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Psychophysiological Response to Social Feedback Using the Chatroom Interact Task in Undergraduate Students

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Abstract
Receipt of both positive and negative social feedback is associated with psychophysiological responses, and such responses vary based on levels of internalizing symptoms and associated cognitive constructs. However, research examining the relationship between physiological response to social feedback and internalizing symptoms is mixed, and there is a need to develop salient tasks to assess responses to social feedback. This paper reports on two studies that examined physiological response to social feedback in undergraduate students using the Chatroom Interact Task (CIT). We also explored associations between physiological response to social feedback and internalizing symptoms and associated constructs. Participants were 48 (35 female; Study 1) and 65 (55 female; Study 2) undergraduate students. Participants completed self-report questionnaires of internalizing symptoms and associated cognitive constructs. They also completed the CIT to assess response to acceptance and rejection, while physiological data, including electrocardiogram and respiration to derive respiratory sinus arrhythmia (RSA), were acquired. Results across both studies were largely consistent. There were significant differences in RSA during the questionnaire phase and the neutral and acceptance/rejection phases of the CIT. There were no differences between RSA during acceptance and rejection phases. Internalizing symptoms and associated constructs were not related to differences in RSA. The current study indicates questionable validity for the use of the CIT to elicit heightened physiological responses to social feedback in undergraduates and suggests important considerations for the future study of responses to social feedback and the design of associated tasks.

Keywords social feedback; psychophysiology; emotion; anxiety; depression

Social feedback can elicit a range of emotions that are coupled with physiological responses, such as changes in heart rate, pupil dilation, sweating, and cortisol levels (e.g., Muhtadie, Akinola, Koslov, & Mendes, 2015; Sleegers, Proulx, & van Beest, 2017). Depression, anxiety, and associated constructs, such as repetitive negative thinking (RNT; Ehring & Watkins, 2008) and fear of positive and negative evaluation (FPE and FNE, respectively; Reichenberger, Wiggert, Agroskin, Wilhelm, & Blechert, 2017; Weeks, Heimberg, Rodebaugh, & Norton, 2008), have been associated with altered responses to social feedback (e.g., Ottaviani et al., 2016; Stone et al., 2016; Weeks & Zoccola, 2015). Examining the relationships between psychological and physiological responses to social feedback during late adolescence and emerging adulthood, when social evaluation is particularly salient, is critical to our ability to understand how stress affects physiological responses and youth outcomes (e.g., Fassett-Carman, DiDomenico, Steiger, & Snyder, 2020; Silk, Davis, McMakin, Dahl, & Forbes, 2012). The inclusion of both psychological and physiological responses allows for a comprehensive understanding of how social feedback can impact the development of internalizing disorders (e.g., anxiety and depression). Additionally, personally salient and valid tasks are necessary to elicit physiological responses and accurately capture these relationships, particularly in emerging adulthood when less of this work has been done. Thus, the present study examined the use of the

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Chatroom Interact Task (CIT) to assess physiological response to social feedback in undergraduate students. In addition, associations between physiological response and levels of FNE, FPE, RNT, and anxiety and depressive symptoms were explored.

Responding to stress entails both physiological and subjective emotional responses, and physiological responses can be captured using multiple methods, including neural activity (e.g., electroencephalogram), pupil reactivity (e.g., pupillometry), and parasympathetic nervous system (respiratory sinus arrhythmia [RSA], high-frequency heart rate variability) and sympathetic nervous system (skin conductance level and response) activity. Various psychosocial factors have been related to physiological responses to stress (e.g., decreased cardiovascular reactivity to stress and poorer cardiovascular recovery associated with anxiety; dopaminergic dysregulation following exposure to acute stress; see Chida & Hamer, 2008 for review and Bloomfield et al., 2019 for review, respectively). There are also developmental changes that impact physiological responses; some research has found that sympathetic nervous system activity increases and parasympathetic nervous system activity decreases in adolescence to early adulthood (Hollenstein, McNeely, Eastabrook, Mackey, & Flynn, 2012; Pfeifer et al., 1983). Similarly, there are several methods for measuring emotional responses to stress, including neural activity (functional magnetic resonance imaging; fMRI), self-report questionnaires, and tracking facial expressions (Lerner, Gonzalez, Dahl, Hariri, & Taylor, 2005).

Responses to social feedback in the laboratory are often studied using tasks that provide simulated social feedback. One commonly used task is Cyberball, an online ball-tossing game during which participants believe they are playing with two or three others and the participant is eventually excluded in the game (Williams & Jarvis, 2006). Studies have successfully used the Cyberball task in studying effects of ostracism, eliciting negative affect, threatening basic psychological needs, and triggering antisocial or maladaptive reactions (Scheithauer, Alsaker, Wolfer, & Ruggieri, 2013; Williams, 2007). In addition, some studies have examined how physiological reactivity to the Cyberball task differs based on psychological symptoms. Lidia et al. (2021) found that individuals with borderline personality disorder exhibited a further decline in RSA after the inclusion condition of the Cyberball task. Lambe, Craig, and Hollenstein (2019) found that peer victimization was more strongly associated with depressive symptoms when youth also demonstrated blunted RSA reactivity to the Cyberball task. Although these studies demonstrate associations between physiological reactivity and psychological symptoms, the Cyberball task does not closely mimic real social interactions (e.g., computer characters playing ball as opposed to potential peers) and is likely not as salient or suited to elicit responses that resemble daily social interactions.

Another task that has been used in the study of responses to social feedback in youth specifically (i.e., age 17 and younger) is the CIT (Silk et al., 2012; Silk et al., 2014) that involves receiving peer acceptance and rejection in real-time from virtual peers. In this task, participants are instructed to create a profile, select topics for discussion, and pick profiles of the peers they would be interested in interacting with. The participant is then "matched" with two peers based on mutual interest and complete trials during which they select which peer out of the two they would most like to discuss a topic with and watch as their peers make similar selections (e.g., choosing or "accepting" them, or choosing the other peer or "rejecting" them). The CIT is potentially more salient than Cyberball, as the participant receives dynamic rejection or acceptance feedback from virtual peers on personally salient information domains. This feedback may be a particularly salient elicitor of responses similar to those experienced in day-to-day social interactions. In a sample of youth ages 9-17, Silk and colleagues (2012) found that youth reported feeling angrier, sadder, more excluded, less happy, and less included during rejection compared to acceptance trials of the CIT. In addition, youth demonstrated increased pupil dilation in response to rejection relative to acceptance. Increased response to rejection was greater in older youth relative to younger youth and was associated with lower daily feelings of social connectedness with peers in everyday life. Moreover, in a sample of youth ages 11-17, Silk and colleagues (2014) found that youth with depression reported feeling more sad, nervous, and excluded and less happy immediately after completing the CIT than youth without depression. In addition, youth demonstrated heightened activation in brain regions associated with processing social information, such as the ventral striatum, insula, and parts of the prefrontal and cingulate cortices, in response to social feedback, particularly during periods of social rejection and for youth with depression. Olino and colleagues (2015) examined whether there were differences in how quickly youth acknowledged, via button press, whether they were accepted or rejected and found that youth responded more quickly to acceptance than rejection trials. In addition, offspring of depressed mothers showed reduced striatal activation to social acceptance than offspring of non-depressed mothers. Although this task has shown promise in studying responses to social feedback in adolescents, the CIT has not yet been validated with participants older than 17. Further, it remains unclear whether the task elicits

psychophysiological responses other than neuroimaging and pupillometry, such as RSA, which would provide valuable information and be more accessible (e.g., less expensive method with fewer exclusion/data loss issues than neuroimaging).

Anxiety, including trait (Britton, Lissek, Grillon, Norcross, & Pine, 2011) and social (Richey et al., 2017) anxiety, and depression (Forbes & Dahl, 2012) are associated with threat and reward processing; thus, the degree of physiological responses to social feedback may be influenced by individual differences in these symptoms and in constructs that are also related to internalizing symptoms, such as FNE (Kocijan & Harris, 2016; Wang, Hsu, Chiu, & Liang, 2012; Weeks, 2015), FPE (Reichenberger, Wiggert, Agroskin, Wilhelm, & Blechert, 2017), and RNT (Ehring & Watkins, 2008). It is crucial to examine physiological responses to social feedback as a result of depressive or anxiety symptoms and associated constructs, especially in late adolescence and emerging adulthood when there are documented changes in psychophysiological responses during this time period (Hollenstein et al., 2012; Pfeifer et al., 1983) and when there is an increased risk for the development of internalizing disorders (e.g., Eisenberg, Gollust, Golberstein, & Hefner, 2007; Ibrahim, Kelly, Adams, & Glazebrook, 2013). Although research demonstrates that greater levels of depression, social anxiety, state anxiety, and associated constructs, such as RNT, FPE, and FNE, are associated with altered responses to social feedback, the responses described in the literature are mixed. For example, some research suggests that individuals with a history of depression have greater neural (i.e., dorsal anterior cingulate cortex) reactivity to repeated bouts of negative relative to positive social feedback (Dedovic, Slavich, Muscatell, Irwin, & Eisenberger, 2016), while other research suggests that depression is associated with a blunted response to positive social feedback (Zhang et al., 2017) and social stress in general (see Schiweck et al., 2019 for review).

Similar mixed findings have been reported for RNT (e.g., Aldao, McLaughlin, Hatzenbuehler, & Sheridan, 2014; Ottaviani et al., 2016) and state anxiety (e.g., Rozenman, Vreeland, & Piacentini, 2017; Shimizu, Seery, Weisbuch, & Lupien, 2011). Research of FNE and FPE and physiological response to social feedback is more limited but has shown that FNE and FPE are related to greater gaze avoidance (Weeks, Howell, & Goldin, 2013) and differences in facial-muscular responses (Wiggert, Wilhelm, Reichenberger, & Blechart, 2015) in response to positive and negative evaluative video clips. Moreover, Weeks and Zoccola (2015) found that FPE, but not FNE, predicted heart rate increases during a speech task in which participants were told they were being evaluated by panelists behind a double mirror. Given the conflicting results in the literature, further work is needed to better understand the relationship between physiological responses to social feedback and these constructs.

It has been well-documented that heightened stress reactivity and poor regulation of physiological stress responses are associated with mental health outcomes, and that social feedback may be particularly salient for individuals with greater internalizing symptoms. In addition, late adolescence and emerging adulthood may be particularly relevant periods for the salience of social feedback and peer acceptance. Undergraduate students face many additional challenges (e.g., increased difficulty in course load, greater independence, financial stress, emotional stress), and some research suggests greater rates of internalizing disorders in undergraduate students (e.g., Eisenberg et al., 2007; Ibrahim et al., 2013). Although some tasks involving social feedback (e.g., Cyberball) and social stress (e.g., Trier Social Stress Test; other speech tasks) have been used to study psychophysiological responses to social feedback in this age group, it is critical to have personally salient and valid tasks that more closely relate to everyday social interactions and allow us to study responses to social feedback. The CIT has been related to subjective emotional and physiological responses, social connectedness, and experiences with peers, in younger youth and is a promising task for use in older youth. This research would help us gain a better understanding of social responses and how these responses relate to risk for, and development of, internalizing disorders during this emerging adulthood period.

This study explored the validity of the CIT as a paradigm to elicit physiological responses to social feedback in two studies with undergraduate students, using updated stimuli and discussion topics that are appropriate for this developmental period. Specifically, internal validity of the CIT was evaluated based on whether physiological differences between task conditions emerged. Thus, we would be able to extend the utility of the task to a new physiological process and developmental period. The second study was added in order to have baseline and recovery periods (e.g., rest periods during which psychophysiological data were acquired) as comparisons (i.e., study 1 had questionnaire completion and the CIT task phases; study 2 added baseline and recovery periods in addition to the questionnaire completion and CIT task phases). We hypothesized that individuals would demonstrate greater physiological response to rejection compared to acceptance. In addition, we expected that both social conditions (i.e., rejection and acceptance) would elicit greater responses than the neutral/control conditions. Additionally, this study aimed to explore whether levels of depressive symptoms, state and social anxiety

symptoms, RNT, FNE, and FPE were associated with differences in physiological response to social feedback as a measure of external validity of the CIT. Although these analyses were exploratory in nature, it was hypothesized that greater levels of depressive, state and social anxiety symptoms, and associated constructs would be associated with heightened responses to social feedback, particularly rejection

Method

Participants

There were two studies conducted with independent samples of participants. These studies differed in the physiological conditions acquired (outlined below). Power and sample size was based on power to detect differences in between-condition effects. Assuming an effect of f = .20 for a repeated measures design of 4 and 6 repeated measures, we had power exceeding .80 and .90 for examining differences across conditions in samples of 50 and 65, respectively.

For Study 1, two participants were consented but ultimately not eligible due to age outside eligibility criteria. Eligible participants were 48 (35 female) undergraduate students ranging in age from 18 to 24 years of age (M_{age} = 20.64 years, SD = 1.64). Twenty-nine (58.00%) participants reported their race as White or Caucasian, 10 (20.00%) as Black/African American, 4 (8.00%) as biracial or multiracial, 3 (6.00%) as Asian American, and 2 (4.00%) did not report their race. In regard to ethnicity, 16 percent of the sample identified as Hispanic.

For Study 2, one participant was consented but ultimately not eligible due to age outside eligibility criteria. Eligible participants were 65 (55 female) undergraduate students ranging in age from 18 to 24 years of age (M_{age} = 20.23 years, SD = 1.68). Thirty-six (54.50%) participants reported their race as White or Caucasian, 15 (22.70%) as Black/African American, 6 (9.10%) as Asian American, 5 (7.6%) as biracial or multiracial, and 3 (4.5%) as "Other." In regard to ethnicity, 28.8 percent of the sample identified as Hispanic.

Across both studies, psychophysiological data were lost due to triggers in the CIT not working, as well as due to equipment noise that exceeded the recommended thresholds. These individuals were excluded from analyses, resulting in 43 participants in Study 1 and 57 participants in Study 2.

Measures

Psychophysiological Acquisition and Processing. Psychophysiological data were acquired using a Biopac Systems MP150 wireless acquisition system and AcqKnowledge software version 3.8.1. Specifically, participants' heart rate was monitored continuously using the Electrocardiogram (ECG) amplifier (ECG100C) and a 3-lead system (2 signal inputs and 1 ground) and digitized at a sampling rate of 1kHz. Participants also had their respiration and electrodermal activity (not described here) recorded simultaneously via their respective transducers. ECG data in each segment (baseline, questionnaires, acceptance, rejection, motor match, and recovery) were exported as a series of interbeat intervals (IBIs) in milliseconds from AcqKnowledge for cleaning and processing using QRSTool and CMetX software (Allen et al. 2007). QRSTool interpolates the IBI series in a graphical user interface for semi-automatic R-peak detection, followed by visual inspection and manual correction of any missed beats before exporting to CMetX (Allen, 2002; Allen, Chambers, & Towers, 2007). CMetX calculates various time-domain metrics of heart rate variability from the cleaned data, including respiratory sinus arrhythmia (RSA), defined as the natural log of band-limited (.12–.40 Hz) variance of IBI time series and used as a measure of parasympathetic nervous system activity (Allen et al., 2007). RSA was derived for each phase (e.g., baseline, questionnaires, acceptance, rejection, neutral motor match, and recovery). Data segments containing excessive artifacts due to movement or interference were excluded from analysis (Berntson & Stowell, 1998).

Repetitive Negative Thinking Questionnaire. Participants' levels of RNT were assessed with the brief Repetitive Thinking Questionnaire (RTQ-10; McEvoy et al., 2010; McEvoy et al., 2014). The RTQ-10 is a 10-item self-report questionnaire assessing trait RNT (e.g., "I have thoughts or images about all my shortcomings, failings, faults, and mistakes") in response to feeling "distressed or upset." Items in the RTQ-10 were derived from existing measures of RNT, including the Penn State Worry Questionnaire (PSWQ; Meyer et al., 1990), the Ruminative Responses Scale (RRS; Nolen-Hoeksema & Morrow, 1991), and the Post-Event Processing Questionnaire-Revised (PEPQ-R; McEvoy & Kingsep, 2006). The RTQ-10 is a brief version of the 27-item RNT scale of the Repetitive Thinking Questionnaire, consisting of the ten items that loaded most strongly onto the RNT factor of the full-length measure; the RTQ-10 correlated highly with the longer 27-item RNT scale (McEvoy et al., 2010). Responses are rated on a 5-point scale from 1 (*not at all true*) to 5 (*very true*). In previous studies, the RTQ-10 has demonstrated internal consistency (all αs > 0.89) in clinical (Mahoney et al., 2012; McEvoy et al., 2014) and non-clinical (McEvoy et al., 2010; McEvoy et al., 2014) samples. The RTQ-10 demonstrated internal consistency in the current sample as well (α = 0.94).

Fear of Evaluation. Participants' levels of FNE and FPE were assessed using the Brief Fear of Negative

Evaluation Scale (BFNE; Leary, 1983) and Fear of Positive Evaluation Scale (FPES; Weeks, Heimberg, & Rodebaugh, 2008; Weeks, Heimberg, Rodebaugh, Goldin, & Gross, 2012), respectively. The BFNE is a 12-item self-report measure that assesses fear and distress related to negative evaluation from others, e.g. "I worry about what people think of me even when I know it doesn't make any difference." There are eight straightforwardly worded items, and there is strong evidence to support greater validity of the sum of the straightforwardly worded items only, omitting the reverse-worded items (Rodebaugh et al., 2004; Weeks et al., 2005). Responses are rated on a 5-point scale from 1 (*not at all characteristic of me*) to 5 (*extremely characteristic of me*). In previous studies, the BFNE has demonstrated internal consistency (all αs > 0.92) in undergraduate (Rodebaugh et al., 2004) and clinical (Weeks et al., 2005) samples. The BFNE demonstrated internal consistency in this sample as well (α = 0.95).

The FPES is a 10-item self-report measure that assesses fear and distress related to positive evaluation from others, e.g. "I am uncomfortable exhibiting my talents to others, even if I think my talents will impress them." Two reverse-scored items are included but not utilized in calculating the total score. Responses are rated on a 10- point scale from 0 (*not at all true*) to 9 (*very true*). In previous studies, the FPES has demonstrated internal consistency (all αs > 0.80) in undergraduate (Weeks, Heimberg, Rodebaugh et al., 2008; Weeks et al., 2010) and clinical (Fergus et al., 2009; Weeks et al., 2012) samples. The FPES demonstrated internal consistency in the current sample as well (α = 0.82).

State Anxiety. Participants' state anxiety was assessed using the state items from the State Trait Anxiety Inventory (STAI; Spielberger, 1983). The state anxiety subscale of the STAI is a 20-item self-report assessment of anxiety at the current moment (e.g., statements like: "I feel calm"). Responses are rated on a 4-point scale from 1 (*not at all*) to 4 (*very much so*). In previous studies, the STAI has shown internal consistency (all αs > 0.90; Kabacoff, Segal, Hersen, & Van Hasselt, 1997; Spielberger, 1983). The STAI state anxiety scale demonstrated internal consistency in the current sample as well (α = 0.93). The STAI was z-scored to be consistent with other outcome variables of interest. As the STAI was added during Study 2, only a subset (N=65) of participants completed this assessment. The trait subscale was also administered to this subset of participants; however, due to a form error for some participants, we only examined the state subscale.

Social Anxiety Symptoms. Participants' social anxiety symptoms were assessed using the Social Phobia Scale (SPS; Mattick & Clarke, 1998). The SPS is a 20-item self-report measure that assesses social anxiety symptoms, e.g., "I have become anxious if I have to write in front of people." Responses are rated on a 5-point scale from 0 (*not at all characteristic or true of me*) to 4 (*extremely characteristic or true of me*). In previous studies, the SPS has shown internal consistency (all αs > 0.87; Heimberg, Mueller, Holt, & Hope, 1992; Brown et al., 1997). The SPS demonstrated internal consistency in the current sample as well (α = 0.94).

Depressive Symptoms. Depressive symptoms were assessed using the Center for Epidemiological Studies Depression Scale (CESD; Radloff, 1977) and the Beck Depression Inventory (BDI; Study 1; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) and Beck Depression Inventory-II (BDI-II; Study 2; Beck, Steer, & Brown, 1996). The CESD is a 20-item self-report questionnaire that assesses the frequency of current depressive thoughts and behaviors in the past week (e.g., "I was bothered by things that usually don't bother me") on a 4-point scale from 0 (*rarely or none of the time*) to 3 (*most or all of the time*). The BDI is a 21-item self-report measure of depressive symptoms in the past week. Participants choose the response that best fits them on a 4-point scale of 0 to 3. Both the CESD (Radloff, 1977) and the BDI and BDI-II (Beck, Steer, & Garbin, 1988; Steer, Rissmiller, & Beck, 2000) have demonstrated internal consistency in previous research (αs > 0.85 for the CESD and ranging from 0.73 to 0.92 in nonclinical samples for the BDI and BDI-II). The CESD and BDI both demonstrated internal consistency in the current sample (αs = 0.93 and 0.93, respectively). The association between the CESD and BDI was strong ($r = 0.72$, $p < 0.001$). Thus, a summary depression composite was computed by averaging the z-scores of the total scores of these measures.

Chatroom Interact Task. In order to simulate peer rejection and measure psychophysiological response to social feedback, participants completed the CIT (Silk et al., 2012; Silk et al., 2014) while physiological data were acquired. CIT stimuli (i.e., stock photographs and biography descriptions) were revised to be appropriate for the 18 to 24 age range of participants. In addition, the topics for potential discussions with virtual peers (e.g., "Who would you rather talk to about X?") were updated for this age group (e.g., school, parties, vacations, movies). Prior to initiating the task, participants were first directed to select the preferred images of five same-sex peers out of 20 possible options. Next, participants were asked to choose which two of the five they would most prefer to chat with based on five profile descriptions and were told that each corresponded to a picture that had been selected previously. The two preferred profiles selected were the two virtual peers that the participant engaged with during the CIT, after a member of the research team

informed the participant that they had been "matched" based on mutual interest.

The CIT contains trials arranged in three blocks; one acceptance block where participants were chosen by the virtual peer two thirds of the time, one rejection block in which they were not chosen by the virtual peer two thirds of the time, and one block in which the participant chose between the two virtual peers. Participants also completed a neutral motor match, control condition during which they had to indicate on which face (left or right) a dot appeared. We examined psychophysiological response during certain phases of the task (i.e., acceptance, rejection, and neutral motor match) to determine whether changes in psychophysiology were elicited. The order of the acceptance and rejection blocks (i.e., two versions of the task, one that began with acceptance and one that began with rejection) were randomized across participants.

Procedure

Undergraduate students requested appointments using an online scheduling system. Upon arrival at the laboratory, procedures were reviewed with participants, and all participants provided informed consent. Participants received two credits for Study 1 and two and a half credits for Study 2 towards a class requirement for their participation. In Study 1, this included psychophysiological data acquisition during a 10-minute period to work on self-report measures, followed by the CIT and another 10 minutes of self-report measures; participants completed any remaining self-report measures after physiological data collection ended. In Study 2, psychophysiological data were collected during a 10-minute baseline period (e.g., nature video), followed by 10 minutes of self-report measures, the CIT, and a 10-minute recovery period; participants completed self-report measures after physiological data collection ended. The Institutional Review Board approved all study procedures. Participants were debriefed about the deception (e.g., they were not interacting with peers at other universities) at the end of the study.

Results

Correlations between self-report measures are provided in Tables 1 and 2, and descriptive statistics for psychophysiological data across study conditions are provided in Table 3. In order to examine whether there were psychophysiological differences across study conditions, we used a series of repeated-measures general linear models with the study condition (Study 1: questionnaire period 1, CIT condition, and questionnaire period 2; Study 2: baseline period, questionnaire period, CIT condition, recovery period) serving as the within-subjects variable. In these initial analyses, we also included the task version (one version that began with acceptance, one that began with rejection; randomized across participants) to control for potential order effects. There were no significant interactions between task version and study condition; thus, models omitted the version of the task from analyses.

Results were consistent across both studies. For the initial repeated-measures general linear models, we included questionnaires, acceptance, rejection, and motor match (since these were consistent across both studies). There was a main effect of study condition in both Study 1, $F(3, 42) = 7.62$, $p < 0.001$, and Study 2, $F(3, 55) = 5.86$, $p < 0.01$. In Study 1, post-hoc pairwise comparisons indicated that there were significant differences in RSA during questionnaires vs. acceptance, $M_{diff} = -.33$, $SE = .07$, $p < .001$, questionnaires vs. rejection, $M_{diff} = -.28$, $SE = .08$, $p < .01$, and questionnaires vs. motor match, $M_{diff} = -.23$, $SE = .07$, $p < .001$. RSA during questionnaires was lower than RSA during acceptance, rejection, and motor match. There were no significant differences between acceptance vs. rejection or acceptance/rejection vs. motor match (all ps $> .22$). In Study 2, post-hoc pairwise comparisons indicated that there were significant differences in RSA during questionnaires vs. acceptance, $M_{diff} = -.26$, $SE = .06$, $p < .001$, questionnaires vs. rejection, $M_{diff} = -.17$, $SE = .07$, $p < .05$, and questionnaires vs. motor match, $M_{diff} = -.20$, $SE = .06$, $p < .01$. RSA during questionnaires was lower than RSA during acceptance, rejection, and motor match. There were no significant differences between acceptance vs. rejection or acceptance/rejection vs. motor match (all ps $> .159$).

In Study 2, we also ran these analyses including the baseline and recovery periods to examine whether there were differences between RSA throughout these parts of the study. There was a main effect of study condition, $F(5, 54) = 3.86$, $p < 0.01$. Post-hoc pairwise comparisons showed that in addition to the significant differences in RSA during questionnaires vs. acceptance ($M_{diff} = -.26$, $SE = .06$, $p < .001$), questionnaires vs. rejection ($M_{diff} = -.17$, $SE = .07$, $p < .05$), and questionnaires vs. motor match ($M_{diff} = -.20$, $SE = .06$, $p < .01$) revealed in the previous model, there was also a significant difference between RSA during baseline and questionnaires, $M_{diff} = .13$, $SE = .05$, $p < .05$. RSA was higher during baseline than questionnaires. There were no significant differences between baseline or recovery with acceptance, rejection, or motor match.

Next, we examined whether internalizing symptoms (depressive, anxiety, and social anxiety symptoms) and associated factors (RNT, FNE, and FPE) related to differences in psychophysiological

Table 1. Correlation matrix for self-report measures with mean and standard deviations for Study 1

	RTQ	BFNE	FPES	SPS	CESD	BDI
BFNE	.493**					
FPES	.563**	.476**				
SPS	.516**	.566**	.694**			
CESD	.619**	.452**	.421**	.465**		
BDI	.599**	.542**	.511**	.494**	.744**	
Mean	29.42	37.70	30.35	41.22	16.38	7.45
SD	11.16	10.25	14.28	16.95	10.77	6.07

Note. * $p < .05$; ** $p < .01$; RTQ = Repetitive Negative Thinking Questionnaire, Total; BFNE = Brief Fear of Negative Evaluation Subscale, Total; FPES = Fear of Positive Evaluation Scale, Total; SPS = Social Phobia Scale, Total; CESD = Center for Epidemiological Studies Depression Scale Total; BDI = Beck Depression Inventory, Total

response in each study independently. Given the number of analyses being conducted, we set a threshold of $p < 0.01$ in order to interpret any significant effects. Results suggested that internalizing symptoms and related factors were not associated with differences in RSA across the conditions in either study (all *p*s > .01). Correlations between self-report measures and physiological responses in each phase are reported in the supplemental material (for both studies, study 1, and study 2 in supplemental tables 1, 2, and 3, respectively).

Discussion

Responses to social feedback, including subjective emotional and physiological responses, are particularly important to study during late adolescence and emerging adulthood when peer feedback may be particularly salient due to a variety of social and environmental changes during this period and when there are documented changes in psychophysiological responses (Hollenstein et al., 2012; Pfeifer et al., 1983). Moreover, there is growing literature exploring responses to social feedback and the relationship between psychophysiological responses and internalizing difficulties (i.e., depression and anxiety history and/or symptoms; e.g., Rozenman et al., 2017; Schiweck et al., 2019; Shimizu et al., 2011; Weeks & Zoccola, 2015) and associated factors (i.e., RNT, FNE, and FPE; Aldao et al., 2014; Ottaviani et al., 2016; Weeks et al., 2013; Weeks & Zoccola, 2015; Wiggert et al., 2015). Personally salient and valid tasks are necessary to accurately capture these relationships in late adolescents. Thus, the primary aim of the current study was to explore the use of the CIT as a paradigm to elicit physiological responses to social feedback in undergraduate students. Specifically, internal validity of the CIT was evaluated based on whether physiological differences between task conditions emerged. We also explored associations between physiological responses and depressive and anxiety (i.e., social and state anxiety) symptoms and associated constructs as a measure of external validity of the CIT. Results showed differences in physiological response across study conditions. Specifically, we found differences between RSA during questionnaires and motor match and acceptance/rejection in both Study 1 and Study 2, but no differences between the acceptance, rejection, and motor match control conditions of the CIT or between social feedback phases and the baseline/recovery conditions (Study 2). Additionally, internalizing symptoms and associated constructs were not associated with physiological response in either study.

The current study provided questionable validity of the CIT in eliciting heightened physiological responses to social feedback in undergraduate students. Physiological differences emerged between

Table 2. Correlation matrix for self-report measures with mean and standard deviations for Study 2

		RTQ	BFNE	FPES	STAI	SPS	CESD	BDI
BFNE		.433**						
FPES		.676**	.395**					
STAI^{+}		.420**	.287*	.399**				
SPS		.543**	.660**	.649**	.348**			
CESD		.620**	.178	.446**	.665**	.471**		
BDI		.554**	.344**	.347**	.677**	.449**	.724**	
	Mean	30.60	39.49	28.45	37.16	43.31	18.64	10.29
	SD	10.68	12.08	15.71	11.48	16.23	12.13	10.72

Note. * $p < .05$; ** $p < .01$; RTQ = Repetitive Negative Thinking Questionnaire, Total; BFNE = Brief Fear of Negative Evaluation Subscale, Total; FPES = Fear of Positive Evaluation Scale, Total; STAI = State Trait Anxiety Inventory, State Subscale Total; SPS = Social Phobia Scale, Total; CESD = Center for Epidemiological Studies Depression Scale Total; BDI = Beck Depression Inventory, Total

questionnaires and acceptance/rejection and the neutral motor match condition in both studies. However, these differences were not in the expected direction. Previous research suggests that RSA, a measure of parasympathetic nervous system activity, is greater at rest, and typically decreases when confronted with stress or during increased cognitive or attentional demand (Muhtadie et al., 2015). However, the association between RSA and cognitive load can vary based on the type of task. RSA has been found to be higher during tasks that require controlled perceptual attention and less intensive cognitive processing, such as during questionnaires, compared to tasks that are high in cognitive demand and low in perceptual attention, such as an executive function task (Overbeek, Boxtel, & Westerink, 2014). In the current study, RSA was higher during the acceptance/rejection phases than questionnaires and motor match, and there were no differences in physiological response between the acceptance, rejection, and control conditions of the CIT. It is possible that this pattern is reflective of the increased cognitive and attentional demand required by questionnaires relative to the CIT, which asked participants to consider highly salient topics, such as mood and relationships in their everyday lives. This interpretation is consistent with the differences between the baseline period and questionnaires during Study 2; RSA was higher during baseline than questionnaires, which suggests that completion of questionnaires has greater cognitive load than when at rest. However, an alternative explanation is that rather than questionnaires being especially salient, the CIT may have lacked particular salience for undergraduate students. If this is the case, the lack of salience of the task for emerging adults might be due to poor believability of the task, or the nature of the social feedback may not have been particularly meaningful to individuals of this age (i.e., the simulated rejection of preferring to talk to someone else about a single topic was not salient enough). It is also possible that the participants did not respond as much to social reward as they would to monetary rewards, which are found to be especially salient in emerging adulthood (Ethridge et al., 2017).

The current study also found that levels of self-reported social and state anxiety and depressive symptoms, FNE and FPE, and engagement in RNT were not related to physiological response throughout conditions of the study. Findings from previous studies of the relationship between physiological responses to social feedback and levels of depression (e.g., Dedovic et al., 2016; Schiweck et al., 2019; Zhang et al., 2017),

Table 3. Psychophysiology Mean and Standard Deviations

	Study 1	Study 2
	Mean *(SD)*	Mean *(SD)*
RSA Baseline	-	6.43 *(1.12)*^{T}
RSA Questionnaires	6.40 *(1.02)*	6.31 *(1.16)*
RSA Acceptance	6.73 *(0.93)*^{T}	6.57 *(1.14)*^{T}
RSA Rejection	6.68 *(1.08)*^{T}	6.48 *(1.19)*^{T}
RSA Motor Match	6.63 *(1.01)*^{T}	6.51 *(1.11)*^{T}
RSA Recovery	-	6.39 *(1.11)*

Note. ^{T} Indicates significant differences between the noted study condition and the questionnaires phase. No other condition comparisons were statistically significant at $p < .05$.

social and trait anxiety (e.g., Richey et al., 2017; Rozenman, Vreeland, & Piacentini, 2017; Shimizu et al., 2011), RNT (e.g., Aldao et al., 2014; Ottaviani et al., 2016), and FNE and FPE (Weeks, Howell, & Goldin, 2013; Weeks & Zoccola, 2015; Wiggert et al., 2015) are mixed. For example, some research found that both FNE and FPE related to altered responses to positive and negative evaluative clips (Weeks, Howell, & Goldin, 2013; Wiggert et al., 2015), while other research found FPE, but not FNE, to be related to heart rate increases during an evaluative speech task (Weeks & Zoccola, 2015). These differences in the literature may relate to the types of tasks being used/salience of the tasks, the ages of the participants, the levels of internalizing symptoms and associated constructs, and the assessment methods (e.g., different types of psychophysiological measures, neural measures, self-reported state changes). The current study aimed to fill a gap in the literature by extending the use of the CIT to emerging adults by modifying the task and incorporating a new measure (i.e., RSA) to capture physiological response.

The current results may reflect challenges of using the CIT with physiological measures. The acceptance and rejection conditions contained two-thirds acceptance and two-thirds rejection trials, respectively. While including opposite trials can be beneficial to ensure participants are alert and paying attention rather than falling into a response pattern, the inclusion of some rejection trials in acceptance blocks and vice-versa may have obscured meaningful condition differences in physiological response. Previous studies utilizing the task in youth found differences in responses (using fMRI and eye tracking) to acceptance versus rejection trials (Silk et al., 2012; Silk et al., 2014; Stone et al., 2016). However, an event-related design was not feasible in the current study due to the brevity of the trials, which were likely not lengthy enough to elicit trial-specific physiological responses. To address these limitations, future research could include another cognitive and social task to compare to physiological response during the CIT. In addition, different types of neural and physiological measures that have already been utilized in other age groups (e.g., eye tracking, fMRI) could be explored using the CIT with undergraduates to see if differences in responses to types of social feedback (i.e., acceptance and rejections) emerge.

Investigators have studied multiple factors that can contribute to differences in physiological response to social feedback at varying levels of internalizing symptoms. For example, Rozenman, Vreeland, and Piacentini (2017) found that significant differences in sympathetic nervous system arousal between anxious and non-anxious youth emerged only at low to moderate levels of interpretation bias, such that anxious youth demonstrated greater arousal than healthy controls. Moreover, Ottaviani and colleagues (2016) found that RNT was associated with higher systolic blood pressure and diastolic blood pressure, higher heart rate and cortisol, and lower heart rate variability, but these differences were moderated by

sex, ethnicity, type of induction used to elicit RNT, assessment of state versus trait RNT, focus on worry or rumination, duration of physiological assessment, and quality of the studies. Finally, as individuals with higher levels of internalizing symptoms (Britton, Lissek, Grillon, Norcross, & Pine, 2011; Forbes & Dahl, 2012) have altered threat and reward processing, implicated in response to social feedback, individual differences in these and related constructs should be considered. Though the present study was underpowered to examine moderators, this is an important consideration for future work. It will also be important for future research to explore this question in clinical samples to get a better understanding of differences related to internalizing symptoms and associated constructs specifically.

The current study has a number of important limitations to note. As the study relied on self-report measures of internalizing symptoms and associated constructs, it will be important to include clinical interviews in future research. Additionally, while we assessed depression, social anxiety, and state anxiety, we did not include an assessment of general trait anxiety. However, it should also be noted that a large portion of STAI state anxiety variance is attributable to variance in trait anxiety (Barnes, Harp, & Jung, 2002). Future studies could also rely on mood inductions prior to the CIT to improve our understanding of acute effects of affective states on responses to social feedback. Further, no data were collected following the task on its believability to the participants; as such, we cannot examine whether participants who more strongly believed the events of the task had stronger responses.

The current study takes an important step in studying responses to social feedback during emerging adulthood. It is well known that this period is marked by increased change in stress and social interaction, along with sensitivity to peer feedback and risk for internalizing disorders (e.g., Eisenberg et al., 2007; Fassett-Carman et al., 2020; Ibrahim et al., 2013). However, many different factors appear to play a role in the captured responses to social feedback, including individual levels of symptoms and the salience of the tasks used in the laboratory. Examining the relationships between these constructs during emerging adulthood with personally salient and valid tasks is critical to our ability to understand how stress affects physiological responses. Future research in this area is needed to validate the use of the CIT with undergraduates, or to explore other tasks for use in this period, to enhance our ability to predict and intervene on internalizing symptoms in older youth.

Additional Information

Supplementary Materials

Supplementary materials for this article can be viewed here: https://osf.io/xtu64/?view_only=0eff57518ce14310af4c08c4d8243b76

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Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethical Approval

All procedures were approved by the Temple University's Institutional Review Board. Informed consent was obtained from all individual participants included in the study. Participants were informed about the use of data (e.g., de-identified, analyzed, and submitted for publications) prior to providing informed consent.

Data Availability

Data and study materials are available upon request.

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