender was added as a covariate in the 2(membership: ingroup, outgroup) × 2(context: competition, cooperation) × 2(electrode site: left, right) mixed analysis of covariance. There was no significant effect of any of the factors on the readiness potential (all p-values > .05) and there were almost twice as many females as males in the study. Results are reported without gender as a covariate.

[2] Participants who identified as "other" might not have considered Blacks to be outgroup members (the target outgroup in this study), so we compared analyses excluding and including those participants. There was not a significant change in the results (all p-values > .05), therefore all results are reported including participants who identified as "other."

ingroup and outgroup members. The task was programmed in DirectRT (Jarvis, 2011) and presented in MediaLab (Jarvis, 2011). Participants were instructed not to press any buttons themselves, but simply to observe the other players in the game. After 90 trials, the game was over and the experimenter stopped the EEG recording. Participants completed the AMP measure and then were debriefed and compensated for their participation.

MEASURES

EEG cap and recording software, Joint-Simon task, Affect Misattribution Procedure

EEG RECORDING AND DATA CLEANING

EEG was recorded from 32 tin electrodes embedded in a stretch- lycra cap, with no online filters, and vertical eye movement (VEOG) was monitored using a supra-to suborbital bipolar montage. Ground electrodes were placed on each earlobe, and eye-blinks were recorded by placing electrodes above and below one eye. Impedance was kept under 5 Hz. The EEG was digitized with a sampling rate of 512 Hz with a mathematically referenced average earlobe reference using ASA acquisition hardware and software (Advanced Neuro Technology, Enschede, the Netherlands). Data was filtered using a high-pass filter of 0.01 Hz and a low-pass filter of 30Hz. The data was baseline corrected from 200ms before stimulus presentation up to the stimulus presentation. Segments for grand averages were taken in 1,000ms intervals from 200ms before the stimulus to 800ms after the stimulus. The lateralized readiness potential (LRP) was analyzed for the Cz, C3, C4, FCz, FC3, and FC4, and was defined as the mean negative activity between 250-450ms after stimulus onset. The lateralized readiness potential (LRP) for each participant was found by comparing the magnitude of the RP while observing ingroup members (C3 and FC3 are contralateral to the right hand) and outgroup members (C4 and FC4 are contralateral to the left hand).

JOINT-SIMON TASK

The joint Simon task (Simon, 1969) asks participants to press right and left response keys when they see their assigned stimulus on the screen. Both participants see 3 blank circles centered horizontally on a screen. One participant must press a key with their assigned hand when any of the circles turns their assigned color (either green or red) and the other participant does the same for their assigned hand and color. In a design with 3 participants, one participant is the "observer" while the other two complete the task. In this study, we looked at neural activity of the observer when he or she was anticipating the actions of the other participants (one ingroup and one outgroup member).

AFFECT MISATTRIBUTION PROCEDURE

The AMP measures implicit attitudes towards two stimuli with opposing valences by pairing brief presentations of the positively- or negatively-valenced stimuli with presentations of neutral stimuli. Participants are then instructed to indicate how pleasant they find the neutral stimulus by pressing one of two keys on a keyboard. The theory is that the positivity or negativity of the first stimulus will influence whether people find the second neutral stimulus to be pleasant or unpleasant (Payne et al., 2005). This procedure has been used to study racism (Payne et al., 2005) under the theory that people who are biased against Black people tend to rate stimuli paired with Black faces as unpleasant more often than pleasant, and White faces paired with neutral stimuli as pleasant more often than unpleasant. Scores closer to 0 indicate an association of pleasant with ingroup members and unpleasant with outgroup members. In this study, the White and Black faces were paired with meaningless pictograms and participants pressed the "z" key to rate a character as unpleasant and the "/" key to rate the character as pleasant. In this study, the fixation cross was presented for 500ms, followed by the face for 75ms. A fixation cross appeared 125ms after the face and remained on the screen for 100ms, followed by the pictograph for another 100ms. Participants were told to respond as quickly as possible after seeing the pictograph.

ANALYTICAL PLAN

After cleaning EEG data according to the data cleaning procedure outlined above, a 2(membership: ingroup, outgroup) × 2(context: competition, cooperation) × 2(electrode site: left, right) mixed analysis of variance will determine if there are main effects of membership or context on the LRP (to test hypotheses 1 and 2) , as well as any interactions among the three factors. Next, a Pearson correlation will determine if there is an influence of group bias (as measured by the AMP) on the readiness potential to test hypothesis 3. If there is a significant influence of group bias, performance on the AMP will be added as a covariate to the 3-way analysis of variance in order to investigate the role of bias on the LRP. All main effects and interactions will be further examined through simple effects.

RESULTS

DIFFERENTIAL NEURAL ACTIVITY

This was a 2(membership: ingroup, outgroup) × 2(context: competition, cooperation) × 2(electrode site: left, right) mixed design, with context being the between-subjects factor and membership and electrode site being the within-subject factors. A three-way analysis of variance with membership, context, and electrode site as factors indicated a significant difference in neural activity across electrode sites, $F(1,27) = 32.932$, $p < .001$

Hypothesis 1 : Participants will show a stronger readiness potential for ingroup members than for outgroup members.

As predicted we found less activity on the right electrodes (C4 and FC4; $M = -.014$, $SE = .199$) than the left electrodes (C3 and FC3; $M = 1.990$, $SE = .256$), indicating a larger LRP on the contralateral left side in response to anticipating right hand actions. Figure 1 shows the difference in readiness potential between left and right side electrodes. There was also a marginally significant interaction between membership and electrode site, $F(1,27) = 3.547$, $p = .070$. Simple effects were used to test the first hypothesis, that there would be a stronger lateralized readiness potential for ingroup members than for outgroup members. Simple effects showed a stronger LRP for ingroup members ($M = -.168$, $SE = .232$) than for outgroup members ($M = .140$, $SE = .181$), $p = .018$. There was not a significant main effect of membership, $p = .215$.

Hypothesis 2: Participants will show a stronger readiness potential with outgroup members when they believe the outgroup member is competing against the ingroup member rather than cooperating with the ingroup member.

A planned contrast to test the second hypothesis, that participants would show a stronger LRP for outgroup competitors than for ingroup competitors, revealed no significant interaction between membership and context, p = .280, nor any significant difference in the LRP in the competition and cooperation conditions, p = .205. There were no significant interactions between electrode and context, p = .192, or three-way interaction among membership, context, and electrode site, p = .300. These findings suggest participants initially showed stronger motor resonance with ingroup members. Table 1 in Appendix B shows the results of the 2(membership: ingroup, outgroup) × 2(context: competition, cooperation) × 2(electrode site: left, right) mixed analysis of variance.

NEURAL ACTIVITY PREDICTS AMP SCORES

Hypothesis 3: The strength of activation at electrodes C3 and FC3 will be positively correlated with scores on the Affective Misattribution Paradigm, which would indicate a relationship between the LRP and bias against outgroup members.

Analyses of the neural activity did reveal interesting trends, but since the interaction among membership, context, and electrode did not reach significance, we decided to include scores in the AMP as a covariate. This analysis was used to test our third hypothesis, that bias against the outgroup would influence the strength of the LRP. It is possible that we would only see the hypothesized effect in people who are biased against the outgroup. Suggesting that group bias indeed might affect the LRP, we found a marginally significant positive correlation between scores on the AMP and the readiness potential while observing outgroup members, r=.353, p=.084. Since the readiness potential is negative, this correlation shows a smaller readiness potential in response to outgroup members in biased participants. Including scores on the AMP as a covariate in the three-way analysis of variance resulted in a significant interaction between membership and electrode site (See Table 2 in Appendix B for an ANCOVA table; see Figure 2 in Appendix A for a graph), $F(1,22) = 2.131$, $p = .024$, and a significant three-way interaction between membership, electrode site, and score on the AMP, $F(1,22) = 4.375$, $p = .048$. Simple effects for the member by electrode interaction showed less LRP for outgroup members over the left electrode site ($M = .123$, $SD = .204$) than for ingroup members ($M = -.203$, $SD = .270$), $p = .018$. Simple effects for the three-way interaction of membership, electrode site, and context indicated less LRP for outgroup members ($M = 2.588$, $SD = 1.721$), compared to ingroup members ($M = -.275$, $SD = 1.088$), over the left electrode site only in the competition setting, $p = .043$ (See Figure 3 in Appendix A for a graph of this simple effect). There was not a significant interaction between scores on the AMP and context, $p=.204$. Including scores on the AMP as a covariate revealed significant effects in line with our predictions. There was a weaker LRP with outgroup members in a competitive context, and this effect was reliant on the strength of a participant's bias towards the outgroup member.

DISCUSSION

This study found mixed support for the predictions of greater neural resonance for ingroup members in the cooperative condition and greater neural resonance for outgroup members in the competitive condition. There was a main effect of membership on the readiness potential, with greater neural activity while observing ingroup members than outgroup members, replicating the finding that we resonate more with ingroup members than with outgroup members (e.g. Gutsell & Inzlicht, 2013; Hollander et al., 2011).

Introducing bias as measured by the AMP as a covariate into the model revealed a strong effect of bias on the LRP, which was in line with our predictions and in support of previous research. This suggests that bias against outgroup members leads to greater neural resonance with ingroup members. Furthermore, this bias contributed to the magnitude of the LRP for ingroup and outgroup members. Contrary to our predictions based on past literature (e.g. Ackerman, Shapiro, Neuberg, Kenrick, Becker, Griskevicius, & Schaller, 2006; Cikara, Farnsworth, Harris, & Fiske, 2010; Glick, 2002; Zink, Tong, Chen, Basset, & Stein, 2008) there was still a bias against outgroup members even when they were threatening competitors. One possible explanation lays in the task itself and the manner in which co-players were introduced. It is possible that since the participants only saw the ingroup and outgroup members as photos on the computer screen before the observation round, the task became more relevant than the other players. So although there was a difference in the strength of motor resonance for ingroup and outgroup members, the context manipulation was not successful for all participants. The non-significant difference in LRP between the competition and cooperation conditions supports this claim. The context only mattered to biased participant. Specifically, only biased participants who were told that the Simon task was really a competition showed a stronger LRP for outgroup members than for ingroup members. In line with previous research, outgroup competitors were more motivationally relevant than outgroup non-competitors (e.g. Ackerman, et al., 2006; Gutsell & Inzlicht, 2013; Fiske et al., 2002), although in this study bias drove the degree to which outgroup competitors were motivationally relevant.

There are some other limitations to consider. First, participants were not told which hand the other players were told to use or which key to press, so the data was analyzed on the assumption that participants believed ingroup players also pressed the right control key with their right hand (as participants did in earlier trials) and outgroup players pressed the left control key with their right hand. However, the stronger lateralization on the left side supports our assumption that participants believed outgroup members were assigned the left control key.

The inclusion of feedback on the other players' performance would allow us to examine oFRN (observer feedback-related negativity). A study by Kang, Hirsh, and Chasteen (2010) found greater oFRN for pairs with greater self-other overlap than pairs with less self-other overlap, or the degree to which a person sees themselves as similar to another person. It is possible that this study could have found a similar effect for ingroup and outgroup oFRN. Research could also examine memory for the number of mistakes made by ingroup and outgroup members.

Future studies should also use this design with a warning stimulus before the target stimulus on the Simon task to examine observer ERN (event-related negativity; e.g. Masaki, Falkenstein, Stürmer, Pinkpank, & Sommer, 2007; Nigbur, Ivanova, & Stürmer, 2011). This would allow us to look at the readiness potential not just when observers know another player will respond, but also when observers first decide that another player must make a response, and the type of response he or she must make. We could also then examine the latency differences in motor resonance for ingroup and outgroup members.

This study showed that people who are biased against outgroup members anticipate the actions of outgroup members in a competitive context. We interact with outgroup members on a daily basis, and are often required to work together in order to complete a task (e.g. when sales and product development teams work together to complete a special project; students of different racial backgrounds completing a group project together). Even though we interact with outgroup members on a frequent basis, our preference for ingroup members over outgroup members means we resonate less with outgroup members. This decreased motor resonance with outgroup members, especially in a competitive context, can harm coordinated cross-group efforts and interactions.

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APPENDIX A

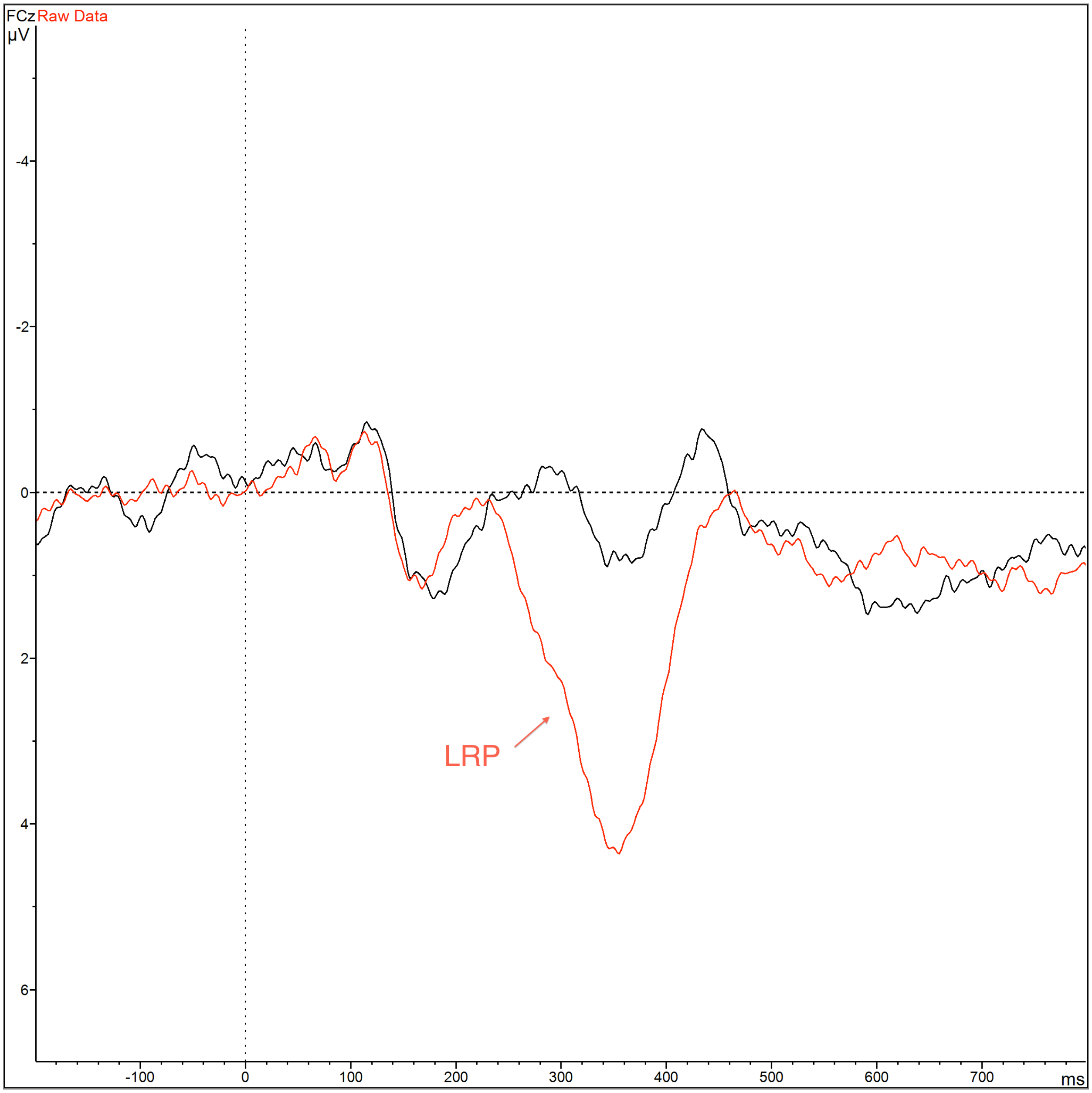

Figure 1. *The red line represents activity while observing ingroup members*. *The black line represents activity while observing outgroup members*. *Since the LRP is a negative wave, there is stronger LRP activation while observing ingroup members than while observing outgroup members*. *The dotted line shows baseline activity*.

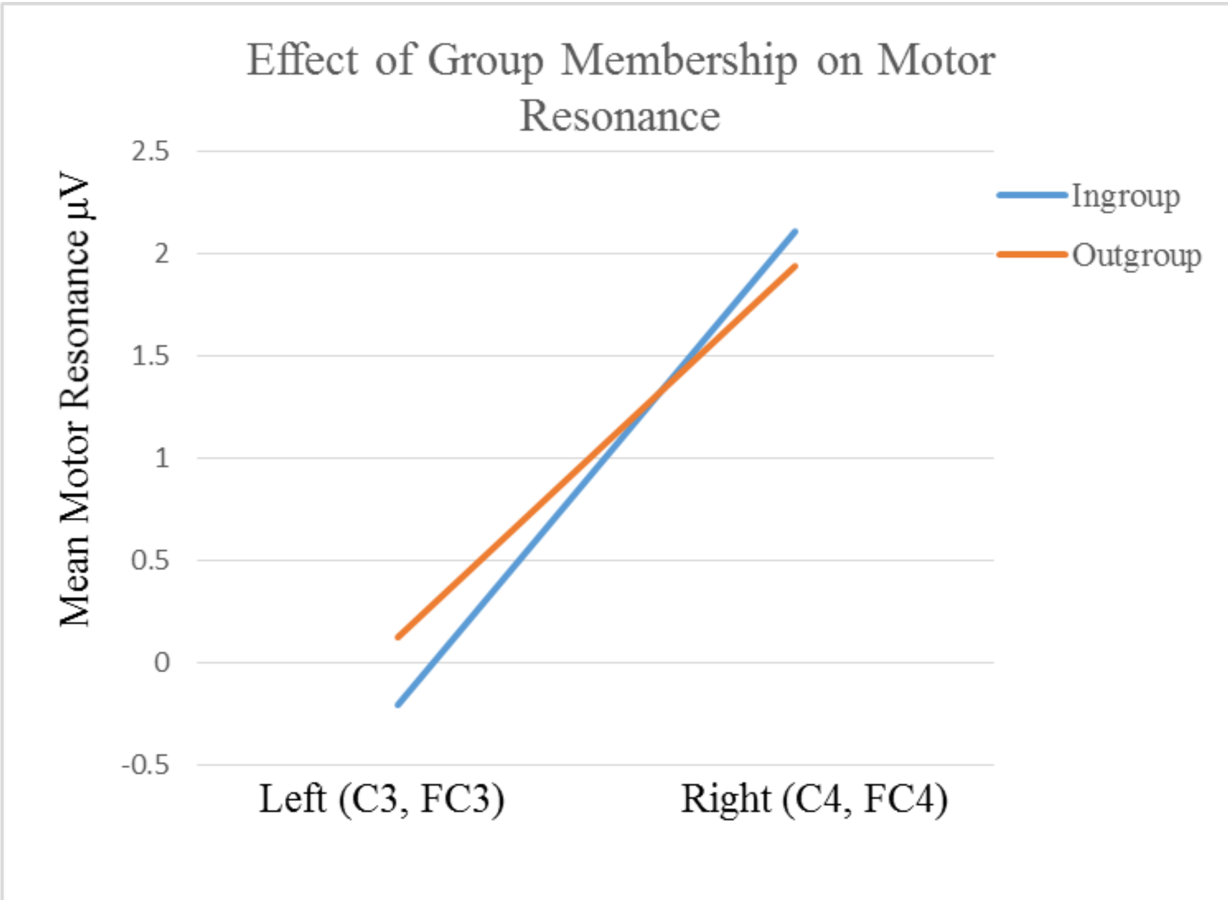

Figure 2. *Graph represents the membership by electrode interaction when scores on the AMP are included as a covariate, F(1,22) = 2.131, p = .024.*

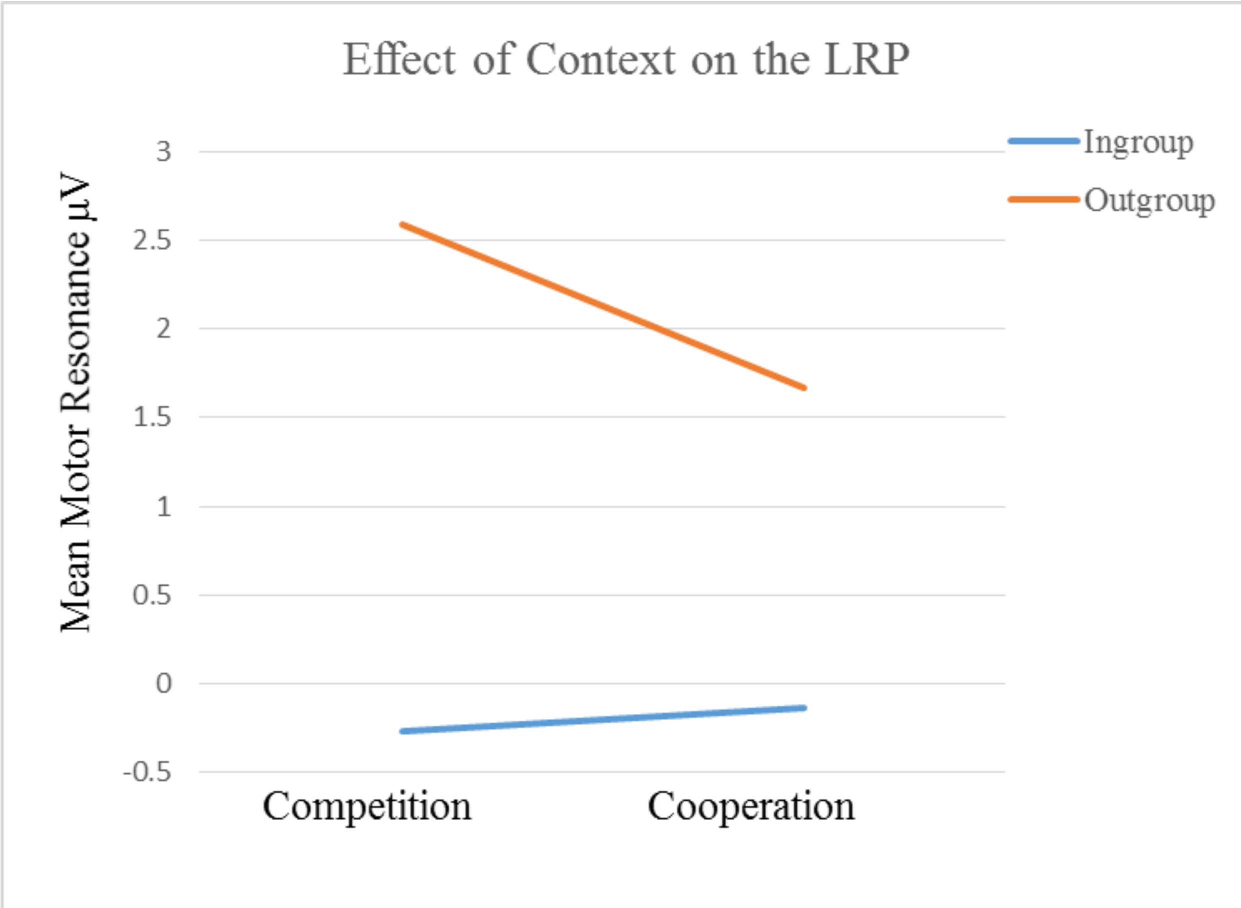

Figure 3. *Graph shows the 3-way interaction among context, membership, and electrode site. Note: only means for the left electrodes were used because simple effects revealed those to be the site of the interaction.*

Appendix B
(tables)

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	member	electrode	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
member	Linear		.221	1	.221	1.613	.215	.056
member * RCondition	Linear		.167	1	.167	1.217	.280	.043
Error(member)	Linear		3.701	27	.137			
electrode		Linear	115.188	1	115.188	32.932	.000	.549
electrode * RCondition		Linear	6.271	1	6.271	1.793	.192	.062
Error(electrode)		Linear	94.438	27	3.498			
member * electrode	Linear	Linear	1.391	1	1.391	3.547	.070	.116
member * electrode * RCondition	Linear	Linear	.438	1	.438	1.117	.300	.040
Error(member *electrode)	Linear	Linear	10.589	27	.392			

Table 1. Results of the 2(membership: ingroup, outgroup) × 2(context: competition, cooperation) × 2(electrode site: left, right) mixed analysis of variance.

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	member	electrode	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
member	Linear		.118	1	.118	.807	.379	.035
member * AMPscore	Linear		.035	1	.035	.238	.631	.011
member * RCondition	Linear		.051	1	.051	.349	.560	.016
Error(member)	Linear		3.215	22	.146			
electrode		Linear	107.713	1	107.713	26.148	.000	.543
electrode * AMPscore		Linear	1.754	1	1.754	.426	.521	.019
electrode * RCondition		Linear	2.533	1	2.533	.615	.441	.027
Error(electrode)		Linear	90.627	22	4.119			
member * electrode	Linear	Linear	2.131	1	2.131	5.862	.024	.210
member * electrode * AMPscore	Linear	Linear	1.590	1	1.590	4.375	.048	.166
member * electrode * RCondition	Linear	Linear	.051	1	.051	.141	.711	.006
Error(member *electrode)	Linear	Linear	7.998	22	.364			

Table 2. A display of the 2(membership: ingroup, outgroup) × 2(context: competition, cooperation) × 2(electrode site: left, right) mixed analysis of covariance with AMP added as a covariate.