cortex 130 (2020) 302–317

Available online at www.sciencedirect.com

ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Special Issue "Understanding Others": Research Report

Impact of couple conflict and mediation on how romantic partners are seen: An fMRI study

Halima Rafi [a,e,*], *François Bogacz* [a,b], *David Sander* [a,c] and *Olga Klimecki* [a,c,d,**]

[a] *Swiss Center for Affective Sciences, University of Geneva, Geneva, Switzerland*
[b] *Computer Vision and Multimedia Laboratory, University of Geneva, Battelle Campus, Carouge, Switzerland*
[c] *Laboratory for the Study of Emotion Elicitation and Expression, Department of Psychology, University of Geneva, Geneva, Switzerland*
[d] *Laboratory for Behavioral Neurology and Imaging of Cognition, Department of Neuroscience, Medical School, University of Geneva, Geneva, Switzerland*
[e] *Department of Psychology, University of Geneva, Geneva, Switzerland*

ARTICLE INFO

Article history:
Received 31 October 2019
Reviewed 31 January 2020
Revised 30 March 2020
Accepted 27 April 2020
Published online 26 June 2020

Keywords:
fMRI
Conflict management
Couple satisfaction
Positive affect
Ventral striatum

ABSTRACT

Previous studies on romantic love have reported increased neural activity in the brain's reward circuitry such as the striatum. To date, the extent to which this activity is modulated by couple conflict in general and mediated couple conflict in particular, is unknown. The present study seeks to fill this gap by randomly assigning 36 romantic heterosexual couples to a mediated or non-mediated conflict discussion. Before and after the conflict discussion, self-reports and functional neuroimaging data in response to a picture of the romantic partner versus an unknown person were acquired. Self-reports indicate that mediation increases conflict resolution, satisfaction about the contents and process of the discussion and decreases levels of remaining disagreement. Pre-conflict neuroimaging results replicate previous studies on romantic love, showing activations in the striatum, insula, anterior and posterior cingulate gyrus, orbitofrontal cortex, hippocampus, temporal and occipital poles and amygdala when viewing the romantic partner versus an unknown person. The general effect of conflict on neural activations in response to the romantic partner across both conditions consisted of deactivations in the striatum, insula, thalamus, precuneus and ventral tegmental area. Small volume correction analyses revealed that participants in the mediated condition trended towards having greater activation in the nucleus accumbens than participants in the non-mediated condition when looking at the romantic partner versus the unknown after the conflict discussion. Parametric modulation analyses also revealed greater activity in the nucleus accumbens when viewing the romantic partner versus the unknown for participants who felt more satisfied after the conflict resolution. Our results illustrate that mediation improves conflict resolution and is

* *Corresponding author*. Swiss Center for Affective Sciences, University of Geneva, Chemin des Mines 9, 1202, Geneva, Switzerland.
** *Corresponding author*. Swiss Center for Affective Sciences, University of Geneva, Chemin des Mines 9, 1202, Geneva, Switzerland.
E-mail addresses: Halima.Rafi@unige.ch (H. Rafi), Olga.Klimecki@unige.ch (O. Klimecki).

https://doi.org/10.1016/j.cortex.2020.04.036

associated with increased activity in the nucleus accumbens, a key region in the brain's reward circuitry.

1. Introduction

Social connection is a basic human need that increases physical well-being (Brown, Nesse, Vinokur, & Smith, 2003), empathetic behaviors (Cialdini, Brown, Lewis, Luce, & Neuberg, 1997) and protects against mental illnesses such as depression (Hawkley, Masi, Berry, & Cacioppo, 2006). Intergroup and interpersonal relationships, such as romantic partnerships, are vulnerable to strong emotions, which, in turn, can lead to conflict-related behaviors (Halperin, 2015; Nair, 2008). In fact, early studies concluded that "to be in conflict is to be emotionally activated" (Jones, 2000). Chronic conflict in interpersonal relationships leads to increased negative affect, disregard, and disaffirmation between romantic partners (Abbey & Andrews, 1985), making the satisfactory resolution of conflict important for both social and mental well-being. Third-party mediation is a promising means to this end. This study uses behavioral and neuroimaging tools to examine how i) conflict affects the neural representation of romantic partners, and ii) how mediation impacts conflict resolution.

1.1. *Neural representations of romantic love*

When testing the biological underpinnings of romantic love, neuroimaging studies have shown increased activity in core regions of the dopaminergic reward system when viewing one's romantic partner versus a control stimulus. Control stimuli have varied in previous work ranging from a familiar neutral acquaintance (i.e., Acevedo, Aron, Fisher, & Brown, 2012; Aron et al., 2005; Fisher, Aron, & Brown, 2005; Xu et al., 2011; Younger, Aron, Parke, Chatterjee, & Mackey, 2010) and friends matched to the partner on gender, age, and relationship length (i.e., Bartels & Zeki, 2000), to erotic pictures, autobiographical pictures, and landscape pictures (Stoessel et al., 2011). The regions implicated in romantic love include the ventral striatum, caudate nucleus, putamen, ventral tegmental area (VTA) (Aron et al., 2005; Bartels & Zeki, 2000, 2004; Fisher et al., 2005; O'Doherty, 2004; Xu et al., 2011), nucleus accumbens (NAcc) (Acevedo et al., 2012; Younger et al., 2010) and the globus pallidus (Bartels & Zeki, 2000, 2004). Other areas that have been observed in relation to romantic and maternal love are the medial and lateral orbital prefrontal cortex (mOFC and lOFC, respectively) (Acevedo et al., 2012; Xu et al., 2011; Younger et al., 2010), both of which are associated with hedonic experiences and reward processing (Kringelbach & Berridge, 2009). Romantic love has also been associated with activations in the posterior cingulate cortex (Bartels & Zeki, 2000), which is also involved in attention, arousal, and pain regulation (for review see Medford & Critchley, 2010) and the insula (Bartels & Zeki, 2000; Ortigue, Bianchi-Demicheli, Hamilton, & Grafton, 2007; Stoessel et al., 2011), which is critical for interoception and emotion processing (e.g., Critchley, Wiens, Rotshtein, Öhman, & Dolan, 2004). The precuneus, a key component of the default mode network (for a review see van der Heuvel & Pol, 2010), is also involved in the neural presentation of romantic partners (Stoessel et al., 2011; Xu et al., 2012; Younger et al., 2010). Many of the regions implicated in romantic love also show increased activation in studies on positive affect, namely the mOFC, NAcc, putamen, pallidum, and VTA (Beauregard, Courtemanche, Paquette, & St-Pierre, 2009; Klimecki, Leiberg, Lamm, & Singer, 2013; Kringelbach & Berridge, 2009). However, this pattern of activation associated with romantic love is not ubiquitous: studies have also found decreases in the mOFC, precuneus, amygdala and the temporal loves in response to the romantic partner (Bartels & Zeki, 2000; Xu et al., 2011; Zeki, 2007). Moreover, one study looking at long-term romantic love found that participants who were still with their partners at 40 months after an initial assessment (as opposed to those who had separated) showed less activation during early-stage love in the medial orbitofrontal cortex (Xu et al., 2012). Zeki (2007) proposed that deactivations seen in the orbitofrontal lobe, temporal lobe and the precuneus when viewing the romantic partner signify the inhibition of critical judgements, which may be necessary for the initiation and continuation of a romance.

Studies on the neural correlates of romantic love found, in addition to increased activations in striatal areas associated with reward processing (Delgado, 2007; Samejima, Ueda, Doya, & Kimura, 2005), decreased activation in the amygdala, an area important for relevance detection (Sander, Grafman, & Zalla, 2003), when women viewed the face of their romantic partner compared to the face of opposite-sex friends whom they had known for the same duration as their romantic partner (Bartels & Zeki, 2000, 2004). The role of the amygdala remains unclear in maternal love, with studies showing decreased amygdala activation in women when viewing the face of their own child compared to the face of a same-aged child they were acquainted with (Bartels & Zeki, 2004) and others showing increased activation in children who saw their mother's face as compared to an unknowns' face (Tottenham, Shapiro, Telzer, & Humphreys, 2012) and in mothers who saw the face of their infants as compared an unknown child (Strathearn & Kim, 2013). While these studies shed light on how the brain represents important social ties such as romantic partnerships, it remains unknown how such representations are impacted by couple conflict. In addition, the impact of third-party mediation during conflict on the brains' representation of romantic partners has yet to be studied.

1.2. *Couple conflict and third-party mediation*

In order to reduce stress-related emotions and to strengthen constructive emotions in interpersonal interactions, mediation, which is a negotiation facilitated by a third party, can be employed (Bogacz, Pun, & Klimecki, 2020; Folger & Bush, 1994, 2005; Folger & Simon, 2017). Mediation is a relatively understudied tool in conflict resolution, with the majority of existing studies being in comparison to legal proceedings (Barough, Shoubi, & Preece, 2013; Brett, Barsness, & Goldberg, 1996; Shaw, 2010), without a proper control group (Kaiser & Gabler, 2014) or role-playing conflict instead of using real conflict (Jameson, Bodtker, Porch, & Jordan, 2009). The current state of research on mediation leaves room to improve on and there is a need for empirical randomized controlled studies to assess whether mediation is a viable tool for conflict resolution, as compared to other techniques such as negotiation, arbitration and legal proceedings. Interpersonal couple conflict, with its intense emotions, provides a suitable medium to assess the causal impact of a third-party mediator on conflict. In regard to romantic love, research suggests that the manner of argumentation is as important to marital well-being as the contents of the argument (Halford, Markman, Kline, & Stanley, 2003). Consequently, one important role of mediation is to provide structure for the discussion and to help manage negative emotions such as anger, frustration, and fear (Senft, 2015) and to reinforce positive emotions. By providing structure, mediators aim at controlling how the discussion unfolds in order to allow space for couples to pre-emptively make requests of each other for how to communicate, express themselves honestly, ask questions, take time to think through new information, and respond authentically without hostility (Senft, 2015). There are three main styles of mediation that are practiced today: evaluative, facilitative and transformative mediation (Zumeta, 2000). Evaluative mediation is often used in the judicial system where the third party voices their opinion and makes recommendations instead of focusing on the underlying interests of the involved parties. In facilitative mediation, mediators do not offer their own opinions but instead facilitate constructive and honest dialogue between parties so that they can reach their own solution together. Mediators structure the discussion but the parties themselves control the contents and the outcome. Lastly, transformative mediation is similar to facilitative mediation but aims for the more long-term effect of transforming destructive habits in both the parties and their relationship into constructive habits (Folger & Bush, 1994, 2005).

1.3. *Emotion intelligence and mindfulness*

The ability to resolve conflict has previously been linked to personality traits, and to emotional intelligence (EI) (Jordan & Troth, 2004) as well as to mindfulness (Wachs & Cordova, 2007). EI can be defined as the ability to recognize and understand the meanings of one's own and others' emotions, to reason and problem-solve on the basis of complex emotions, and finally, to manage emotions in oneself and others (Mayer, Salovey, & Caruso, 2000). Mindfulness is defined as a state of consciousness in which one is oriented to the present moment and pays nonjudgmental attention to experiences that unfold (Kabat-Zinn, 2003; Wachs & Cordova, 2007).

Couple studies show that perceiving one's partner to have a higher EI and not avoiding discussion of relationship problem is linked to higher relationship satisfaction (Smith, Heaven, & Ciarrochi, 2008) and couples with both partners low on EI tend to have high conflict and negative relationship quality (Brackett, Warner, & Bosco, 2005). In a conflict discussion paradigm, trait mindfulness was shown to predict lower emotional stress responses and positive change in perception of the relationship post-conflict and was related to better communication quality during the discussion (Barnes, Brown, Krusemark, Campbell, & Rogge, 2007). In addition, mindfulness has been shown to significantly help participants release negative emotions instead of dwelling on them (Brown, Goodman, & Inzlicht, 2013). However, to date, studies on conflict resolution between couples have not investigated if and how third-party mediation is related to trait mindfulness and emotional intelligence.

1.4. *The present study*

To test the impact of conflict and mediation on brain responses to romantic partners, we employed the design of a recent behavioral study of Bogacz and colleagues (Bogacz et al., 2020) and added a pre- and post-conflict neuroimaging task, modeled off of previous paradigms measuring brain responses to romantic partners compared to a neutral stimulus (Acevedo et al., 2012; Aron et al., 2005; Xu et al., 2011). The present study tested the following hypotheses on the behavioral level: first, in regard to conflict outcomes, we hypothesized that third-party mediation would result in more satisfactory conflict resolution and greater positive affect post-conflict as opposed to non-mediated conflict. Second, we hypothesized that greater trait EI and trait mindfulness would correlate with better conflict resolution outcomes, as measured by the satisfaction questionnaire. On the neural level, we tested the following four hypotheses: first, we hypothesized that the pre-conflict neuroimaging task would replicate results of previous studies on the neural representation of romantic partners. Second, we hypothesized that interpersonal conflict would change this neural representation of romantic partners such that there would be decreased activation in regions associated with romantic love, reward, and positive affect in both groups post-conflict as compared to pre-conflict. Third, we hypothesized that meditation as compared to no mediation during conflict would result in increased post-conflict activation in key brain areas associated with romantic love, such as the caudate nucleus, VTA, mOFC and the NAcc. Fourth, we hypothesized that participants who 1) felt more satisfied post-conflict and 2) rated themselves as feeling more positively during the post-conflict romantic partner rating task as compared to the unknown rating task, would also have greater activation in regions associated with romantic love, such as the caudate nucleus, VTA and the NAcc, when looking at their romantic partner as compared to an unknown post-conflict.

2. Materials and methods

2.1. Participants

18 heterosexual couples (mean age = 23.5 years, SD = 4.17, mean relationship duration = 2.6 years, SD = 1.60) participated in the control group and 18 heterosexual couples (mean age = 24 years, SD = 3.65, mean relationship duration = 2.6 years, SD = 1.38) participated in the mediated group. This sample size is in line with both previous research on romantic love (Acevedo et al., 2012; Xu et al., 2012) and general social neuroscience research (Lieberman, Berkman, & Wager, 2009). All couples were Caucasian with the exception of two couples of Arab descent, both of which were in the mediated group. Couples were randomly assigned to one of the two groups (mediation or control), matching both groups for age and length of relationship. Within the control group, 18 participants completed the fMRI task (mean age = 24.1 years, SD = 3.71, 11 females). Within the mediated group, 18 participants completed the fMRI task (mean age = 23.7 years, SD = 3.64, 9 females).

All inclusion and exclusion criteria were established prior to the start of the experiment. Volunteers were included if they had been in a romantic relationship for more than one year, if they spoke French or English fluently and if they were at least 18 years old. The mediators (7 in total, 4 females and 3 males) were members of the same professional mediation association (the Swiss Chamber of Commercial Mediation, Section Romande) and were selected based on their common understanding of mediation as a facilitative (as opposed to evaluative) approach to conflict resolution. Due to the scheduling complexities, the mediators could not be randomly assigned to their sessions but were allocated based on temporal availability. All participants were right-handed with normal or corrected-to-normal vision, and no history of neurological or psychiatric disease. Participants gave written informed consent and were paid for their participation. This study was approved by the federal Swiss Ethics Committee on research involving humans.

2.2. Questionnaires

All volunteers individually completed five online profiling questionnaires in French or English administered with Google Forms (Mountain View, CA, USA) before the start of the experiment: (1) the Dyadic Adjustment Scale (Heeren, Douilliez, Peschard, Debrauwere, & Philippot, 2011; Spanier, 1976) which measures the quality of the relationship and includes ratings of the level of disagreement on 15 recurring topics of conversation (see Supplementary Materials, Note S4), which were used to identify the topic of the conversation during the experiment; (2) the Profile of Emotional Competence (Brasseur, Grégoire, Bourdu, & Mikolajczak, 2013), which measures intrapersonal and interpersonal emotional competence, and served as a proxy for emotional intelligence, (3) the Five-Facet Mindfulness Questionnaire (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006), which measures the level of dispositional mindfulness, (4) the Inclusion of Other in the Self scale (Aron, Aron, & Smollan, 1992), which measures self-reported interpersonal closeness, and (5) the Positive and Negative Affect Schedule assessment (Crawford & Henry, 2004; Watson, Clark, & Tellegen, 1988), as a self-reported measure of affect.

2.3. Procedure

The behavioral task was modeled off of the paradigm used by Bogacz et al. (2020) and was conducted in the following stages (Fig. 1): all participants completed the Inclusion of Other in the Self scale (Aron et al., 1992) and the Positive and Negative Affect Schedule assessment (Watson et al., 1988). Then, member one of the couple (illustrated by the red line in Fig. 1) completed the functional magnetic resonance imaging (fMRI) task. During this time, member two of the couple (illustrated by the blue line in Fig. 1) completed two economic distribution decision-making tasks on a computer (the Ultimatum Game and the Dictator Game, detailed in Rafi, Bogacz, Sander, & Klimecki, 2020). Couple members were randomly assigned to either the fMRI or the decision-making task, except in two cases where the couple member assigned to the fMRI task was unable to complete it because of counterindications to fMRI. In these cases, we reassigned the fMRI task to the other couple member who did not have counterindications to fMRI. Then couples reunited for the mediated or non-mediated conflict discussion. Couples were directed into a private room equipped with video-cameras, which were used to record facial and body expressions of each participant (and mediator if applicable) throughout the conflict. At the beginning of the discussion couples were asked to choose one topic of recurrent disagreement together, discuss it for a maximum of 60 min and try to find a solution to their disagreement. Immediately after the discussion, satisfaction was self-assessed by the couple and, in the mediated group, also by the mediator. The Satisfaction Questionnaires measured 1) the existence of an agreement or not, assessed on a binary scale (yes or no), 2) the level of satisfaction concerning the contents and process of the conflict resolution, assessed on an 11-point scale from 0 (very unsatisfied) to 10 (very satisfied) and 3) the level of disagreement remaining between parties at the end of the discussion, assessed using a 11 point scale from 0 (very low) to 10 (very high). Finally, both members independently filled out the 7-point Inclusion of Other in the Self scale (Aron et al., 1992) and Positive and Negative Affect Schedule (Watson et al., 1988) again, before member one repeated the fMRI task while member two repeated the decision-making tasks.

Mediators were privately instructed before the experiment on how to lead the conversation in the mediated condition (for details please see Supplementary Materials, Note S1). In the non-mediated group, minimal written guidelines were given to the couples prior to the start of the conversation in order to introduce some structure in the discussion (see Supplementary Materials, Note S2). In order to control for the presence of a third person as in Bogacz et al. (2020), a silent third person was always present in the same room and a mediator listened to the conversation via Skype. The mediator was invisible and silent to the parties until the debrief. Couples were informed that the mediator would be listening online and that a third party would be in the room with them but would not be listening or in any way involved with the discussion. Couples could only see the back of the third party, who sat at a different table and wore headphones during the entirety of

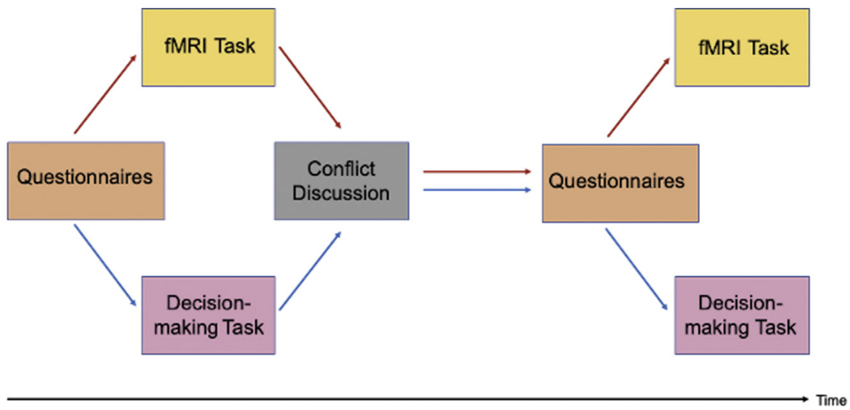

Fig. 1 – Depiction of the study timeline. The red line indicates the tasks completed by member 1 of the couple and the blue line indicates the tasks completed by member 2. The conflict was either mediated by a third party or was done in the presence of a silent third party and a silent mediator (who was present via Skype).

the conversation. The reason why we needed the invisible presence of a mediator was that the experimenter was not a mediator herself and would not have been able to intervene and moderate the discussion if it was becoming too heated between the couple members. This was never necessary. At the end of both mediated and non-mediated experiments, after the collection of all data, the mediator helped to reduce any remaining levels of tension between the participants and provided contact information of a local mediation center for further follow-up on the topic of disagreement to all couples, should it be needed.

The Positive and Negative Affect Schedule was filled out on a computer in the lab and a technical issue made that data prior to the conflict discussion was not collected properly for three participants, who were thus excluded from analyses involving the Change in Positive Affect and Change in Negative Affect. Two couples who did not fill out properly the Satisfaction Questionnaires were excluded from analyses involving the Satisfaction about the Contents and the Satisfaction about the Process of the discussion. One participant who did not fill out properly the Inclusion of Other in the Self was excluded from analyses involving the Inclusion of Other in the Self at the end of the conversation.

2.4. *Paradigms*

The neuroimaging task consisted of photographs of the romantic partner's face, rating tasks, a null condition, count-back tasks and an unknown's face, which served as the control stimulus. While in previous studies participants were shown the face of opposite-sex acquaintances (Acevedo et al., 2012; Aron et al., 2005) or close friends (Bartels & Zeki, 2000) as the control stimulus, the present study used photographs of an opposite-sex, unknown person in order to better control for differences in photo quality and size, level of attractiveness and facial expression and angle, all of which can impact neural activation (Kesler-West et al., 2001; Posamentier & Abdi, 2003; Sato, Yoshikawa, Kochiyama, & Matsumura, 2004), between the romantic partner and control stimulus. 6 close-up photographs of the romantic partner's face (i.e., the couple member partaking in the decision-making task) were taken upon the participants' arrival to the lab using a Nikon D5000 camera. To avoid habituation, the photos consisted of two different expressions, smiling and neutral, at three different angles, looking straight ahead, 45° to the left and 45° to the right. The photographs of the unknown's face were obtained from a database, the Karolinska Directed Emotional Faces (KDEF) (Lundqvist, Flykt, & Öhman, 1998). For each couple, 6 pictures of a same-sex unknown individual's face, also with smiling and neutral expressions at three different angles, who was approximately the same age and attractiveness as the romantic partner were used. To control for attractiveness, 4 independent parties (2 females and 2 males) rated the pictures of each romantic partner and the unknown on individual attractiveness to ensure that the unknown individual was not too different to the romantic partner in attractiveness. 6 sequences (Fig. 2) were pseudorandomized and repeated 4 times such that the neuroimaging task consisted of 24 sequences in total. Each fMRI session was split into 2 runs (12 sequences). Each sequence consisted of a picture of the romantic partner's and unknown's face, which were shown for 7 s each. In general, each sequence showed the romantic partner's face, which was followed by a null screen and a count-back task, and an unknown's face, which was followed by a null screen. Each run included two rating tasks. For each run there was one rating task for the romantic partner and one for the unknown, after the null condition (always looking straight ahead with neutral expression). During the rating tasks, participants used a button box with their right hand to rate how they felt after seeing either the previous photograph (either the romantic partner's face or the unknown's face) on a continuous, 11-point scale from "frowny face" to a "smiley face". As shown in Fig. 2, the ratings tasks were always presented with a neutral rating which the participant would then move towards the frowny face or smiley face. The rating tasks did not have a time limit. The null condition was jittered between 3 and 4 s. During the count-back tasks, participants were shown a random 4-digit number and asked to count backwards in increments of 3 until the number disappeared. A countback task followed the

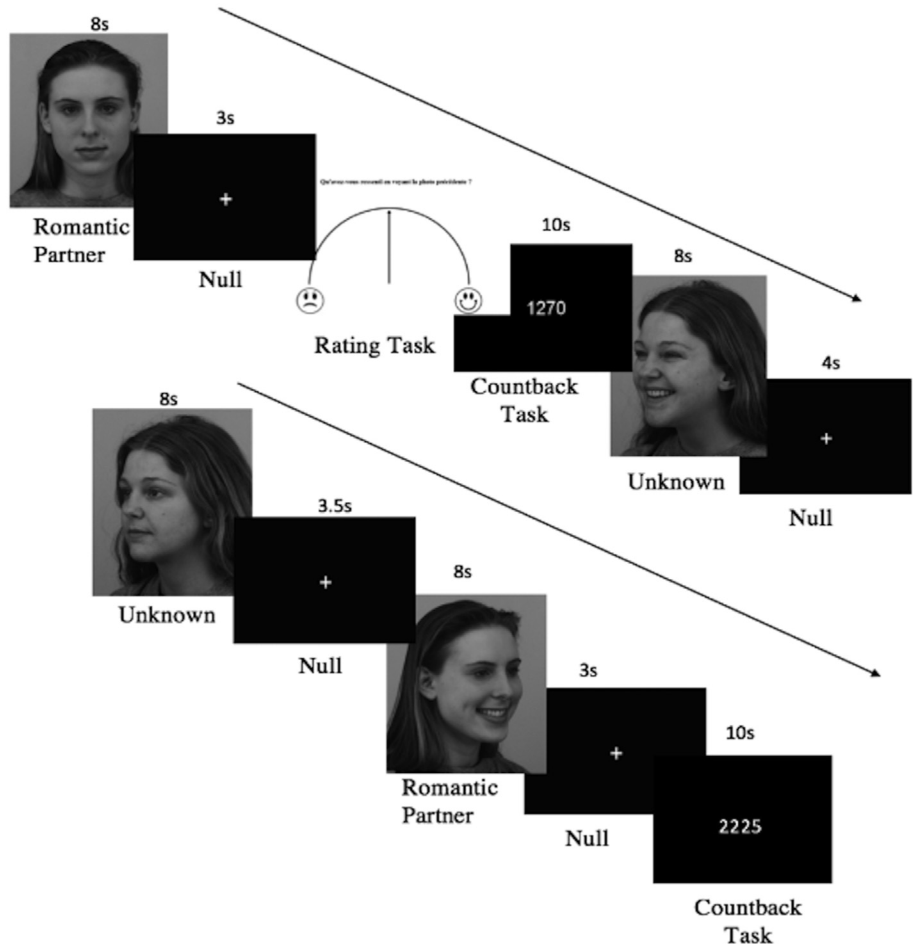

Fig. 2 – Two example fMRI sequences. To guard participant confidentiality, the faces shown are from the Karolinska Directed Emotional Faces (KDEF) database (Lundqvist et al., 1998). Top: the romantic partner's face was shown first (with a "neutral" expression, looking straight ahead), then the null condition, a rating task, the countback task, the unknown's face (smiling, at a 45° angle to the left), followed by another null screen; Bottom: the unknown's face (with a "neutral" expression at a 45° angle to the left) was shown first, followed by a null screen, the romantic partner's face (smiling at a 45° angle to the right), another null screen and a count-back task.

presentation of the romantic partner's face except for in sequences containing a romantic partner rating task, in which case the countback task was presented after the rating task. In line with previous studies, the countback task lasted 10 s and served as a distractor to avoid carry-over effects of neural activity elicited from the romantic partner's face (Acevedo et al., 2012; Aron et al., 2005; Xu et al., 2011). After the first run, there was a short pause during which the participant's comfort inside the scanner was checked. Each run lasted approximately 8 min.

2.5. *fMRI data acquisition and analyses*

Functional images were obtained with a 3 T MRI scanner (Trio Tim, Siemens, Germany) with a single-shot gradient-echo T2*-weighted EPI sequence (36 slices, matrix size 64 × 64, voxel size = 3.2 × 3.2 × 3.2 mm^3, slice gap = .96 mm, flip angle $\alpha = 80°$, TR = 2100 msec, TE = 30 msec), using a 32-channel phased array coil. Structural images were acquired with a T1-weighted sequence (3D MPRAGE, 256 × 256 × 192 voxels, voxel size = 1.0 mm isotropic, flip angle $\alpha = 9°$, TR = 1900 msec, TI = 900 msec, TE = 2.27 msec, phase oversampling 15%, slice oversampling 16.7%). A susceptibility weighted imaging (SWI) sequence was also acquired. Dummy scans were taken and discarded before the beginning of the first experimental sequence to allow for the stabilization of the magnetic field inside the scanner. SPM12 (http://www.fil.ion.ucl.ac.uk/spm) was used to preprocess and analyze the functional images (http://www.fil.ion.ucl.ac.uk). Functional images were manually reoriented to put the anterior commissure at the origin of the coordinate system (0, 0, 0) and realigned to the mean image of each session. Functional images were then co-registered using each participant's structural T1 scan as the reference image and the mean functional image as the source image, segmented and spatially normalized to the standard Montreal Neurological Institute (MNI) EPI template. Finally, functional images were smoothed using an 8 mm full width at half-maximum (FWHM) Gaussian kernel. General linear models (GLM) and parametric modulations of rating tasks and results of the satisfaction questionnaire were implemented using SPM12. In order to control for habituation, the present study used photographs displaying the romantic partner and unknown person in 2 different expressions (smiling and neutral) and 3 different angles (looking straight ahead, 45° to the right and 45° to the left). To model the data on the first (within subject) level, hemodynamic responses for the entire duration of each event (i.e., the romantic partners' face, unknowns' face, null condition, rating task and countback task) were modelled. More specifically, each angle (looking straight ahead, 45° to the right and 45° to the left) and expression (neutral or smiling) of the romantic partners' face and the unknowns' face were modelled separately and convolved using a standard hemodynamic response function. First-level GLMs for each participant were computed in a single design matrix using the pre-conflict session, which encompassed runs 1 and 2, and the post-conflict session, which encompassed runs 3 and 4. Movement parameters estimated during realignment (x, y, z translations and pitch, roll, and yaw rotations) as well as four constant vectors, corresponding to the two runs within the pre-conflict session and the two runs within the post-conflict session, were included in the matrix as variables of no interest. When assessing differences in brain responses to all combinations of the different angles and expressions, results revealed no significant difference in activation in regions previously associated with romantic love at the whole brain level between angles for the romantic partner or unknown (see section 3.3. Neuroimaging Results). Subsequently, we grouped all three angles for further analysis. Separate contrasts were made for neutral, smiling and combined (neutral and smiling) expressions for the pre- and post-conflict data, as well as for post-conflict minus pre-conflict data. Pre- and post-conflict contrasts included the following: (a) romantic partner – unknown, (b) romantic partner – null condition, (c), romantic partner – rating tasks, (d) unknown – romantic partner, (e) unknown – null condition, (f), unknown – rating tasks. The post-conflict minus pre-conflict contrasts included the following: (a) (romantic partner post – unknown post) – (romantic partner pre – unknown pre), (b) (unknown post - romantic partner post) – (unknown pre – romantic partner pre).

The resulting individual maps of *t*-statistics were fed into a full factorial design on the second level with one factor, "Group" (2 levels: mediated and non-mediated) with unequal variance and assumed independence. Statistical comparisons between conditions were performed by standard whole-brain analyses with one-sample *t*-tests, analyses of variance, and linear regressions in SPM. For all manipulation checks, whole-brain analyses had significance levels set to $p < .05$ FWE-corrected at the peak level, with a cluster extent of $k = 5$. In line with previous research suggesting that cluster-level thresholding with a FWE correction of $p < .05$ better allows the study of robust effects in affective and social neuroscience, which can be more subtle compared to basic motor and

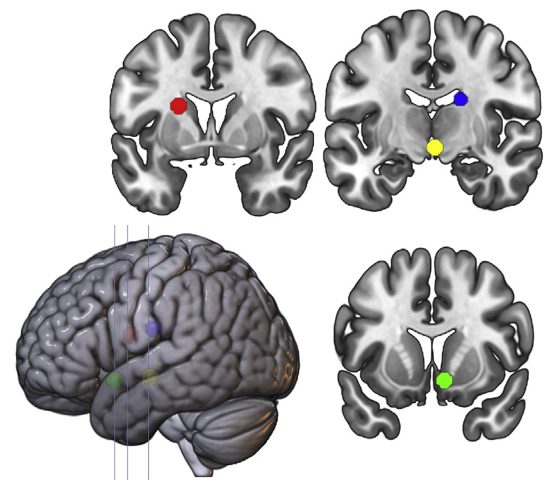

Fig. 3 – Region of interest mask. Hypothesis-driven analyses were carried out using 4 regions of interest. Regions of interest were combined in one joint mask and are as follows: blue is the right posterior caudate body; red is the left anterior caudate body; green is the right NAcc; yellow is the right VTA.

visual effects (Lieberman & Cunningham, 2009), all subsequent whole brain analyses had a significance level set to a cluster-level threshold of $p < .05$ FWE-corrected. Similarly, in order to study effects related to affective and social phenomena, we followed the lead of previous studies on romantic love by using small volume correction (SVC) analysis using a sphere as a region of interest on a priori regions associated with romantic love. Small volume extraction was performed using the Marsbar toolbox within SPM 12. Four regions of interest were chosen based on previous research on romantic love (Acevedo et al., 2012): the NAcc, anterior caudate body, posterior caudate body and VTA (Supplementary Table A). Peak coordinates for each sphere were based on previous neuroimaging studies on early-stage romantic love as depicted in Table 1 in the 2012 paper by Acevedo and colleagues (Acevedo et al., 2012). All spheres had a radius of 5 mm and, to control for multiple comparisons, all spheres were combined to create one joint mask with four regions of interest (Fig. 3).

2.6. *Statistical analysis of behavioral data*

On the behavioral level, we tested the following 5 hypotheses to assess in how far mediation can have an impact on couple conflict as compared to no mediation: mediation would result in i) more agreements obtained on the topic of discussion, ii) increased Satisfaction about the Contents of the discussion and increased Satisfaction about the Process of the discussion,

Table 1 – Group differences in levels of conflict across 15 different topics as measured by the Dyadic Adjustment Scale prior to the conflict discussion.

	Control Group		Mediation Group		Independent *t*-tests to assess between group differences		
	Mean	SD	Mean	SD	t	df	*p*
Average Level by Couple	2.05	.65	1.90	.41	.80	34	.43
Maximum Level by Couple	3.84	1.34	3.94	1.05	−.28	34	.78

iii) decreased Level of Disagreement after the discussion, iv) increased self-reported positive affect and decreased self-reported negative affect, and v) increased interpersonal closeness after the conversation. In line with current practices about dyadic data analysis (Kenny, Kashy, & Cook, 2006), we first analyzed the Pearson correlation between couple members to determine whether data were independent between couples. When there was an independence of data between the couple members (as indicated by a p value $\geq .20$ for Pearson correlations between couple members), we analyzed the data using each participant as a unit of analysis in analysis of variance (ANOVA) or Multivariate Analysis of Variance (MANOVA). When there was non-independence of data (as indicated by a p value $< .20$ for Pearson correlations), a hierarchical linear model (HLM) analysis was employed with gender (men and woman) as a level-1 predictor variable, and group (mediation and control) as a level-2 predictor variable. All questionnaire data was analyzed using IBM SPSS 25 software (Armonk, NY, USA).

3. Results

3.1. Baseline group differences

3.1.1. *Testing for differences between the mediated and the non-mediated group*

To test whether the mediated and non-mediated groups differed in their perception of the romantic partner before and after the conflict we conducted paired-sample t-tests on the average rating of the romantic partner and the average rating of the unknown before and after the discussion. Results revealed that the average rating of the romantic partner was higher than the average rating of the unknown both pre- and post-conflict for both groups (for details, please refer to Supplementary Materials, Note S3).

To test whether the mediated and non-mediated groups were similar in regard to baseline characteristics as assessed by questionnaires, independent t-tests were conducted with condition as a factor and Dyadic Adjustment Score, Mindfulness and Emotional Competence as dependent variables. As shown in Supplementary Materials, Table B, independent sample t-tests revealed that groups did not differ in Dyadic Adjustment Score, Mindfulness and Emotional Competence (all $t \leq .63$ and all $p \geq .53$). Couples chose their topic of conflict from 15 general topics outlined in the Dyadic Adjustment Score (see Supplementary Materials, Note S4). The original topic of discussion chosen by the couples was the one for which the average level of disagreement, which was rated on a scale from 1 = Always Agree to 6 = Always Disagree, was the highest (both couple members scored the topic high) or one where there was an apparent disagreement on the score (one couple member scored low, the other scored high). To assess group differences, we first calculated the Average and Highest level of the disagreement for each participant across the 15 possible topics. The calculation of Pearson correlation coefficients (Alferes & Kenny, 2009) revealed that the Average level and the Highest level were not independent between couple members (both $p \leq .001$). We thus calculated the Average Level of disagreement by couple and the Highest Level of disagreement by couple. Independent t-tests did not show any difference between the control and mediation conditions for the Average Level by couple [$t(34) = .80$, $p = .43$] and the Highest Level by couple [$t(34) = -.28$, $p = .78$] (Table 1). Furthermore, although the means for the Average Level by couple indicated that the overall level of disagreement between couple members was quite low across both conditions, the Highest Level was 3.84 in the non-mediated condition, and 3.94 in the mediated condition, indicating that both groups had at least one topic for which they had moderate-to-large disagreements.

3.1.2. *Correlations between baseline measures*

To test to what extent age and Dyadic Adjustment Score, Mindfulness or Emotional Competence were interrelated, we conducted Spearman correlations (age and Dyadic Adjustment Score were not normally distributed). Emotional Competence was positively correlated with the Dyadic Adjustment Score ($r_s = .25$, $p = .038$). All other correlations were not significant (all $r_s \leq .12$ and all $p \geq .30$). To test to what extent Mindfulness and Emotional Competence were interrelated, we conducted Pearson correlations that showed that they were positively correlated ($r = .65$, $p < .001$).

In summary, participants who had greater emotional competency felt better adjusted within their romantic relationship and were more mindful.

3.1.3. *Relation between age, baseline personality traits and variables related to the conflict*

To test how far dispositional mindfulness, emotional competence and couple adjustment (Mindfulness, Emotional Competence and Dyadic Adjustment Score) and age were related to the outcome variables of the conflict discussion (Change in Positive Affect, Change in Negative Affect, Satisfaction about the Contents of the discussion, Satisfaction about the Process of the discussion, Inclusion of Other in the Self after the discussion and Level of Disagreement after the discussion), we conducted Spearman correlations (for age and Dyadic Adjustment Score, that were not normally distributed) and Pearson correlations (for Mindfulness and Emotional Competence). Age positively related to the Change in Positive Affect ($r_s = .26$, $p = .03$), meaning that the older participants were, the greater their change (post-versus pre-conflict) was in positive affect, as measured by the PANAS. To investigate whether gender had an impact on outcome variables, we conducted independent t-tests which revealed no significant difference between gender (all $t \leq .9$ and all $p \geq .13$). For further details on the relationships between personality traits and outcome variables, please refer to Supplementary Materials, Note S5.

3.2. *Effects of mediation on outcomes related to the conflict discussion*

On the behavioral level, the main aim of the study was to test the effects of mediation on conflict-related outcomes including the existence of an Agreement after the discussion, the Satisfaction about the Contents and the Process, the Level of Disagreement after the discussion and the Inclusion of Other in the Self after the discussion. To test the impact of mediation on the existence of an Agreement at the end of the

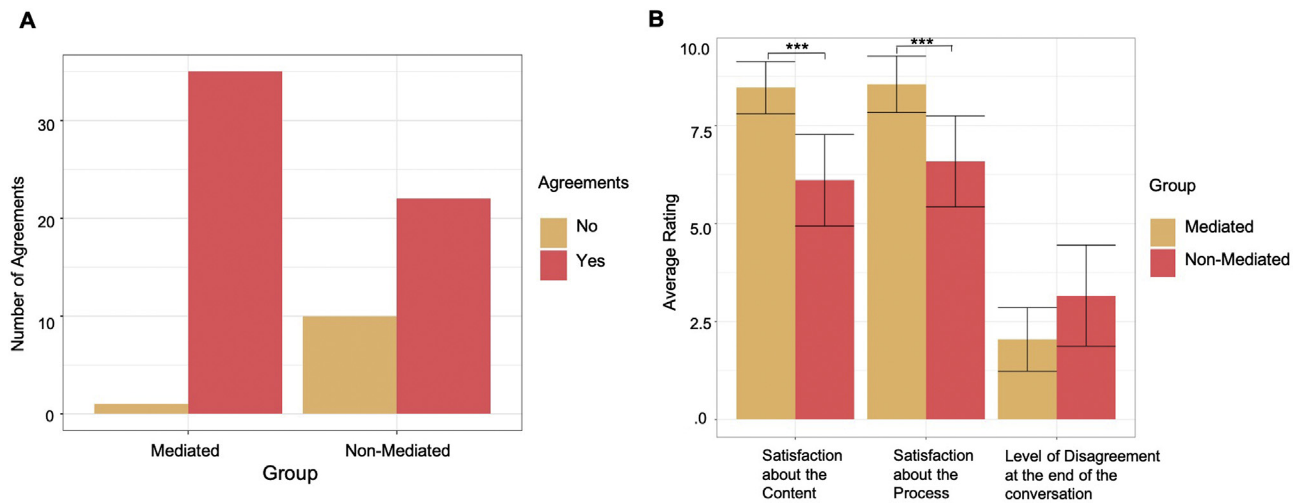

Fig. 4 – Results of the Satisfaction Questionnaire. (A) The mediated group had a significantly higher number of reached agreements (the binary variable 'Number of agreements' was measured by asking: "Did you reach an agreement?" Yes/No) and (B) was significantly more satisfied with the content and the process of the discussion and had significantly lower levels of disagreement post-discussion as compared to the non-mediated group. Error bars indicate one standard deviation from the mean. * indicates $p < .001$.**

discussion, a chi-squared test was conducted. This test revealed that the mediated group had a significantly higher number of agreements than the non-mediated group [$X^2(1) = 10.13$, $p < .05$] (Fig. 4A), which is in line with previous findings (Bogacz et al., 2020).

Pertaining to the Change in Positive Affect, Change in Negative Affect, Inclusion of Other in the Self after the conversation, the Satisfaction about the Contents of the discussion, the Satisfaction about the Process of the discussion and the Level of Disagreement after the discussion, the calculation of Pearson correlation coefficients revealed that these variables were not independent across couple members (all $p \leq .12$). We thus conducted HLM analyses on the following outcome variables: i) Change in Positive Affect, ii) Change in Negative Affect, iii) Inclusion of Other in the Self after the conversation, iv) Satisfaction about the Contents of the discussion, v) Satisfaction about the Process of the discussion and vi) Level of Disagreement after the discussion , For each of those HLM analyses we used gender of couples (men or women) as a repeated measure level 1 variable and group (mediation or control) as a level 2 variable. We also tested several models, starting with fixed effects only, then including random intercepts at the couple level, then testing different covariance structures (compound symmetry and heterogeneous compound symmetry) and, when relevant, based on the above reported correlation of Dyadic Adjustment Score with the outcome measures (the Inclusion of Other in the Self after the conversation, the Satisfaction about the Contents of the discussion and Level of Disagreement after the discussion), adding this variable to the model or in a similar way, adding age for the Change in Positive Affect. We compared the fit of the models by using a chi-square test of the significance of the change in -2LogLikelihood (-2LL) when changing the number of parameters in the models (Field, 2013) (see Supplementary Tables C, D, E and F). We thus computed the basic model and then, when relevant, we also report the model with the best fit. Pertaining to the Satisfaction about the Contents of the discussion, as depicted in Fig. 4B and in line with previous findings (Bogacz et al., 2020), the first HLM model used was the best fit and showed that mediation increased the Satisfaction about the Contents of the discussion [$b = 2.36$, $F(4,34) = 21.72$, $p \leq .001$]. Using heterogeneous compound symmetry, which allows for different variances for men and women, did not improve the model.

Pertaining to the Change in Positive Affect, the first HLM model showed no significant impact of condition on the Change in Positive Affect [$b = -.26$, F (4, 32.7) = .02, $p = .88$]. Adding age into the HLM model did not improve the fit and still did not show any significant effect of condition [$b = -.51$, F (5, 34.88) = .10, $p = .75$], while age tended to have an effect [$b = .38$, F (5, 63.93) = 2.90, $p = .094$]. Pertaining to the Change in Negative Affect, the first HLM model showed no significant impact of condition on the Change in Negative Affect [$b = -.24$, F (4, 34.47) = .023, $p = .88$].

Pertaining to the Satisfaction about the Process of the discussion, the first HLM model showed that mediation increased the Satisfaction about the Process of the discussion [$b = 1.91$, F (4, 34) = 19.82, $p \leq .001$]. In the HLM model with the best fit (a change of 5.1 in -2LL for a change of 1 in degrees of freedom compared to the original model, which is significant with $p < .05$), the following were found to have a significant effect on the Satisfaction about the Process of the discussion: use of mediation [$b = 1.91$, F (5, 33.95) = 21.85, $p < .001$], and the Dyadic Adjustment Score [$b = .032$, F (5, 43.65) = 5.63, $p = .022$]. Adding an interaction between condition and the Dyadic Adjustment Score did not improve the model [$p = .17$ and no change in 2LL]. Using heterogeneous compound symmetry did not improve the model either.

Pertaining to the Inclusion of Self in the Other at the end of the conversation, the first HLM model did not show any effect of mediation on the Inclusion of Self in the Other at the end of the conversation ($p = .63$). However, in another model, the following were found to have a tendency to have an effect on the Inclusion of Self in the Other at the end of the conversation: use of mediation [$b = -2.94$, F (6, 52.6) = 2.83, $p = .0.98$] as well as the Dyadic Adjustment Score [$b = .18$, F (6, 55.6) = 3.3, $p = .0.74$] and the interaction between the condition and the Dyadic Adjustment Score [$b = .02$, F (6, 52.95) = 3.1, $p = .0.84$], such that higher Dyadic Adjustment Scores were related to higher levels of Inclusion of Self in the Other. Using heterogeneous compound symmetry did not improve the model.

Pertaining to the Level of Disagreement after the discussion, the first HLM model showed that mediation had a tendency to decrease the Level of Disagreement after the discussion [$b = -1.13$, F (4, 34) = 3.68, $p = .063$]. In the HLM model with the best fit (a change of 5.1 in -2LL for a change of 1 in degrees of freedom compared to the original model, which is highly significant with $p < .001$), the following effects on the Level of Disagreement after the discussion were observed: a trend for the use of mediation [$b = -1.03$, F (5, 34.04) = 3.80, $p = .059$] and a significant effect of the Dyadic Adjustment Score [$b = -.05$, F (5, 56.15) = 11.41, $p < .001$]. There was no interaction between the condition and the Dyadic Adjustment Score ($p = .64$ and no change in 2LL). Using heterogeneous compound symmetry did not improve the model.

No relationship was found between couple members' ratings and the mediators' ratings of either the Satisfaction about the Contents or the Satisfaction about the Process of the discussion (for details, please refer to Supplementary Materials, Note S6).

In summary, the mediated group was better able to resolve their conflicts and was more satisfied with the contents and the process of the discussion as compared to the non-mediated group. The mediated group also had a tendency towards having lower levels of disagreement post-conflict as compared to the non-mediated group. Participants who were older had a tendency to feel more positively after the conflict as compared to before the conflict. Similarly, participants in the mediated group and participants who felt better adjusted within their romantic couple, as measured by the total Dyadic Adjustment Score, had a tendency to feel closer to their romantic partner post-conflict than those in the non-mediated group and those who felt less well-adjusted within their romantic couple. No other significant effects were found.

3.3. Neuroimaging results

3.3.1. Manipulation checks

Manipulation checks confirmed greater activation in the precentral gyrus, postcentral gyrus and supplementary motor area contralateral to the hand used during rating tasks as compared to all other events ($p < .05$ FWE-corrected; see Supplementary Table G for a full list of regions). Similarly, when viewing faces as compared to all other events, participants had increased activation in the fusiform face gyrus and occipital cortex ($p < .05$ FWE-corrected; Supplementary Table H). Effects of different facial angles and expressions can be found in Supplementary Materials, Note S7.

3.3.2. Pre-conflict neuroimaging results

We first aimed to replicate the results of previous studies on the neural representation of romantic partners by testing the pre-conflict scans of the contrast (Romantic partner - unknown) for smiling, neutral and all expressions and all groups. We restricted the search volume to a priori defined regions of interest (Supplementary Table A) by using SVC with an FWE-corrected significance threshold of $p < .05$. SVC analysis for the pre-conflict contrast (Romantic partner − unknown) for smiling expressions revealed activations in the NAcc [x = 11, y = 13, z = −6, Z = 3.07, $p < .05$ FWE-corrected]. SVC results for the pre-conflict contrast (Romantic partner − unknown) for all expressions and for neutral expressions revealed no suprathreshold activity in any of our regions of interest.

Subsequent whole brain analyses for the contrast (Romantic partner − unknown) for all facial expressions (smiling and neutral) revealed activations in regions previously associated with romantic love (the mOFC, NAcc, precuneus and bilateral putamen) (Fig. 5) (for details, please refer to Supplementary Materials, Note S8, Tables I–K). As previous research showed an impact of different facial expressions on brain activation (Kesler-West et al., 2001; Posamentier & Abdi, 2003; Sato et al., 2004), we conducted whole-brain analyses for the pre-conflict contrast (Romantic partner-unknown) for smiling and neutral faces separately. As described in Supplementary Materials Note S8 and as shown in Supplementary Tables J and K, these contrasts also revealed regions associated to romantic love, albeit with variations (e.g., mOFC and precuneus for smiling expressions and Nacc and anterior insula for neutral expressions). Consequently, we always added a separate analysis for smiling and neutral expressions, in addition to the analysis of all expressions (smiling and neutral together) in our following contrasts of interest.

In summary, our pre-conflict results show a pattern of activation previously associated with romantic love and

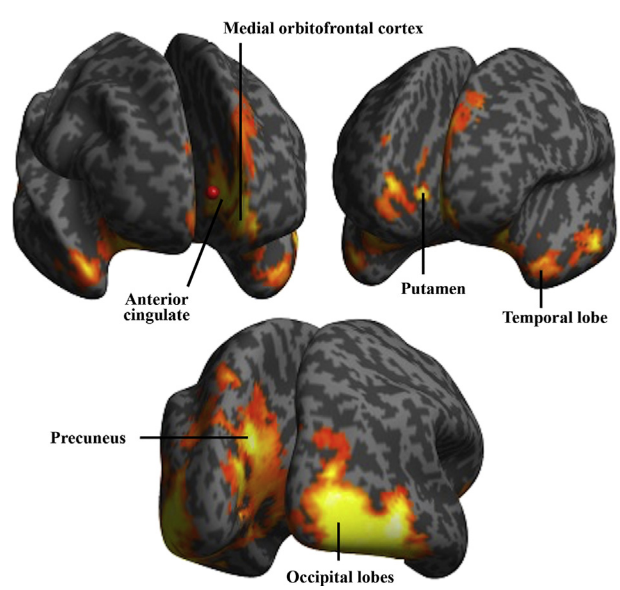

Fig. 5 — Pre-conflict whole brain activations for the contrast (Romantic partner − unknown) for all expressions and groups, $p < .05$ FWE-corrected.

reward, that includes the mOFC, precuneus, NAcc and bilateral putamen.

3.3.3. *Effects of conflict on the neural representation of romantic partners*

Next, we analyzed whether interpersonal conflict resulted in increases in brain activity when looking at the romantic partner versus the unknown, post-conflict minus pre-conflict, for all expressions, smiling expressions and neutral expressions across both mediated and non-mediated groups. We found no significant results using SVC analyses on a priori regions (Supplementary Table A) nor on the whole brain level. We then assessed whether conflict resulted in deactivations when viewing the romantic partner as compared to the unknown, post-conflict as compared pre-conflict, for all expressions across both groups. SVC analysis for this contrast revealed significant deactivations in regions associated with romantic love, namely the VTA and posterior caudate body (Table 2) (for whole-brain results for all expressions please refer to Supplementary Materials, Note S9, Table L. No activation was seen for only smiling or only neutral facial expressions). In summary, participants in all groups showed decreased activation in regions associated with romantic love, namely the VTA and caudate body post-conflict as compared to pre-conflict.

3.3.4. *Effect of mediation on post-conflict brain activations*

To test whether the mediated group had greater activation in regions associated with romantic love as compared to the non-mediated group after the conflict, we compared post-conflict brain activations when seeing the romantic partner versus the unknown between groups. SVC analysis (Supplementary Table A) on the contrast (Romantic partner post-conflict − unknown post-conflict) for smiling expressions, for the mediated group minus the non-mediated group, revealed a trend for the mediated group to have greater activity in the NAcc compared to the non-mediated group post-conflict (x = 8, y = 10, z = −8, Z = 2.66, $p = .064$ FWE-corrected). No significant activation was seen in any other of our a priori regions. No significant activation was seen in any a priori region for the contrast (Romantic partner post-conflict − unknown post-conflict) for smiling expressions, non-mediated group minus mediated group. SVC analysis for the same contrast using all expressions and neutral expressions revealed no suprathresholds at any of our regions of interest (for whole-brain results, please refer to Supplementary Materials, Note S10).

In summary, the mediated group, as compared to the non-mediated group, trended towards having greater activity in the NAcc, an important region of the brain's reward circuitry, when looking at their romantic partner compared to an unknown.

Table 2 − SVC deactivations for the contrast [(Romantic partner post-conflict − unknown post-conflict) - (romantic partner pre-conflict - unknown pre-conflict)], for all expressions and all groups.

Brain Region	Talairach Coordinates			
	x	y	z	Z
Right Ventral Tegmental Area	4	−16	−6	3.72
Right Caudate Body, posterior	14	−16	20	4.96

Note. $p < .05$ FWE-corrected.

3.3.5. *Relationship between post-conflict brain activations and conflict outcomes*

To test to what degree post-conflict brain activations were related to our behavioral measures of successful conflict resolution (Satisfaction about the Contents and Process of the discussion and Level of disagreement after the discussion) we conducted a series of parametric modulation analyses using the results of the satisfaction questionnaire.

SVC analyses revealed a significant positive correlation between activation in the NAcc and post-conflict Satisfaction about the Process of the discussion (x = 4, y = 13, z = −9, Z = 2.87, $p < .05$ FWE-corrected) and a trend for a positive correlation between activation in the NAcc and increased post-conflict Satisfaction about the Contents of the discussion (x = 4, y = 13, z = −9; Z = 2.75, $p = .051$, FWE-corrected) for the contrast (Romantic partner − unknown), smiling expressions across both groups. None of our other regions of interest showed suprathreshold voxels. No regions of interest had suprathreshold voxels for same contrast using only neutral expressions nor all expressions. Parametric analyses revealed no significant results at the whole brain level ($p < .05$, FWE-corrected), across both groups and using all expressions, only smiling expressions and only neutral expressions.

To test whether the in-scanner ratings of affect towards the romantic partner correlated with activity in regions previously associated with romantic love, we conducted parametric analyses using the pre- and post-conflict results of romantic partner rating task minus the unknown rating task. SVC analysis revealed that the post-conflict difference between the ratings for the romantic partner and the unknown person and activation in the NAcc trended towards significance (x = 8, y = 13, z = −6; Z = 2.52, $p = .089$, FWE-corrected), for the contrast [Romantic partner − unknown], smiling expressions. None of our other regions of interest showed suprathreshold activations. No regions of interest had suprathreshold activations for the contrast [Romantic partner − unknown], neutral or all expressions. No relationship between pre-conflict activation and the results of the rating tasks was found for the contrast [Romantic partner − unknown] for all, smiling or neutral expressions.

In summary, participants who were more satisfied with the process of the discussion had greater activation in the NAcc when viewing their romantic partner as compared to an unknown post-conflict. Participants who were more satisfied with the contents of the discussion trended towards the same result. Finally, participants who had a larger difference between the post-conflict rating of the romantic partner versus the unknown person also trended towards having greater activity in the NAcc post-conflict.

4. Discussion

The present study had several aims. On the behavioral level, we wanted to test the impact of third-party mediation on conflict resolution in romantic couples. On the neural level, we first aimed to replicate previous work on brain responses to the perception of romantic partners. Secondly, we investigated if and how interpersonal conflict altered brain responses to romantic partners. Thirdly, we examined whether third-party mediation during conflict resolution modulated this change. Finally, we tested whether post-conflict satisfaction and subjective affective ratings related to the romantic partner before or after conflict correlated with brain activations in regions associated with romantic love.

4.1. *Behavioral results*

Our behavioral results on conflict resolution outcomes show that mediation has a beneficial effect on conflict resolution in romantic couples, which is in line with results from another study from our lab (Bogacz et al., 2020). More specifically, in the present study, mediation improved satisfaction about the Contents and Process of the discussion, the Level of Disagreement after the discussion and whether or not an agreement was reached by the end of the 60 min conversation on a topic of recurring disagreement. Contrary to the previous study from our lab (Bogacz et al., 2020), we did not find a trend for the impact of mediation on the Change in Positive Affect or the Change in Negative Affect. In regard to mindfulness, we found that higher trait Mindfulness was related to lower Level of Disagreement after the discussion. This supports existing literature showing an association between mindfulness and better conflict outcome (Barnes et al., 2007). In addition, we found a positive correlation between Satisfaction about the Contents of the discussion and the Dyadic Adjustment Scale score, as well as a negative correlation between the Level of Disagreement after the discussion and the total Dyadic Adjustment Score. This implies that relationship adjustment may be an indicator of successful conflict resolution in romantic couples. Emotional intelligence scores were positively correlated with the Dyadic Adjustment scores, suggesting that while emotional intelligence is not associated with greater post-conflict satisfaction by itself, it is related to better relationship adjustment which, in turn, is associated with better conflict resolution. Because both EI and mindfulness can be learned and improved upon (Crane et al., 2012; Schutte, Malouff, & Thorsteinsson, 2013), future studies assessing emotional intelligence and mindfulness are needed build upon these findings to better understand how these traits influence conflict resolution in romantic couples in mediated and non-mediated settings.

4.2. *Pre-conflict neuroimaging results*

In regard to neuroimaging, SVC analysis for the pre-conflict contrast (Romantic partner – unknown) revealed significant activation in a central region related to romantic love, namely the nucleus accumbens (Acevedo et al., 2012; Aron et al., 2005; Bartels & Zeki, 2000).

Whole-brain analyses for the same contrast revealed increased activation in the medial orbitofrontal cortex, precuneus, putamen, right anterior insula, right occipital and temporal poles, the right occipito-temporal gyrus and the bilateral amygdala. Previous studies on romantic partners that have used pictures of familiar acquaintances or friends as the control stimulus instead of unknowns have typically found deactivations in the amygdala (Aron et al., 2005; Bartels & Zeki, 2000, 2004). However, as previously mentioned, the amygdala can be viewed as a relevance detector that is not only involved in the processing of negative information but also of positive information (Sander et al., 2003). In the present study, an increase in amygdala activity in the pre-conflict contrast (Romantic partner – unknown) could be driven by the fact that the unknown person's face held much less personal significance and was therefore substantially less relevant to participants than their romantic partner's face. This result is consistent with studies showing that the amygdala is activated in children and adolescents who saw their mother's face as compared to unknowns' matched faces (e.g., Tottenham et al., 2012), or in mothers who saw the face of their infants as compared an unknown child (e.g., Strathearn & Kim, 2013). The activation in the medial orbitofrontal cortex is partially in line with previous studies (Acevedo et al., 2012; Xu et al., 2011 (in their sample of Chinese participants); Younger et al., 2010), but is contrary to earlier research on romantic love which found deactivations in the medial orbitofrontal cortex (Aron et al., 2005; Bartels & Zeki, 2000, 2004; Zeki, 2007). Although Bartels and Zeki argued that deactivation in the medial orbitofrontal cortex and the precuneus could signify the suspension of critical judgement when seeing the romantic partner, one can also argue that the medial orbitofrontal cortex is associated with hedonic experience processing (Kringelbach & Berridge, 2009) and therefore may be related to reward. In addition, the present activations in response to the romantic partner resemble activations in the default mode network (Bressler & Menon, 2010; Corbetta, Patel, & Shulman, 2008) or abstract representations (Margulies et al., 2016). Alongside the activations in visual cortices, the present study also identified activations in the anterior insula, which is important for interoception (Critchley et al., 2004), and the ACC and anterior insula, which are critical for empathy (Fan, Duncan, de Greck, & Northoff, 2011; Lamm, Decety, & Singer, 2011). Taken together, the present activations may represent a mixture of sensory experiences, interoception, empathy and abstract thoughts.

4.3. *Effects of conflict on the neural representation of romantic partners*

To assess the impact of interpersonal conflict, we compared post- and pre-conflict brain activations to the romantic partner versus the unknown. SVC analyses showed decreased activations in regions typically involved in romantic love including the VTA and posterior caudate (Acevedo et al., 2012; Aron et al., 2005) when viewing the romantic partner versus the unknown, post-conflict as compared to pre-conflict, across both mediated and non-mediated groups. In addition, whole brain analyses for the same contrast showed that interpersonal conflict resulted in deactivations in the right precuneus, posterior insula, superior parietal lobe, superior frontal gyrus, posterior cingulate cortex, middle cingulate gyrus, thalamus and the striatum, the last of which has been implicated in previous studies on romantic love (Acevedo et al., 2012; Bartels & Zeki, 2000, 2004; Ortigue et al., 2007; Xu et al., 2011; Zeki, 2007). These results support the hypothesis that conflict changed the neural representation of romantic partners, particularly by decreasing activations in regions previously associated with romantic love (Aron et al., 2005; Bartels & Zeki, 2000, 2004; Fisher et al., 2005; O'Doherty, 2004; Xu et al., 2011) and positive affect (Beauregard et al., 2009; Klimecki et al., 2013; Kringelbach & Berridge, 2009).

4.4. *Effects of mediation during conflict on the neural representation of romantic partners*

At post-conflict, the mediated group trended towards having greater activation in the nucleus accumbens when viewing their romantic partner versus the unknown as compared to the non-mediated group. This preliminary result was found using small volume correction and while it does not reach significance, an effect possibly due to our sample size, it goes in the direction of our hypothesis that third-party mediation during interpersonal conflict may result in greater activity in regions associated with positive affect and reward. It would be important to replicate this result and to study the long-term impact of mediation on neural representations of romantic partners, given that this preliminary finding suggests nucleus accumbens activation when seeing the romantic partner may be increased through third-party mediation.

Parametric modulation analyses across both the mediated and non-mediated groups revealed a positive correlation between satisfaction with the process of the conflict resolution discussion and post-conflict activation in the nucleus accumbens when viewing the romantic partner versus the unknown, for smiling expressions. In addition, there was a trend for a relation between satisfaction about the contents of the conflict resolution discussion and activation in the nucleus accumbens. Together with the increased level of satisfaction in the mediated group these results may suggest a promising association between better conflict resolution and greater activation in the brains' reward circuitry post-conflict.

Similarly, across both mediated and non-mediated groups, we found a trend towards a positive correlation between positive ratings of the romantic partner versus the unknown (acquired during the in-scanner rating tasks), and activation in the nucleus accumbens when viewing the romantic partner versus the unknown post-conflict, for smiling expressions. As the nucleus accumbens is a dopamine rich region, its association with positive affect when viewing the romantic partner as compared to the unknown post-conflict, as well as its increased activation in the mediated as compared to the non-mediated group post-conflict, suggest the involvement of motivational and reward processes. Future randomized controlled studies with larger sample sizes are needed to investigate this possibility in more detail.

4.5. *Limitations and conclusions*

While the majority of previous studies on romantic love contrasted the romantic partner's face with a familiar acquaintance (Acevedo et al., 2012; Aron et al., 2005; Bartels & Zeki, 2000, 2004), in the present study the control stimulus took the form of an unknown person of the same sex, and similar age and level of attractiveness as the romantic partner. When comparing our results, it is important to keep in mind that familiarity was uncontrolled for in order to minimize noise and different patterns of brain activation in response to differences in attractiveness, quality, size, angles and expressions of the images shown in the fMRI paradigm. Given that our pre-conflict neuroimaging results replicate previous findings on the representation of romantic partners in the brain, we remain confident that our choice of control stimulus did not affect the main outcomes of the present study. In addition, in an attempt to guard the ecological validity of the experiment, participants chose the conflict topic during their hour-long conversation with or without a mediator and were allowed to switch topics once if need be. While the severity of the conflict differed between couples, the total Dyadic Adjustment score, which includes a measure of frequency and severity of the conflict topics discussed in our study, did not differ between groups. For future research, it would be interesting to code participant facial expressions and behavior using the Specific Affect Coding System (SPAFF) to segregate the hour-long discussion into discrete episodes. It would then be possible to assess if and how specific episodes of the conflict influence outcome measures of the behavioral and neural level. Despite these limitations, the present study replicates previous research on the neural correlates of romantic love as measured by viewing ones' romantic partner compared to an unknown person and provides preliminary evidence for how interpersonal conflict and third-party mediation can change the neural representation of romantic partners. Furthermore, it provides empirical evidence for the beneficial impact of mediation on conflict resolution in romantic couples.

Funding

This research was supported by the National Center of Competence in Research (NCCR) for the Affective Sciences, financed by a grant from the Swiss National Science Foundation (51NF40-104897), hosted by the University of Geneva.

Open practices

The study in this article earned an Open Materials badge for transparent practices. Study procedures and study analyses were not pre-registered in a time-stamped, institutional registry prior to the research being conducted. We report how we determined our sample size, all data exclusions, all inclusion/exclusion criteria, whether inclusion/exclusion criteria were established prior to data analysis, all manipulations, and all measures in the study. Individual anonymized data and digital study materials (including experimental task code, stimuli and analysis code), that are necessary and sufficient to reproduce analyses and data presentations reported in the present study can be found online: https://data.mendeley.com/datasets/bhyvpjwbzp/3. Medically sensitive data, namely participant T1 scans and their ages, will be made available upon request to the corresponding author, subject to approval by the federal Swiss Ethics Committee on research involving humans.

Declaration of Competing Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Acknowledgements

We would like to thank Bruno Bonet and Frédéric Grouiller from the Brain and Behavior Laboratory for helping with the collection of fMRI data as well as Fabien Carruzzo, Stéphanie Magalhaes and Laurene Da Silva Pereira for helping with the collection of the behavioral data. We are grateful to Sebastian Baez Lugo for his help in analyzing the fMRI data and to Andrés Posada for his help with Cogent toolbox. We are grateful to the mediators who participated pro bono to the experiments (by alphabetical order): Viktoria Aversano, François Bogacz, Richard Hill, Christophe Imhoos, Jeremy Lack, Isabelle Laugier and Fernanda Salina. We would especially like to thank Jeremy Lack for his help in setting up the panel of mediators.

No part of the study procedures or analyses was pre-registered prior to the research being conducted.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cortex.2020.04.036.

REFERENCES

Abbey, A., & Andrews, F. M. (1985). Modeling the psychological determinants of life quality. *Social Indicators Research, 16*(1982), 1–34.

Acevedo, B. P., Aron, A., Fisher, H. E., & Brown, L. L. (2012). Neural correlates of long-term intense romantic love. *Social Cognitive and Affective Neuroscience, 7*(2), 145–159. https://doi.org/10.1093/scan/nsq092.

Alferes, Valentim, & Kenny, David (2009). SPSS programs for the measurement of nonindependence in standard dyadic designs. *Behavior Research Methods*.

Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology, 63*(4), 596–612. https://doi.org/10.1037/0022-3514.63.4.596.

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*(1), 327–337. https://doi.org/10.1152/jn.00838.2004.

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment, 13*(1), 27–45. https://doi.org/10.1177/1073191105283504.

Barnes, S., Brown, K. W., Krusemark, E., Campbell, W. K., & Rogge, R. D. (2007). The role of mindfulness in romantic relationship satisfaction and responses to relationship stress. *Journal of Marital and Family Therapy, 33*(4), 482–500. https://doi.org/10.1111/j.1752-0606.2007.00033.x.

Barough, A. S., Shoubi, M. V., & Preece, C. N. (2013). Evaluating the effectiveness of mediation and arbitration processes in resolving disputes in the Malaysian construction industry. *International Journal of Civil Engineering (IJCE), 2*(1), 21–28.

Bartels, A., & Zeki, S. (2000). The neural basis of romantic love. *Neuroreport, 11*(17), 3829–3834. https://doi.org/10.1097/00001756-200011270-00046.

Bartels, A., & Zeki, S. (2004). The neural correlates of maternal and romantic love. *Neuroimage*. https://doi.org/10.1016/j.neuroimage.2003.11.003.

Beauregard, M., Courtemanche, J., Paquette, V., & St-Pierre, É.L. (2009). The neural basis of unconditional love. *Psychiatry Research - Neuroimaging, 172*(2), 93–98. https://doi.org/10.1016/j.pscychresns.2008.11.003.

Bogacz, F., Pun, T., & Klimecki, O. M. (2020). *Improved conflict resolution in romantic couples in mediation compared to negotiation*. Revised and resubmitted.

Brackett, M. A., Warner, R. M., & Bosco, J. S. (2005). Emotional intelligence and relationship quality among couples. *Personal Relationships, 12*(2), 197–212. https://doi.org/10.1111/j.1350-4126.2005.00111.x.

Brasseur, S., Grégoire, J., Bourdu, R., & Mikolajczak, M. (2013). The profile of emotional competence (PEC): Development and validation of a self-reported measure that fits dimensions of emotional competence theory. *Plos One, 8*(5). https://doi.org/10.1371/journal.pone.0062635.

Bressler, S. L., & Menon, V. (2010). Large-scale brain networks in cognition: Emerging methods and principles. *Trends in Cognitive Sciences*. https://doi.org/10.1016/j.tics.2010.04.004.

Brett, J. M., Barsness, Z. I., & Goldberg, S. B. (1996). The effectiveness of mediation: An independent analysis of cases handled by four major service providers. *Negotiation Journal, 12*(3), 259–269. https://doi.org/10.1111/j.1571-9979.1996.tb00099.x.

Brown, K. W., Goodman, R. J., & Inzlicht, M. (2013). Dispositional mindfulness and the attenuation of neural responses to emotional stimuli. *Social Cognitive and Affective Neuroscience, 8*(1), 93–99. https://doi.org/10.1093/scan/nss004.

Brown, S. L., Nesse, R. M., Vinokur, A. D., & Smith, D. M. (2003). Providing social support may be more beneficial than receiving it: Results from a prospective study of mortality. *Psychological Science, 14*(4), 320–327. https://doi.org/10.1111/1467-9280.14461.

Cialdini, R. B., Brown, S. L., Lewis, B. P., Luce, C., & Neuberg, S. L. (1997). Reinterpreting the empathy-altruism relationship: When one into one equals oneness. *Journal of Personality and Social Psychology, 73*(3), 481–494. https://doi.org/10.1037/0022-3514.73.3.481.

Corbetta, M., Patel, G., & Shulman, G. L. (2008). The reorienting system of the human brain: From environment to theory of mind. *Neuron, 58*(3), 306–324. https://doi.org/10.1016/j.neuron.2008.04.017.

Crane, R. S., Kuyken, W., Williams, J. M. G., Hastings, R. P., Cooper, L., & Fennell, M. J. V. (2012). Competence in teaching mindfulness-based courses: Concepts, development and assessment. *Mindfulness, 3*(1), 76–84. https://doi.org/10.1007/s12671-011-0073-2.

Crawford, J. R., & Henry, J. D. (2004). The Positive and Negative Affect Schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample. *British Journal of Clinical Psychology, 43*(3), 245–265. https://doi.org/10.1348/0144665031752934.

Critchley, H. D., Wiens, S., Rotshtein, P., Öhman, A., & Dolan, R. J. (2004). Neural systems supporting interoceptive awareness. *Nature Neuroscience, 7*(2), 189–195. https://doi.org/10.1038/nn1176.

Delgado, M. R. (2007). Reward-related responses in the human striatum. *Annals of the New York Academy of Sciences, 1104*, 70–88. https://doi.org/10.1196/annals.1390.002.

Fan, Y., Duncan, N. W., de Greck, M., & Northoff, G. (2011). Is there a core neural network in empathy? An fMRI based quantitative meta-analysis. *Neuroscience and Biobehavioral Reviews, 35*(3), 903–911. https://doi.org/10.1016/j.neubiorev.2010.10.009.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. Sage.

Fisher, H., Aron, A., & Brown, L. L. (2005). Romantic love: An fMRI study of a neural mechanism for mate choice. *Journal of Comparative Neurology, 493*(1), 58–62. https://doi.org/10.1002/cne.20772.

Folger, J., & Bush, R. (1994). *The promise of mediation. Responding to conflict through empowerment and recognition*. San Francisco.

Folger, J., & Bush, R. (2005). A response to Gaynier's "Transformative mediation: In Search of a Theory of Practice". *Conflict Resolution Quarterly, 23*(1). https://doi.org/10.1017/CBO9781107415324.004.

Folger, J., & Simon, D. (2017). Transformative mediation: Illustrating a relational view of conflict intervention. In *The mediation handbook (pp. 72–86). Routledge. The mediation handbook* (pp. 72–86).

Halford, W. K., Markman, H. J., Kline, G. H., & Stanley, S. M. (2003). Best practice in couple relationship education. *Journal of Marital and Family Therapy, 29*(3), 385–406. https://doi.org/10.1111/j.1752-0606.2003.tb01214.x.

Halperin, E. (2015). *Emotions in conflict: Inhibitors and facilitators of peace making. Routledge*.

Hawkley, L. C., Masi, C. M., Berry, J. D., & Cacioppo, J. T. (2006). Loneliness is a unique predictor of age-related differences in systolic blood pressure. *Psychology and Aging, 21*(1), 152–164. https://doi.org/10.1037/0882-7974.21.1.152.

Heeren, A., Douilliez, C., Peschard, V., Debrauwere, L., & Philippot, P. (2011). Cross-cultural validity of the five facets mindfulness questionnaire: Adaptation and validation in a French-speaking sample. *Revue Europeenne de Psychologie Appliquee, 61*(3), 147–151. https://doi.org/10.1016/j.erap.2011.02.001.

van der Heuvel, M., & Pol, H. E. H. (2010). Exploring the brain network: A review on resting-state fMRI functional connectivity. *European Neuropsychopharmacology, 20*, 519–534. https://doi.org/10.1016/j.euroneuro.2010.03.008.

Jameson, J. K., Bodtker, A. M., Porch, D. M., & Jordan, W. J. (2009). Exploring the role of emotion in conflict transformation. *CONFLICT RESOLUTION QUARTERLY, 27*(2), 185–202. https://doi.org/10.1002/crq.

Jones, T. S. (2000). Chapter 6: Emotional communication in conflict: Essence and impact. In W. F. Eadie, & P. E. Nelson (Eds.), *The language of conflict and resolution*.

Jordan, P. J., & Troth, A. C. (2004). Managing emotions during team problem solving: Emotional intelligence and conflict resolution. *Human Performance, 17*, 137–144. https://doi.org/10.1207/s15327043hup1702.

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice, 10*(2), 144–156. https://doi.org/10.1093/clipsy/bpg016.

Kaiser, P., & Gabler, A. M. (2014). Prozessqualität und Langzeiteffekte in der Mediation. *Zeitschrift Für Konfliktmanagement, 17*(6), 180–184.

Kenny, D. A., Kashy, D. A., & Cook, W. L. (2006). *Dyadic data analysis*. Guilford press.

Kesler-West, M. L., Andersen, A. H., Smith, C. D., Avison, M. J., Davis, C. E., Kryscio, R. J., et al. (2001). Neural substrates of facial emotion processing using fMRI. *Cognitive Brain Research, 11*(2), 213–226. https://doi.org/10.1016/S0926-6410(00)00073-2.

Klimecki, O. M., Leiberg, S., Lamm, C., & Singer, T. (2013). Functional neural plasticity and associated changes in positive affect after compassion training. *Cerebral Cortex, 23*(7), 1552–1561. https://doi.org/10.1093/cercor/bhs142.

Kringelbach, M. L., & Berridge, K. C. (2009). Towards a functional neuroanatomy of pleasure and happiness. *Trends in Cognitive Sciences, 12*(11), 479–487. https://doi.org/10.1016/j.tics.2009.08.006.

Lamm, C., Decety, J., & Singer, T. (2011). Meta-analytic evidence for common and distinct neural networks associated with directly experienced pain and empathy for pain. *NeuroImage, 54*(3), 2492–2502. https://doi.org/10.1016/j.neuroimage.2010.10.014.

Lieberman, Matthew, & Cunningham, William (2009). Type I and Type II error concerns in fMRI research: re-balancing the scale. *Social Cognitive and Affective Neuroscience*.

Lieberman, M. D., Berkman, E. T., & Wager, T. D. (2009). Correlations in social neuroscience aren ' t voodoo. *Perspectives on Psychological Science, 4*(3), 299–307. https://doi.org/10.1111/j.1745-6924.2009.01128.x.

Lundqvist, D., Flykt, A., & Öhman, A. (1998). *The Karolinska directed emotional faces - KDEF*. Department of clinical neuroscience, psychology section, Karolinska institutet.

Margulies, D. S., Ghosh, S. S., Goulas, A., Falkiewicz, M., Huntenburg, J. M., Langs, G., et al. (2016). Situating the default-mode network along a principal gradient of macroscale cortical organization. *Proceedings of the National Academy of Sciences of the United States of America, 113*(44), 12574–12579. https://doi.org/10.1073/pnas.1608282113.

Mayer, J. D., Salovey, P., & Caruso, D. R. (2000). *Emotional intelligence as zeitgeist, as personality, and as a mental ability*.

Medford, N., & Critchley, H. D. (2010). Conjoint activity of anterior insular and anterior cingulate cortex: Awareness and response. *Brain Structure & Function, 214*(5–6), 535–549. https://doi.org/10.1007/s00429-010-0265-x.

Nair, N. (2008). Towards understanding the role of emotions in conflict: A review and future directions. *International Journal of Conflict Management, 19*(4), 359–381. https://doi.org/10.1108/10444060810909301.

Ortigue, S., Bianchi-Demicheli, F., Hamilton, A. F. D. C., & Grafton, S. T. (2007). The neural basis of love as a subliminal prime: An event-related functional magnetic resonance imaging study. *Journal of Cognitive Neuroscience, 19*(7), 1218–1230.

O'Doherty, J. P. (2004). Reward representations and reward-related learning in the human brain: Insights from neuroimaging. *Current Opinion in Neurobiology, 14*(6), 769–776. https://doi.org/10.1016/j.conb.2004.10.016.

Posamentier, M. T., & Abdi, H. (2003). Processing faces and facial expressions. *Neuropsychology Review, 13*(3), 113–143. https://doi.org/10.1023/A:1025519712569.

Rafi, H., Bogacz, F., Sander, D., & Klimecki, O. M. (2020). *Incidental emotions of pleasure and hatred evoked during couple conflict influence economic decision-making behavior*. Revised and resubmitted.

Samejima, K., Ueda, Y., Doya, K., & Kimura, M. (2005). Representation of action-specific reward values in the striatum. *Science, 310*(5752), 1337–1340. https://doi.org/10.1126/science.1115270.

Sander, D., Grafman, J., & Zalla, T. (2003). The human amygdala: An evolved system for relavance detection. *Reviews in the Neurosciences, 14*, 303–316. Retrieved from papers2://publication/uuid/C26D8BD4-30B0-4CBB-A753-6D7CBAAC5229.

Sato, W., Yoshikawa, S., Kochiyama, T., & Matsumura, M. (2004). The amygdala processes the emotional significance of facial expressions: An fMRI investigation using the interaction between expression and face direction. *NeuroImage, 22*(2), 1006–1013. https://doi.org/10.1016/j.neuroimage.2004.02.030.

Schutte, N. S., Malouff, J. M., & Thorsteinsson, E. B. (2013). Increasing emotional intelligence through training: Current status and future directions. *The International Journal of*

Emotional Education, 5(1), 56–72. Retrieved from http://www.um.edu.mt/__data/assets/pdf_file/0005/183884/vol5i1p4.pdf.

Senft, L. P. (2015). Transformative mediation: Transforming the adversarial ethic. *Experience, 24*(8).

Shaw, L. A. (2010). Divorce mediation outcome research: A meta-analysis. *Conflict Resolution Quarterly, 27*(4), 447–467. https://doi.org/10.1002/crq.

Smith, L., Heaven, P. C. L., & Ciarrochi, J. (2008). Trait emotional intelligence, conflict communication patterns, and relationship satisfaction. *Personality and Individual Differences, 44*(6), 1314–1325. https://doi.org/10.1016/j.paid.2007.11.024.

Spanier, G. B. (1976). Measuring dyadic adjustment: New scales for assessing the quality of marriage and similar dyads. *Journal of Marriage and the Family, 38*(1), 15. https://doi.org/10.2307/350547.

Stoessel, C., Stiller, J., Bleich, S., Boensch, D., Doerfler, A., Garcia, M., et al. (2011). Differences and similarities on neuronal activities of people being happily and unhappily in love: A functional magnetic resonance imaging study. *Neuropsychobiology, 64*(1), 52–60. https://doi.org/10.1159/000325076.

Strathearn, L., & Kim, S. (2013). Mothers' amygdala response to positive or negative infant affect is modulated by personal relevance. *Frontiers in Neuroscience, 7*(7 OCT), 1–10. https://doi.org/10.3389/fnins.2013.00176.

Tottenham, N., Shapiro, M., Telzer, E. H., & Humphreys, K. L. (2012). Amygdala response to mother. *Developmental Science, 15*(3), 307–319. https://doi.org/10.1111/j.1467-7687.2011.01128.x.

Wachs, K., & Cordova, J. V. (2007). Mindful relating: Exploring mindfulness and emotion repertoires in intimate relationships. *Journal of Marital and Family Therapy, 33*(4), 464–481. https://doi.org/10.1111/j.1752-0606.2007.00032.x.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales.No Title. *Journal of Personality and Social Psychology, 54*(6), 1063–1070.

Xu, X., Aron, A., Brown, L., Cao, G., Feng, T., & Weng, X. (2011). Reward and motivation systems: A brain mapping study of early-stage intense romantic love in Chinese participants. *Human Brain Mapping, 32*(2), 249–257. https://doi.org/10.1002/hbm.21017.

Xu, X., Brown, L., Aron, A., Cao, G., Feng, T., Acevedo, B., et al. (2012). Regional brain activity during early-stage intense romantic love predicted relationship outcomes after 40 months: An fMRI assessment. *Neuroscience Letters, 526*(1), 33–38. https://doi.org/10.1016/j.neulet.2012.08.004.

Younger, J., Aron, A., Parke, S., Chatterjee, N., & Mackey, S. (2010). Viewing pictures of a romantic partner reduces experimental pain: Involvement of neural reward systems. *PLoS ONE, 5*(10). https://doi.org/10.1371/journal.pone.0013309.

Zeki, S. (2007). The neurobiology of love. *FEBS Letters, 581*(14), 2575–2579. https://doi.org/10.1016/j.febslet.2007.03.094.

Zumeta, Z. (2000). Styles of mediation: Facilitative, evaluative, and transformative mediation. *Mediate.Com*, 1–5.