Love Me Not: Cardiac Responses to Romantic Rejection in Online Dating

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Abstract

Romantic love is a fundamental human need, yet the rise of online dating platforms has made romantic rejection a frequent experience. While the psychological consequences of social rejection are documented, less is known about romantic rejection and how individual differences, such as Adverse Childhood Experiences (ACEs) and attachment styles, influence the immediate physiological processing of rejection. The present study investigated the effects of ACEs and attachment styles on cardiac deceleration and subjective pain in response to feedback in a simulated online dating environment. Participants (N = 49) completed the ACE-Questionnaire and Revised Adult Attachment Scale before engaging in a "Tinder-like" task where they received acceptance or rejection feedback while electrocardiogram (ECG) data was recorded. Results revealed that rejection feedback caused significant cardiac deceleration and higher subjective pain ratings compared to other feedback conditions. However, neither ACEs nor attachment style showed significant associations to cardiac deceleration and subjective pain. These findings suggest that while online rejection elicits heart deceleration, this response was not associated with ACEs or attachment style in the present non-clinical sample.

Love, the answer to all of one's problems, people often think. A basic human need that is seen across most cultures, playing an essential role in human motivation and fulfilling the need for connection as well as belongingness (Maslow, 1943; Baumeister et al., 1993; Baumeister & Leary, 1995; Jankowiak & Fischer, 1992). Although usually perceived solely as a social motivator, romantic love has played a crucial role in human evolution, proving to be essential in mate selection and reproduction (Bode & Kushnick, 2021; Jankowiak & Fischer, 1992). Nevertheless, the concept of romantic love has evolved over time; what was once expressed and expected from love has shifted into something more complex (Schwartz & Velotta, 2018). Instead of simply affection, sex, and loyalty, individuals seek connections that contribute to their personal growth and self-esteem for the purpose of becoming a better person. Meanwhile, people have less time due to increasing work demands, reducing time spent with friends, and overall having less time for themselves. Love itself has not only inherently become more intricate but has also become harder to fit into one's busy schedule (Schwartz & Velotta, 2018). This lack of time has made love-seeking seem more difficult and inconvenient, giving rise to the existence of online dating. Online dating services began their popularity in the 90s, with websites such as OkCupid leading the market at the time. Although these have been available since, this form of dating carried a sense of stigma and was often used as a last resort (Schwartz & Velotta, 2018). With time, online dating platforms have developed their interface, becoming increasingly convenient and meeting their busy clients' demands. One of the current leading dating apps, Tinder, now holds 9.6 million subscribers, reaching 6.5 million downloads as of May 2025 (Kumar, 2025). While these platforms have simplified access to potential partners, they also frequently expose individuals to romantic rejection. The increased availability of choices in online dating inevitably exposes users to more romantic rejection, making it a central feature to

modern dating. In addition, this higher number of partner options can lead users into a 'rejection mindset', a mindset by which individuals become increasingly pessimistic and decrease their acceptance rate as they swipe through profiles (Pronk & Denissen, 2019). The more partners one rejects, the more likely they are to develop a rejection mindset, thereby increasing the likelihood of future rejections. Although romantic rejection can occur during in-person dating, the latter highlights a greater magnitude of the problem, one exclusive to online dating (Pronk & Denissen, 2019). While online dating has expanded people's opportunities for connection, it has also increased the frequency as well as intensity of romantic rejection. Given the increased exposure to such platforms, understanding the effects romantic rejection may have on mental health is crucial. Although the current research is limited, the existing literature provides serious statements as to the consequences of such rejection, including suicide, suicidal ideation, self-harm and depression among many others (Mearns, 1991; Fisher et al., 2010; Fisher et al., 2014; Cawley et al., 2019). Mearns (1991) found that more than 40% of their participants were clinically depressed when assessing subjects who experienced romantic rejection from a past partner. Although romantic rejection seems universal, the severity of its effects on each person may vary. The existing literature suggests that individuals with insecure attachment styles developed from rejection in early childhood may experience higher levels of rejection sensitivity (Bowlby, 1982; Fisher, 2014; Downey & Feldman, 1996). Furthermore, early adverse experiences such as inconsistent, neglect or threats of abandonment, may lead to sensitivity towards losses and rejections in the future. These sensitivities may therefore make people more vulnerable to the serious consequences of romantic rejection (Bowlby, 1982; Fisher, 2014). Such qualities may shape how individuals respond to rejection both emotionally and neurologically, raising the importance of examining not only the subjective experience of romantic rejection but

also its neurological effects. To address this gap in the literature and expand knowledge on the neuronal basis of romantic rejection, we looked at cardiac responses induced by such rejection. Although it is important to note that the current research available regarding neurological changes from romantic rejection induced through online dating is still limited.

Researching romantic rejection gives rise to complications in laboratory research designs, thus oftentimes, subjective measures such as autobiographical accounts were used instead (Baumeister et al., 1993). Whilst there are relatively few studies on romantic rejection, there is substantially more research on social exclusion as well as social rejection.

Eisenberger, a pioneer in social exclusion research hypothesized the social pain experienced through social exclusion to share neural correlates with physical pain (Eisenberger, et al., 2003; Eisenberger, 2012). To do so, the Cyberball paradigm was often used. With the use of fMRI, Cyberball findings show an activation of the dorsal anterior cingulate cortex (dACC) as well as the anterior insular cortex (AI), areas previously found to be related to physical pain (Eisenberger et al., 2003; Eisenberger, 2012; Treede et al., 1999; Gunther Moor et al., 2012; MacDonald & Leary, 2005). Paracetamol research on social exclusion further supports this association (De Wall et al., 2010). Using the same task, participants who ingested paracetamol, showed less activation in both the dACC and AI than the placebo group (De Wall et al., 2010; Eisenberger 2012). While being excluded can elicit feelings of social pain, it does not necessarily lead the individual to perceive themselves as rejected. Thus, the distinction between social exclusion and social rejection must be considered as these represent different phenomena and use different paradigms in their research (Van der Veen, 2014).

To better capture the process of social rejection, researchers such as Somerville and colleagues (2006) explored dACC activation in expectancy violation. The combination of

expectancy violation and social pain is thought to serve as a neural alarm system in response to social exclusion and rejection (Somerville et al., 2006; Onoda et al., 2009; Gunther Moor et al., 2012).

Somerville's (2006) social rejection paradigm suggests that feelings of rejection are associated with increased dACC activation, a region implicated in both expectancy violation and social pain (Somerville et al., 2006). These findings were further supported by multiple studies (Moor et al., 2010; Van der Veen et al., 2014). Additionally, Moor and colleagues (2010 & 2012) found a relationship between cardiac deceleration and unexpected social rejection, suggesting that dACC activation is associated with cardiac deceleration measured via electrocardiography (ECG).

Past research on social exclusion and rejection primarily relied on fMRI imaging (Eisenberger et al., 2003; Eisenberger, 2012; Treede et al., 1999; Moor et al., 2012; MacDonald & Leary, 2005; De Wall et al., 2010). However, due to its low temporal resolution, fMRI is limited in its ability to record precise neurological responses (Kim et al., 1997; Van der Veen, 2019). In contrast, ECG provides a more temporally precise measure due to its sensitivity to rapid electrical changes in heart activity, whilst also being associated with dACC activation during social rejection (Moor et al., 2010; Van der Veen et al., 2014; Van der Veen et al., 2019; Papousek et al., 2014).

While research on social exclusion and social rejection has provided important insights into the neural correlates of social pain, romantic rejection has received considerably less empirical attention despite being a common experience. Romantic rejection studies are limited, and simulating real-life scenarios is difficult; the ability to elicit genuine romantic expressions within the constraints of neuroimaging has been a significant challenge (Van der Veen, 2019;

Cooper et al., 2013; Zhang et al., 2021). To address these limitations, Cooper and colleagues (2013) introduced an experimental paradigm designed to evoke romantic evaluation and rejection while maintaining experimental control. Within this speed dating paradigm, participants were placed in an fMRI while making romantic judgements on other participants. It was found that rejection from a desired partner would elicit rostral ACC activation, a region involved in affective aspects of distress and previously implicated in social pain processing (Cooper et al., 2013). They also found expectancy violations to slow down emotional processing and decrease happiness ratings, similarly to Somerville and colleagues (2006). While fMRI allows for the localization of brain activity, as previously stated, its relatively low temporal resolution limits the assessment of rapid emotional responses to rejection.

To address the latter, Van der Veen (2019) drew inspiration from Cooper's (2013) task and created a new paradigm for examining romantic rejection in online dating. Within the study, ECG was used to capture physiological responses to romantic rejection at a higher temporal resolution, specifically changes in heart rate reflecting cardiac deceleration. The findings showed a consistent pattern of cardiac deceleration following romantic rejection, which has been associated with neural processes involving the dACC, in line with previous research on social rejection (Moor et al., 2012; Moor et al., 2010; Van der Veen et al., 2014;). While these findings provide evidence for physiological responses associated with romantic rejection, further insight into the neural processes has been provided by EEG research. When investigating the neural correlates of anticipatory motivation, reward processing, and social pain in an online romantic rejection task, researchers found that theta power was largest during rejection. Theta responses were found to be source localized in regions implicated with physical pain processing, specifically the ACC, dlPFC, and supplementary motor cortices. In addition, reward positivity

was found to be highest when participants found a match, and stimulus preceding negativity was larger when participants anticipated acceptance rather than rejection. (Zhang et al. 2021).

Together, these studies indicate romantic rejection to elicit physiological and neural responses associated with physical and social pain. However, research on romantic rejection remains relatively limited, and the existing paradigms have predominantly been examined on heterosexual samples. As a result, it remains unclear the extent to which these findings are generalizable to more diverse dating populations, highlighting the need for further investigation in broader populations. In addition, other contextual factors may come into play in same-sex non-heteronormative dating contexts, which may influence the way in which romantic rejection is experienced.

While the current research gives insight into the mechanisms involved in romantic rejection, they do not thoroughly explore why some individuals may experience this stronger than others. Individual differences, particularly those developed in early childhood often play a significant role in one's emotional development, especially within the romantic context. According to Bowlby's (1982) attachment theory, the way in which individuals interact with their care givers form internal models, guiding one's perception of the self and relationship towards others. Those who experience an ambiguous environment when younger may develop either an anxious or an avoidant attachment style. Research on attachment theory suggests insecure attachments to experience higher levels of rejection sensitivity (Downey & Feldman, 1996; Bowlby, 1982; Fisher, 2014; Burklund et al., 2007; Van der Veen et al., 2014; Eisenberger, 2012). Anxiously attached individuals are characterized by fear of abandonment and lower self-esteem, creating anxieties about whether they will be accepted and supported by others, whilst avoidants emotionally distance themselves due to a fear of rejection (Downey &

Feldman, 1996; Bowlby, 1982). In terms of neural differences, heightened dACC activation shows a relationship with rejection sensitivity. (MacDonald & Leary, 2005; Burklund et al., 2007; Eisenberger, 2012). One study suggests those anxiously attached to show an increased activation of the dACC, in the meantime avoidant attachment style participants were associated with lower dACC activity (De Wall et al, 2012; Eisenberger, 2012).

Similarly, individuals exposed to adverse childhood experiences (ACEs) show comparable trends of increased rejection sensitivity. ACEs refer to a range of early-life stressors, including various forms of child maltreatment (e.g., emotional, physical, or sexual abuse) as well as neglect and household dysfunction. Extensive research has demonstrated that exposure to ACEs is associated with long-term alterations in emotional regulation, threat detection, and stress responsivity, which can persist into adulthood (Bremmer, 2006; McLaughlin, Sheridan & Lambert, 2014). These changes may increase vulnerability to social pain and heightened sensitivity to rejection later in life (Anda et al., 2006; Bowlby, 1982; Gao et al., 2024). Given that ACEs often contribute to the development of insecure attachment styles, these two phenomena are closely related and may influence one another in a bidirectional manner.

The above research suggests both attachment styles and ACEs may heighten one's vulnerability towards romantic rejection by increasing rejection sensitivity. For that reason, the present study aims to examine the influence of ACEs as well as attachment styles on the experience of romantic rejection in online dating, by extending on Van der Veen's (2019) romantic rejection paradigm. Firstly, it investigates whether individuals with high ACE scores show greater cardiac deceleration responses. Additionally, it expects for higher ACE scores to reflect higher subjective pain scores due to rejection sensitivity. Furthermore, when looking into the effect of attachment styles, anxiously attached individuals are expected to exhibit stronger

cardiac deceleration responses and higher subjective pain scores, once again due to heightened rejection sensitivity. In other words, individuals with higher ACE and those with an anxious attachment style are predicted to exhibit stronger physiological responses to romantic pain, aligning with the current literature. Lastly, an exploratory hypothesis is included, where the study examines whether participants with insecure attachment styles differ in their swiping behaviors. Avoidantly attached individuals tend to protect themselves from vulnerability and possible rejection (Bowlby, 1982), which could translate into more cautious romantic decision-making. Based on this, we expected that avoidant participants might swipe 'yes' less often. However, because this is the first time attachment styles have been examined within this specific romantic rejection paradigm, this prediction remained exploratory.

Together, these hypotheses aim to extend the existing knowledge on romantic rejection in online dating, as well as understand the individual vulnerabilities that may further exacerbate the pain elicited by potential romantic partners.

Methods

Participants and Ethics

During Stage 1, a total of 110 individuals initially participated in our study, the majority of this sample consisted of Psychology students from Erasmus University Rotterdam. The sample included a diverse range of sexual orientations, gender identities, and ethnic backgrounds. Participants were recruited through online platforms via a flier that included a QR code.

During Stage 2, 56 of the initial participants remained in the study. After deleting missing data and duplicate respondents, our final sample comprised n= 49 participants. The exclusion

criteria included the presence of neurological and psychiatric disorders, as well as the active use of medications or drugs that affect brain function. Participants were also required to be between the ages of 18 and 30 as well as have English proficiency. The study was approved by the Department of Psychology's Research Ethics Review Committee/Internal Review Board at Erasmus University Rotterdam.

Materials

Pre-Screening

Before beginning the tasks, participants had to fill in a prescreening online form to ensure they met the inclusion criterion. The form first listed the requirements for participation. Following this list, participants were asked to state whether they had any psychiatric or neurological illnesses and whether they were actively taking any medication. The form is followed by requesting their name, email, phone number, and concludes with a signature on the informed consent. At this stage, participants were not yet anonymized for the sake of communication with the researchers.

Stage 1: Online Dating Task

Before receiving the task, participants were required to send a picture of themselves and a brief description of themselves, which included their leisure activities, nationality, etc. Once all participants had sent their information, they were sent an evaluation task via email; which was administered through Qualtrics. The participant had to rate others based on whether they would consider dating them or not. This task aimed to mimic an online dating app interface, such as Tinder, as best as possible. Each profile the participant came across would include a picture of a different participant, a description of that participant, and a description of what they are looking for. Under each profile, participants were also asked to rate 'perceived attractiveness' and their

'estimated reciprocation' on a 0-10 numeric scale. Additionally, they were asked, "Would you date?" to which they responded either "Yes" or "No".

Stage 2: Questionnaires

After participants completed the first stage, they were asked to come back for an in-lab romantic evaluation task. Once in the lab, participants completed multiple questionnaires before proceeding with the task.

Revised Adult Attachment Scale. The Revised Adult Attachment Scale (RAAS) (Collins, 1996) is an 18-item self-report questionnaire to assess individual differences in attachment styles. The questionnaire covers the different characteristics of attachment styles through three subscales, each containing 6 items: 1) the close subscale ($\alpha = .77$), measuring a person's comfort with closeness and intimacy; 2) the depend subscale ($\alpha = .78$), looks at the extent to which a person believes people can be relied on when needed and their comfort with depending on others; lastly, 3) the anxiety subscale ($\alpha = .85$), measures the extent at which a person worries about being rejected and abandoned by others. The Cronbach's Alpha for all three subscales was calculated in a sample of undergraduates (Collins, 1996).

Adverse Childhood Experiences Questionnaire. The Adverse Childhood Experiences Questionnaire (ACE-Q) (Felitti et al., 1998) is made up of 10 dichotomous (Yes/No) items covering the themes of psychological, physical, and sexual abuse; violence against one's mother; and living with household members who abused substances, were mentally ill or suicidal, or ever imprisoned. ACE-Q scores are commonly categorised as No reported adversity (0 ACE), Low to moderate adversity (1-3 ACE), High adversity (4+ ACE), and Very high adversity (6+ ACE) (Felitti et al., 1998; Hughes et al., 2017). Regarding internal consistency, Cronbach's alpha ranges from .70 to .76 (Oláh et al., 2023; Wingenfeld et al., 2010). Participants were told about

the sensitive nature of this questionnaire before commencing and were assured they did not have to answer if they felt uncomfortable.

Other Questionnaires. In addition to the questionnaires relevant to this paper, the Beck Depression Inventory (BDI-II) was used to measure depression, the Highly Sensitive Person Questionnaire (HSP) was used to measure sensitivity, Rosenberg's Self-Esteem Scale was used to measure participant self-esteem, the Perceived Mate Value Scale was used to measure self-perceived desirability as a sexual or romantic partner, the Cognitive Emotion Regulation Questionnaire (CERQ) was used to assess one's use of cognitive strategies in response to a stressful event, Brief COPE was used to assess coping strategies used to deal with stress, the Eysenck Personality Scale (RSS) was used to asses personality traits, the State-Trait Anxiety Inventory (STAI) to measure general anxiety, Liebowitz Social Anxiety Scale (LSAS) was used to measure social anxiety, and lastly, The Adults Rejection Sensitivity Questionnaire (ARSQ) was used to measure rejection sensitivity.

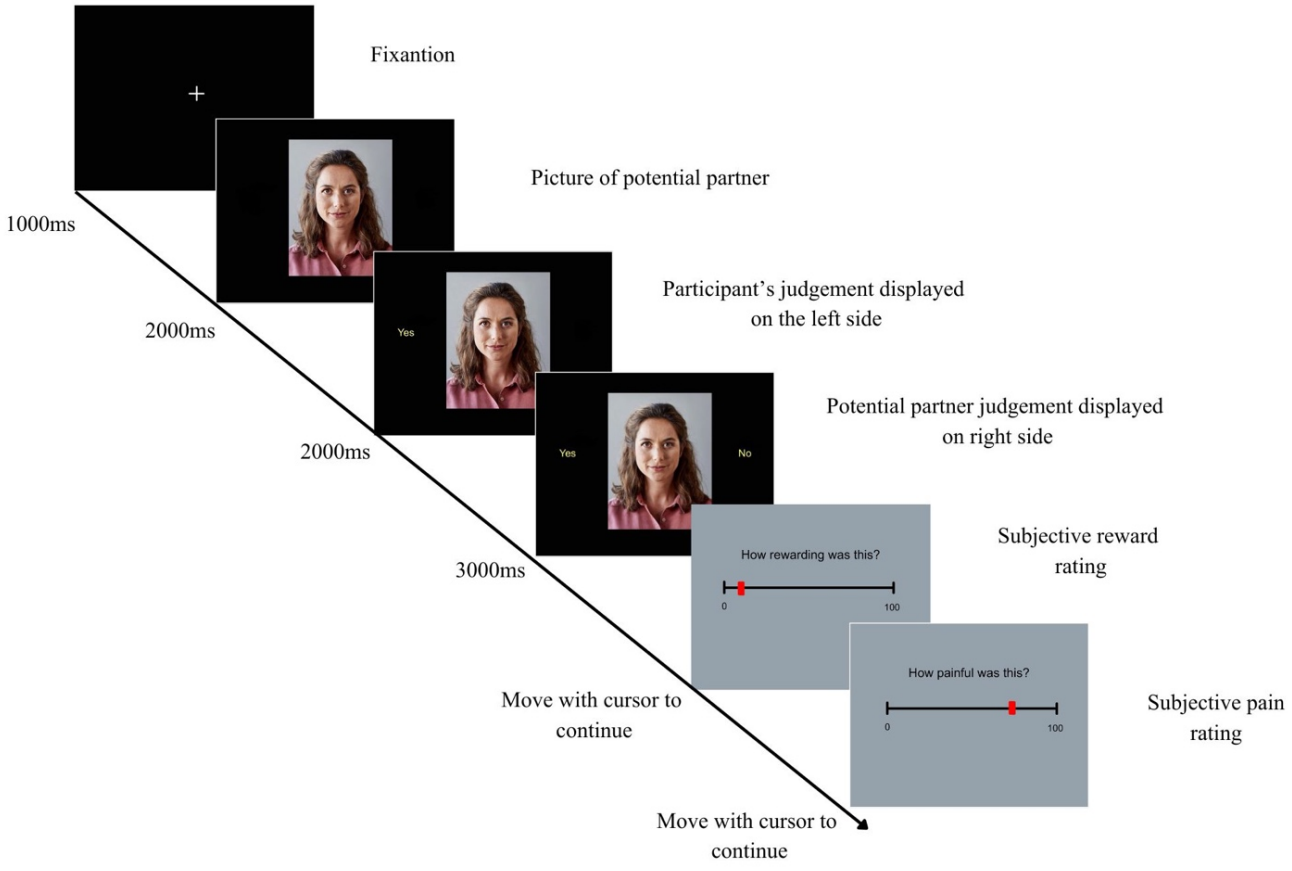
Stage 2: Romantic Evaluation Task

After completing the relevant questionnaires, participants continued with the romantic evaluation task. The design of the romantic evaluation task was based on that used by Van der Veen et al. (2019) and Cooper et al. (2010). Before beginning the tasks, the researchers connected the participant to a 32 electrode EEG cap as well as skin electrodes on the left and right mastoids, left infraorbital, left supraorbital, left and right lateral canthi, and a subcostal ECG electrode on the left rib cage. The task was explained to the participants, who were informed that they would see the photographs of the other participants again. This time, they would also see their own judgment on the left side of the screen and the potential partner's judgment on the right. An example trial is shown in Figure 1. After each participant's photograph

and judgments, participants were asked to rate “how rewarding was this?” and “how painful was this?”, both on a sliding scale from 1 to 100. A total of 120 photographs were presented on a CRT screen using the E-prime software (Psychology Software Tools, Pittsburgh, PA) in a single block. Ten fake profiles were added to provide ‘yes’ as feedback to every participant. The task lasted an average of 30 minutes. At the end of the task, each participant was debriefed accordingly.

Figure 1

Single-trial overview of the romantic feedback task.



Note. Example of a rejection condition trial for the romantic evaluation task. The picture was taken from Getty Images by Morsa Images (2016) and was not used in the experiment.

Data Acquisition

Participants were connected to both an EEG and an ECG. Both ECG and EEG data were recorded using the BioSemi Active-Two system. ECG signals were obtained from a single lead placed below the left ribcage, using a low-pass filter of 134 Hz and digitized at a sampling rate of 512 Hz with 24-bit A/D conversion. Skin contact quality was verified before the start of the recording. EEG and ECG data were processed offline using Brain Vision Analyzer 2 (Brain Products GmbH, Munich, Germany). For the analysis of cardiac responses, R-peaks were automatically detected in the ECG signal using the peak detection algorithm implemented in Brain Vision Analyzer, and inter-beat intervals (IBIs) were calculated between consecutive R-peaks. The R-peak series were visually inspected for artifacts, with missing peaks interpolated and spurious detections removed. Four consecutive IBIs following feedback presentation were selected; the concurrent (IBI 0) and three subsequent IBIs (IBI 1, IBI 2, and IBI 3) were extracted and used as measures of heart rate deceleration. The four post-feedback IBIs (IBI0-IBI3) were baseline-corrected to the second pre-feedback IBI (IBI-2) to account for individual differences in resting heart rate.

Data Processing and Statistical Analyses

The data were analyzed using repeated measures ANOVAs, repeated measures ANCOVAs, and a one-way ANOVA using SPSS (version 27). The statistical significance level was set at $p < .05$. Prior to conducting the analysis, the assumptions were checked using SPSS. Firstly, the data were checked for outliers using scatter plots, Cook's distance (values larger than 1), and standardized residuals (absolute z-scores greater than 3.29). Influential cases identified through Cook's distance, as well as standardized residuals exceeding ±3.29, were examined but not automatically excluded. Scatter plots of standardized residuals and predicted values were

used to check for linearity. For normality of residuals, Q-Q plots and Shapiro-Wilk's test were inspected. Levene's test was used to check for homogeneity. Within the ANCOVA models, homogeneity of regression slopes was assessed by testing the interaction effect between the covariate and independent variable. In ANCOVA, linearity was checked with scatterplots between the covariate and the dependent variable. Huynh-Feldt correction was applied to variables with more than 2 factors; however, uncorrected degrees of freedom were reported. Lastly, independence of observations was ensured, as each participant contributed data independently. Any detected assumption violations were addressed using appropriate data transformations.

Cardiac Deceleration Differences

Firstly, a 2x2x4 repeated measures ANOVA was conducted to examine the effect of feedback type on cardiac deceleration measured through Inter-beat Intervals (IBI) during the romantic evaluation task. The analysis aimed to explore whether different combinations of own x other judgements elicited different IBI responses. The analysis specifically examined the IBI changes elicited when one's own judgment is 'Yes', and the other says 'No' (rejection effect). Own feedback (Yes/No) with two levels, others' feedback (Yes/No) with two levels, and sequential (IBI0-IBI3) with four levels were treated as within-subject factors.

Secondly, a repeated measures analysis of covariance (ANCOVA) was conducted to examine the effects of feedback type on cardiac responses during the romantic evaluation task. The total ACE score was included as a continuous covariate. Own feedback (yes, no), Other feedback (yes, no), and sequential IBI (IBI0-IBI3) were included as within-subjects factors. This analysis aimed to test whether higher levels of adverse childhood experiences were associated with greater cardiac deceleration in response to rejection feedback. The ANCOVA examined the

main effect of ACE, as well as potential interactions between ACE and the within-subjects factors.

A second ANCOVA was conducted, just as the previous one; the test examined the effects of feedback on cardiac responses, this time with Attachment Styles as a between-subjects factor. The variable attachment style was dichotomized into secure attachment style (= 0) and insecure attachment style (= 1). The insecure attachment style category included avoidant, anxious, and disorganized attachment styles. This analysis aimed to test whether insecure attachment styles were associated with stronger cardiac deceleration in response to rejection from a fellow participant. This analysis includes the main effect of Attachment Styles as well as its interactions with judgment type and sequential IBI.

Subjective Pain Differences

A repeated measures ANOVA was conducted to investigate the effects of feedback type on subjective pain ratings during the rejection task. Subjective pain was used as the dependent variable. Own feedback and Other feedback were treated as within-subjects factors. The analysis tested for main and interaction effects to determine whether higher ratings of pain were reported when rejected in comparison to other feedback conditions.

Secondly, to examine whether ACE scores influenced the effects of feedback type on subjective pain, the same repeated-measures model was re-run with ACE included as a covariate (ANCOVA). All other specifications of the analysis remained identical.

An additional repeated measures ANCOVA was conducted to explore whether attachment style influenced subjective pain responses across the different feedback conditions. In this model, attachment style was included as a between-subjects factor, Own feedback and Other feedback remained the within-subjects factors, and subjective pain was the dependent variable.

Lastly, to explore differences in swiping behavior patterns across the attachment styles, a one-way ANOVA was conducted. The yes responses were transformed into percentages and compared across attachment styles to determine whether there were differences.

Results

A total of 56 individuals (N = 56) initially participated in the romantic feedback task. Seven participants who had missing data on the IBI measure were excluded to ensure comparability. The final sample was of 49 participants. When screening for influential cases, all Cook's Distance scores were >1, meaning there were no influential cases. Seven standardized residuals exceeded the ±3.29 across different variables. No participant exceeded this threshold on more than one measure. Inspection of the raw data showed no impossible values or entry errors, the scores reflected individual variability in participants (e.g., consistently reporting higher subjective pain ratings across conditions). Therefore, the data points remained. Re-running the analyses without these cases yielded the same pattern of results, confirming the robustness of the findings.

Participant demographics are presented in Table 1. The overview of the mean and standard deviation for ACE and attachment styles is shown in Table 2.

Table 1

Demographic characteristics of the final sample

Statistic	Age	Gender			
		Male	Female	Non-binary	Prefer not to say
n	49	21	26	1	1
Mean (SD)	22.02 (2.61)				
	Sexual orientation				
	Gay	Bisexual	Heterosexual	Queer	Unsure
n	1	7	35	3	3

Note. Descriptive statistics for the final sample (N=49). Including n, Mean and Standard Deviation (SD) for Age, and frequencies for Gender and Sexual orientation

Table 2

Descriptive statistics of key study variables

	ACE	Attachment style	
		Not secure (0)	Secure (1)
n	49	34	15
Mean (SD)	1.69 (1.46)		

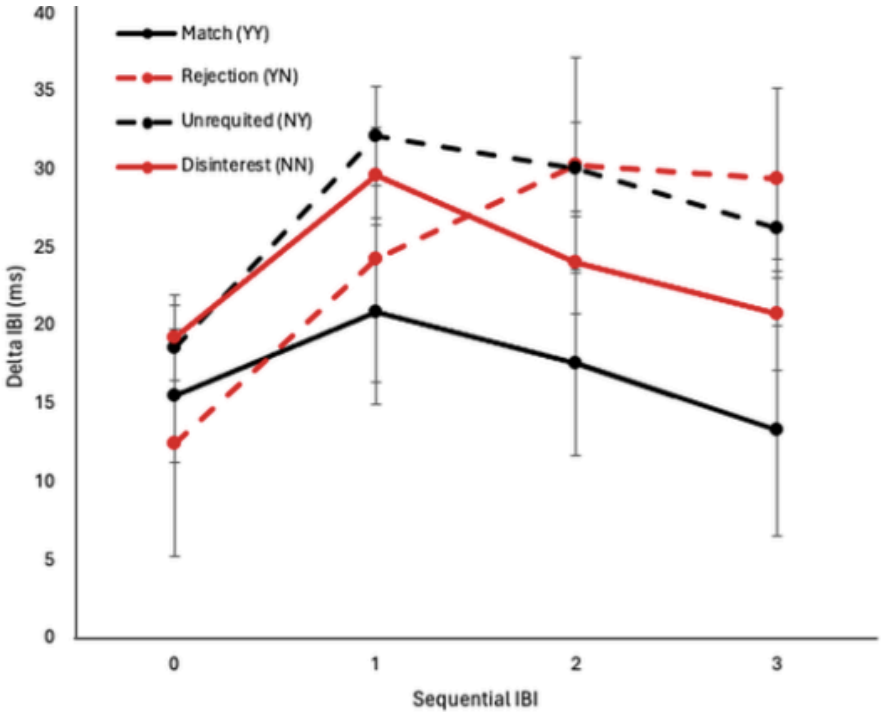
Note. Descriptive statistics for key study variables Adverse childhood experiences (ACE) and Attachment style. Attachment style was dichotomized into "0 = not secure" (incl. anxious, avoidant and disorganized attachment styles) and "1 = secure"

The first main analysis is a 2x2x4 repeated measure ANOVA, which examined the effects of participants' own choices in relation to others' judgments on cardiac deceleration, measured through inter-beat intervals (IBI0-3). Q-Q plots for the combination of own judgement, others' judgement, and inter-beat interval (IBI) suggested approximate normality. Normality was further supported by Shapiro–Wilk's test, indicating the data to be approximately normally distributed across conditions, although a few early inter-beat intervals showed minor deviations. Given the moderate sample size and the robustness of repeated measures ANOVA to such deviations, no data transformations were applied. Since the within-subject factors had 4 levels, the Sphericity assumption was tested. Mauchley's test of sphericity was violated for all effects involving IBI (all $p < .001$), therefore, the Greenhouse–Geisser correction was applied. The repeated measures ANOVA analysis yielded a significant main effect of IBI, $F (1.70, 81.35) = 6.13$, $p = .005$, $\eta^2 = .11$, meaning cardiac deceleration changed at different time points. A significant interaction was also found between participants' own judgements and that of the

potential partners, F (1, 48) = 5.55, p = .02, η^2 = .10, suggesting cardiac responses to potential partners' feedback to be dependent on participants' own evaluations. Providing evidence toward an existing rejection effect. Lastly, the three-way interaction between own judgement, potential partner judgement, and IBI was significant, F (1.80, 144) = 7.66, p = .001, η^2 = .14, indicating the effect of rejection on cardiac deceleration to vary across inter-beat intervals, or in other words, change over time. Mean cardiac deceleration across IBI0-3 for each combination of participants' and potential partners' judgements is illustrated in Figure 2.

Figure 2

Mean cardiac deceleration for match (Yes-Yes), rejection (Yes-No), unrequited (No-Yes), and disinterest (No-No)



Note. Error bars represent 95% confidence intervals.

To see which feedback conditions differ and at what time points, pairwise comparisons were looked at. When participants said "Yes", there was no significant difference in cardiac

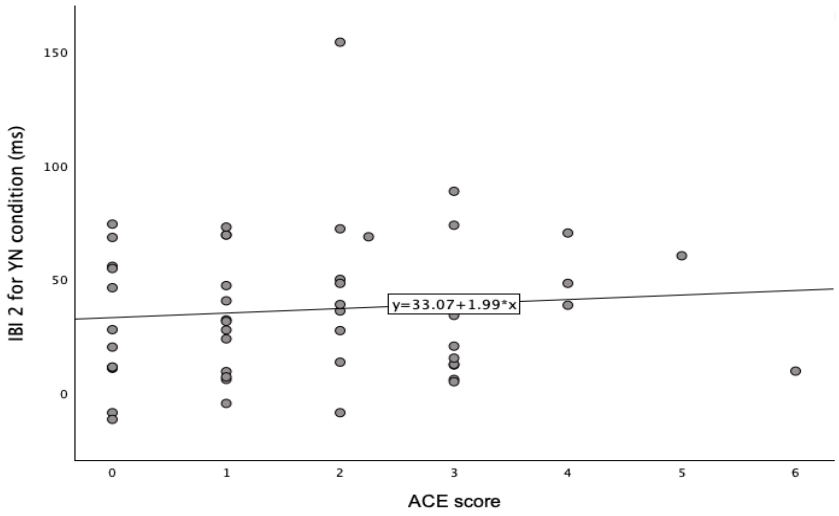
deceleration between when the potential partner said “Yes” and when they said “No” during early cardiac intervals IBI0, M_{diff} = -.96, p = .89, and IBI1, M_{diff} = -9.72, p = .22. At later intervals, however, a rejection effect emerged. Both IBI2, M_{diff} = -18.798, p = .008, and IBI3, M_{diff} = -20.77, p = .005, showed cardiac deceleration to increase when own judgment is “Yes”, and the other participant says “No”. This suggests that the emotional impact of rejection manifests during later cardiac intervals. Additionally, a significant effect was also found when participants said “No” and others said “Yes”; this was only significant for IBI2, M_{diff} = -5.73, p < .05.

Secondly, a 2x2x4 ANCOVA was conducted, to examine the effect of Adverse Childhood Experiences on IBI changes in response to being rejected by a potential partner. Before running the analysis, the appropriate assumptions were checked.

Mauchly’s test indicated the sphericity assumption to be violated across all effects involving IBI, for this reason, we use Greenhouse-Geisser. No major deviations or nonlinear patterns were observed when visually inspecting scatter plots, indicating an approximately linear relationship. In addition, no significant interaction effects were found between ACE scores and any within factors, meaning homogeneity of slopes assumption was met. In the ANCOVA, the main effect of ACE was not significant, $F(1, 47) = 1.01$, p = .32, η^2 = .02. ACE scores did not significantly predict IBI changes across any feedback condition. All interactions involving ACE were also non-significant. Overall, ACE scores did not alter cardiac deceleration responses to rejection.

Figure 3

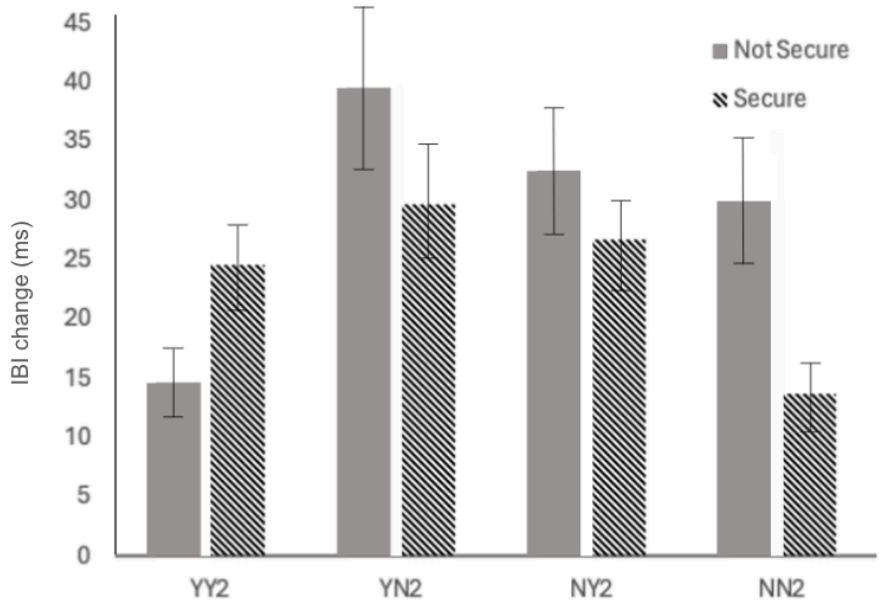
Scatter of ACE scores and IBI 2 in the Yes-No condition



The third analysis was also a 2x2x4 design examining the effects of Attachment styles (secure = 1, not secure = 0) on IBI changes when experiencing romantic rejection. Sphericity checks using Mauchly's test of sphericity showed violations across all interactions with IBI, therefore, Green House Geisser correction was used. Homogeneity of variances were checked with Levene's test for homogeneity, all variances are equal across all groups. The main effect of Attachment styles was not significant, $F = .903$, $p = .35$, $\eta^2 = .02$. Insecure attachment styles did not significantly affect cardiac deceleration when experiencing romantic rejection. The interaction between Attachment style and all other within factors (own judgement, other judgement and IBI) were not significant, all $F < 2.50$ and all $p > .12$. The visual depiction of mean IBI2 time across all feedback conditions for attachment styles is depicted in Figure 4.

Figure 4

Mean cardiac deceleration changes in secure and not secure attachment styles across IBI2 feedback conditions.



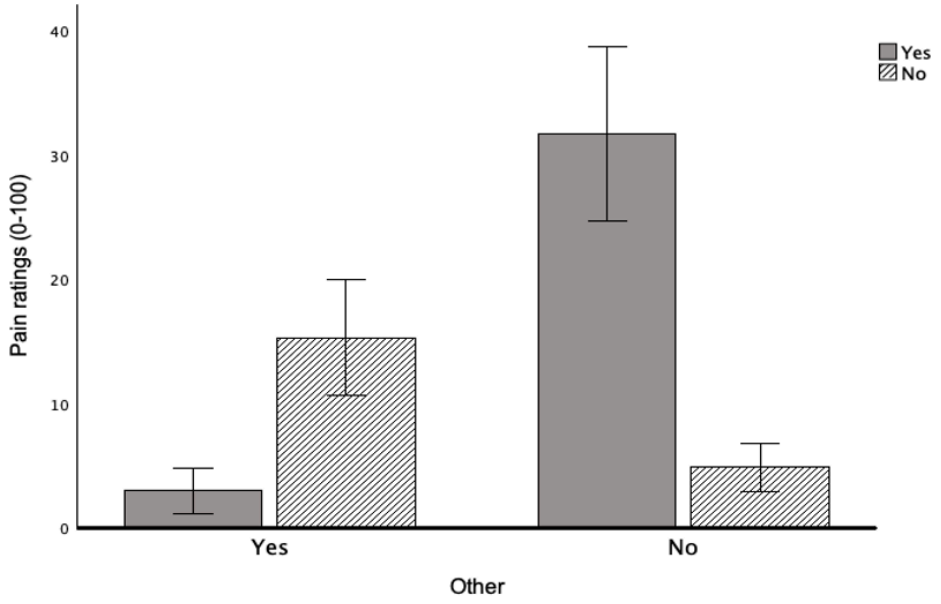
Note. Error bars represent 95% confidence intervals.

To examine the effects of own judgement and the potential partner's judgement on subjective pain scores, a 2×2 repeated-measures ANOVA was conducted. Q–Q plots revealed minor departures from normality, especially in the lower tail, which are expected for 0–100 scale pain ratings. As repeated-measures ANOVA is robust to such deviations, all analyses were carried out without adjustment. There was a significant main effect of own judgement, $F(1, 48) = 21.85$, $p < .001$, $\eta^2 = .31$. Participants reported higher pain when they had indicated interest in the potential partner compared to when they had not. Others' judgement also showed a significant main effect, $F(1, 48) = 28.89$, $p < .001$, $\eta^2 = .38$, meaning participants experienced greater pain when they received a rejection from the potential partner compared to an acceptance. Lastly the interaction effect between own judgement and potential partners judgement was significant, $F(1, 48) = 88.09$, $p < .001$,

$\eta^2 = .65$. Thus, the effect of the potential partner's judgement on pain, depended on the participant's own judgement, in other words, rejection elicited the highest pain when participants had indicated interest themselves. Pairwise comparisons were examined to examine how specific combinations of own and other judgements influenced subjective pain. When participants indicated "Yes", pain was significantly higher when the potential partner responded with "No" rather than "Yes," $M_{diff} = 28.69$, $p < .001$, indicating that rejection was especially painful when participants had expressed interest. When participants indicated "No", pain was also higher when the potential partner responded with "Yes" compared to "No," $M_{diff} = 10.44$, $p < .001$. This suggests that mismatched outcomes, either liking someone who rejects you (YN) or being liked by someone you reject (NY) produce greater subjective pain than matched outcomes (YY or NN). These mean differences are depicted in Figure 5.

Figure 5

Mean subjective Pain Ratings Across Own and Other Judgements



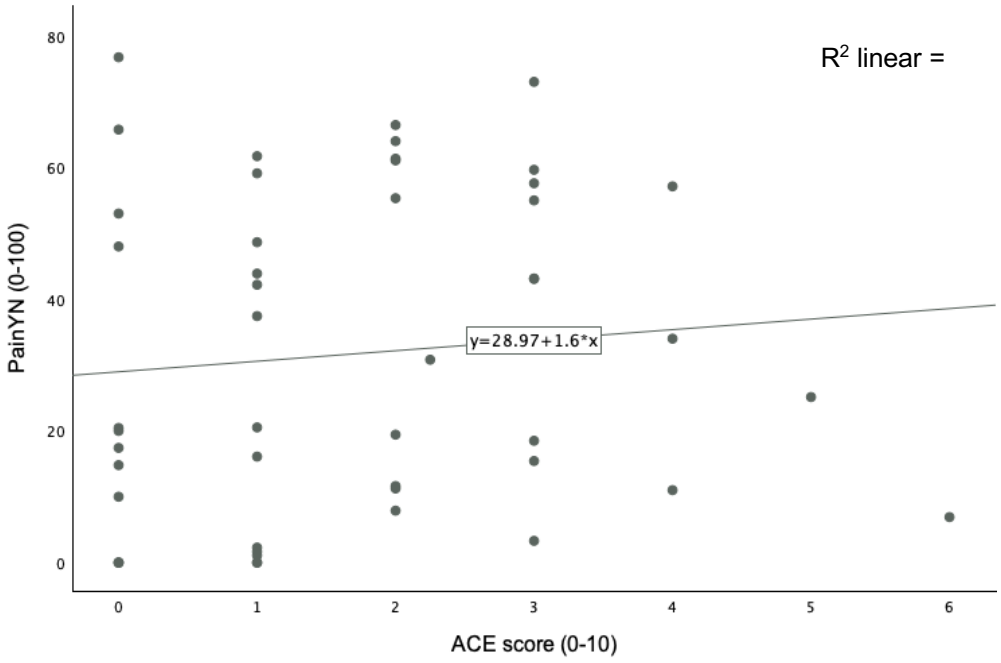
Note. Mean pain scores reported in each feedback condition, based on whether participants said "Yes" or "No" and whether the potential partner responded with "Yes" or "No." Error bars represent 95% confidence intervals.

To examine whether adverse childhood experiences (ACE) influenced pain responses to judgment outcomes, a 2×2 repeated-measures ANCOVA was conducted with ACE as a covariate. Scatterplots between ACE and pain were used to check for linearity, despite the clustering of ACE no major deviations of linearity were identified. The assumption of linearity was considered met. There were no significant interaction effects between ACE and own judgement, or potential partners' judgement, hence the homogeneity of slopes assumption was met. The ANCOVA showed no significant main effect of ACE, $F(1, 47) = 19.9$, $p = .84$, $\eta^2 = .001$, indicating that ACE scores did not predict changes in subjective pain ratings across feedback conditions. Interactions involving ACE were also non-significant (all $F < 1.45$, all $p > .24$). Overall, ACE scores

did not influence subjective pain responses to rejection. Figure 6 presents the score distribution of ACE scores in relation to subjective pain when the participant is rejected.

Figure 6

Scatter of ACE scores and Pain in the Yes-No condition

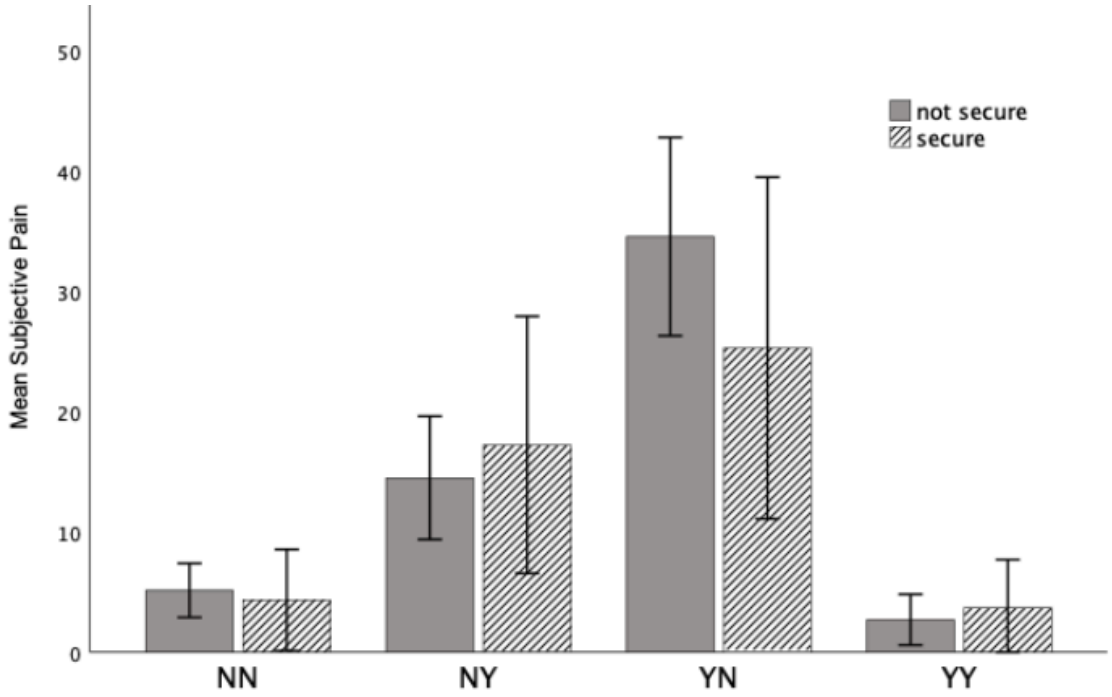


To examine whether attachment style (secure = 1, insecure = 0) influenced subjective pain, a 2×2 repeated-measures ANOVA was conducted. Homogeneity of variances was assessed using Levene's test, which indicated no violations, suggesting that group variances were equivalent. The main effect of attachment style was not significant, $F(1, 47) = 0.38$, $p = .64$, partial $\eta^2 = .005$, indicating that insecure attachment did not significantly predict subjective pain during romantic rejection. Interactions between attachment style and any within-subject factors (Own Judgement, Other Judgement, or their interaction) were also non-significant, all $F < 3.71$,

all $p > .06$. Mean subjective pain scores across feedback conditions for each attachment group are shown in Figure 7.

Figure 7

Mean subjective pain scores across feedback conditions for each attachment group.



Note. Error bars represent 95% confidence intervals.

Lastly, a One-way ANOVA was performed to explore the swiping behavior differences in attachment styles by using "Yes" swipe percentage. Visual inspection of Q–Q plots indicated that the distribution of yes-swipe percentages was approximately normal within each attachment group. Therefore, the normality assumption for the ANOVA was considered met. Levene's Test of homogeneity confirmed homogeneity of variances was met. The ANOVA revealed no significant effect of attachment style on yes-swipe percentage, $F(2, 46) = 0.35$, $p = .71$. This indicates that avoidantly attached participants did not swipe "yes" less often than the other attachment groups.

Discussion

This study examined how romantic feedback influences cardiac deceleration and subjective pain and whether these responses are shaped by Adverse Childhood Experiences (ACEs) and attachment styles. In addition, we investigated whether attachment style was associated with swiping behaviors. Results show that cardiac deceleration was largest when participants wanted to go on a date but were rejected. Unrequited feedback, defined as the participant not expressing interest while receiving interest from the other person, elicited the second highest level of cardiac deceleration. However, neither ACE scores nor attachment style were associated with cardiac deceleration in response to feedback. Subjective pain ratings were higher when participants were rejected, but ACE scores and attachment style did not influence subjective pain reactions to feedback. Swiping behavior differences between the attachment styles were also not found.

Before examining the effects of ACE and attachment styles, it was important to see whether rejection alone increased cardiac deceleration during the task. Cardiac deceleration was highest when the participant was rejected by someone they were interested in, in line with the existing literature (Van der Veen, 2019). However, this study unexpectedly found unrequited love to elicit the second highest level of cardiac deceleration, whereas Van der Veen (2019) reported greater cardiac deceleration in response to disinterest. This suggests that participants might experience an increase in romantic pain when responding no to another participant yet receiving a positive response in return. A reason as to why this may have occurred is the differences between our research design and that of previous paradigms. Van der Veen and colleagues' (2019) study, for instance, consisted of a heterosexual sample group, where men were only shown women and vice versa. As stated earlier, our study includes multiple sexual

orientations, exposing individuals with opposing sexual orientations to each other. The current literature suggests that heterosexual men are more likely to experience masculinity threats in response to homosexual men; this finding applies to effeminate homosexual men (Glick et al., 2007; Wellman et al., 2021; Salvati et al., 2021). The studies indicate that heterosexual men may experience heightened masculinity threat when encountering same-gender individuals who deviate from conventional masculine norms, especially when these individuals are seen as more feminine and express same-sex attraction. This bias stems from their desire to create distance from such men to uphold gender norms (Glick et al., 2007; Wellman et al., 2021; Salvati et al., 2021). There is currently no research examining this effect in female counterparts. Receiving feedback from someone of a different sexual orientation may also constitute as an expectancy violation. Prior research suggests that expectancy violations in social situations can produce cardiac deceleration responses, which may explain the unexpected effect observed, where expectancy violation could have influenced cardiac responses to feedback (Le Poire & Burgoon, 1996; Mendes et al., 2007).

It was hypothesized that more ACEs would be associated with an increase in cardiac deceleration when rejected by a potential romantic partner, however, this effect was not found in the current study. Previous research found that more ACEs are associated with increased rejection sensitivity, and may therefore heighten one's vulnerability towards social pain, including romantic rejection (Anda et al., 2006; Bowlby, 1982; Gao et al., 2024). One explanation for why the relationship was not found to be significant in the current study could be the non-clinical nature of our sample, which may have affected the variability of ACE scores in our sample. The sample in this study largely consisted of healthy international Psychology master's students. Most participants scored well below the threshold of low to moderate adversity

on the Adverse Childhood Experiences Questionnaire, leading to a floor effect; the lack of variability was likely insufficient to reveal significant associations of ACE and cardiac deceleration when romantically rejected. Most research concerning ACEs treat the score of 4 as an informal cut-off point, with many findings suggesting risks for negative outcomes tend to increase sharply from that point onward (Watt et al., 2022; Hardcastle et al., 2018; Bryan, 2019; Hughes et al., 2017). In our sample, five participants scored a 4 or above, with one score of 5 and one score of 6, which suggests that the sample may not have contained enough high-risk cases to reveal strong associations. Most of the scores were in the 0 to 3 range. Additionally, our study excluded individuals with neurological or psychiatric disorders, thereby further limiting variability. Previous research suggests ACE to be strongly associated with poorer mental health outcomes, increasing the chances of developing psychiatric disorders such as depression (Daníelsdóttir et al., 2024; Hughes et al., 2017; Hughes et al., 2019; Petruccelli, Davis, & Berman, 2019; Copeland et al., 2018). Including individuals with psychiatric disorders may have increased the ACE score variability of our sample.

Regarding attachment styles, it was anticipated that insecure attachment styles would lead to an increase in cardiac deceleration in romantic rejection, this effect was not found in the current study. Previous research suggests insecure attachment styles to experience higher rejection sensitivity (Downey & Feldman, 1996; Bowlby, 1982; Fisher, 2014; Burklund et al., 2007; Van der Veen et al., 2014; Eisenberger, 2012). Therefore, individuals with insecure attachment styles were expected to show a heightened sensitivity to rejection.

The proportion of securely vs non securely attached participants observed in the present sample may reflect typical distribution in non-clinical student populations, rather than indicating a predominantly vulnerable sample (Hazan & Shaver, 2017).

One possible explanation to the findings in this study, may be the unequal group sizes between the attachment styles. The sample consisted of 15 securely attached individuals and 34 in the non-secure group. The attachment groups were therefore unbalanced. Unequal group sizes, especially when combined with dichotomization, reduce power and can obscure between-group differences (Sauzet & Peacock, 2014). Furthermore, dichotomizing attachment styles may have obscured distinct effects associated with anxious versus avoidant attachment. Current research indicates attachment styles should be treated as dimensional rather than categorical, due to anxiety and avoidance reflecting continuous and distinct underlying processes that are lost when people are boxed into broad categories like “secure” or “insecure”, let alone a category such as not secure (Fraley, 2019; Fraley et al., 2011). FMRI studies suggest, anxious and avoidant attachment styles exhibit opposing response patterns in the brain. The dACC is often associated with the experience of social pain; anxiously attached individuals were associated with heightened dACC activity, whilst avoidants showed dampened dACC activity (Eisenberger et al., 2003; DeWall et al., 2010; DeWall et al., 2012). These findings further suggest comparing the attachment styles separately, as together they may neutralize any existing effect.

Considering our sample mostly consists of healthy (without psychiatric disorders) psychology master students, the high proportion of participants classified as insecurely attached is noteworthy. One possible explanation is that individuals with non-secure attachment styles may be more likely to engage in online dating, which could increase the likelihood of participation in online dating paradigms. Multiple studies have found that anxiously attached people report using online dating platforms more frequently than other attachment styles (Chin et al., 2018; Topino et al., 2025; Coffey et al., 2022; Jonason & Bulyk, 2019). Potentially due to a heightened motivation to seek romantic connection (Chin et al., 2018). In addition, avoidantly

attached individuals may initially prefer online dating, as it enables them to have easier control over the interactions and allows them to create emotional distance (Nelson, 2024). Although speculative, these patterns may partially account for the attachment distribution in the current sample.

Subjective pain responses were highest following romantic rejection compared to all other feedback conditions. This aligns with the previous research showing that self-reported pain is greatest following an unexpected event, such as romantic rejection in the present paradigm (Torzillo et al., 2024).

The study hypothesized that higher ACE scores would be associated with higher subjective pain ratings. The existing literature suggests that individuals with higher ACE scores have an increased level of rejection sensitivity, possibly inducing higher levels of subjective pain (Anda et al., 2006; Bowlby, 1982; Gao et al., 2024). However, this effect was not found within this study. Similarly to our cardiac findings, this may be due to the lack of variability of ACE scores in our sample, as well as the exclusion of individuals with psychiatric disorders. A recent fMRI study by Truchan (2025), looking at amygdala and dorsolateral prefrontal cortex activation, contradicts our initial hypothesis. They suggest that individuals with higher ACE scores are less responsive to social rejection due to early-life exposure, which may help build resilience in adulthood. The latter may apply to romantic rejection and may suggest that high ACE scores are negatively associated with higher subjective pain. However, this interpretation may not apply across all levels of adversity. It is possible that individuals with moderately high ACE scores exhibit greater resilience to romantic rejection, whereas individuals with more severe ACE exposure may show heightened vulnerability to subjective social pain. This pattern would be consistent with an inverted U-shaped relationship between ACEs and subjective pain

responses, which could not be tested in the current study due to sample characteristics (Seery et al., 2010).

The fourth hypothesis examined whether attachment styles were associated with higher subjective pain ratings during the rejection task, however, no differences in subjective pain were observed across the attachment styles. One possible explanation is that attachment-related differences tend to emerge most strongly in emotionally meaningful or attachment-relevant contexts (Fraley, 2019). Although the present paradigm successfully elicits affective and physiological responses to romantic feedback, the brief nature of online dating may not be sufficient to fully engage participants attachment styles. Since feedback was provided by strangers rather than emotionally significant others, attachment related differences in subjective pain may not have been expressed. This raises the question of whether real-world online dating interactions, which typically involve short term engagement, are sufficient to activate attachment processes. As previously mentioned, uneven group sizes between the secure and non-secure groups, together with a dichotomizing, may have limited the detection of differences between the attachment styles, given that they were grouped together for comparison. (Sauzet & Peacock, 2014; Fraley, 2019; Fraley et al., 2011).

As exploratory hypothesis, the study looked at swiping behavior differences between the attachment styles, predicting fewer ‘yes’ swipes from those with an avoidant attachment style. The prediction was based on the notion that avoidants tend to create emotional distance due to fear of rejection and may therefore become more cautious when making romantic decisions (Downey & Feldman, 1996; Bowlby, 1982). However, no such association was found in the current study. Although the research on attachment styles and online dating is highly limited, some do suggest avoidants are less inclined to use dating apps due to their expectations of

failure, inability to commit, and striving for emotional distance (Chin et al., 2018; Topino et al., 2025). Even so, others suggest that avoidants may be more inclined to use such apps due to the perceived lack of intimacy, allowing users increased control over their interactions and the ability to self-disclose at their own pace (Nelson, 2024). Negative associations were found between avoidant attachment style and seeking self-disclosure, supporting the idea that avoidants would benefit from controlled self-disclosure opportunities such as online dating apps (Bartholomew, 1990; Mikulincer & Shaver, 2016). The association between a decrease in giving positive feedback and an avoidant attachment style remains unclear within the existing literature. In addition, there was a low percentage of positive feedback across all participants, despite their attachment style. When combining all attachment styles, participants gave a mean of 22% 'yes' responses. A possible reason for this may be the design of the task itself. Since the sample consisted of multiple different genders and sexual preferences; as a result, the task included profiles that did not correspond to participants' sexual orientation, meaning they often had to swipe on individuals to whom they were not sexually attracted. For instance, heterosexual men swiping on homosexual men. This is likely the reason for the low positive feedback percentage.

The current study consists of many strengths. By combining cardiac deceleration and subjective pain ratings, the study was able to capture physiological and subjective changes in the experience of romantic rejection. Furthermore, the task closely resembles online dating platforms, increasing the generalizability of our findings to real-world online dating. Additionally, our sample, unlike previous studies of a similar nature, includes different sexual orientations. Increasing inclusivity within the sample further strengthens the validity of the research design.

Despite the strengths, several limitations indicate that the results should be interpreted carefully. Firstly, the sample was relatively small, limiting the statistical power and, in turn, hindering our ability to find subtle effects and inflating effect sizes. Small samples may hide true population effects; therefore, a replication using a larger sample would be ideal. In addition, the attachment groups were highly imbalanced, something that is less likely to occur in larger samples. The sample was highly homogeneous, mostly consisting of healthy, well-educated master's psychology students. Increasing variability, for instance, including people with psychiatric disorders, may be beneficial for further research on ACE and attachment styles within this context. The ACE questionnaire provides only a brief assessment of childhood adversity and therefore does not fully capture the complexity of the construct. Testing for factors related to ACE may be interesting for future research. Developing a more detailed questionnaire for ACE in which the consequences of adversity are considered may better reflect the construct. Lastly, although an inclusive sample, having multiple sexual orientations in one sample may give rise to the influence of external factors (e.g., expectancy violation). Allowing participants to swipe only on people who share their sexual orientation would better capture the experience of romantic rejection and make the design more generalizable, given that dating apps typically include such filters.

Overall, the present study found that romantic rejection was associated with greater cardiac deceleration and higher subjective pain ratings compared to non-rejection conditions, consistent with previous findings using similar paradigms. In contrast, ACE scores and attachment style were not significantly associated with cardiac deceleration, subjective pain or swiping behaviors. These findings likely reflect characteristics of the sample design, such as limited variability in ACE scores influenced by the exclusion of individuals with psychiatric

disorders and the dichotomization of attachment styles potentially canceling out attachment related effects. Additionally, it remains unclear whether brief, interactions with unfamiliar partners within online dating, are sufficient to consistently activate attachment processes during the task. It is important to note that the finding that unrequited interest elicited pronounced cardiac deceleration was unexpected and has not been consistently reported in previous romantic rejection paradigms. This suggests a potentially distinct physiological sensitivity to unrequited romantic interest. This observation highlights an interesting direction for future research to further examine the mechanisms underlying cardiac responses to different forms of romantic evaluation and potential moderating factors. Nevertheless, the study demonstrates that the online dating romantic rejection paradigm elicits physiological and subjective romantic pain responses. Future research should consider larger and more diverse samples, greater variability in exposure to adversity, more comprehensive ACE scales, and more dimensional approaches of measuring attachment, which may better capture attachment subtype-specific responses to romantic rejection.

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