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Linking social reward responsiveness and affective responses to the social environment: an ecological momentary assessment study

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Abstract

Social support is a key predictor of well-being, but not everyone experiences mental health benefits from receiving it. However, given that a growing number of interventions are based on social support, it is crucial to identify features that make individuals more likely to benefit from social ties. Emerging evidence suggests that neural responses to positive social feedback (i.e., social reward) might relate to individual differences in social functioning, but potential mechanisms linking these neural responses to psychological outcomes are yet unclear. This study examined whether neural correlates of social reward processing, indexed by the reward positivity (RewP), relate to individuals' affective experience following self-reported real-world positive social support events. To this aim, 193 university students (71 % females) underwent an EEG assessment during the Island Getaway task and completed a 10-day ecological momentary assessment where participants reported their positive and negative affect (PA, NA) nine times a day and the count of daily positive and negative events. Experiencing a higher number of social support positive events was associated with higher PA. The RewP moderated this association, such that individuals with greater neural response to social feedback at baseline had a stronger positive association between social support positive events count and PA. Individual differences in the RewP to social feedback might be one indicator of the likelihood of experiencing positive affect when receiving social support.

1. Introduction

Social support is a key predictor of well-being (Taylor, 2011; Thoits, 2011). A substantial body of research has demonstrated that people who receive social support —defined as the perception or experience that one is loved and cared for by others (Taylor, 2011) —rate higher on measures of both psychological and physical health (Dimatteo, 2004; Silvers & Peris, 2023; S. E. Taylor, 2011; Wang et al., 2018). Social support has been shown to promote positive emotions (Siedlecki et al., 2014; Taylor, 2011; Taylor et al., 2014), buffer against the deleterious effects of stress exposure (Dalgard et al., 1995; Ditzen & Heinrichs, 2014; Eisenberger et al., 2007; Howard et al., 2017), improve treatment outcomes for a variety of diseases (Kelly et al., 2017; Wang et al., 2018), and reduce overall mortality (Holt-Lunstad et al., 2010). Moreover, at a within-person level, there is evidence for greater well-being on days when people experience more social support (Liu et al., 2019). Despite this compelling work, not everyone seems to benefit from overtures of support from others (Auerbach et al., 2011; Rueger et al., 2008; Santini et al., 2015; Scholz et al., 2012), and those who benefit less may also experience worse mental and physical health outcomes (Turner & Brown, 2010). Hence, to optimize and design effective interventions based on social support as a stress-alleviating strategy, it is crucial to better understand who can best capitalize on social ties (Rueger et al., 2016; Thoits, 2011).

Emerging evidence suggests that neural responses to positive social feedback—also called social rewards—may relate in important ways to individual differences in social functioning (Tamir & Hughes, 2018). For instance, adolescents with reduced neural response to positive feedback from peers also have less supportive relationships with peers (Flores et al., 2018; Panier et al., 2022), as well as reduced positive affect following peer interactions (Flores, et al., 2018). Similarly, adult women with a smaller neural response to social rewards also report decreased relationship quality (Freeman et al., 2022). Further, blunted neural responses to social rewards have been linked to a variety of psychopathological outcomes associated with interpersonal difficulties (Freeman et al., 2023; Olino et al., 2015; Pegg et al., 2019; Rappaport et al., 2023; Richey et al., 2014; Sequeira et al., 2021). However, potential mechanisms linking these neural responses to psychological outcomes are yet unclear.

One possibility is that neural responses to social rewards are associated with the strength of affective responses to positive social events. Previous research using monetary incentives has found that larger or more sustained neural responses to rewards are associated with more positive affect (PA; Duttweiler et al., 2023; Forbes et al., 2009; Heller et al., 2015). Similarly, a recent study from our lab using ecological momentary assessment (EMA) demonstrated that, though PA increased on days when participants reported more general positive events, this increase was strongest for those with a larger neural response to monetary rewards (Renault et al., 2023). For individuals with a smaller response to these rewards, the link between daily positive events and affective outcomes was not significant. Although these findings are promising, some important gaps remain. For instance, although monetary and social incentives elicit overlapping neural responses (Ait Oumeziane et al., 2019a; Gu et al., 2019), there is also evidence for category-specific patterns of responding, with distinct patterns of neural activation and behavioral responses across reward types (Banica et al., 2022; Chan et al., 2016; Hardin et al., 2007; Morelli et al., 2015; Rademacher et al., 2010; Sescousse et al., 2013; Spreckelmeyer et al., 2009). Moreover, alterations in the processing of distinct types of reward have been suggested to differentially capture specific features of hedonic functioning (Banica et al., 2022), suggesting that it may be useful to examine associations between daily affective experiences and neural responses to social rewards as well. Further, although our previous work collapsed across multiple types of positive events (e.g., Renault, et al., 2023), different positive events have been shown to elicit distinct affective responses (Chun et al., 2022). For example, positive interpersonal events have been found to generate greater positive affect than non-interpersonal events (e.g., achievement events; Chun et al., 2022; Dasch et al., 2008; Jaremka et al., 2011) and activities in which individuals receive social support typically elicit greater well-being (Lyubomirsky & Layous, 2013).

One previous study found that a larger neural response to social rewards moderated associations between experiences of emotional closeness and PA, such that those with a larger neural response to social rewards showed the strongest association between positive events and PA (Flores et al., 2018). Furthermore, there is extensive evidence that suggests that variability in mood reactivity to daily events is associated with the development and maintenance of psychopathology (Bylsma & Rottenberg, 2011; Houben et al., 2015; O'Neill et al., 2004; Schneiders et al., 2006). Altogether, these results then suggest that neural responses to social reward may be useful predictors for which individuals are most likely to show affective benefits from positive social experiences, and subsequently may experience the positive buffering effects of social support. Given these premises, the present study sought to extend our previously published work (Renault et al., 2023) to test whether neural responses to social rewards might moderate the association between daily experiences of social support and PA.

The measure of neural responses to rewards that we used in this study was the reward positivity (RewP), an event-related potential (ERP) that appears at fronto-central scalp sites 250-350 ms following feedback and is enhanced following positive outcomes (e.g., monetary or social rewards) relative to negative outcomes (e.g., monetary loss or social rejection). The RewP has been conceptualized as a signal stemming from reward-related brain regions (Holroyd et al., 2008, 2011; Holroyd & Coles, 2002). Particularly, studies that combined functional magnetic resonance imaging (fMRI) with electroencephalogram (EEG) found that the RewP was correlated with the hemodynamic activity across reward-related regions, particularly the ventral striatum and medial prefrontal cortex (Becker et al., 2014; Carlson et al., 2011). The RewP has been associated with self-reported affective functioning, whereby those with a reduced RewP amplitude also show higher trait and state negative affect (NA; Bress et al., 2013; Foti et al., 2011) and less PA (Weinberg & Shankman, 2017), though there is also some evidence that the RewP may be more closely related to PA in daily life (Renault, et al., 2023). However, the majority of these studies have been conducted using monetary incentives. There is increasing evidence for task- and incentive-dependent modulations of the RewP (e.g., Ethridge et al., 2017; Ethridge & Weinberg, 2018). Indeed, the RewP shows at best modest associations for the same component across different incentives and tasks (Banica et al., 2022; Ethridge & Weinberg, 2018), indicating that reward sensitivity has both domain-general and category-specific properties. Moreover, the RewP elicited by different incentive types shows distinct associations with features of hedonic functioning (Banica et al., 2022), suggesting results from monetary reward studies may not generalize to investigations using other types of reward. Consistent with this, there is some evidence to suggest that the RewP to social acceptance may be more tightly associated with affect and behavior following a variety of social experiences than the monetary RewP (Banica et al., 2022; Pegg et al., 2019; Weinberg et al., 2021), suggesting it will be useful to examine whether the RewP to social acceptance predicts affect following positive social support experiences.

The goal of this study was to establish whether neural correlates of social reward processing (i.e., RewP) relate to individuals' affective experience following self-reported real-world positive social support events. In particular, we examined (1) whether the occurrence of a larger number of self-reported positive events related to receiving social support was associated with greater PA and (2) whether social reward sensitivity, indexed by the RewP to social acceptance relative to rejection, moderated the association between the occurrence of positive social support events and PA over the course of a 10-day period. A large, unselected sample of undergraduates completed a laboratory EEG assessment during a social reward task and completed a 10-day ecological momentary assessment (EMA). We predicted that being exposed to more positive social support events would be associated with higher PA. In addition, we predicted that the social RewP would moderate this association, such that participants with a larger RewP to social acceptance would show a stronger association between the number of social support events and PA relative to those with a smaller RewP. To test the specificity of these associations, we also examined interactions with positive non-support experiences (i.e., positive achievements), and with NA.

2. Method

2.1 Participants

This investigation is part of an ongoing multi-wave longitudinal study for which 512 first-year undergraduate students were recruited from 2016, 2017, 2018, 2019, 2021, and 2022 (no in-person data were collected in 2020 due to the COVID-19 pandemic) to complete at least one laboratory visit. Students at McGill University were recruited through different channels (e.g., flyers, social media) and received course credit or $20 compensation for their time. Participants were not screened for mental health conditions prior to admission into the study, nor was the presence of clinical diagnoses assessed once enrolled. Because the EMA component was not introduced until 2018, only 204 of the 512 participants completed these surveys. Nine additional participants were excluded from the analyses because of technical problems during EEG data collection (e.g., absence of markers in the continuous signal), one participant was excluded as they only completed one EMA survey, and one participant was excluded because they were an outlier on age (35 years old), leaving a total of 193 participants. Of the final sample, 136 were female (70 %), 49 were male (25 %), three were non-binary (1.6 %), one was two-spirit (0.5 %), three did not identify as any of the provided options (1.6 %), and one did not disclose this information (0.5 %). Participants had a mean age of 18.2 (standard deviation (*SD*) = 0.53, range between 18 and 21). Additionally, 51.30 % were White, 1.03 % were Black, 23.31 % were East Asian, 3.10 % were South Asian, 5.70 % were Middle Eastern, 1.03 % were Hispanic, 3.62 % were Southeast Asian, 7.78 % indicated another ethnicity, and 3.11% did not indicate their ethnicity. A subset of the participants' EMA data was included in a recent publication examining whether monetary reward processing moderates the association between positive events (collapsing across non-social and social) and PA (Renault et al., 2023). In addition, some of the participants' EEG data from the same task were previously reported in other publications from our lab (Freeman et al., 2023; Weinberg et al., 2021). Complete study information can be found at the following link: https://osf.io/4tgau/.

2.2 Procedure

At the beginning of their first semester in university, undergraduate students were invited to complete a two-hour laboratory visit wherein EEG was acquired during different experimental tasks. During the laboratory visit, participants were also asked to participate in the EMA. As part of the ongoing study, the EMA surveys aim to explore the protective role of reward sensitivity during times of stress (for more details see Renault et al., 2023). Thus, participants who agreed to complete these surveys were asked to identify the date of their first midterm exam, and surveys were sent beginning two days before their first midterm. In addition, participants identified a suitable individualized 10-hour time window (e.g., 9 a.m. – 7 p.m.) for completing the EMA protocol. Participants had the option to send up to 90 responses over the 10-day period surrounding their first midterm. Participants were prompted to fill out eight one-minute surveys at random times with at least an hour between each survey during the 10-hour window they had selected. In addition, participants filled out a five-minute survey at the end of their selected time window every evening. For participants enrolled in the study between 2016 to 2021, surveys were sent through the phone application MetricWire (Trafford, 2015). From 2022 onwards, participants completed the same EMA protocol using Survey Signal which sends a Qualtrics link to participants' smartphones. Software type was a control variable in all the statistical analyses. On average, participants completed 42.2% of surveys (M = 38.02, SD = 25.63, median = 35 surveys). Initially, participants were compensated with $2 per day when they completed 8 or more surveys, totaling up to $20. However, to encourage survey completion, changes to the compensation were made in subsequent years. During the second year of EMA data collection, participants were compensated with $2 per day when they completed 7 or more surveys, with a bonus of $5 (up to $25) if they completed every survey sent over the 10-day period. Finally, from 2019 onwards (i.e., the third year of EMA data collection), participants were compensated with $3 for every day they completed at least 5 surveys and $1 for every day they completed 2 to 4 surveys, for a potential total amount of $30. The study was conducted in accordance with the Declaration of Helsinki and was approved by the McGill University Research Ethics Board.

2.3 Measures

2.3.1 Ecological momentary assessment

Momentary positive (PA) and negative affect (NA) and the count of positive and negative events were measured with the EMA. In all assessments, the Positive and Negative Affect Schedule (PANAS-21; Watson et al., 1988) was employed to assess momentary affective states. In this questionnaire, participants rate how much they felt each of 21 emotions (10 for PA and 11 for NA) at a given moment on a 5-point Likert scale ranging from "very slightly or not at all" to "extremely." The scale consisted of 21 emotions (e.g., distressed, enthusiastic, proud), and separate scores for PA and NA were calculated by summing participants' responses on each survey item specific to PA or NA. PA and NA scores for each survey range from 10 to 50 (11 to 55 for NA) with higher scores indicating higher levels of PA or NA.

In the five-minute evening survey, participants were also asked to complete a checklist of 87 potential events (47 positive and 40 negative) that might have happened to them that day. The list of events was loosely based on preexisting scales (Barrera, 1981; Cohen & Hoberman, 1983). The full list of possible events can be found at the following link: https://osf.io/4tgau/. For this investigation, we focused on positive social support events (n = 28, e.g., "*A family member comforted me when I was sad or upset*") and positive academic achievement events as a control (n =9, e.g., "*I made progress on an assignment or studying for a test*"). The coding of events into positive social support and achievement events was done through lab consensus in a meeting. The list of specific items relative to social support and achievement events is available in the supplementary material (Table S1).

2.3.2 Island getaway task

To assess social reward sensitivity, the island getaway (IG; Kujawa et al., 2014) task was employed (original task code is available at: http://arfer.net/projects/survivor, and code for the task described in this study is available at https://osf.io/457jd/?view_only=ec82f4c0ee2344e0bb1dd04ca8038cc7). Participants were informed that they would be playing a "Survivor-style" game against participants in other laboratories across North America. Participants generated a profile for themselves which included a picture. On each trial, participants viewed a coplayer's profile and were asked to vote to keep them in the game or kick them out of the game. Following each vote, participants then viewed a 1000 ms fixation cross and either a green thumbs up or a red thumbs down indicating whether that coplayer voted to accept or reject them, respectively. Each feedback trial (accept or reject) was displayed for 2000 ms. After the feedback, participants rated how much they liked the coplayer using a 9-point Likert scale from "not at all" to "extremely" as well as how much they thought other people would like that individual. Participants completed 51 trials across six rounds and received approximately 50% acceptance and 50% rejection feedback from coplayers.

2.5 Electroencephalographic recording and preprocessing

Electroencephalographic (EEG) signal was recorded continuously with BrainVision actiCHamp system (Brain Products, Munich, Germany) through 32 scalp electrodes based on the 10/20 system and a ground electrode at Fpz. Sampling rate was set to 1000 Hz, and impedance was kept below 10 kΩ. No online filter was used.

Offline analyses were conducted in BrainVision Analyzer software (Brain Products, Munich, Germany). Offline band-pass filters (0.01Hz-30Hz) were applied. Data were referenced to an average of the mastoid electrodes (TP9 and TP10). Ocular artifacts were corrected using a variation of the Gratton method using FP1 as the reference channel for vertical eye movements and FT9 as the reference channel for horizontal eye movements (Gratton et al., 1983). Intervals for individual channels were rejected using an automatic procedure applying these criteria: (a) voltage step > 30 μV/ms, (b) a change of >150 μV within 200 ms, (c) activity < -125 μV or >

125 μV, or (d) activity < 0.5 μV within 100 ms. Channels with fewer than five useable trials were interpolated from three to four surrounding electrodes. Data were then segmented separately for acceptance or rejection conditions; baseline correction was conducted using the 200 ms period before feedback onset. Trials were then averaged separately for acceptance or rejection conditions.

2.6 EEG analysis

The average waveforms were decomposed into distinct components through a temporospatial principal component analysis (PCA) using the ERP PCA Toolkit (Dien, 2010). For each participant, the grand average for each condition (accept, reject) containing all time points and electrodes was entered into a data matrix. A temporal PCA was first conducted, using a Promax rotation (Dien, 2010; Dien et al., 2007), and a parallel test was conducted on the resulting Scree plot (Cattell, 1966), in which the Scree of the actual dataset was compared to a Scree plot derived from a fully random dataset. The number of temporal factors to be retained was identified based on the largest number of factors that account for a greater proportion of variance than the fully random dataset (Dien, 2010). Based on this criterion, 14 temporal factors were extracted for rotation. The covariance matrix and Kaiser normalization were used (Dien et al., 2005). For each factor, scores representing the percentage of variance in the initial data captured by that factor were obtained for every combination of electrode and trial type. Then, a spatial ICA with an Infomax rotation was conducted on each of the 14 temporal factors to identify their spatial distribution. Based on a second parallel test (i.e., Scree plot), three spatial factors were obtained from each of the temporal factors. The resulting temporospatial PCA therefore identified 42 factor combinations that accounted for 77% of the total variance in the data.

Data extracted from this PCA represent the loadings of each participant's data onto the factor combination at the peak channel and time point; these loadings were then converted back to microvolts to assess the timing and spatial voltage distributions. Subsequently, to identify the components that significantly differentiated between acceptance and rejection feedback, a robust analysis of variance (ANOVA, Wilcox & Keselman, 2003) was conducted on the 21 temporospatial PCA factor combinations that accounted for more than 0.5% of the total variance in the data. Ten components significantly differentiated the two conditions and, of these, three spatially and temporally resembled known ERP components. The component reflecting most closely the RewP was a central positivity that was greater for accept relative to reject feedback $T_{WJt}/c(1.0, 177.0) = 20.09$, $p < .001$ and was maximal at 337 ms (Figure 1). The standardized residuals of the RewP (RewP_{resid}) using the mean response to reject feedback to predict the mean response to accept feedback, both at electrode Cz, were used for the following analyses.

2.7 Statistical analyses

Intraclass correlation coefficients (ICCs) were calculated for mixed-effect models predicting PA and NA from only the random intercept allowing for individual variation at the ID and Day levels, to verify that values differences were due to individual variability and not to random fluctuations or measurement error. The ICC is a measure of the proportion of total variance in the dependent variable that can be attributed to individual variations defined in the random intercept (i.e., individual variations across different days). To estimate the within-person reliability of the PANAS (for PA and NA items, separately), Cronbach's alpha was computed.

To evaluate whether the number of positive social support events, the RewP_{resid}, and their interaction were associated with greater PA, a linear mixed-effect model was employed. The same model with NA as the dependent variable was also performed. To account for the hierarchical structure of the dataset, participants' survey responses were nested within each day, which were in turn nested within each participant. This approach offers several benefits for analyzing repeated measures structures, leading to more accurate parameter estimates and better model fit. For instance, multilevel modeling accounts for both within-subjects variability and individual differences across participants (Flores et al., 2018).

Two repeated measures models were conducted (one predicting PA and one predicting NA) with the lme4 (Bates et al., 2014) and lmerTest (Kuznetsova et al., 2015) packages. The models had three levels: surveys (level 1), days (level 2), and participants (level 3). Both models included day, and participant ID as random intercepts, while the count of positive social support events, the $RewP_{resid,}$ and their interaction were specified as fixed factors. Because the type of software used to deliver EMA prompts changed during the study, EMA software type was also included as a covariate. For the fixed effects, the estimated coefficient (*b*), standard error (SE), *t* values, and confidence intervals for each parameter included in the final model were reported. In addition, the *p*-values obtained through the Satterthwaite approximation (implemented in the lmerTest library) were reported. A *p*-value of .05 was the cutoff for statistical significance. Simple slopes and Johnson-Neyman intervals were employed to probe significant interactions. To ensure that the effect was specific to positive social support events and not to positive events more broadly, sensitivity analyses were subsequently conducted substituting the number of positive social support events with another type of positive event – namely, events associated with personal achievement (e.g., getting a good grade, $n = 5$).

Before reporting the final model's results, a Bayesian Information Criterion (BIC) model selection was employed to assess whether a model including random slopes for positive event count within each participant and random intercept for both participant and day would be superior to our existing model that only included random intercepts of participant and day. The more complex models were not a better fit (PA: BIC = 32147; NA: BIC = 31935) than the initial model (PA: BIC = 32139; NA: BIC = 31927) for either PA or NA. In other words, there is no significant improvement in model fit by including the additional random slope. Hence, it was possible to report and interpret the initial models. Moreover, each model was compared with a simpler model (null model including only random factors) using the ANOVA function, which provided the chi-square statistics and the related *p*-value of the likelihood ratio test. All models detailed above provided a better fit than a null model.

Finally, for descriptive purposes, Pearson's correlations were conducted between the $RewP_{resid}$, and positive events (social support and achievement), controlling for the number of surveys completed by each individual. Also, to explore whether completion rates were not influenced by PA, NA, or stress levels, we conducted Pearson's correlation between the number of surveys completed by each individual and PA and NA.

3. Results

The results of ICCs are presented in Table 1 and suggested moderate-to-substantial agreement among measurements of PA and NA at the day-level. Moreover, participants on average reported higher PA ($M = 23.23$) than NA ($M = 21.03$; $p < .001$). The Cronbach's alpha coefficients for the PA and NA items were 0.96 and 0.94, respectively, indicating high internal consistency and reliability of the scale items.

The results of the mixed-effect models predicting PA are shown in Table 2. In the model with social support events as a predictor, positive social support events count was a significant predictor of PA. Namely, individuals had greater PA on days on which they reported receiving greater social support. This effect was also moderated by the $RewP_{resid}$, such that individuals with greater neural response to social feedback at baseline had a more positive association between social support positive events count and PA over the 10-day period (Figure 2). Johnson-Neyman interval showed that the slope of positive event count on PA was significant and positive when the $\mathrm{RewP}_{\mathrm{resid}}$ was outside of the interval [-14.84, -0.56] (Figure 2, panel b). In this regard, 152 participants fell in the significant interval, while 41 did not. Simple slope analyses showed that the slope of positive social support events count on PA was significant when $\mathrm{RewP}_{\mathrm{resid}}$ values were within the mean (0.01), and one standard deviation (SD) higher than the mean (1.02), but not at one SD lower than the mean (-0.99) (Figure 2, panel a). In contrast, in the model with positive personal achievement events as a predictor, only achievement positive event count was a significant predictor of PA, and the interaction effect was not significant. As in the first model, individuals had greater PA on days where they experienced more positive events associated with personal achievement (Table 2).[1]

The results of the mixed-effect models predicting NA are shown in Table 3. In the model with positive social support events, event count was a significant predictor of NA. Specifically, individuals had greater NA on days when they received more social support. Likewise, the model with positive events related to personal achievement as a predictor showed the same significant effect of positive event count on NA. The $\mathrm{RewP}_{\mathrm{resid}}$ did not significantly predict NA, nor interact with event counts to predict NA, in either model.

Regarding correlations' results, significant inverse correlation between the $\mathrm{RewP}_{\mathrm{resid}}$ and positive social support event count emerged (Pearson's $r = -0.16$). There was no significant

[1] Due to the inhomogeneity of the gender distribution, the same analyses were conducted with gender as a covariate, but including men and women genders only. In this analysis, shown in the supplement (Table S2), the main results of our models did not vary. The effect of gender was significant only on the positive affect model, whereby men reported higher levels of positive affect than women. In addition, there were no gender differences in the social RewP.

correlation between the $RewP_{resid}$ and positive achievement event count. Finally, no correlation between the number of surveys completed by each individual and positive or negative affect emerged.

3. Discussion

The overarching goal of this study was to investigate whether individual differences in social reward sensitivity, indexed by the RewP, influenced the association between self-reported daily experiences of social support and PA throughout a 10-day ecological momentary assessment period. In particular, we found that those who had a larger RewP to rewarding social feedback experienced more positive affect when exposed to positive social support events in their daily lives.

Previous studies have suggested that those with greater neural response to monetary rewards tend to present with higher positive affect when exposed to overall positive events (Duttweiler et al., 2023; Forbes et al., 2009; Heller et al., 2015). However, the relevance of social rewards as well as the specificity of positive events are unclear. Building on previous evidence showing distinct psychophysiological patterns to social relative to monetary rewards (Banica et al., 2022), it may be that the RewP to social acceptance specifically captures features of hedonic functioning in the social domain and, thus, might be an indicator of those who might be more predisposed to benefit from interventions based on social support experiences. Additionally, given that social support is a core predictor of psychological and physical well-being and that a growing number of interventions are based on social support, it is crucial to identify features that make individuals more likely to benefit from social ties.

Thus, extending from previous findings and as hypothesized, the current study demonstrates that individuals with greater neural sensitivity to *social* feedback are more likely to experience positive affect when reporting a greater occurrence of received positive *social support* events. Notably, this effect was selective to the social environment (i.e., positive social support event count) and was not significant for non-social events (i.e., positive academic achievement event count). Additionally, the RewP and its interaction with received social support was only significantly associated with positive, and not negative, affect. This is in line with the literature suggesting separate and independent systems for positive and negative affect (Diener & Emmons, 1984; Folkman & Moskowitz, 2000), and supports the involvement of the RewP in responding mostly to pleasant and appetitive experiences (Hajcak Proudfit, 2015).

Interestingly, greater positive social support event count was not only a positive predictor of self-report PA but also NA. Similar associations have been previously reported (e.g., Bolger et al., 2000), although most findings generally suggest that lower levels of social support are associated with more negative outcomes, such as lower well-being, greater NA, and depressive symptoms (Alsubaie et al., 2019; Crocker & Hakim-Larson, 1997; Ellonen et al., 2008; Rueger et al., 2016; Turner & Brown, 2010). One potential explanation for this inconsistency may be that people receive more support on days when they are in greater distress and are experiencing and/or expressing more NA (Auerbach et al., 2011; Scholz et al., 2012). High levels of NA might also drive people to seek out additional social support over the course of the day, particularly if the support events they had already experienced had not resulted in an affective benefit. Future studies might seek to understand this effect better by examining social support events and affect concurrently throughout the day. It could also be the case that receiving social support dampens individuals' feelings of self-worth and competence, leading to higher negative affect (Gray et al., 2020; Scholz et al., 2012), or that receiving social support may be a response to an increase in adversity and stress in the environment (Seidman et al., 2006). Additionally, multiple factors may explain the higher NA reported in individuals that receive more positive social support events, such as the source of the support (parents vs. peers; Thoits, 2011) and the form of social support (emotional vs. instrumental; Santini et al., 2015). While the present study includes both emotional and instrumental social support events, some studies have reported a negative influence of instrumental social support events on mental health outcomes (Bolger et al., 2000; Deelstra et al., 2003), suggesting that future investigations might benefit from separating distinct forms of social support. Indeed, social support is also not a homogenous category, and some events may be more impactful than others (e.g., Bolger et al., 2000; Deelstra et al., 2003). The aim of this initial study was to explore the association with social support, broadly considered, and no hypothesis was formulated on specific effects for different types of social support. Nevertheless, exploring how different types of social support events influence affective experiences might be a relevant future direction.

This study additionally compared positive social support events to positive academic achievement events. Unexpectedly, a greater number of positive academic achievement events was *also* positively associated with greater NA. One possible explanation for this is that higher academic achievers are typically performance-oriented, which represents a vulnerability factor for negative affect and depressive symptoms (e.g., Sideridis, 2005). Hence, negative affect has been suggested to motivate change in service of academic success, as the experience of negative emotions in college students might indicate inadequate progress (e.g., Barker et al., 2016; Oishi, Diener, & Lucas, 2007). However, further research looking at how specific forms of positive events influence affective states is warranted.

We would also note here that the EMA data collection was conducted during a period of heightened stress exposure, consistent with the broader aims of the parent study. The results of this study suggest that people with a larger RewP to social rewards may be most likely to benefit from social support in times of heightened stress, but it is not clear whether this effect would be specific to stressful contexts. As noted above, stress exposure can alter both mean levels and variability of PA and NA (Bolger et al., 2000; Seidman et al., 2006; Scholz et al., 2012), as well as the types and amounts of social support experiences that people receive and that they seek out (Bolger et al., 2000; Deelstra et al., 2003). An important avenue for future investigations, therefore, will be to understand whether these results replicate when levels of stress exposure are more variable across the sample.

Furthermore, the results of the present study suggest that when exposed to similar events (e.g., receiving social support), variation in neural sensitivity to social reward can predict which individuals experience more or less positive affect. Given previous evidence that neural responses to social reward are associated with psychopathology, particularly depression (e.g., Ait Oumeziane et al., 2019b; Pegg et al., 2021), as well as *risk* for depression (e.g., Freeman et al., 2022; Olino et al., 2015), these results may point to a pathway whereby the processes reflected in these neural responses are associated with the development of depression. For instance, it is possible that individuals with a smaller social RewP, who appear to derive fewer affective benefits from social support, may find social support less reinforcing, and be less likely to seek it out in the future. Considering the crucial role that social support has in buffering against psychopathological conditions (Auerbach et al., 2011; Rueger et al., 2016; Turner & Brown, 2010), the diminished exposure to positive social interactions and social support might then heighten the risk for the development of depression (Auerbach et al., 2011). However, although the present study explored initial associations between neural responses to social reward and affective responses to daily experiences, the presence of psychopathology was not assessed in this unselected sample of young adults. Future studies should explore these associations in different conditions (e.g., depression and social anxiety) and high-risk groups.

Although further research will be needed to demonstrate that the processes captured by the RewP represent mechanisms for depressive illness, such work may be useful in identifying novel intervention points and strategies. Promising initial studies have shown that the RewP can be modulated through specific psychological (Pegg & Kujawa, 2020) or neuroscientific (e.g., transcranial magnetic stimulation, Biernacki et al., 2020; Ryan et al., 2022), interventions. Hence, exploring whether the manipulation of social reward sensitivity might allow people to derive affective benefits from social support could be an interesting venue to better disentangle the role of the RewP in shaping affective responses to the social environment.

A notable limitation of the present study is that only 42.3% of surveys were completed. This is on par with previous studies in similar samples (Grégoire et al., 2020; Williams et al., 2021; Wrzus & Neubauer, 2023); however, those who complied with the procedure may represent a more motivated and conscientious subsample. Nevertheless, among non-clinical samples, adherence to EMA does not seem to be associated with individual differences in personality or well-being (Courvoisier et al., 2012; Grégoire et al., 2020), suggesting that our sample might be representative of the population of undergraduate students. Another limitation of this study is the assessment of affect and social support events at different times throughout the day. While PA and NA were assessed multiple times throughout the day, social support events were evaluated once at the end of each day. Although the use of a checklist, rather than a free report, minimized potential effects of recall bias (Ben-Zeev et al., 2009; Fredrickson, 2000;

Schembre et al., 2018), this method still raises the possibility that individuals experiencing higher PA throughout the day may be more inclined to perceive or recall more social support events in the evening, potentially biasing the association between social support and PA. Consequently, the observed relationship between social support events and PA may be confounded by the timing of assessments, highlighting the need for future studies to employ concurrent assessments of both affect and social support events to explore their interplay more accurately.

Additionally, the checklist of positive events employed in this study was used to assess received (and not perceived) social support events each day, or tangible acts of support that participants reported experiencing. Daily perceived social support, which involves individuals' subjective beliefs regarding the availability and quality of support, was not directly assessed in this EMA investigation. However, future studies should include measures of perceived social support as well, to better identify the links between the RewP, social support, and affective outcomes. This choice was motivated by the fact that received support measures instruct participants to recall specific examples of behavior rather than general perceptions, reflecting a more accurate index of support provided by the social environment (Haber et al., 2007). For instance, perceived support might be subject to biases due to individual differences in perceptual, memory, and personality features (Haber et al., 2007). However, perceived support has been shown to have numerous benefits on mental health (e.g., reduced anxiety, improved treatment outcomes; Reid et al., 2016; Wang et al., 2018) and future studies looking at how individual differences in social reward processing influence affect when exposed to perceived social support are warranted.

In sum, the present study adds to the current literature exploring how neural responses to reward shape affective responses to the social environment, and particularly to receiving social support. Results indicate that a larger RewP to social acceptance is associated with greater positive affect on days when people received more social support. Future work might further explore how neural responses to social rewards may be leveraged to identify individuals who are more likely to benefit from positive social support and to more clearly identify the role of these neural responses in the development of psychopathology.

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Data availability statement

This study was not preregistered. Data, scripts, and measures used in the study are available at the following link: https://osf.io/4tgau/

Author contributions

A.W. conceived and designed the study; C.H.Y and G.O.A. conducted the study; C.D.A., C.H.Y, and G.O.A. analyzed the data; C.D.A. and A.W. wrote the paper, and all authors reviewed the manuscript.

Conflict of interest statement

The authors declare no competing interests.

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Intraclass correlation coefficients (ICCs)		
	Level 2	Level 3
Positive affect	0.71	0.59
Negative affect	0.75	0.57

Table 1. Intraclass correlation coefficients (ICCs) for each linear mixed-effect model. Level 2 reflects correlations between scores of the same person on the same day, while level 3 reflects correlation of scores from any subject regardless of the day.

Predictor	*b*(SE)	Degrees of freedom	*t*	95% CI	*p*
Positive affect model (count of positive social support events)					
Intercept	**22.64 (0.65)**	**165.11**	**34.66**	**[21.37, 23.92]**	**< .001**
Positive social support event count	**0.75 (0.21)**	**706.27**	**3.56**	**[0.34, 1.17]**	**< .001**
RewP$_{resid}$	0.19 (0.57)	161.43	0.33	[-0.93, 1.30]	.74
EMA software	0.31 (1.27)	163.04	0.25	[-2.17, 2.80]	.80
Positive social support event count * RewP$_{resid}$	**0.50 (0.23)**	**700.76**	**2.18**	**[0.05, 0.95]**	**.03**
Positive affect model (count of positive personal achievement events)					
Intercept	**22.64 (0.65)**	**164.63**	**34.62**	**[21.36, 23.92]**	**< .001**
Positive achievement event count	**0.65 (0.16)**	**629.46**	**4.11**	**[0.34, 0.96]**	**< .001**
RewP$_{resid}$	0.07 (0.57)	160.56	0.14	[-1.04, 1.19]	0.89
EMA software	0.25 (1.27)	160.33	0.20	[-2.22, 2.73]	.84
Positive achievement event count * RewP$_{resid}$	0.17 (0.16)	625.49	1.10	[-0.14, 0.49]	0.28

Table 2. Linear mixed-models predicting positive affect from reward positivity to social feedback (RewP$_{resid}$), positive event count (social support [above], or personal achievement [below]), and the interaction between positive event count and RewP$_{resid}$. Significant effects are shown in bold.

Predictor	*b*(SE)	Degrees of freedom	*t*	95% CI	*p*
Negative affect model (count of positive social support events)					
Intercept	**20.86 (0.67)**	**166.16**	**31.24**	**[19.56, 22.17]**	**< .001**
Positive social support event count	**0.65 (0.26)**	**751.66**	**2.51**	**[0.15, 1.15]**	**.01**
$RewP_{resid}$	0.17 (0.58)	161.47	0.29	[-0.97, 1.30]	.78
EMA software	0.31 (1.31)	164.27	0.24	[-2.23, 2.85]	.81
Positive social support event count * $RewP_{resid}$	-0.27 (0.28)	746.94	-0.96	[-0.83, 0.28]	.34
Negative affect model (count of positive personal achievement events)					
Intercept	**20.87 (0.67)**	**166.28**	**31.36**	**[19.57, 22.17]**	**< .001**
Positive achievement event count	**0.70 (0.20)**	**660.48**	**3.59**	**[0.32, 1.09]**	**<.001**
$RewP_{resid}$	0.10 (0.58)	161.00	0.17	[-1.03, 1.23]	.85
EMA software	0.48 (1.29)	161.29	0.37	[-2.04, 2.30]	0.71
Positive achievement event count * $RewP_{resid}$	-0.07 (0.20)	658.31	-0.35	[-0.46, 0.32]	.73

Table 3. Linear mixed-models predicting negative affect from reward positivity to social feedback ($RewP_{resid}$), positive event count (social support or personal achievement), and the interaction between positive event count and $RewP_{resid}$. Significant effects are shown in bold.

Figure 1. Waveforms and scalp topographies depicting temporospatial factor combination corresponding to the reward positivity in the Island Getaway task.

Figure 2. (Panel a) Interaction effect of Positive Social Support event count and RewP to social feedback to predict positive affect. Ninety-five % confidence bands are presented in different colors. (Panel b) Johnson-Neyman intervals showed that the RewP significantly impacted the slope of PA on positive event count (social support) in this interaction for RewP > − 0.56.