RELATIONSHIP QUALITY FACTORS INFLUENCE EARLY AND LATE EVENT-RELATED POTENTIALS TO ROMANTIC PARTNERS: EVIDENCE FROM A FACIAL PROCESSING TASK

by

Erin N. Burdwood

A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Master of Arts in Psychology

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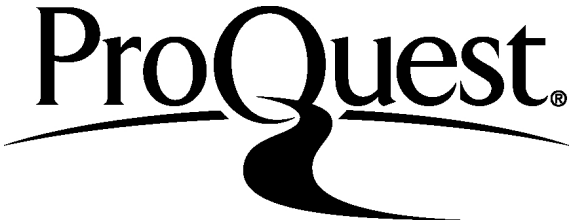

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I would like to thank my advisor, Robert Simons, for his input and guidance throughout this and many other projects. I would also like to thank my wonderful lab mates Emilio Valadez, Kathryn Roberts, Emily Stanley, and Christina Hong for their support and advice, as well as Jean-Phillipe Laurenceau for allowing me to consult with him about this project. Finally, I would like to thank the two most important individuals in my life: Tiernan Palmquist and Bentley Burdwood. Their support, patience, and love made this work possible.

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ABSTRACT

The present study employed event-related potentials (ERPs) to examine the association between neural responses to romantic partners and relationship quality factors. Participants passively viewed photos of their romantic partners, celebrities, and strangers during a computerized facial processing task. All participants demonstrated enhanced positivity to partner faces at early (VPP) and late (P3 and LPP) ERP components, furthering the notion that significant others elicit more motivated and sustained attention than do other familiar or unfamiliar individuals. Neural responses to romantic partner faces were influenced by factors including overall relationship quality, investment, and communication quality, though these associations varied by gender. Results highlight the key role that relationship quality factors play in the immediate processing of romantic partners – a finding with implications for couples counseling and research.

Chapter 1

INTRODUCTION

Significant others play a key role in our daily lives. From childhood and adolescence to adulthood and old age, relationships with these individuals have a major influence on both short- and long-term functioning (Flor, Turk, & Rudy 1989; Lempers & Clark-Lempers, 1992; Steinhauser et al., 2000). In particular, the presence of high-quality romantic relationships is continuously cited as a central feature of a happy life, with those engaged in fulfilling relationships and marriages reporting higher levels of overall satisfaction across the lifespan (Creighton Zollar & Williams, 1987; Diener, Oishi, & Lucas, 2009; Diener & Seligman, 2002; Mroczek & Spiro, 2005). The success of a relationship is largely dependent upon how well it is maintained (Baxter & Simon, 1993), and this upkeep begins with the simple act of attending to one's partner. But what factors determine how well one attends to his or her significant other, and what are the implications of these differences? The aim of the present study was to examine how relationship quality factors influence the amount of attention allocated to one's romantic partner, indexed by neural activity, in order to better understand the role that relationship quality plays in instantaneous responses to these key individuals.

Facial processing studies are often used to assess an individual's immediate response to a given person, with numerous neuroimaging and electrophysiological studies examining these responses across a variety of groups, conditions, and cultures (e.g., Aron et al., 2005; Bartels & Zeki, 2000; Eimer & Holmes, 2007; Fisher et al., 2002; Guerra et al., 2001). Such research provides a unique window into the mechanisms of human recognition and bonding, as facial processing is associated with evolutionarily useful

procedures including the detection of threat and the identification of familiar and unfamiliar others. Perhaps more importantly in modern society, facial processing is also associated with more elaborative processes such as the retrieval and updating of emotionally salient memory, as well as the facilitation of bonding and attachment (Depue & Morrone-Strupinsky, 2005; Grand, Mondloch, Maurer, & Brent, 2001; Parr, 2011; Zebrowitz, 2006). In fact, processing the face of a personally significant individual, such as a parent, child, or romantic partner, has been shown to elicit high levels of activation in brain regions associated with motivation and reward processing, including the right ventral tegmental area, right caudate and medial caudate nucleus, and right postero-dorsal body (Aron et al., 2005; Fisher, Aron, & Brown, 2005). Studies examining event-related potentials (ERPs) complement this neuroimaging work, indexing stimulus salience and motivated attention while providing a higher level of temporal precision and thereby allowing for a more exact examination of the time course of facial processing. Several of these studies, including work by Langeslag, Jansma, Franken, and Van Strien (2007) and Guerra and colleagues (2011), have demonstrated that late ERPs including the P3 and late positive potential (LPP) demonstrate more positive amplitudes and longer latencies in response to loved persons than to friends, familiar others, or strangers, indicating a higher level of motivated attention towards these individuals.

In addition to these robust effects of face type (loved vs. familiar vs. unfamiliar), recent findings suggest that a person's neural response to the face of a loved one is influenced by relationship quality factors. Grasso, Moser, Dozier, and Simons (2009), for instance, found that mothers' awareness of their influence on their children's development, positive feelings towards the parent/child relationship, and pleasure derived

from parenting were associated with enhanced P3 and LPP amplitudes when viewing photos of their own children. In a similar study on college students, Grasso and Simons (2010) demonstrated that higher levels of perceived parental support and fewer negative parent-child interactions were associated with greater late ERP positivity when viewing a parent's face.

Despite this compelling evidence that neural responses to a loved one are influenced by relationship quality factors, strikingly few studies have examined this phenomenon in the context of romantic relationships. In fact, although the wide range in quality of romantic relationships is well-documented (e.g., Fincham & Linfield, 1997), facial processing studies typically lump these relationships together into one supposedly homogeneous category without considering factors that may influence a person's response to his or her partner. Though Aron et al. (2005) demonstrated that higher levels of romantic passion were associated with greater activation in the right anteromedial caudate, no studies to date have examined the effect of other interpersonal variables, including overall relationship quality, on responses to one's partner, and none have studied this with the temporal precision of ERPs.

As noted, the goal of the present study was to examine the influence of relationship quality factors on an individual's neural response to his or her romantic partner. Findings would further clarify the role that these interpersonal factors play in immediate responses to romantic partners, which may subsequently influence overt responses to and communication with those partners. Previous work on microexpressions (Matsumo & Hwang, 2011; Pease & Pease, 2004; Stuart, Waller, & Schubert, 2009) has demonstrated that a person's instantaneous reaction to a stimulus is typically displayed in

some small way on his or her face, which is often (consciously or subconsciously) detected by the observer and ultimately influences communication between the two. As facial processing tasks, and EEG tasks in particular, are able to index one's immediate response to a given stimulus, the notion that relationship factors may influence this response before interpersonal communication even begins has clear implications for couples therapy, which often identifies communication as an early treatment target. Furthermore, the successful maintenance of a romantic relationship begins with and is heavily reliant upon each partner attending to the other, further highlighting the importance of considering what factors might help or hinder that process (Baxter & Simon, 1993). Findings would therefore alert the fields of facial processing and interpersonal research to the importance of considering relationship quality factors when examining romantic relationships.

In line with previous studies, it was hypothesized that faces of romantic partners would elicit more positive ERPs than other familiar or unfamiliar faces, regardless of relationship quality. The components of interest in the present study were the vertex positive potential (VPP), the P3, and the LPP. The VPP, considered to be the positive counterpart to the N170, is thought to index facial recognition and is associated with more basic, immediate processing (Joyce & Rossion, 2005; Rossion & Jacques, 2012; Wheatley, Weinberg, Looser, Moran, & Hajcak, 2011). As such, it was not expected to be associated with relationship quality factors. However, enhanced P3 and LPP positivity was predicted to be associated with better relationship quality, as these components are related to more elaborative processing involving memory and personal salience. No

specific hypotheses were made regarding gender differences, though such differences were planned to be explored.

Chapter 2

METHOD

2.1 Participants

Participants were 41 undergraduate students (23 female) enrolled in a psychology course at the University of Delaware. Each had indicated that he or she was currently in a committed dating relationship and all participants received course credit or financial compensation for participating in this study. Participants were between the ages of 18 and 24 years of age (M = 19.33), with 92.7% classified as Caucasian and 97.6% engaged in a heterosexual relationship.

2.2 Stimuli

A digital photo of each participant's romantic partner was obtained. Photos were cropped such that only the head was visible, with a size of approximately 750 x 750 pixels (7.5 x 7.5 inches). The photos were converted to grayscale, with the space surrounding the head colored black and the edges of the head softened with the blur tool. Celebrity photos were royalty-free images obtained from Internet sites, and stranger photos were taken from databases of facial pictures that have been established for research purposes. Celebrity and stranger photos were edited in the same manner as partner photos. Software packages used to edit photos include Apple iPhoto, Microsoft PowerPoint, and Microsoft Paint.

2.3 Measures

Relationship quality. Participants were administered the Quality of Marriage Index (QoM; Norton, 1983, edited) to assess the current quality of their romantic

relationship. Items including "My relationship with my partner makes me happy" were rated on a 7-point Likert scale of agreement.

Investment in relationship. Participants were administered the Investment Size subscale of the Investment Model Scale (IS-IMS; Rusbult, Martz, & Agnew, 1998) to assess their level of investment in and commitment to their romantic relationship. Items including "I have put a great deal into our relationship that I would lose if the relationship were to end" were rated on a 9-point Likert scale of agreement.

Communication patterns. Participants were administered the Romantic Partner Conflict Scale (RPCS; Zacchilli, Hendrick, & Hendrick, 2009) to assess typical communication and conflict patterns in their relationship. This measure yields six subscale scores, including tendencies towards compromise, avoidance, interactional reactivity, separation, domination, and submission, which were summed to a communication composite score for the purpose of analyses. Items including "In order to resolve conflicts, we try to reach a compromise" were rated on a 5-point Likert scale of agreement.

2.4 Procedures

The experimenter explained the requirements of the study to potential participants during an initial meeting. Those interested in participating in the experimental portion of the study completed a consent form and provided the experimenter with the email address of their romantic partner, to whom the experimenter sent a consent form for their photo to be used in the study. Participants were also asked to provide the experimenter with a straight-faced, well-lit digital photo of their romantic partner for use in the experimental session.

During this initial meeting, participants were also asked to identify the faces of six celebrities that were gender-, ethnicity-, and roughly age-matched to their romantic partner. For the experimental session, each was randomly assigned to view one of the celebrities he or she had identified as well as one of six gender-, ethnicity-, and roughly age-matched strangers.

Upon receiving the partner consent form and photo for a given participant, the experimenter scheduled him or her for a 60-minute experimental session. Following a brief orientation to the electrophysiological recording equipment, sensors were attached and participants were placed in a small room to begin the computer task. They were told that on each trial they would see one of three faces – their partner, a previously identified celebrity, or a stranger – after which they would view a screen with three names and be asked to indicate which face they just viewed via button press. This was done to ensure that participants remained attentive to the experimental task. Each face was presented for 1000 ms via Presentation software (Neurobehavioral Systems, Inc.) following a fixation cross that appeared for 200-600 ms. Faces were randomly presented 40 times each for a total of 120 trials. After completing this task, participants responded to the three measures (QoM, IS-IMS, RPCS) and a demographic questionnaire on a separate computer in Qualtrics.

2.5 Psychophysiological Recording and Data Reduction

EEG data were recorded from an electrocap with 30 embedded Ag/Cl sintered electrodes (Electro-Cap International) and from two additional electrooculography (EOG) electrodes placed 1 cm under each eye to record eye blinks and other eye movement artifacts. Data were recorded with a right mastoid (M2) reference and forehead ground

(AFZ) and were digitized at 500 Hz using Snapmaster software (HEM Data Corporation) with James Long Company Isolated Bioelectric Amplifiers. Impedances for all electrodes were below 20 KΩ for each participant. BESA software was used to correct continuous EEG data for eye blinks, after which the data were band-pass filtered from 0.1 to 30 Hz with a Butterworth digital filter and referenced to the average of the left and right mastoids. Trials containing artifacts exceeding a threshold of ±75 μV were rejected.

Regions of interest (ROIs) for the VPP, P3, and LPP were chosen in accordance with previous studies (e.g., Grasso & Simons, 2010; Grasso et al., 2009; Polich, 2012; Pratt, 2012; Rossoin & Jacques, 2012) and confirmed via visual inspection. The VPP was quantified as the mean amplitude between 175 – 195 ms post-stimulus onset at Cz; P3 as the mean amplitude between 300 – 475 ms post-stimulus onset at Cz and Pz; LPP as the mean amplitude between 550 – 700 ms post-stimulus onset at Cz and Pz. Questionnaire scores and mean component amplitudes were analyzed using SPSS (Version 21) and MPLUS 7 (Muthén & Muthén, 1998-2012).

Chapter 3

RESULTS

Raw waveforms from each ROI are presented in Figures 1 and 2. Outliers (N = 1) were removed using the quartile labeling method (Hoaglin & Iglewicz, 1987). Analyses for ERP components of interest are presented below.

3.1 ERP Components

3.1.1 VPP

A repeated-measures analysis of variance (ANOVA) conducted with face type (partner, celebrity, or stranger) as the within-subject variable yielded a main effect of face type on the VPP, $F(2, 80) = 3.522$, $p = .034$, $\eta_p^2 = .081$. Bonferroni-corrected pairwise comparisons indicated that mean VPP amplitude was significantly more positive towards partner faces than towards stranger faces ($p = .025$). Neural responses to partner faces were not significantly different from responses to celebrity faces ($p = .513$), nor were responses to celebrity and stranger faces different from one another ($p = .723$). This suggests that the VPP is sensitive to major differences in the personal significance of a face, but is unable to differentiate between levels of facial familiarity.

3.1.2 P3

A repeated measures ANOVA with a Greenhouse-Geisser correction revealed a main effect of face type on the P3, $F(1.617, 63.046) = 28.846$, $p < .001$, $\eta_p^2 = .425$. Consistent with past research, partner faces elicited significantly larger mean P3 amplitudes than celebrity ($p < .001$) or stranger faces ($p < .001$). Responses to celebrity and stranger faces were not significantly different ($p = .283$). These findings are in line with the conceptualization of the P3 as an index of personal significance and emotional

salience, suggesting that individuals are, in general, more motivated to attend to their romantic partner than to familiar or unfamiliar others.

3.1.3 LPP

A repeated measures ANOVA revealed a main effect of face type on the LPP, $F(2, 80) = 10.476$, $p < .001$, $\eta_p^2 = .212$. In line with past work, partner faces elicited significantly larger mean LPP amplitudes than celebrity ($p < .001$) or stranger faces ($p = .003$). Responses to celebrity and stranger faces were not significantly different ($p > .999$). This suggests that romantic partners elicit more sustained attention than others, regardless of familiarity.

3.2 Relationship Quality Factors

All predictor variables (relationship quality, investment, and communication quality) were mean-centered prior to analyses. In order to examine the unique influence of relationship quality factors on the processing of partner faces independent of the effects of familiarity or general face processing, the average neural response to celebrity and stranger faces was subtracted from the response to the partner face for each participant at each ROI. A path model with the VPP, P3, and LPP difference waves as outcome variables and gender, relationship quality, investment size, communication quality, and the interactions between gender and relationship quality, investment, and communication quality as predictor variables was tested. See Table 1 for descriptive statistics and correlations among variables. This model was saturated, meaning that there were at least as many estimated parameters as there were data points. Goodness of fit indices are therefore not reported.

3.2.1 VPP (Table 2)

Higher relationship quality tended to be associated with decreased VPP amplitude towards romantic partners, though this trend was not statistically significant (β = -0.107, p = .056, Figure 3). Conversely, greater relationship investment was associated with increased VPP amplitude towards romantic partners (β = 0.081, p = .044, Figure 4). No other factors were associated with VPP amplitude.

3.2.2 P3 (Table 3)

Higher relationship quality was associated with decreased P3 amplitude towards romantic partners (β = -0.337, p < .001), though this trend was significantly different for men and women (β = 0.799, p = .001). Tests of simple effects revealed that, among women, better relationship quality was associated with decreased P3 amplitude, b = -0.337, $t(22)$ = -5.500, p < .001. The association between relationship quality and P3 amplitude tended to be positive among males, though this association did not reach statistical significance, b = 0.462, $t(18)$ = 2.002, p = .057. This interaction is illustrated in Figure 5.

Greater investment was also associated with increased P3 amplitude towards romantic partners (β = 0.104, p = .024). This relationship was different across genders (β = -0.360, p = .003), with females exhibiting increased P3 amplitude at higher levels of investment, b = 0.104, $t(22)$ = 2.250, p = .034, and males exhibiting the opposite pattern, b = -0.256, $t(18)$ = -2.33, p = .029. This interaction is illustrated in Figure 6.

Similarly, better communication quality was associated with increased P3 amplitude (β = 0.066, p = .001), though this pattern was also different for men and women (β = -0.240, p = .005). For women, better communication quality was associated

with increased P3 amplitude, b = 0.066, $t(22)$ = 3.291, p = .003, while men exhibited decreased P3 amplitude at higher levels of communication quality, b = -0.174, $t(18)$ = -2.092, p = .048. This interaction is illustrated in Figure 7.

3.2.3 LPP (Table 4)

In general, females exhibited more positive LPP amplitude towards their romantic partners than did men (β = -0.933, p = .021). Better relationship quality tended to be associated with decreased LPP amplitude, though this association was not statistically significant (β = -0.108, p = .076). However, this effect was significantly different for men and women (β = 0.542, p = .022). Tests of simple effects revealed that, for women, better relationship quality tended to be associated with decreased LPP amplitude, b = -0.108, $t(22)$ = -1.779, p = .088, while the opposite trend was true for men, b = 0.434, $t(18)$ = 1.862, p = .075. This marginal interaction is illustrated in Figure 8.

Greater relationship investment was associated with more positive LPP amplitude (β = 0.103, p = .015), though this trend was also significantly different for men and women (β = -0.396, p = .001). Among women, higher levels of investment were associated with more positive LPP amplitude, b = 0.103, $t(22)$ = 2.445, p = .022, while the opposite was true of men, b = -0.293, $t(18)$ = -2.682, p = .013. This interaction is illustrated in Figure 9.

Although there was no effect of communication quality on LPP amplitude (p = .685), the interaction between communication quality and gender was marginally significant (β = -0.165, p = .054). Tests of simple effects indicated that, among men, there tended to be an inverse relationship between communication quality and LPP amplitude, b = -0.157, $t(18)$ = -1.880, p = .073. There was no association between

communication quality and LPP amplitude for women (p = .702). This marginal interaction is illustrated in Figure 10.

Table 1

Descriptive Statistics and Correlations Among Variables.

Measure	Mean (SD)	Pearson correlation (*r*)				
		1	2	3	4	5
1. Mean VPP amplitude (μV)	0.510 (1.391)					
2. Mean P3 amplitude (μV)	1.892 (1.908)	.506**				
3. Mean LPP amplitude (μV)	1.139 (1.625)	.317*	.543**			
4. Relationship quality (QoM)	39.184 (4.942)	-.380*	-.509**	-.339*		
5. Investment (IS-IMS)	50.195 (7.146)	.149	.155	.018	-.074	
6. Communication quality (RPCS)	19.194 (17.494)	-.058	.051	.402	.553**	-.080

Note. All component amplitudes are partner-specific.
* $p < .05$. ** $p < .01$. All *p*-values are two-tailed.

Table 2

Estimates From Path Model For Partner-Specific VPP Amplitude.

			95% *CI*	
Between-subject effects	Estimate (SE)	*p-value*	Lower	Upper
Gender	-0.092 (0.397)	.816	-0.746	0.561
Relationship quality (QoM)	-0.107 (0.056)	.056	-0.199	-0.015
Investment (IS-IMS)	0.081 (0.040)	.044	0.015	0.029
Communication quality (RPCS)	0.011 (0.018)	.545	-0.019	0.041
			95% *CI*	
Interaction effects	Estimate (SE)	*p-value*	Lower	Upper
Relationship quality by Gender	0.138 (0.211)	.514	-0.210	0.486
Investment by Gender	-0.142 (0.104)	.171	-0.313	0.029
Communication quality by Gender	-0.033 (0.074)	.658	-0.154	0.089
R^2	0.201 (0.113)	.077		

Note. All *p*-values are two-tailed.

Table 3

Estimates From Path Model For Partner-Specific P3 Amplitude.

			95% *CI*	
Between-subject effects	Estimate (SE)	*p-value*	Lower	Upper
Gender	0.035 (0.447)	.938	-0.700	0.770
Relationship Quality (QoM)	-0.337 (0.061)	< .001	-0.438	-0.236
Investment (IS-IMS)	0.104 (0.046)	.024	0.028	0.180
Communication Quality (RPCS)	0.066 (0.020)	.001	0.033	0.099
			95% *CI*	
Interaction effects	Estimate (SE)	*p-value*	Lower	Upper
Relationship Quality by Gender	0.799 (0.235)	.001	0.411	1.186
Investment by Gender	-0.360 (0.123)	.003	-0.562	-0.158
Communication Quality by Gender	-0.240 (0.086)	.005	-0.381	-0.099
R^2	0.528 (0.119)	< .001		

Note. All *p*-values are two-tailed.

Table 4

Estimates From Path Model For Partner-Specific LPP Amplitude.

			95% *CI*	
Between-subject effects	Estimate (SE)	*p-value*	Lower	Upper
Gender	-0.933 (0.405)	.021	-1.599	-0.267
Relationship Quality (QoM)	-0.108 (0.061)	.076	-0.208	-0.008
Investment (IS-IMS)	0.103 (0.042)	.015	0.034	0.172
Communication Quality (RPCS)	0.008 (0.021)	.685	-0.026	0.042
			95% *CI*	
Interaction effects	Estimate (SE)	*p-value*	Lower	Upper
Relationship Quality by Gender	0.542 (0.237)	.022	0.152	0.932
Investment by Gender	-0.396 (0.122)	.001	-0.596	-0.196
Communication Quality by Gender	-0.165 (0.086)	.054	-0.306	-0.024
R^2	0.428 (0.127)	< .001		

Note. All *p*-values are two-tailed.

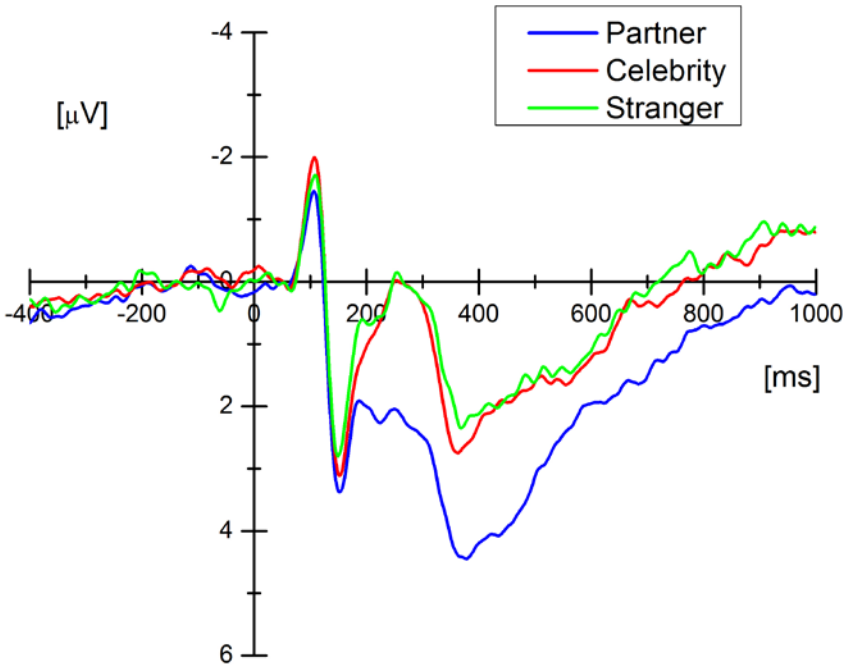

Figure 1. Raw ERP waveforms at Cz.

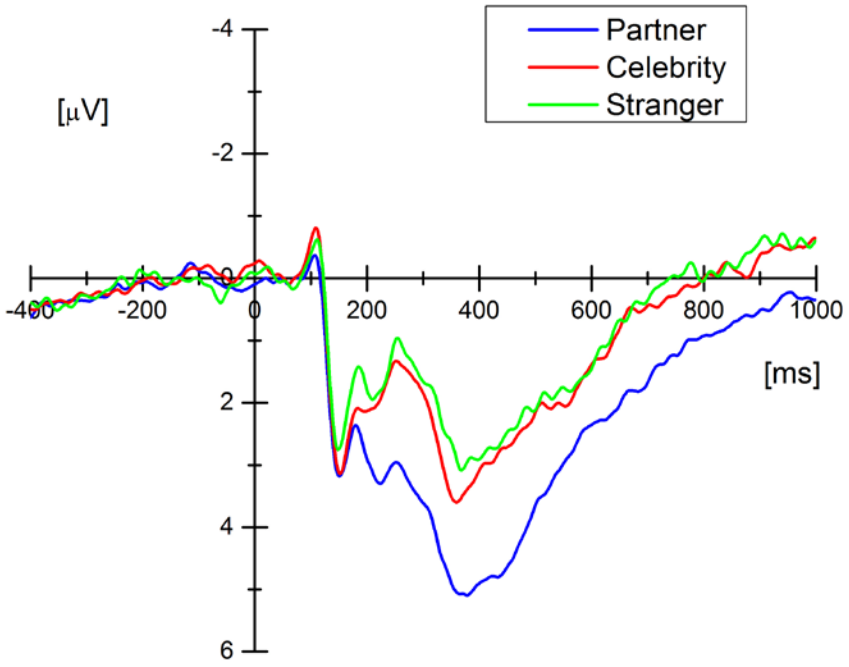

Figure 2. Raw ERP waveforms at the central-parietal ROI.

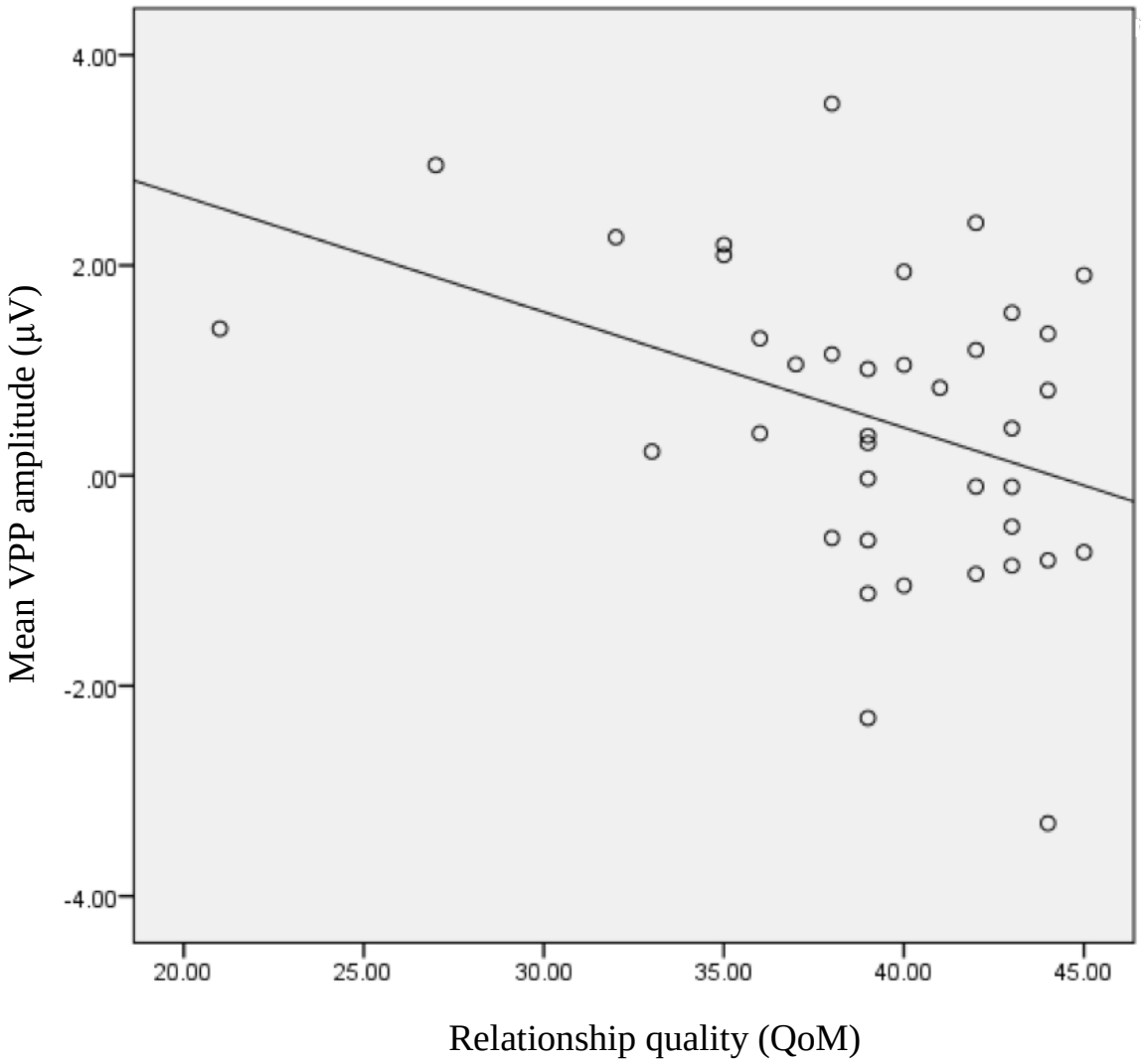

Figure 3. Association between relationship quality and mean VPP amplitude in response to partner faces (p = .056).

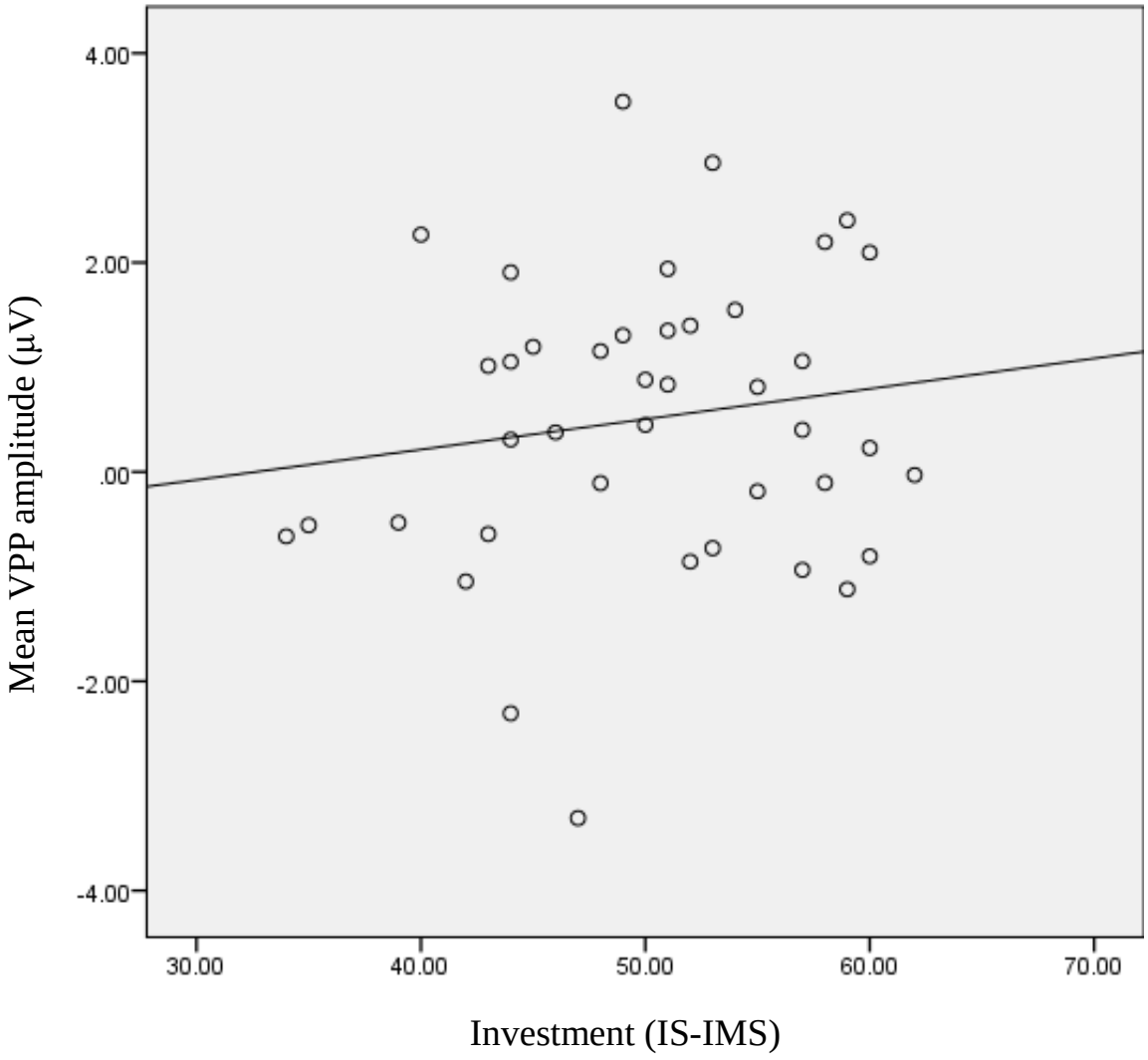

Figure 4. Association between investment in relationship and mean VPP amplitude in response to partner faces (p = .044).

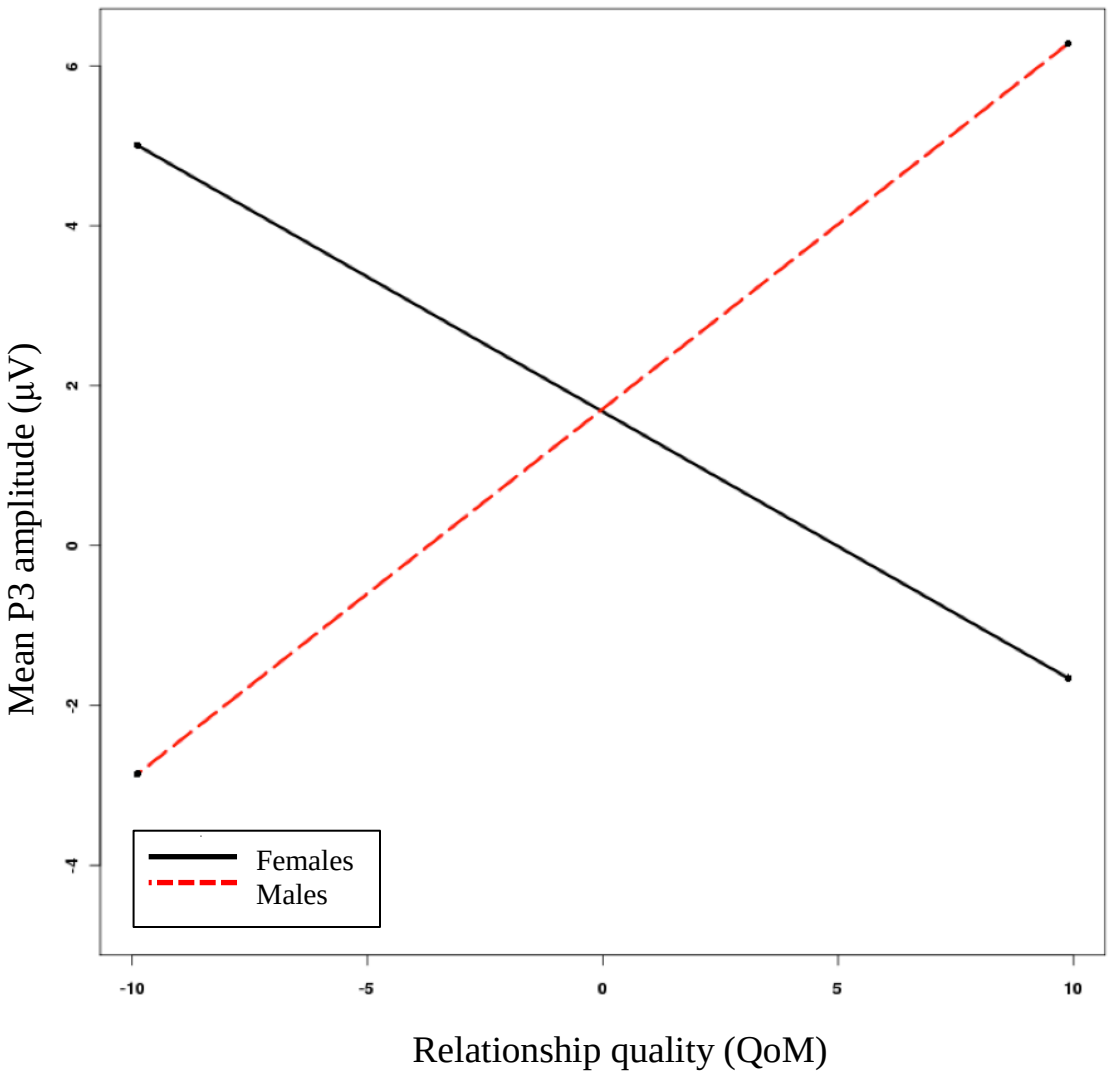

Figure 5. Interaction between gender and relationship quality for mean P3 amplitude in response to partner faces (p = .001).

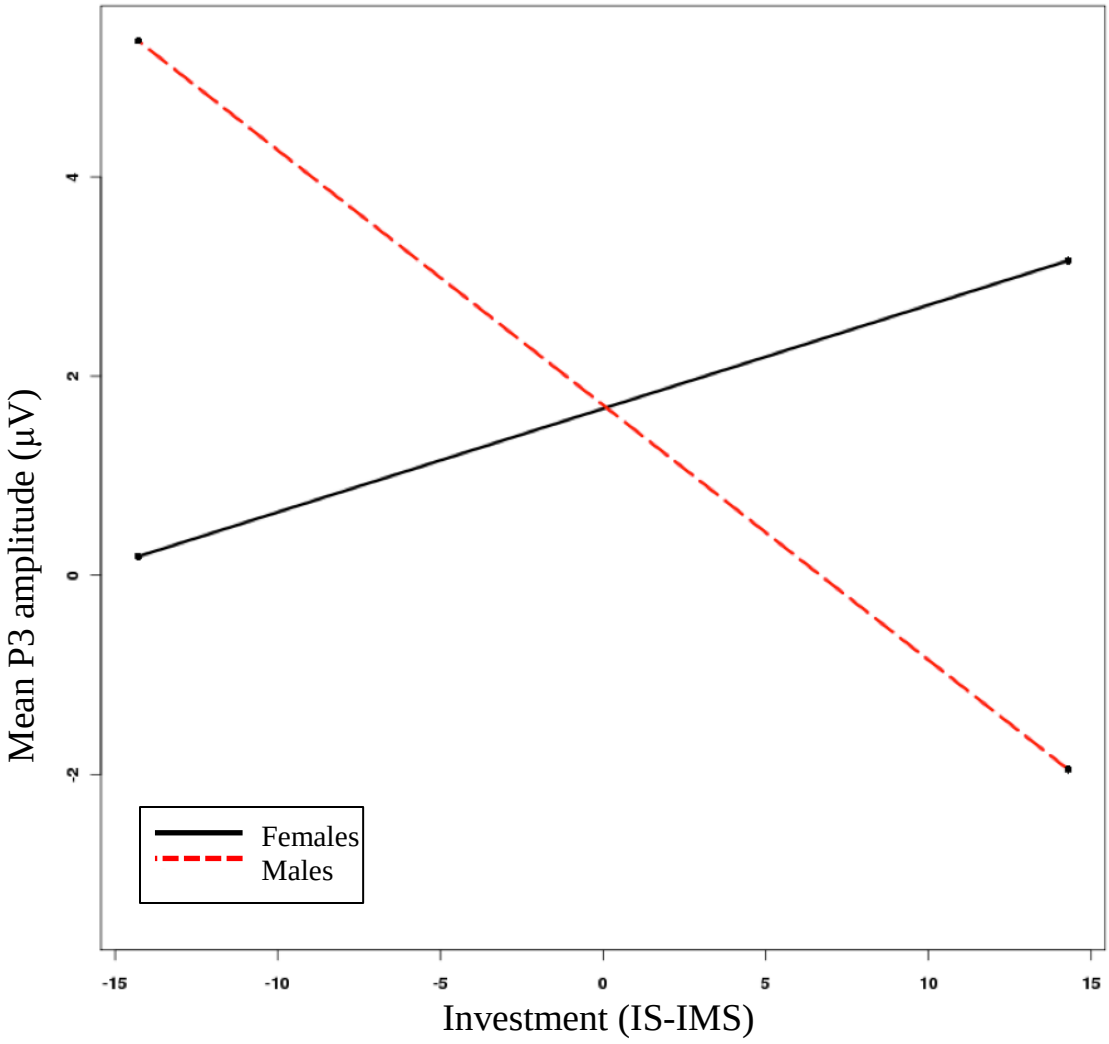

Figure 6. Interaction between gender and investment in relationship for mean P3 amplitude in response to partner faces (p = .003).

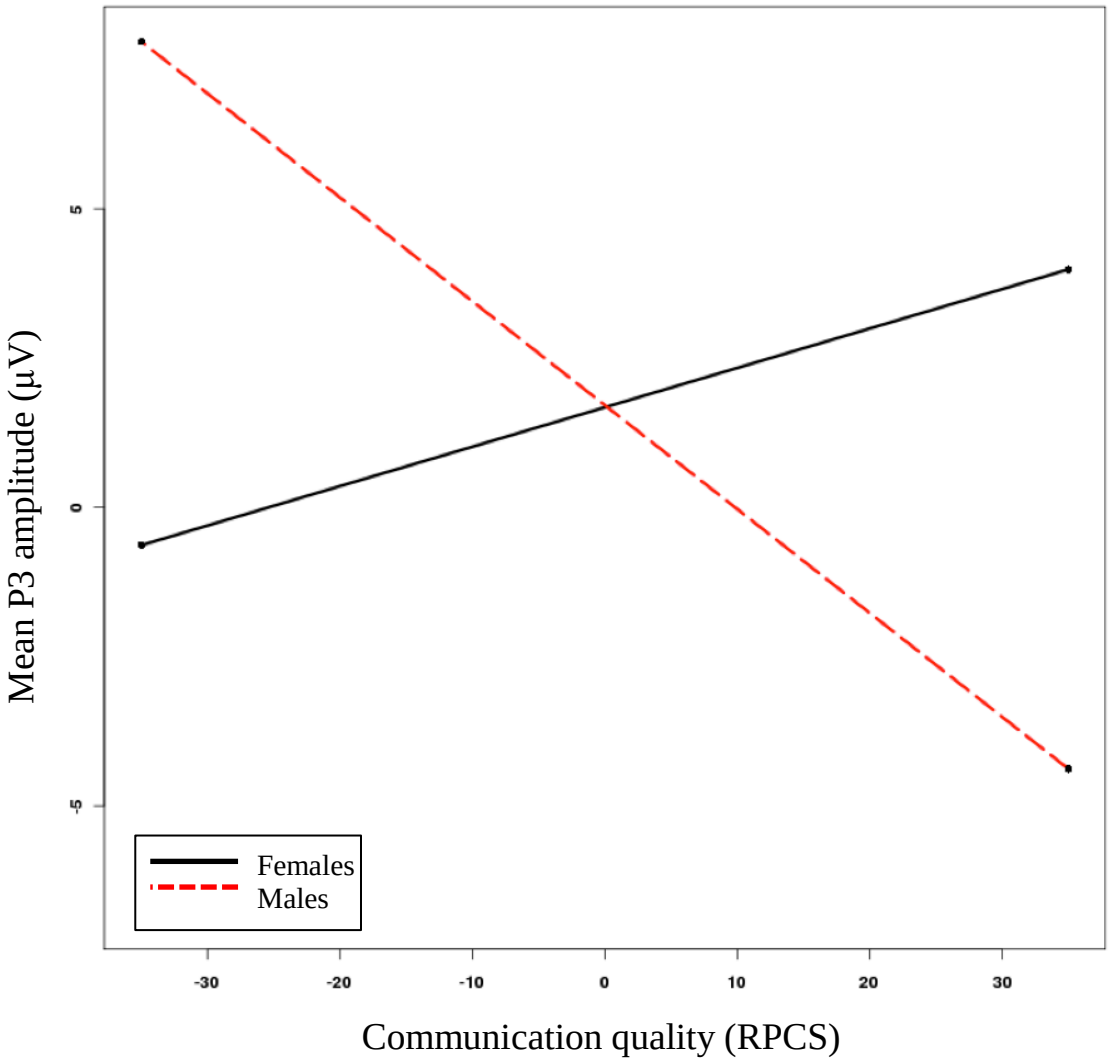

Figure 7. Interaction between gender and communication quality for mean P3 amplitude to partner faces (p = .005).

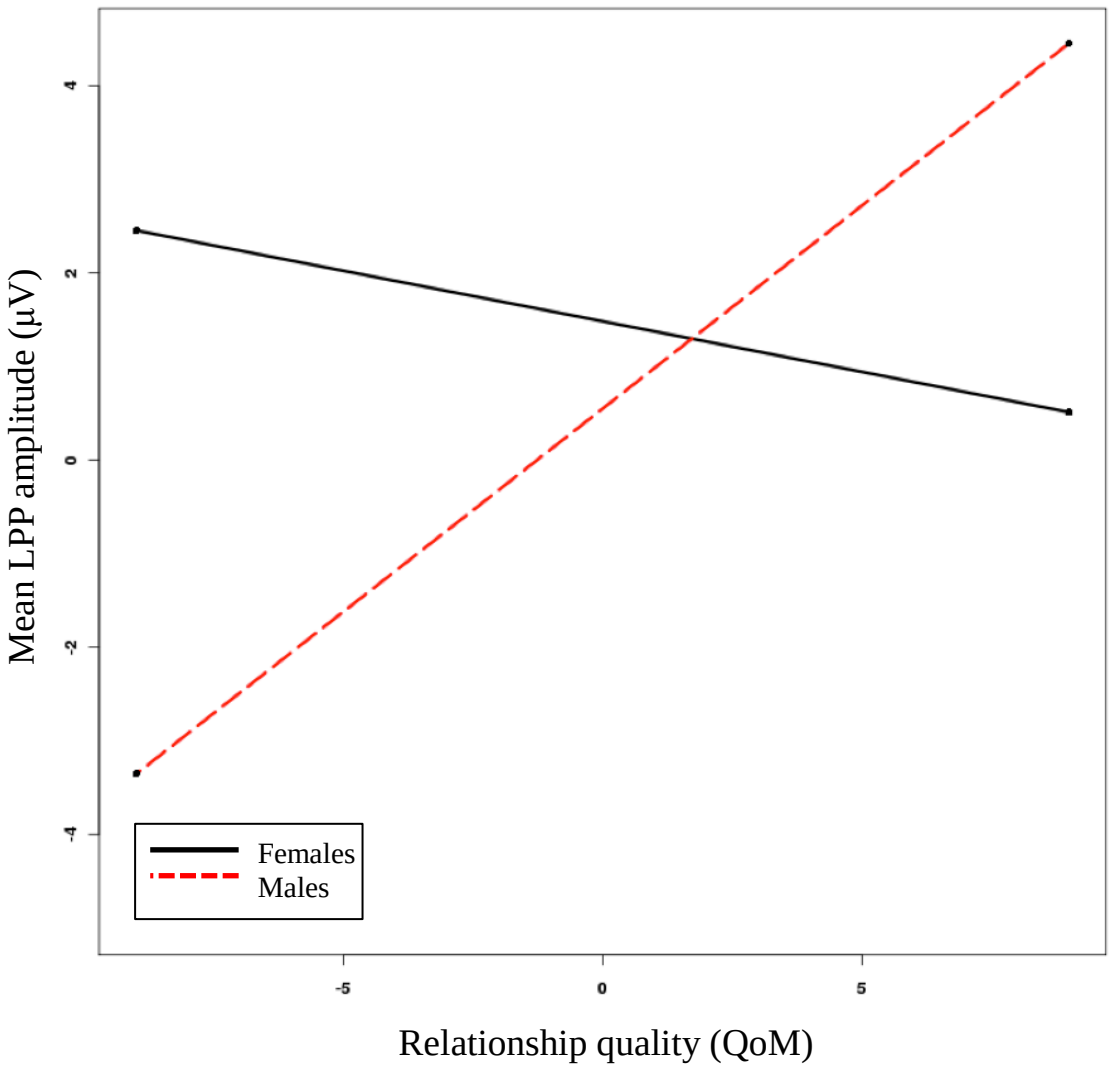

Figure 8. Interaction between gender and relationship quality for mean LPP amplitude to partner faces (p = .022).

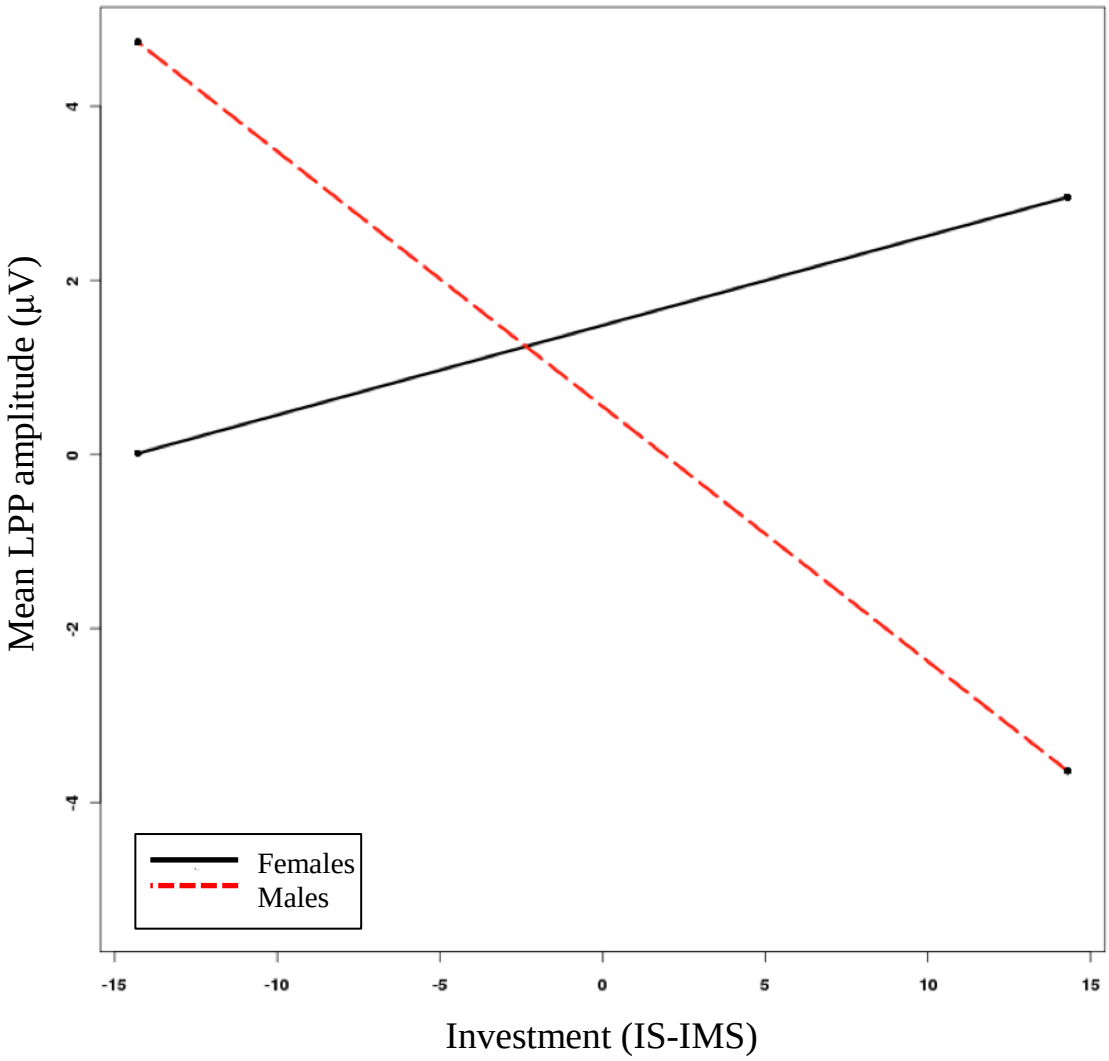

Figure 9. Interaction between gender and investment in relationship for mean LPP amplitude to partner faces (p = .001).

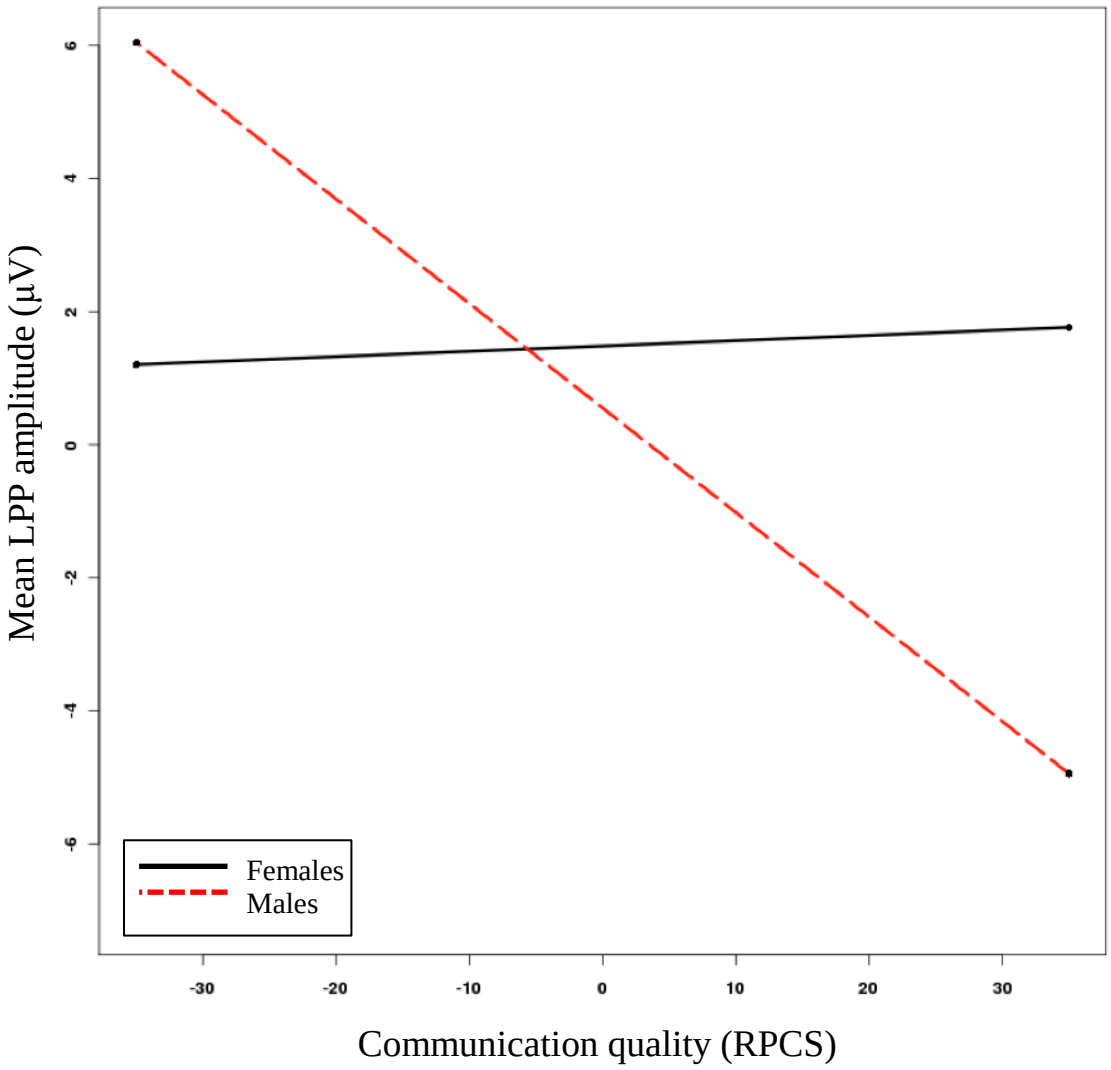

Figure 10. Interaction between gender and communication quality for mean LPP amplitude to partner faces (p = .054).

Chapter 4

DISCUSSION

The results of this study replicate past research demonstrating overall enhanced positivity to the face of a significant other (Grasso et al., 2009; Grasso & Simons, 2010; Guerra et al., 2011; Langeslag et al., 2007). Consistent with hypotheses, the mean amplitudes of the P3 and LPP were significantly more positive to partner faces than to celebrity or stranger faces, supporting the notion that individuals attend more closely to stimuli that are more personally significant. Findings are also in line with the conceptualization of these components as indices of motivated attention, as neuroimaging studies provide complementary evidence that viewing a photo of one's romantic partner increases activity in brain regions associated with reward seeking and empathy (Aron et al., 2005; Bartels & Zeki, 2000; Fisher, Aron, Mashek, Li, & Brown, 2002). The VPP, however, demonstrated enhanced positivity to partner faces relative to strangers, but not to celebrities. Previous studies have had mixed results regarding such early components' sensitivities to stimulus content, and present findings suggest that the VPP is more sensitive to highly salient faces (e.g., partners) than to personally irrelevant faces (e.g., strangers), but is unable to differentiate between familiarity conditions (partner vs. celebrity, celebrity vs. stranger).

Present findings also replicate work by Grasso and colleagues (2009; 2010) indicating that late components such as the P3 and LPP are influenced by relationship quality factors. However, the association between these factors and VPP amplitude was unexpected. Although the VPP is thought to index only facial recognition (Joyce & Rossion, 2005; Rossion & Jacques, 2012; Wheatley et al., 2011), these results suggest

that relationship quality factors are so salient that they influence even these early, lower-level processes. Specifically, results indicated that there is a direct relationship between investment and mean VPP amplitude, such that individuals who are more invested in their romantic relationships allocate more attention to their partners very early on. This is in line with hypotheses that higher scores on relationship quality measures would be associated with enhanced ERP component positivity, though this effect appears to occur earlier than anticipated.

Overall relationship quality also influenced the VPP, although the direction of this association was not as predicted; worse relationship quality was associated with enhanced VPP positivity, suggesting more early attention allocated to one's partner. Although this finding stands in contrast to past studies demonstrating that better relationship quality is associated with more positive ERPs, it is important to note that these other studies (Grasso et al., 2009; Grasso & Simons, 2010) assessed the less transient parent/child relationship. One's parent is always going to be one's parent, and one's child is always going to be one's child, but romantic relationships are far less permanent. The inverse association between relationship quality and allocated attention may thus be reflective of a heightened urge to monitor one's partner or the relationship for conflict within more tenuous, less secure relationships.

An assessment of the interaction between relationship quality and gender at later ERP components revealed that the above relationship holds true for females, but not for males. Females also demonstrated generally enhanced LPP amplitude to partner faces relative to males, indicating that women tend to "linger" more on and devote more sustained attention to their romantic partners than do men. Given that females tend to

feel less secure in romantic relationships, experiencing "heightened sensitivity to relationship threat [which] yields…worry and vigilance," it follows that women might feel the need to "keep an eye" on their romantic partners both in general and when the relationship seems less satisfactory or secure in particular (Laurenceau, Kleinman, Kazynski, & Carver, 2010, p. 408). Similarly, Floyd and Markman (1983) found that wives' levels of reported marital dysfunction were more similar to actual levels of dysfunction than were husbands' reports, suggesting that females tend to be more attuned to relationship duress and focus on the relationship more intensely when things are not going well.

Males, on the other hand, appear to devote more attention to partners with whom they have a higher quality relationship. In line with this, Laurenceau and colleagues (2010) found no association between threat sensitivity and perceived relationship quality among males, indicating that men don't necessarily feel the need to monitor the relationship or attend more to their romantic partner when the relationship is going poorly. Further, Gable and Harmon-Jones (2008) note that stimuli which are high in positive approach-motivation, such as partners with whom one has a high quality relationship, tend to narrow the attentional field, causing individuals to focus more strongly on and devote more attention to the given appetitive stimulus. The direction of the association between relationship quality and ERP component amplitude for males is in line with previous studies (none of which considered gender differences), and supports the notion that these late components are indicative of motivated attention (Hajcak, Weinberg, Macnamara, & Foti, 2012).

Among women, better communication quality and higher levels of relationship investment were associated with more attention allocated to partner faces. This result is also in line with the conceptualization of these later components as indices of motivated attention and personal significance, though it stands in stark contrast to the inverse association between relationship quality and ERP positivity among female participants. This discrepancy may be due to the fact that, regardless of how well things are going in one's romantic relationship, the upkeep of strong communication and investment requires high levels of motivation, attention, and care (Campbell & Foster, 2002; Gaelick, Bodenhausen, & Wyer, 1985; Markman, Renick, Floyd, Stanley, & Clements, 1993; Rusbult, 1983). Past work has shown that females tend to prioritize the maintenance of a romantic relationship more than males, emphasizing factors including openness and equity over general happiness in the relationship (Baxter, 1986). Women may therefore allocate more attention to partners in whom they have a strong investment or with whom they communicate well, as investment and effective communication ultimately motivate and require high levels of attention to one's partner.

Conversely, worse communication quality and lower relationship investment were associated with more attention allocated to romantic partners among males. This may indicate that men have a more "triaged" approach to relationships, wherein more time and resources are devoted to situations or relationships that seem less permanent or stable. This is in line with research indicating that men tend to take a more "casual" approach to dating relationships relative to females, and may only attend to more serious aspects of the relationship when it is in jeopardy (Fengler, 1974; Sedikides, Oliver, & Campbell, 1994). These findings might also be explained by an avoidant pattern of attachment,

wherein men attempt to pre-empt a potential rejection by reducing their involvement in and attentional resources devoted to the maintenance of a significant relationship in which they have invested quite a bit (Downey, Feldman, & Ayduk, 2000). Past work (Simon & Baxter, 1993) has demonstrated that men are more likely to experience avoidant attachment and tend to utilize more avoidant strategies of relationship maintenance than women. Avoidant men have also been found to engage in relatively enduring, long-lasting relationships, which may explain the contrast between these findings and those for overall relationship quality among men (Kirkpatrick & Davis, 1994).

Overall, the results of the present study make a distinction between relationship quality and sustainability. While the quality of a romantic relationship appears to pull for threat sensitivity from women and approach motivation from men, factors that are more explicitly associated with commitment to and upkeep of the relationship, such as investment and effective communication, are associated with the opposite pattern of attention allocation across genders. Although these sustainability factors may be implicated in the overall quality of a relationship, the analyses utilized in the present study allowed for the examination of the unique effect of each of the three relationship quality factors independent of one another. Results thereby suggest that, in addition to the striking gender differences across these factors, overall relationship quality influences attention allocation in a fundamentally different manner than do investment and communication quality.

The results of the present study have clear implications for couples counseling and research. Although communication is often identified as an early treatment target for

romantic partners, these findings suggest that reactions to one's partner occur even before communication begins. As demonstrated by research on microexpressions, such instantaneous reactions are often displayed on an individual's face and may influence the progression of a subsequent conversation (Matsumo & Hwang, 2011; Pease & Pease, 2004; Stuart et al., 2009). It is important to note, however, that the results of the present study do not specify direction of effects; it is possible, for instance, that men experience lower relationship quality because they are not attending as well to their romantic partners. It may therefore be important for clinicians to intervene even earlier in the communication process, perhaps by simply teaching each partner to attend more thoroughly and immediately to the other. Findings also highlight the potentially counterintuitive notion that increased attention allocation to one's partner is not always positive. In some circumstances, clinicians may need to teach clients to attend less intensely to their romantic partners, decreasing hypervigilance and allowing the relationship and the partner to breathe. Furthermore, the robust associations between relationship quality factors and neural responses to partner faces emphasize the necessity of considering romantic relationships as a highly heterogeneous category in research design, analysis, and interpretation.

The present study is not without limitations. Although the sample size used is not unusual for studies employing psychophysiological methods, the relatively small number of participants may have reduced statistical power. Future studies should utilize larger samples to focus on earlier components, such as the VPP, in order to assess how sensitive these lower-level indices are to more abstract stimulus features. Furthermore, the sample was highly homogeneous, with 92.7% identifying as Caucasian and 97.6% engaged in a

heterosexual relationship. Future studies should strive for diversity in participant recruitment in order to examine any potential differences between these and other groups. Members of different types of relationships, including long-term married couples, newlyweds, and casually dating couples, should also be studied in future experiments in order to determine if the present pattern of results is specific to college students in committed relationships. It will also be important for future studies to replicate the gender differences reported in the present experiment, as no specific hypotheses were made regarding male and female outcomes. Finally, factors such as threat sensitivity and attachment should be directly assessed in future studies in order to strengthen or modify the interpretations made regarding the results of the present study.

Facial identification and perception is a crucial and evolutionarily fine-tuned process by which we identify a range of socially useful information. It is also a process by which we access and update our experiences with and feelings towards salient persons in our lives, including romantic partners. Through the use of event-related potentials, the present study highlighted the role that relationship quality factors play in the immediate processing of our loved ones; an area that has rich implications for the development and maintenance of these relationships.

REFERENCES

Acitelli, L. (1992). Gender differences in relationship awareness and marital satisfaction among young married couples. *Personality and Social Psychology Bulletin, 1*(18), 102-110.

Aron, A., Fisher, H., Mashek, D.J., Strong, G., Li, H., & Brown, L.L. (2005). Reward, motivation, and emotion systems associated with early-stage intense romantic love. *Journal of Neurophysiology, 94*, 327-337.

Bartels, A., & Zeki, S. (2000). The neural basis of romantic love. *NeuroReport, 11*(7), 3829-3834.

Baxter, L.A. (1986). Gender differences in hetero-sexual relationship rules embedded in break-up accounts. *Journal of Social and Personal Relationships, 3*(3), 289-306.

Baxter, L.A., & Simon, E.P. (1993). Relationship maintenance strategies and dialectical contradictions in personal relationships. *Journal of Social and Personal Relationships, 10*(2), 225-242.

Campbell, W.K., & Foster, C.A. (2002). Narcissism and commitment in romantic relationships: An investment model analysis. *Personality and Social Psychology Bulletin, 28*(4), 484-495.

Creighton Zollar, A., & Williams, J.S. (1987). The contribution of marriage to the life satisfaction of black adults. *Journal of Marriage and the Family, 49*, 87-92.

Depue, R.A., & Morrone-Strupinsky, J.V. (2005). A neurobehavioral model of affiliative bonding: Implications for conceptualizing a human trait of affiliation. *Behavioral and Brain Sciences, 28*(3), 313-395.

Diener, E., Oishi, S., & Lucas, R.E. (2009). Subjective well-being: The science of happiness and life satisfaction. In C.R. Snyder & S.J. Lopez (Eds.), *Oxford handbook of positive psychology* (2nd ed., pp. 187-194). New York, New York: Oxford University Press.

Diener, E., & Seligman, M.E.P. (2002). Very happy people. *Psychological Science, 13*(1), 81-84.

Downey, G., Feldman, S., & Ayduk, O. (2000). Rejection sensitivity and male violence in romantic relationships. *Personal Relationships, 7*(1), 45-61.

Eimer, M., & Holmes, A. (2007). Event-related brain potential correlates of emotional face processing. *Neuropsychologia, 45*, 15-31.

Fengler, A.P. (1974). Romantic love in courtship: Divergent paths of male and female students. *Journal of Comparative Family Studies, 5*(1), 134-139.

Fincham, F.D., & Linfield, K.J. (1997). A new look at marital quality: Can spouses feel positive and negative about their marriage? *Journal of Family Psychology, 11*(4), 489-502.

Fisher, H., Aron, A., & Brown, L.L. (2005). Romantic love: An fMRI study of a neural mechanism for mate choice. *The Journal of Comparative Neurology, 49*, 58-62.

Fisher, H.E., Aron, A., Mashek, D., Li, G., & Brown, L.L. (2002). Defining brain systems of lust, romantic attraction, and attachment. *Archives of Sexual Behavior, 31*(5), 413-419.

Flor, H., Turk, D.C., & Rudy, T.E. (1989). Relationship of pain impact and significant other reinforcement of pain behaviors: The mediating role of gender, marital status and marital satisfaction. *Pain, 38*(1), 45-50.

Floyd, F.J., & Markman, H.J. (1983). Observational biases in souse observation: Toward a cognitive/behavioral model of marriage. *Journal of Consulting and Clinical Psychology, 51*(3), 450-457.

Gable, P.A., & Harmon-Jones, E. (2008). Approach-motivated positive affect reduces breadth of attention. *Psychological Science, 19*(5), 476-482.

Gaelick, L., Bodenhausen, G.V., & Wyer, R.S. (1985). Emotional communication in close relationships. *Journal of Personality and Social Psychology, 49*(5), 1246-1265.

Grasso, D.J., Moser, J.S., Dozier, M., & Simons, R. (2009). ERP correlates of attention allocation in mothers processing faces of their children. *Biological Psychology, 81*, 95-102.

Grasso, D.J., & Simons, R.F. (2010). Perceived parental support predicts enhanced late positive brain potentials to parent faces. *Biological Psychology, 86*, 26-30.

Guerra, P., Rafaela, R.C., Vico, C., Volchan, E., Anllo-Vento, L., & Vila, J. (2011). Filial versus romantic love: Contributions form peripheral and central electrophysiology. *Biological Psychology, 88*, 196-203.

Hajcak, G., Weinberg, A., MacNamara, A., & Foti, D. (2012). ERPs and the study of emotion. In S. J. Luck & E. S. Kappenman (Eds.), *The Oxford handbook of event-related potential components* (pp. 441-472). New York, New York: Oxford University Press.

Hoaglin, D.C., & Iglewicz, B. (1987). Fine tuning some resistant rules for outlier labeling. *Journal of the American Statistical Association, 82,* 1147-1149.

Joyce, C., & Rossion, B. (2005). The face-sensitive N170 and VPP components manifest the same brain processes: The effect of reference electrode site. *Clinical Neurophysiology, 116*(11), 2613-2631.

Kirkpatrick, L.A., & Davis, K.E. (1994). Attachment style, gender, and relationship stability: A longitudinal analysis. *Journal of Personality and Social Psychology, 66*(3), 502-512.

Langeslag, S.J.E., Jansma, B.M., Franken, I.H.A., & Van Strien, J.W. (2007). Event-related potential responses to love-related facial stimuli. *Biological Psychology, 76,* 109-115.

Laurenceau, J.P., Kleinman, B.M., Kaczynski, K.J., & Carver, C.S. (2010). Assessment of relationship-specific incentive and threat sensitivities: Predicting satisfaction and affect in adult intimate relationships. *Psychological Assessment, 22*(2), 407-419.

Le Grand, R., Mondloch, C.J., Maurer, D., & Brent, H.P. (2001). Neuroperception: Early visual and face processing. *Nature, 890.*

Lempers, J.D., & Clark-Lempers, D.S. (1992). Young, middle, and late adolescents' comparisons of the functional importance of five significant relationships. *Journal of Youth and Adolescence, 21*(1), 53-96.

Markman, H.J., Renick, M.J., Floyd, F.J., Stanley, S.M., & Clements, M. (1993). Preventing marital distress through communication and conflict management training: A 4- and 5-year follow-up. *Journal of Consulting and Clinical Psychology, 61*(1), 70-77.

Matsumoto, D., & Hwang, H.S. (2011). Evidence for training the ability to read microexpressions of emotion. *Motivation and Emotion, 35,* 191-191.

Mroczek, D.K., & Spiro III, A. (2005). Change in life satisfaction during adulthood: Findings from the veterans affairs normative aging study. *Journal of Personality and Social Psychology, 88*(1), 189-202.

Muthén, L.K. and Muthén, B.O. (1998-2012). Mplus User's Guide. Seventh Edition. Los Angeles, CA: Muthén & Muthén.

Norton, R. (1983). Measuring marital quality: A critical look at the dependent variable. *Journal of Marriage and Family, 45,* 141-151.

Parr, L.A. (2011). The evolution of face processing in primates. *Philosophical Transactions of the Royal Society, 366*(1571), 1764-1777.

Pease, A., & Pease, B. (2004). *The definitive book of body language*. New York, New York: Bantam Dell.

Polich, J. (2012). Neuropsychology of P300. In S. J. Luck & E. S. Kappenman (Eds.), *The Oxford handbook of event-related potential components* (pp. 159-188). New York, New York: Oxford University Press.

Pratt, H. (2012). Sensory ERP components. In S. J. Luck & E. S. Kappenman (Eds.), *The Oxford handbook of event-related potential components* (pp. 89-114). New York, New York: Oxford University Press.

Rossion, B., & Jacques, C. (2012). The N170: Understanding the time course of face perception in the human brain. In S. J. Luck & E. S. Kappenman (Eds.), *The Oxford handbook of event-related potential components* (pp. 115-141). New York, New York: Oxford University Press.

Rusbult, C.E. (1983). A longitudinal test of the investment model: The development (and deterioration) of satisfaction and commitment in heterosexual involvements. *Journal of Personality and Social Psychology, 45*(1), 101-117.

Rusbult, C.E., Martz, J.M., & Agnew, C.R. (1998). The Investment Model Scale: Measuring commitment level, satisfaction level, quality of alternatives, and investment size. *Personal Relationships, 5*, 357-391.

Sedikides, C., Oliver, M.B., & Campbell, W.K. (1994). Perceived benefits and costs of romantic relationships for women and men: Implications for exchange theory. *Personal Relationships, 1*, 5-21.

Simon, E.P., & Baxter, L.A. (1993). Attachment-style differences in relationship maintenance strategies. *Western Journal of Communication 57*(4), 416-430.

Steinhauser, K.E., Christakis, N.A., Clipp. E.C., McNeilly, M., McIntyre, L., & Tulsky, J.A. (2000). Factors considered important at the end of life by patients, family, physicians, and other care providers. *The Journal of the American Medical Association, 284*(19), 2476-2482.

Stuart, P.A., Waller, B.M., & Schubert, J.N. (2009). Presidential speechmaking style: Emotional response to micro-expressions of facial affect. *Motivation and Emotion, 33*, 125-135.

Wheatley, T., Weinberg, A., Looser, C. Moran, T., & Hajcak, G. (2011). Mind perception: Real but not artificial faces sustain neural activity beyond the N170/VPP. *PLoS One, 6*(3): e17960. doi:1371/journal.pone.0017960

Zacchilli, T.L., Hendrick, C., & Hendrick, S. (2009). The Romantic Partner Conflict Scale: A new scale to measure conflict in dating relationships. *Journal of Social and Personal Relationships*, 1073-1096.

Zebrowitz, L.A. (2006). Finally, faces find favor. *Social Cognition, 24*(5), 657

Appendix

IRB APPROVAL LETTER

RESEARCH OFFICE

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DATE: October 10, 2014

TO: Erin Burdwood, B.S.
FROM: University of Delaware IRB

STUDY TITLE: [520453-6] ERP Correlates of Relationship Quality Factors in Individuals Processing Faces of Their Romantic Partners

SUBMISSION TYPE: Continuing Review/Progress Report

ACTION: APPROVED
APPROVAL DATE: October 10, 2014
EXPIRATION DATE: October 30, 2015
REVIEW TYPE: Expedited Review

REVIEW CATEGORY: Expedited review category # *(7)*

Thank you for your submission of Continuing Review/Progress Report materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure.

If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.