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Social facilitation of emotion regulation: Uncovering the mechanisms and outcomes of social regulatory support

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Social facilitation of emotion regulation:

Uncovering the mechanisms and outcomes of social regulatory support

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Psychology

by

Razia Sukaina Sahi

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ABSTRACT OF THE DISSERTATION

Social facilitation of emotion regulation:

Uncovering the mechanisms and outcomes of social regulatory support

by

Razia Sukaina Sahi

Doctor of Philosophy in Psychology

University of California, Los Angeles, 2023

Professor Naomi Ilana Eisenberger, Co-Chair

Professor Jennifer Ashley Silvers, Co-Chair

Decades of research demonstrate that emotion regulation — the collection of strategies people use to manage emotional states — is critical for health and well-being. However, most of this research focuses on how we regulate our own emotions. In everyday life, we often receive help from others with managing our emotional states, and, in the absence of supportive relationships, physical and mental health tend to suffer. To understand *how* relationships impact wellbeing, it is critical to unpack how social interactions shape emotion regulation processes. Across four separate studies using a novel dyadic paradigm designed to examine how social support from friends can impact emotion regulation, this dissertation tests: (Paper 1) whether social support can potentiate emotion regulation strategies in-the-moment; (Paper 2) whether the effects of social support linger to facilitate emotion regulation when people are alone; and (Paper 3)

whether features of vocal expression — namely acoustic pitch — influence social emotion regulation outcomes. First, we found that reappraising negative stimuli (i.e., reinterpreting its content to change its emotional impact) was more effective with help from a friend, as compared to reappraising independently. We found that this difference was not driven by the quality of reappraisals, or a mere buffering effect from hearing the friend's voice, suggesting that social support selectively potentiated reappraisal efficacy. Next, we showed that social support improved regulatory outcomes both in-the-moment when receiving support and when people encountered the same stimuli again on their own, demonstrating how social interactions can help prepare individuals to independently cope with distressing events. Finally, we demonstrated that higher support giver pitch during social emotion regulation was associated with better regulatory and relationship outcomes, providing insight into how people effectively communicate during supportive interactions. By investigating how social relationships can be leveraged to improve emotion regulation, this work advances our understanding of how social contexts shape health and wellbeing over time and highlights potential pathways for ameliorating emotion dysregulation.

The dissertation of Razia Sukaina Sahi is approved.

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DEDICATION

This dissertation is dedicated to my Nana-Papa and Nani-Ma – for their wisdom, curiosity, and nurturance.

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1. Sahi, R. S. (2019). It's okay to be angry: A functionalist perspective of the dangers of over-regulating anger. *Philosophical Topics* [special issue on emotion regulation] *47* (2), 53-73.
2. Sahi, R. S. & Eisenberger, N. I. (2020). Why don't you like me: The role of the mentalizing network in social rejection. To appear in: Gilead M. & Ochsner, K.N., *The Neural Basis of Mentalizing - A Social-Cognitive and Affective Neuroscience Perspective*. New York: Springer.
3. Sahi, R. S., Dieffenbach, M. C., Gan, S., Lee, M., Hazlett, L. I., Burns, S. M., Lieberman, M. D., Shamay-Tsoory, S. G., & Eisenberger, N. I. (2021). The comfort in touch: Immediate and lasting effects of handholding on emotional experiences. *PLOS ONE*.
4. Sahi, R. S., Ninova, E., & Silvers, J. A. (2021). With a little help from my friends: Selective social potentiation of emotion regulation. *Journal of Experimental Psychology: General.* PMID: 33166161
5. Sahi, R. S., Schwyck, M. E., Parkinson, C., & Eisenberger, N. I. (2021). Having more virtual interaction partners during COVID-19 physical distancing measures may benefit mental health. *Scientific Reports*. PMID: 34521876
6. Guassi Moreira, J. F., Sahi, R., Ninova, E., Parkinson, C., Silvers, J. A. (2022) Performance and belief-based emotion regulation capacity and tendency: Mapping links with cognitive flexibility and perceived stress. *Emotion*. PMID: 32463278
7. Sahi, R. S., He, Z., Silvers, J. A., & Eisenberger, N. I. (2022). One size does not fit all: Decomposing the implementation and differential benefits of social emotion regulation strategies. *Emotion*. PMID: 36480403
8. Sahi, R. S., Eisenberger, N. I., & Silvers, J. A. (2023). Peer facilitation of emotion regulation in adolescence. *Developmental Cognitive Neuroscience.*
9. Guassi Moreira, J. F., Sahi, R. S., Calderon Leon, M., Saragosa-Harris, N., Waizman, Y., Sedykin, A., Ninova, E., Peris, T., Gross J., & Silvers, J. A. (in revision at *Emotion*). A data-driven typology of emotion regulation profiles.
10. Sahi, R. S., Gaines, E. M., Nussbaum, S. G., Lee, D., Lieberman, M. D., Eisenberger, N. I., & Silvers, J. A. (in revision at *Emotion*). You changed my mind: Immediate and enduring impacts of social emotion regulation.

INTRODUCTION

While emotions are generally useful for shaping how individuals communicate, learn, and respond to their environments, the inability to effectively regulate emotions underlies a host of mood and anxiety disorders (Aldao et al., 2010; Campbell-Sills & Barlow, 2007), and can severely disrupt social relationships (Eisenberg et al., 2014; Gross, 1998a). Given the importance of emotion regulation in health, well-being, and social functioning, extensive research has investigated how people implement emotion regulation strategies across a variety of contexts (English et al., 2017; Sheppes et al., 2012; Troy et al., 2017). However, most of this work has focused on how individuals regulate their own emotional states, whereas in everyday life, we often rely on and solicit regulatory support from the people around us, a process we describe as "social emotion regulation" (Sahi, Ninova, & Silvers, 2021; Sahi, et al., 2022; Sahi et al., under review; Sahi, Eisenberger, & Silvers, in revision).

Although considerable research has demonstrated the importance of social relationships in well-being (Beckes & Coan, 2011; Berkman, Glass, Brissette, & Seeman, 2000; Uchino, Bowen, de Grey, Mikel, & Fisher, 2018), limited work has assessed how people help regulate each other's emotions. Several theoretical frameworks suggest that people effectively use emotion regulation strategies to support others (Niven et al., 2009; Reeck et al., 2016; Zaki & Williams, 2013), but there is a dearth of empirical research unpacking how these strategies are socially implemented, and to what ends. For example, reinterpreting how one thinks about a negative event has been shown to effectively change how one feels about that event. But it is unknown whether having a close other reinterpret events for us could be *more* effective than doing it ourselves, both in-the-moment while experiencing something negative, and later on when re-encountering negative stimuli without social support. Furthermore, little is known about

how dynamic features of social interaction, such as a speaker's vocal patterns, shape regulatory outcomes. Research suggests that a speaker's pitch can impact how a listener perceives a message (Pell & Kotz, 2021; Pisanski et al., 2016), illuminating a potential avenue through which a support giver can effectively communicate during social emotion regulation.

The present collection of studies examines whether the efficacy of emotion regulation strategies is selectively enhanced by social support (Paper 1: Studies 1 - 3), whether these effects last to promote future self-regulation (Paper 2: Study 4), and how a speaker's vocal patterns shape social regulatory outcomes (Paper 3: Studies 1, 3, and 4). Collectively, these aims provide insight into several points of possible intervention for emotion dysregulation that can be easily implemented by systematically leveraging existing social relationships towards improving well-being.

Paper 1: Examine whether social support potentiates emotion regulation in-the-moment.

Study 1. We used a well-validated emotion self-regulation paradigm to develop a novel social emotion regulation paradigm that would allow us to compare the effects of regulating emotions on one's own to regulating emotions with help from a close friend. In the self-regulation task, participants either "look" naturally at or "reinterpret" the content of negative (e.g., people fighting) and neutral (e.g., people walking) images. During the "reinterpret" trials, participants tried to change how they thought about the content of the image, for example by thinking about how the situation would be resolved or by focusing on an aspect of the situation that wasn't as bad as it seemed. The social emotion regulation task was the same as this self-regulation task except that participants saw a cue to "look" naturally or, instead of reinterpreting on their own, "listen" to their friend reinterpreting the stimuli for them. Importantly, we asked the support-giving friends to read reinterpretations for the social emotion regulation task from a

script, allowing us to control for the content of the reinterpretations across participants. We collected this data in a sample of 40 friend-pairs (i.e., 80 participants). Results indicated that hearing a friend reinterpret stimuli was more effective in reducing negative affect than reinterpreting it on one's own.

Study 2. While study 1 established a difference between regulating alone and regulating with help from a friend, there were several alternative explanations for this effect that we sought to rule out. For example, the scripted reinterpretations read by friends during social emotion regulation may have been better than reinterpretations that participants generated when regulating independently, which would suggest that our script was responsible for improving emotion regulation rather than social support from the friend. Thus, in study 2 we recorded reinterpretations generated by participants during cognitive regulation in a sample of 24 participants, and then tested whether a separate sample of 40 participants undergoing a social regulation task noticed any differences in these reinterpretations and those from our script in study 1. We found that the two sets of reinterpretations were roughly statistically equivalent, suggesting that our results in study 1 were not driven by a difference in the types of reinterpretations used in each task.

Study 3. In study 3, we sought to examine whether the difference between self-regulation and social regulation was explained by a general social buffering effect. In other words, if hearing the friend say anything at all reduced negative affect relative to saying something to oneself, then social support may have had a buffering effect regardless of the emotion regulation strategy in use. To test this question, we used the same paradigm as study 1, and introduced an additional control condition to both tasks such that participants would either "count" calmly to themselves while viewing negative stimuli, or "listen" to their friend counting. In a sample of 40

friend-pairs (i.e., 80 participants), we found that listening to a friend count was not associated with lower negative affect than counting to oneself, but, in line with study 1, listening to a friend reinterpret negative stimuli was associated with lower negative affect than reinterpreting alone. Thus, across studies 1-3 we addressed Aim 1 and demonstrated that social support selectively potentiated emotion regulation. The results of this work have been published in a high-impact journal (Sahi, Ninova, & Silvers, 2021, *Journal of Experimental Psychology: General*).

Paper 2: Examine whether socially facilitated emotion regulation outcomes persist when individuals are alone.

Study 4. In study 4, we investigated whether social regulation had a lasting impact on how people responded to negative stimuli. Thus, we replicated the procedure of study 1 in a sample of 60 friend-pairs (i.e., 120 participants) with an additional follow-up task. One day after participants left the lab, the member of the friend pair that completed the regulation tasks passively viewed and rated negative images they saw during these tasks – this time, without social support or instructions to regulate. We found that participants responded less negatively to aversive images that were socially regulated (i.e., reappraised with the help of a friend) both immediately and over time, as compared to images that had been previously solo regulated (i.e., reappraised on one's own) or not regulated (i.e., passively viewed). Importantly, because studies 1-3 only sampled women, in study 4 we used a gender-split sample of same-gender dyads to assess possible gender differences in our findings. Interestingly, we found that the regulatory boost from social support observed both in the lab and at follow-up was driven by women friend-pairs. The results of this work are pre-printed and currently in revision at a notable journal (Sahi, et al., 2023).

Paper 3: Examine whether features of vocal expression influence social regulatory outcomes.

Studies 1, 3, and 4. To address whether vocal features impact social regulation, we used Bayesian parameter estimation to assess whether the support giver's vocal pitch – as indexed by fundamental frequency – was associated with better social emotion regulation outcomes in studies 1, 3, and 4. We found cumulative evidence that higher support giver pitch was associated with lower negative affect in the friend during the task, as well as some evidence that higher support giver pitch during social emotion regulation was associated with how positively the friend viewed their relationship with the support giver more generally. While these samples consisted primarily of women, preliminary results indicate that higher support giver pitch was not beneficial in men dyads. The results of this work were presented at the 2023 Social Affective Neuroscience Society Conference and are currently in preparation for submission to a peer-reviewed journal.

CHAPTER 1: WITH A LITTLE HELP FROM MY FRIENDS: SELECTIVE SOCIAL POTENTIATION OF EMOTION REGULATION

Abstract

Decades of research has pointed to emotion regulation (ER) as a critical ingredient for health, well-being, and social functioning. However, the vast majority of this research has examined emotion regulation in a social vacuum, despite the fact that in everyday life individuals frequently regulate their emotions with help from other people. The present collection of pre-registered studies examined whether social help increases the efficacy of reappraisal, a widely-studied ER strategy that involves changing how one thinks about emotional stimuli. In Study 1 (N = 40 friend pairs), we compared the efficacy of reinterpreting the content of negative stimuli alone (solo ER) to listening to a friend reinterpret the stimuli (social ER). We found that social ER was more effective than solo ER, and that the efficacy of these strategies was correlated within individuals. In Studies 2 and 3, we replicated effects from Study 1, and additionally tested alternate explanations for our findings. In Study 2 (N = 40 individuals), we failed to find evidence that social ER was more effective than solo ER due to a difference in the quality of reinterpretations, and in Study 3 (N = 40 friend pairs), we found that social help did not significantly attenuate negative affect in the absence of reappraisal. In sum, we found that social help selectively potentiates the efficacy of reappraisal, and that this effect was not merely the outcome of social buffering. Together, these results provide insight into how social relationships can directly lend a hand in implementing ER strategies.

Introduction

Emotion regulation (ER) is defined as the process by which individuals control the experience and expression of their emotions (Gross, 1998b). While emotions are generally functional in shaping how individuals communicate, learn, and respond to their environments (Keltner & Haidt, 1999), the inability to effectively regulate emotions underlies a host of mood and anxiety disorders (Aldao et al., 2010; Campbell-Sills & Barlow, 2007), and can severely disrupt individuals' ability to navigate relationships (Eisenberg et al., 2014; Gross, 1998a). Given the importance of ER in individuals' health, well-being, and social functioning, extensive research has investigated how individuals implement ER strategies across a variety of contexts (English et al., 2017; Sheppes et al., 2012; Troy et al., 2017).

One widely studied strategy for controlling emotional states, cognitive reappraisal, involves reinterpreting how we think about a stimulus in order to change how we feel about it (Gross, 1998b; Uusberg et al., 2019). For example, if someone fails to get their dream job, they might tell themself that there are other great opportunities out there and that they will succeed in finding a desirable job eventually. Such reframing of negative events is thought to decrease negative emotions by increasing engagement of executive control centers of the brain and decreasing engagement in regions of the brain that are associated with heightened emotionality (Buhle et al., 2014; Ochsner & Gross, 2005). From a clinical perspective, this strategy is considered to be so effective in managing emotions that it is a critical component of cognitive behavioral therapy (CBT), a widely implemented clinical treatment program for individuals suffering from a range of psychopathologies including depression, anxiety, and substance abuse that involves behavioral interventions alongside cognitive restructuring (A. Beck, Emery, & Greenberg, 2005; Dimidjian & Davis, 2009).

Though individuals can and often do reappraise alone, they also often receive help in reframing negative events (Gross et al., 2006; Niven et al., 2009; 2011; 2015). Imagine getting the call saying you did not get the job. What would you do? Many people may turn to a close friend or relative to share the distressing news. In turn, the support giver may say something like "don't worry - there are a lot of great opportunities out there and you're going to find a job that's the right fit for you." Hearing this reinterpretation of the event may be more effective than trying to reinterpret it alone because it provides an outside perspective of events that already feel negative from the experiencer's perspective. While there are several theoretical frameworks for interpersonal emotion regulation suggesting that people effectively use reappraisal to regulate each other's emotions (Niven et al., 2009; Reeck et al., 2016; Zaki & Williams, 2013), the vast majority of empirical research on ER has examined how individuals regulate on their own.

Existing research suggests that social relationships can facilitate ER processes through implicit and explicit forms of social support. In terms of implicit emotional support, the presence of close others has repeatedly been shown to be a simple yet powerful means of buffering against negative emotions across species and across the lifespan (Bowlby, 2002; Hazan & Shaver, 1987). For example, simply looking at a picture of a loved one has been shown to decrease negative affect (Eisenberger et al., 2011; Master et al., 2009). When the presence of a close other is accompanied by touch (e.g., holding the hand of a close other), there seems to be even greater buffering against negative affect. For example, research suggests that holding the hand of a romantic partner decreases physical pain relative to their mere presence (Coan et al., 2006). Indeed, research suggests that these effects of social support on negative affect can be leveraged to develop and treat psychopathology (Brewin et al., 2000; Kilpatrick et al., 2007; Ozer et al., 2003; Pietrzak et al., 2010). Notably, such forms of implicit social support do not require close others to directly

engage with individuals' efforts to regulate their emotions. Instead, such support provides a source of comfort, potentially facilitating a calmer baseline from which individuals can manage their own emotions (Beckes & Coan, 2011; Gee et al., 2014).

In terms of explicit emotional support, research suggests that people often share their experiences with others in order to receive socio-affective or cognitive support (Rimé, 2009). Whereas socio-affective support involves receiving comfort and validation from another person, cognitive support involves receiving help with reappraisal (i.e., reinterpreting the meaning of negative events). While socio-affective support tends to make people feel better in the short-term, cognitive support is thought to be more useful in terms of long-term outcomes (Brans, Van Mechelen, Rimé, & Verduyn, 2014; Rimé, 2009, 2012). Although some research has investigated the differential benefits of these two forms of explicit emotional support in terms of how individuals evaluate such support and those who offer it (Niven et al., 2015; Pauw, Sauter, van Kleef, & Fischer, 2018), no work to date has directly compared how reappraisal differs across intrapersonal and interpersonal contexts. In other words, it remains unknown whether reappraising with help from others is more effective than reappraising alone.

Overview of present investigation

The present collection of studies builds on prior work to examine whether the efficacy of ER strategies is selectively enhanced by social support in three pre-registered studies. In Study 1, we compared the efficacy of reinterpreting negative stimuli alone (solo ER) to the efficacy of listening to a friend reinterpret the stimuli (social ER). We tested three competing hypotheses regarding the efficacy of social ER: (1) social ER is more effective than solo ER; (2) solo ER is more effective than social ER; or (3) social and solo ER are equally efficacious. We additionally examined whether social ER and solo ER were correlated within individuals to assess whether the

efficacy of social ER, like solo ER, varies as a function of individual differences in ER ability (Gross & John, 2003). Finally, we conducted exploratory analyses to examine whether individual differences in social and emotional tendencies and qualities predicted the efficacy of social ER.

A key finding from Study 1 was that social ER was significantly more effective than solo ER in down-regulating negative affect. However, this study does not elucidate *why* social ER was more effective than solo ER. Thus, in Studies 2 and 3 we aimed to replicate results from Study 1, and additionally followed-up on our results to test alternate explanations for this finding. In Study 2, we examined whether the observed difference between social ER and solo ER was due to a difference in the quality of reinterpretations between the two tasks. We hypothesized that the quality of reinterpretations generated by participants in the lab for a solo ER task would not be significantly different from the quality of reinterpretations used in the social ER task. In Study 3, we assessed one possible mechanism that could explain the observed difference between social ER and solo ER: social buffering. Specifically, we examined whether social ER was more effective than solo ER because of the comforting or distracting nature of the social versus the solo task, regardless of implementing the ER strategy, by including a counting condition in our task. We hypothesized that listening to a friend count slowly (social counting) would not be more effective in reducing negative affect than counting slowly alone (solo counting), suggesting that the observed difference between social ER and solo ER was not merely the result of a social buffering effect.

Research Overview

Across three experiments, we studied how social ER shapes negative affective experiences. We utilized the same exclusion criteria, justification of sample size, analytic approach, and primary outcome measure across all three studies, described below. All procedures were approved by the

local IRB committee. All data, analysis materials, and stimuli are hosted on Open Science Framework and can be accessed upon email request to the first author at rsahi1@ucla.edu (R. Sahi, Ninova, & Silvers, 2020).

Exclusion criteria. Participants individually completed email screenings to ensure their eligibility before coming to the lab. Prospective participants who reported being younger than 18 or older than 39, were not proficient in English, reported having any developmental disability or neurological disorder, any serious physical or psychological illness, or uncorrected vision or hearing were not enrolled in the study. Because previous research indicates that there may be gender differences in reappraisal implementation (McRae et al., 2008) and in social support provision (Neff & Karney, 2005), we restricted our sample to female participants.

Sample size. The rationale for our sample size of 40 across all three studies derives from previous work examining reappraisal using similar reinterpretation paradigms (McRae et al., 2008; Ochsner et al., 2004; Ray et al., 2005). Since these studies found an effect of reappraisal using this type of paradigm with a sample of 20-25 participants, we approximately doubled the sample size to account for our two within-subjects conditions of interest (i.e. social ER and solo ER).

Analytic approach. All analyses were conducted using the statistical package R (Version 1.2.1335). For each study, we created linear mixed-effects models (LMMs, i.e., multilevel regression) with participant ID as the group level variable. This analytic approach allowed us to account for non-independence of errors due to our repeated-measures design, which would result in underestimated standard errors and inflated risk of type I error, while also providing more modeling flexibility than repeated-measures ANOVA. Since repeated-measures ANOVA only uses list-wise deletion, multilevel regression is additionally better at accounting for missing data

(such as trials missed by participants), and therefore has greater statistical power than repeated-measures ANOVA.

Measures. Our primary outcome measure across studies was self-reported negative affect on each trial. To measure negative affect, we asked participants how bad they felt on a scale of 1 to 4, 1 being not bad at all and 4 being very bad, on each trial. We additionally collected exploratory measures during Study 1 relating to social and emotional tendencies and qualities, including measures of relationship quality (Inventory of Peer Attachment: Armsden & Greenberg, 1987; Social Provisions Scale: Cutrona & Russell, 1987; 2-Way Social Support Scale: Shakespeare-Finch & Obst, 2011), emotion regulation frequency and ability (Emotion Regulation Questionnaire: Gross & John, 2003; Reappraisal Capacity: Troy et al., 2017; Interpersonal Regulation Questionnaire: Williams et al., 2018), self regulation tendency (Self Regulation Scale: Schwarzer et al., 1999), empathic tendency (Interpersonal Reactivity Index: Davis, 1983), loneliness (UCLA Loneliness: Russell, 1996), traits/mood (Beck Depression Index: Beck et al., 1988; Perceived Stress Scale: Cohen et al., 1983; State Trait Anxiety Inventory: Spielberger et al., 1983), and personality (Eysenck Personality Inventory: Eysenck, 1968). Since these exploratory measures did not significantly correlate with any of our outcome variables during Study 1 (p's > 0.05), we used the questionnaire portions of Studies 2 and 3 to collect data for a separate study on ER capacity and tendency (Guassi Moreira, in press).

Study 1

In Study 1, our primary aim was to examine whether social ER was more effective than solo ER. To test this question, we created a novel social reappraisal paradigm based on a widely used paradigm for measuring solo reappraisal ability that involves reinterpreting the content of negative stimuli (Ochsner et al., 2004). Our social reappraisal paradigm modified this task such

that participants would listen to a close friend reinterpreting the negative stimuli, allowing us to directly compare the efficacy of using this strategy alone to receiving help with it. In order to maintain consistency in the quality of reinterpretations across dyads, the reinterpretations provided by the friend during the social ER task were scripted ahead of time by the research team.

In addition to comparing negative affect during the social versus the solo ER task, we tested whether the efficacy of social ER was correlated with individuals' ability to regulate alone. In doing so, we aimed to examine whether (a) ER works better for some individuals than others, regardless of social help (i.e. the efficacy of social ER and solo ER are correlated), or (b) social help is more effective for some people than others in enhancing the effects of ER (i.e. the efficacy of social ER and solo ER are not correlated).

Method

Participants. We recruited pairs of female friends ($N = 44$ dyads, $N = 88$ participants) that reported having a close relationship from the University of California Los Angeles (UCLA) campus through flyers and emails. Four dyads were excluded during data collection due to technical difficulties during the session, leaving a final sample of 40 dyads ($N = 80$ participants). The mean age of this sample was 19.4 years, and the sample was approximately 55% Asian, 24% White/Caucasian, 10% Latino/Hispanic, and 2% Black/African American. The remaining participants identified as multiracial or another identity.

Task development. Visual stimuli for our tasks (social task and solo task) were drawn from the International Affective Picture System (Lang et al., 2008), the Open Affective Standardized Image Set (Kurdi et al., 2017), and from freely available online sources. First, a total of 127 images were selected: 91 negative and 36 neutral. Next, two members of the research team generated reinterpretations meant to decrease negative affect for the 91 negative images. Then, all images

and the negative image reinterpretations were independently rated online on Amazon Mechanical Turk (mTurk) by 45 participants. Participants viewed each image and provided a negative affect rating in response to the question "How bad do you feel?" on a scale of 1=not bad at all to 4=very bad. Neutral images were rated only once, while negative images were presented a second time along with the reinterpretation generated by the research team. During the second presentation, participants were asked to read the reinterpretation and provide a negative affect rating using the same scale as the first rating.

The rating on the first negative image presentation (without reinterpretation) was subtracted from the rating from the second negative image presentation (with reinterpretation). We used this difference score to determine which negative images could be successfully reinterpreted, and would thus be appropriate for our reinterpretation task. The 72 negative image-reinterpretation pairs that resulted in the greatest reduction in negative affect were distributed into four scripts with 18 images per script such that the average affect ratings did not significantly differ between scripts. All neutral images were also distributed into two scripts with 18 images per script. Using these 4 negative image sets and 2 neutral image sets, we created 4 versions of the tasks that counterbalanced image sets across the social and solo tasks (e.g. V1 solo task: negative image set 1 – reinterpret, negative image set 2 – look, neutral image set 1 – look; V1 social task: negative image set 3 – reinterpret, negative image set 4 – look, neutral image set 2 - look).

Procedure. Upon arriving, one participant from each dyad was randomly assigned to be the "experiencer" in the study and the other participant was assigned to be the "helper". After assignment and consenting, the friend pairs were separated for the remainder of the study. As each participant completed their tasks, they were reminded of each other's role in the study. Experiencers were reminded that the helpers were trying to help them decrease their negative

response to some of the images, and helpers were reminded that their job was to help their friend feel less negatively about some of the images they would see. Both participants completed the same set of questionnaires.

Experiencer. The experiencer began by completing questionnaires. Next, the experiencer completed a brief training using powerpoint designed to prepare them for two computerized tasks: the solo task and the social task. As part of this training, experiencers saw sample negative images (which were not used in the experimental task) and were instructed on how to respond to different cues. Next, the experiencers completed these two tasks using E-Prime in counterbalanced order. The solo task utilized a standard reinterpretation paradigm (Ochsner et al., 2004), and the social task utilized a slightly modified version of this task created for this study.

Each of these two tasks included three conditions with 18 trials each: negative-reinterpret, negative-look, and neutral-look. While it was important for us to include a neutral-look condition to give participants a break from looking at negative images and to obtain a comparison condition for the negative-look condition, we did not include a neutral-reinterpret condition in either task primarily because this condition did not make sense from the participants' perspective (i.e. there was no negative content to reinterpret). Thus, we had an incomplete 2 (valence: negative vs. neutral) x 2 (instruction: reinterpret vs. look) x 2 (task: solo vs. social) design with 6 conditions total. We accounted for this incomplete design with our subsequent modeling choices.

In the solo task, participants were first presented with an instructional cue to "look" or "reinterpret" for 2 s, followed by a negative or neutral social image for 8 s. Following the look cue, participants were instructed to look and let themselves respond naturally to the image, and following the reinterpret cue, they were instructed to think about the image in a way that would reduce their negative emotional response to it (e.g. "They look upset at each other, but they are

finally coming to terms about something they've disagreed about."). Next, they provided a negative affect rating (3 s), and then relaxed while viewing a fixation cross before the next trial (Figure 1a). The social task followed a similar procedure, except that instead of seeing a cue to "reinterpret" they saw a cue to "listen". Following the listen cue, the experiencer was instructed to listen to the helper describe the image in a way that was meant to help reduce their negative emotional response to the image. During the listen trials, images were presented for an additional 1 s to allow participants to view the image briefly before hearing the audio clip of the reinterpretation (Figure 1b). In between the two tasks, experiencers took a 5-minute break to watch a video meant to provide a brief non-emotional distraction (https://www.youtube.com/watch?v=qed4ynPYVIA).

Unbeknownst to the experiencers, the reinterpretations that the experiencers heard during the "listen" trials were not generated by the helpers. Instead, the helpers read reinterpretations from a script that was generated by the research team for the purpose of standardizing the reinterpretations in the social task across dyads. Thus, at the end of both tasks, experiencers were asked about their perceptions of the study and debriefed on the details of the study.

Helper. The helpers began by completing a relationship salience task (i.e. "Take a moment to think about some memories that you have with the friend you came with today. When you are finished, please pick one memory and write a paragraph describing it."). Since the helpers would not be in the presence of their friend throughout the study, this salience task was designed to prompt them to think about their friendship with the experiencer before completing the helping task. In other words, this salience task was meant to make the helping task feel more social, despite the physical absence of the friend during the task.

After the salience task, the helper moved on to the helper task where they recorded 18 reinterpretations from the script generated by the research team (e.g. “I’m sure that person will recover from the accident quickly”). Each reinterpretation was one sentence and took about 4 s to read out loud. Helpers were instructed to read the reinterpretations in a natural way so that the reinterpretations of the images would feel helpful to their friend as they viewed negative images. These reinterpretations were not read to the experiencers live during the task, but were rather spliced into the task after all the recordings were completed. After the helper completed the recordings, they filled out questionnaires. At the end of the study, helpers were asked about their perceptions of the study.

Analyses

Since we used an incomplete design, it would have been difficult to interpret results when modeling main effects and interactions using the complete dataset. Thus, we analyzed the data in two stages. First, we filtered the data for look trials only and ran a LMM (i.e. a multilevel regression model) with valence of the images (negative vs. neutral) as the predictor variable, self-rated negative affect (trial-level) as the outcome variable, and participant ID as the group-level random variable. This model allowed us to check our manipulation and ensure that participants had greater negative affect in response to the negative images than the neutral images.

Next, we filtered the full dataset for negative image trials only, and ran a LMM with instruction type (reinterpret vs. look) and task (solo vs. social) as the predictor variables, self-rated negative affect as the outcome variable, and participant ID as the group-level random variable. Since our primary comparison of interest was between the solo-reinterpret (i.e. solo ER) and social-reinterpret (i.e. social ER) conditions, we included an interaction term between instruction and task and followed up with Tukey-adjusted pairwise comparisons to specifically compare social

ER versus solo ER. For both of these models, we initially included version of the task (1-4) and which task they completed first (solo vs. social) as predictors of no interest in the model, but since they did not significantly predict the outcome variable (p's > 0.05), they were removed.

To examine the relationship between the efficacy of social ER and solo ER, we first calculated difference scores between look-negative and reinterpret-negative for the social task (i.e. social ER efficacy) and solo task (i.e. solo ER efficacy) for each participant. Then, we calculated the Pearson correlation coefficient between social ER efficacy and solo ER efficacy.

Results

Our analysis of "look" trials suggested that there was a significant effect of valence, b = -1.55, t(2748.83) = -61.09, p < .0001, 95% CI = [-1.60, -1.50], on participants' negative affect, such that participants reported higher negative affect on the negative-look trials (M = 2.65, SD = 0.96) than the neutral-look trials (M = 1.09, SD = 0.33). Our analysis of "negative" trials revealed that there was no main effect of task (solo vs. social), b = 0.06, t(2724.24) = 1.36, p = .17, 95% CI = [-0.03, 0.14], on participants' negative affect, but there was a significant main effect of instruction, b = -1.15, t(2724.30) = -27.02, p < .0001, 95% CI = [-1.23, -1.07], such that participants reported higher negative affect on the negative-look trials (M = 2.65, SD = 0.96) than the negative-reinterpret trials (M = 1.60, SD = 0.75). There was also a significant interaction between task and instruction, b = 0.21, t(2724.22) = 3.44, p < .001, 95% CI = [0.09, 0.32], such that participants reported greater negative affect during solo-reinterpret (M = 1.73, SD = 0.81), than social-reinterpret (M = 1.47, SD = 0.65) , t(2724) = -6.22, p < .0001 (Figure 2a). By contrast, there was no difference between the solo-look and social-look conditions, t(2724) = 1.36, p = 0.17. Additionally, there was a strong correlation between social ER efficacy and solo ER efficacy, r = 0.73, t(38) = 6.53, p < .0001, 95% CI = [0.54, 0.85] (Figure 2b).

Study 2

One question that arose from the Study 1 findings was whether the quality of reinterpretations differed between the solo and social tasks. In other words, were the reinterpretations generated by the research team inherently better in quality than those participants generated themselves during the solo task? If so, social ER may have been more effective than solo ER because of the reinterpretations themselves, and not because of an effect of social help on the efficacy of the ER strategy. Thus, in Study 2, an independent sample of participants (N = 40 individuals) completed the social task from Study 1 that included 18 negative-reinterpret trials where they listened to someone provide reinterpretations of negative images, 18 negative-look trials where they responded naturally to negative images, and 18 neutral-look trials where they responded naturally to neutral images. The negative-reinterpret condition was modified for Study 2 to use a mix of reinterpretations generated by the research team for Study 1 (9 trials) and reinterpretations generated by participants from a separate pilot study (9 trials; details in Task Development), while holding the total number of trials for the task consistent with Study 1 (54 trials). A post-hoc analysis of the Study 1 data suggested that 9 trials for each reinterpretation type were sufficient for obtaining a reliable estimate of social reappraisal (Chakrabartty, 2013; Lord & Novick, 1968; Rudner & Schafer, 2001; see Supplemental Materials for details).

Since the focus of this study was not to compare social versus solo ER, but rather to evaluate whether experimenter-generated reappraisals were more effective than participant-generated reappraisals during social ER, we did not have participants complete the solo task from Study 1. Additionally, participants heard a stranger's voice during the social ER task rather than a friend's voice since this simplified the study procedure for the purpose of comparing the efficacy of the reinterpretations generated by the research team to those generated by participants. While

we did not assess the quality of reinterpretations between the social and solo tasks in Study 1, Study 2 evaluated whether solo ER and social ER reinterpretations likely differed in quality.

Method

Participants. We recruited individual female participants ($N = 42$ individuals) through the UCLA online-participant pool (SONA). 2 participants were excluded during data collection due to technical issues during the session, leaving a final sample of 40 participants. The mean age of this sample was 18.8 years, and the sample was approximately 32.5% Asian, 27.5% White/Caucasian, 25% Latino/Hispanic, 10% Black/African American. The remaining participants identified as multiracial or another identity.

Task development. To develop the modified social task used in Study 2, we adapted the reinterpretation portion of the solo task from Study 1 using Qualtrics to allow participants to write down the reinterpretations they used for the task as they viewed and responded to each negative image (18 trials). We administered this task to 24 female participants recruited through the UCLA online-participant pool. A total of 6 participants completed each of the 4 versions of the modified solo task. Then, we randomly selected reinterpretations from each participant in this study to use in new scripts that included 9 participant-generated reinterpretations and 9 researcher-generated reinterpretations. Finally, a female member of the research team used each of these new scripts to record 4 sets of audio clips (one for each version of the task) using complete sentences for every reinterpretation. These audio clips would be used for the modified social task in Study 2. Aside from this difference in the reinterpretation scripts, and the fact that participants would hear a stranger rather than a friend, this modified social task was exactly the same as the social task completed in Study 1 and was administered using E-Prime.

Procedure. Study 2 followed a similar procedure as Study 1, except that individuals were recruited instead of pairs of friends, and participants did not complete a solo task. After consenting, participants completed a set of questionnaires. Next, they completed a brief PowerPoint training designed to prepare them for the social ER task. Participants were reminded that during the task they would hear someone trying to help them decrease their negative response to some of the images. Then, they completed the modified social ER task described above. At the end of the task, participants were asked about their perceptions of the study.

Analyses. Similar to Study 1, Study 2 utilized an incomplete 2 x 2 design. Thus, we analyzed the data in stages. First, we filtered the data for look trials only and ran a LMM (i.e. a multilevel regression model) with valence of the images (negative vs. neutral) as the predictor variable, self-rated negative affect (trial-level) as the outcome variable, and participant ID as the group-level random variable. Next, we examined whether social ER was effective in reducing negative affect by filtering the data for only the negative image trials and running a LMM with instruction type (reinterpret vs. look) as the predictor variable, self-rated negative affect as the outcome variable, and participant ID as the group-level random variable. To specifically examine whether there was a difference between the participant-generated and researcher-generated reinterpretations in terms of efficacy in reducing negative affect, we filtered the data for only the reinterpretation trials and created a LMM with source of the reinterpretations (participant vs. researchers) as the predictor variable, self-rated negative affect as the outcome variable, and participant ID as the group-level random variable. As with Study 1, we began by including the version of the task (1-4) as a covariate in these models, but since it did not significantly predict the outcome variable (p's > 0.05), it was removed from the models.

Given our explicit interest in testing the null hypothesis in this study, we additionally conducted equivalence testing to examine whether the difference in negative affect associated with participant-generated reinterpretations and researcher-generated reinterpretations is statistically equivalent to zero. Specifically, we used the TOSTER package in R to conduct two one-sided significance tests (Daniel Lakens, 2017; Daniël Lakens, McLatchie, Isager, Scheel, & Dienes, 2020). Since we did not have enough prior information to use a data-driven approach to determine the smallest effect size of interest, we used a medium effect size of $d = 0.3$.

Results

Our analysis of "look" trials suggested that there was a significant effect of valence, $b = -1.61$, $t(1343.84) = -41.34$, $p < .0001$, 95% CI = [-1.69, -1.53], on participants' negative affect, such that participants reported higher negative affect on the negative-look trials ($M = 2.72$, $SD = 1.01$) than the neutral-look trials ($M = 1.11$, $SD = 0.37$). Our analysis of "negative" trials revealed that there was a significant effect of instruction, $b = -0.75$, $t(1341.74) = -14.73$, $p < .0001$, 95% CI = [-0.84, -0.65], on participants' negative affect such that participants reported higher negative affect on the the negative-look trials ($M = 2.72$, $SD = 1.01$) than the negative-reinterpret trials ($M = 1.97$, $SD = 1.02$) (Figure 3a). Finally, our analysis of "reinterpret" trials indicated that there was not a significant effect of source of the reinterpretations (participant vs. researchers), $b = 0.02$, $t(650.64) = 0.33$, $p = .75$, 95% CI = [-0.11, 0.16], on participants' negative affect (Figure 3b). In examining the results of the two one-sided significance tests, given an alpha of 0.05, we found that the null-hypothesis test was not significant, $t(39) = -0.35$, $p = .73$, indicating that the observed difference between participant reinterpretations and researcher reinterpretations is not statistically different from zero, and the equivalence test was marginally significant, $t(39) = 1.55$, $p = .06$, indicating

that the observed difference between participant reinterpretations and researcher reinterpretations is marginally equivalent to zero.

Study 3

A second question we had following Study 1 was whether social ER was more effective than solo ER due to the comforting or distracting nature of the social ER condition as compared to the solo ER condition. In other words, was a "mere presence" effect triggered by hearing the friend's voice enhancing the efficacy of social ER, irrespective of the ER strategy being implemented? If so, then hearing a friend's voice should reduce negative affect even when the friend is not using reappraisal. To test this question, in Study 3 ($N = 40$ dyads) we replicated Study 1 with an additional baseline condition as part of the social and solo tasks: a counting condition. This condition allowed us to examine whether social interaction (i.e. hearing a friend count calmly) reduced negative affect as compared to a matched solo condition (i.e. counting calmly alone).

Method

Participants. We recruited pairs of female friends ($N = 41$ dyads, $N = 82$ participants) that reported having a close relationship from the UCLA campus through flyers and emails. 1 dyad was excluded during data collection due to technical difficulties during the session, leaving a final sample of 40 dyads ($N = 80$ participants). The mean age of this sample was 21 years, and the sample was approximately 50% Asian, 29% White/Caucasian, 30% Latino/Hispanic, and 10% Black/African American. The remaining participants identified as multiracial or another identity.

Task development. Study 3 modified the two computerized tasks from Study 1 to include a counting condition. This counting condition was included as a baseline condition in both the social and solo tasks, and involved counting up or down from a specific number (e.g. "count up from 15" or "count down from 25"). The instruction to count up or down and the number to begin

counting from (i.e. 15, 25, etc.) varied for each trial in order to keep the different trials from being redundant. The number of trials for each condition in the social and solo tasks were modified to maintain the same number of total trials as in Study 1 (54 trials): 18 neutral trials, 12 look trials, 12 count trials, and 12 reinterpret trials. We chose to include this counting condition as our baseline condition because we could control the content of the condition across social and solo tasks and across participants, and because it was a task that could be presented to participants as being a potentially helpful meditative activity during negative affective situations (Goldin & Gross, 2010; Rasmussen et al., 2019).

Procedure. Study 3 followed a similar procedure as Study 1, except that participants were additionally trained to respond to a "count" instruction. Upon arriving, one participant from each dyad was randomly assigned to be the "experiencer" in the study and the other participant was assigned to be the "helper". After assignment and consenting, the friend pairs were separated for the remainder of the study. As each participant completed their tasks, they were reminded of each other's role in the study. Experiencers were reminded that the helpers were trying to help them decrease their negative response to some of the images using different strategies, and helpers were reminded that their job was to help their friend feel less negatively about some of the images they would see using different strategies. Both participants completed the same set of questionnaires.

Experiencer. The experiencer began by completing questionnaires. Next, they completed a brief PowerPoint training that prepared them for the social and solo ER tasks. As part of this training, experiencers saw sample images (which were not used in the experimental task) and were instructed on how to respond to different cues, including look, reinterpret, and count for the solo ER task, and look or listen for the social ER task. The instructions for the look and reinterpret cues were exactly the same as Study 1. When they saw the cue to count, participants were instructed to

count, calmly and slowly, up or down from a specific number presented on the screen. When they saw the cue to listen, participants were instructed to listen to their friend either reinterpreting the negative stimuli, or counting, calmly and slowly, up or down from a specific number presented on the screen. Thus, the cue to listen could signify that they were about to hear either a reinterpretation or counting from their friend. After training, the experiencers completed the two tasks using E-Prime in counterbalanced order. In between the two tasks, experiencers took a 5-minute break to watch a brief neutral video. At the end of both tasks, experiencers were asked about their perceptions of the study and debriefed on the details of the study.

Helpers. The helpers began by completing a relationship salience task (same as Study 1). After the salience task, the helper recorded 14 reinterpretations from the script generated by the research team. Next, they recorded 14 audio clips counting up or down from specific numbers. For both sets of recordings, helpers were instructed to speak in a way that would make the audio clips feel helpful to their friend as they viewed negative images. After completing the recordings, helpers completed questionnaires. At the end of the study, helpers were asked about their perceptions of the study.

Analyses. Like Studies 1-2, Study 3 utilized an incomplete design. Thus, we analyzed the data in two stages. First, we filtered the data for look trials only and ran a LMM (i.e. a multilevel regression model) with valence of the images (negative vs. neutral) as the predictor variable, self-rated negative affect (trial-level) as the outcome variable, and participant ID as the group-level random variable. Next, we filtered the data for negative image trials only, and ran a LMM with instruction type (reinterpret vs. look vs. count) and task (solo vs. social) as the predictor variables, self-rated negative affect as the outcome variable, and participant ID as the group-level random variable. Given that we had 3 instruction types in this model, we set the reference group as “look”

such that our model would produce an estimate for look vs. reinterpret and look vs. count. As in Study 1, we included an interaction term between instruction and task (resulting in estimates for look vs. reinterpret by task and look vs. count by task), and followed up with Tukey-adjusted pairwise comparisons to specifically compare social ER versus solo ER, and social counting versus solo counting. For both of these models, we initially included version of the task (1-4) and which task they completed first (solo vs. social) as predictors of no interest in the model, but since they did not significantly predict the outcome variable (p's > 0.05), they were removed. To examine the relationship between the efficacy of social ER and solo ER, we first calculated difference scores between look-negative and reinterpret-negative for the social task (i.e. social ER efficacy) and solo task (i.e. solo ER efficacy) for each participant. Then, we calculated the Pearson correlation coefficient between social ER efficacy and solo ER efficacy.

Results

Our analysis of "look" trials suggested that there was a significant effect of valence, b = -1.21, $t(2321.11) = -43.63$, $p < .0001$, 95% CI = [-1.27, -1.16], on participants' negative affect, such that participants reported higher negative affect on the negative-look trials (M = 2.37, SD = 1.00) than the neutral-look trials (M = 1.15, SD = 0.44). Our analysis of "negative" trials revealed that there was no main effect of task (solo vs. social), b = -0.07, $t(2762.13) = -1.34$, $p = 0.18$, 95% CI = [-0.18, 0.03], on participants' negative affect. However, with look as the reference group, there were significant main effects of counting, b = -0.25, $t(2762.14) = -4.60$, $p < .0001$, 95% CI = [-0.35, -0.14], and reinterpreting, b = -0.83, $t(2762.21) = -15.30$, $p < .0001$, 95% CI = [-0.93, -0.72], such that negative affect was lower on the count trials (M = 2.17, SD = 0.91) and reinterpret trials (M = 1.64, SD = 0.75) as compared to the look trials (M = 2.37, SD = 1.00). While there was no interaction between count (vs. look) and task, b = 0.10, $t(2762.13) = 1.23$, $p = .21$, 95% CI = [-

0.05, 0.25], there was a significant interaction between reinterpret (vs. look) and task, $b = 0.20$, $t(2762.21) = 2.59$, $p < .005$, 95% CI = [0.05, 0.35]. Pairwise comparisons indicated that there was a significant difference between the solo-reinterpret and social-reinterpret conditions, $t(2762) = -2.32$, $p = .02$, such that participants reported greater negative affect during solo-reinterpret ($M = 1.71$, $SD = 0.80$), than social-reinterpret ($M = 1.58$, $SD = 0.70$) (Figure 4a). There was no difference between the solo-look and social-look conditions, $t(2762) = 1.34$, $p = 0.18$. Additionally, as in Study 1, there was a correlation between social ER efficacy and solo ER efficacy, $r = 0.35$, $t(38) = 2.33$, $p = .02$, 95% CI = [0.05, 0.60] (Figure 4b).

Discussion

The present collection of studies examined whether social help selectively increased the efficacy of reappraisal, a widely-studied and utilized ER strategy that involves changing how one thinks about negative stimuli in order to change how they feel about it (Gross, 1998b). Across two studies, we found that social help boosted the efficacy of ER: when individuals heard their friend reappraising negative stimuli, it was more effective in reducing negative affect than reappraising stimuli alone. Importantly, Study 2 suggested that while reinterpretations generated by participants and researchers were not statistically equivalent, it is unlikely that there is a difference in the quality of reinterpretations between the social ER and solo ER tasks since the participant-generated reappraisal condition and researcher-generated reappraisal condition were not statistically different, and were marginally statistically equivalent. Meanwhile Study 3 suggested that the effect of social reappraisal was not due to a social buffering or "mere presence" effect triggered by hearing the friend's voice irrespective of the ER strategy. Rather, social support seemed to *selectively* enhance the efficacy of reappraisal, suggesting that social help may be particularly instrumental in facilitating the implementation of ER strategies. We additionally found that the

efficacy of solo ER and social ER was correlated within individuals across two studies. This finding suggests that ER strategies like reappraisal potentially share a common mechanism across intrapersonal and interpersonal contexts, though further research is necessary to explicitly examine the mechanisms underlying reappraisal in social contexts.

While several theoretical frameworks posit that ER strategies like reappraisal are implemented and effective in social contexts (Niven, 2017; Reeck et al., 2016; Zaki & Williams, 2013), the present research is one of the first to directly compare the efficacy of an ER strategy across interpersonal and intrapersonal contexts. Given that this form of social ER (i.e. providing reinterpretations of negative events for someone else) is common in everyday life (Niven et al., 2015), it is important to examine its efficacy relative to regulating alone. By demonstrating the value of social help in implementing ER, the present work provides novel insight into why social relationships may be so important to individuals' long-term wellbeing and health (Kawachi & Berkman, 2001). Indeed, socially-supported ER may be an under-studied but critical path through which individuals navigate hardship and cultivate resilience in the face of adversity.

While the present research ruled out social buffering as a possible mechanism underlying the efficacy of social ER, we did not test additional possible mechanisms that could help explain why social ER was more effective than solo ER. This will be a critical next step for this line of work and thus we describe here several potential mechanisms that could explain the observed results. One possible explanation for why social ER is more effective than solo ER is because it offers a short-cut to emotion regulation by outsourcing some of the cognitive effort required to self-regulate (Beckes & Coan, 2011). It can be emotionally and cognitively taxing to generate reappraisals since this strategy requires people to engage with the negative stimuli (Sheppes, 2014). In other words, we cannot re-think the meaning of a negative event (e.g. there will be other

great job opportunities) without engaging with our feelings about the event (e.g. I did not get the desired job). Thus, receiving a reappraisal from an outside source, particularly a trusted source like a close friend, may make it easier to change the perception of the stimuli by reducing the experiencer's vulnerability and mental load. This mechanism could be tested by examining whether competing cognitive demands disrupt solo ER to a greater extent than social ER.

Relatedly, reappraisals generated by others may feel more plausible than those we generate ourselves, particularly when the stimuli are personally relevant, since they provide us with some insight into how a more objective outsider might perceive things. Research suggests that people tend to focus on concrete details of their negative experiences (Ayduk & Kross, 2010; Grossmann & Kross, 2010), and that transcending one's own egocentric viewpoint (i.e. adopting a psychologically distanced perspective) can facilitate wise reasoning about emotional events (Kross & Grossmann, 2012). Thus, social ER may facilitate a more distanced perspective of the stimuli, resulting in more effective down-regulation of negative affect related to that stimuli (Kross, Ayduk, & Mischel, 2005). This question of how social ER changes one's perspective of an emotional event could potentially be evaluated through post-hoc interviewing of participants.

Furthermore, it is possible that social ER counters negative emotional experiences with positive feelings of social connection and understanding (Eisenberg et al., 2014). While our findings suggest that social ER is not more effective than solo ER because of a "mere presence" effect triggered by hearing the friend's voice, it is possible that receiving reappraisals from a close other is more rewarding or comforting than hearing them count because it more clearly demonstrates that they are engaging with the stimuli. In other words, hearing someone elses' perspective of what we're experiencing may facilitate a sense of shared experience, which allows individuals to obtain a more reliable worldview and helps them maintain a sense of connectedness

to those around them (Echterhoff, Higgins, & Levine, 2009). This mechanism could be tested by assessing how connected participants feel to their friends before and after engaging in social ER, as compared to when they regulate alone. Future work can explicitly examine these proposed mechanisms, and whether they operate independently or in parrallel during social ER.

The present research builds on prior work demonstrating the role of social scaffolding on ER processes. In contrast to scaffolding techniques which support someone else's regulatory efforts by, for example, modeling ER or providing instructions to regulate (A. S. Morris, Silk, Steinberg, Myers, & Robinson, 2007), the present studies examined whether one person can directly provide ER strategies to regulate someone else's emotions (Niven et al., 2009; Rimé, 2009; Zaki & Williams, 2013). Given the widespread use of scaffolding techniques in clinical and educational programs aimed at boosting ER efficacy (Domitrovich et al., 2005; Kovacs & Lopez-Duran, 2012; Rasmussen et al., 2019), our work has the potential to contribute to the development of novel interventions that leverage social relationships in more active roles during ER. Indeed, some prior work has demonstrated how social interactions can be leveraged towards enhancing engagement with online CBT-based clinical treatment programs. Specifically, Morris and colleagues developed a platform that crowd-sourced supportive reappraisals, and found that participants who used this platform demonstrated increased engagement and greater clinical benefits relative to those assigned to an expressive writing task (R. R. Morris, Schueller, & Picard, 2015). While this work does not compare the efficacy of the social CBT program to more traditional CBT programs where participants self-regulate, it does suggest that social support can be leveraged in clinical treatment to increase engagement and adherence. It is possible that social interventions that entail such explicit regulation of others' emotions are particularly useful in boosting ER efficacy when individuals are having difficulty regulating on their own, though

further research is required to examine this proposition. Future interventions may target individuals' ability to regulate others' emotions, as opposed to their own emotions, particularly in group settings where such social ER may increase group cohesion and decrease the potential consequences of heightened individual or collective negative emotional experiences (Friesen et al., 2013; Niven et al., 2012). Such interventions are especially worth exploring in light of accumulating research suggesting that regulating others' emotions can improve one's own emotions (Doré et al., 2017; Inagaki & Eisenberger, 2012).

Since this research is amongst the first to specifically examine the efficacy of social ER relative to solo ER, there are several limitations that can be explored in future work. For example, our work specifically examined social ER in the context of a close female friendship (in a predominantly undergraduate sample). Thus, it is unclear the extent to which social help boosts the efficacy of ER in other relationships. It is possible that social help boosts the efficacy of ER when the person providing the reinterpretations is a close other, but not when they are a distant other. While we found that social ER was still effective in reducing negative affect as compared to no regulation (i.e., passively viewing negative images) when the reinterpretations were provided by a stranger, future work can explicitly compare social ER across different types of relationships, such as friendships, parent-child relationships, or work relationships. It is possible that some social support figures are more effective in facilitating this type of social ER than others, particularly at different developmental timepoints (Rimé, 2009), providing some insight into the mechanisms underlying this form of ER. Relatedly, there may be specific factors about a relationship, such as degree of trust or similarity between individuals' viewpoints, that shape ER outcomes that would be informative to study in the future. Additionally, future work can sample from a more diverse population including both genders and extend beyond an undergraduate sample.

Our study utilized a classic reappraisal paradigm, allowing it to directly build on prior ER work with insights about how this ER strategy comparatively unfolds in a social context. However, this lab-based paradigm comes with the limitation of presenting participants with impersonal stimuli. Reappraisal is known to be a helpful ER strategy in reducing negative affect, but in everyday life this strategy sometimes backfires, such as when negative events allow few opportunities for reinterpretation, or when the event is highly intense/challenging (Somerville, 2013). Relatedly, while our study design provided reinterpretations that were intended to be useful during social ER, in real life there is no such guarantee. Thus, future work should investigate the everyday contexts in which social ER is helpful, the degree to which friends spontaneously offer helpful reinterpretations in real life, and how social help shapes the outcome of ER processes across situational contexts. It is possible that social help could be ineffective in certain contexts, or that it would be helpful in contexts where solo ER is particularly difficult. In order to further enhance the ecological validity of such research, future work could utilize daily-diary or ecological momentary assessment studies to examine how such social regulatory processes unfold outside of the lab.

Finally, this research is limited to examining a single ER strategy. Future work can investigate how other ER strategies, like putting feelings into words (Torre & Lieberman, 2018), differ across intrapersonal and interpersonal contexts, and can compare this ER strategy to other forms of social support, such as social scaffolding (A. S. Morris, Criss, Silk, & Houltberg, 2017). While additional work would be informative with regards to painting a broader picture of social ER and its mechanisms, the present work meaningfully sets the stage for such research and provides important preliminary insights into how individuals directly regulate each other's

emotions using paradigmatic ER strategies that have been predominantly studied in a social vacuum.

Figures

(a) Solo Task

(b) Social Task

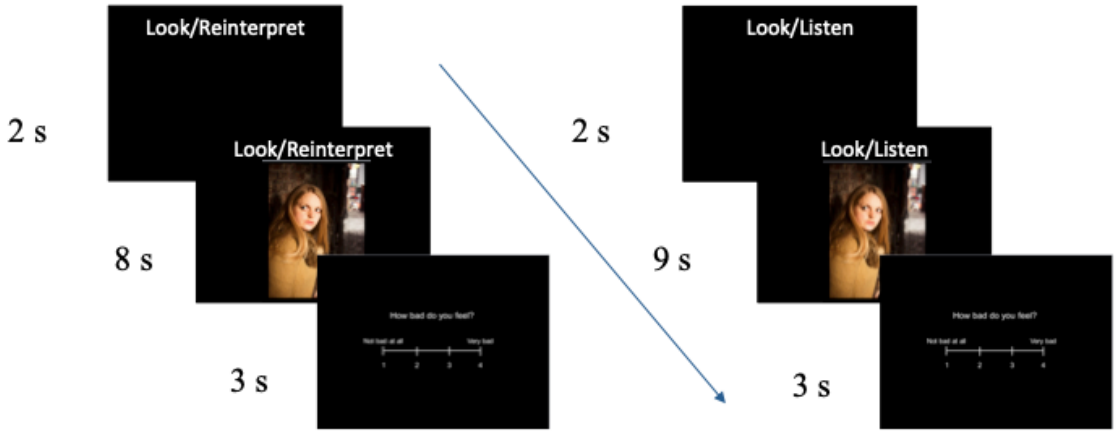
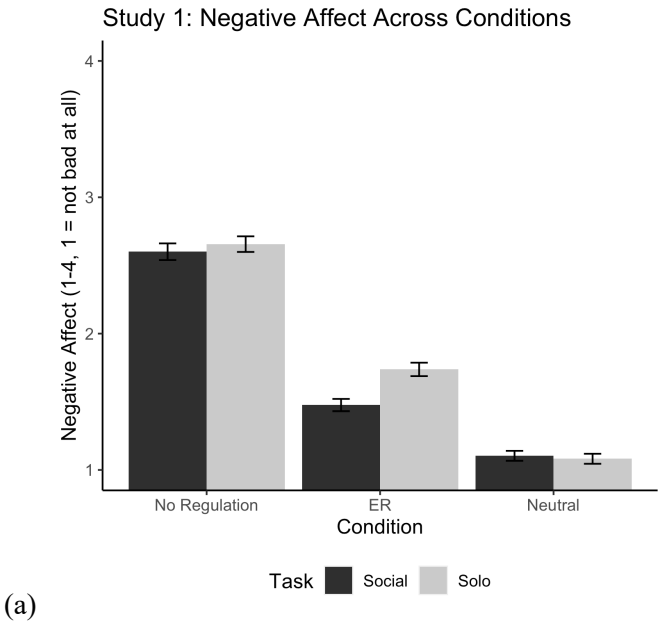
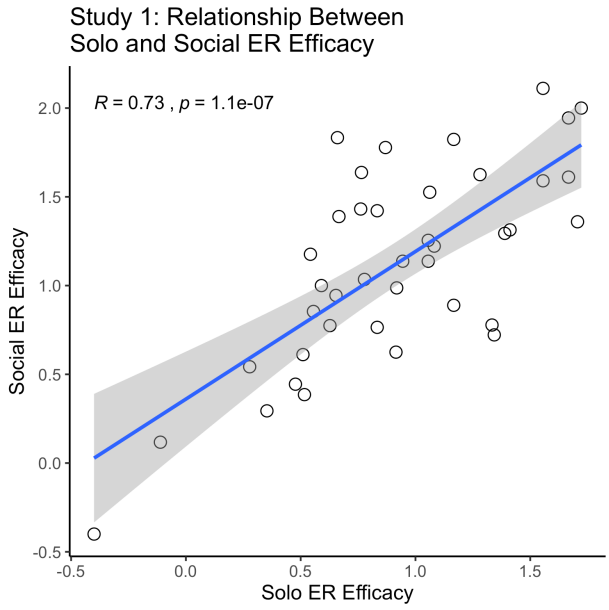


Figure 1. (a) The solo task in Study 1 began with a 2 s cue to "look" or "reinterpret", followed by an image presentation for 8 s, and a rating screen for 3 s. **(b)** The social task in Study 1 followed a similar procedure, except that instead of seeing a cue to "reinterpret" they saw a cue to "listen", and image presentation lasted an additional 1 s to allow for sufficient time to view the image and listen to the audio clip.

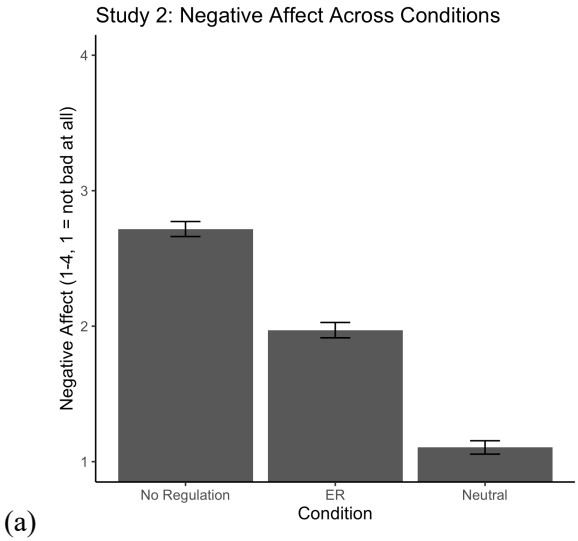


(a)

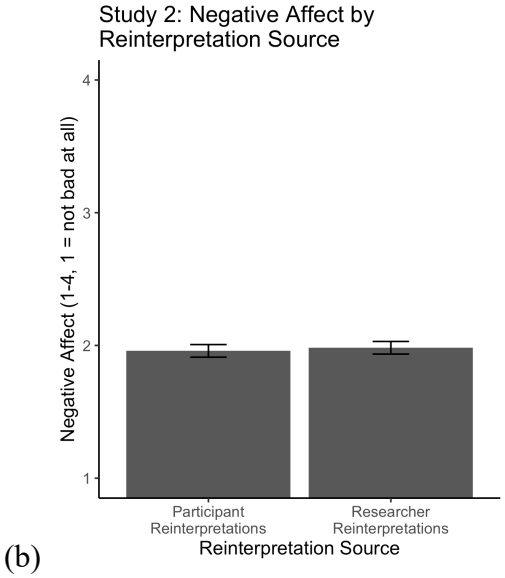


(b)

Figure 2. In study 1, **(a)** there were no significant differences between the solo and social tasks for the no regulation and neutral conditions, but social emotion regulation (ER) was associated with lower negative affect than solo ER, $p < 0.0001$, and **(b)** social ER efficacy was highly correlated with solo ER efficacy, $p < 0.0001$.

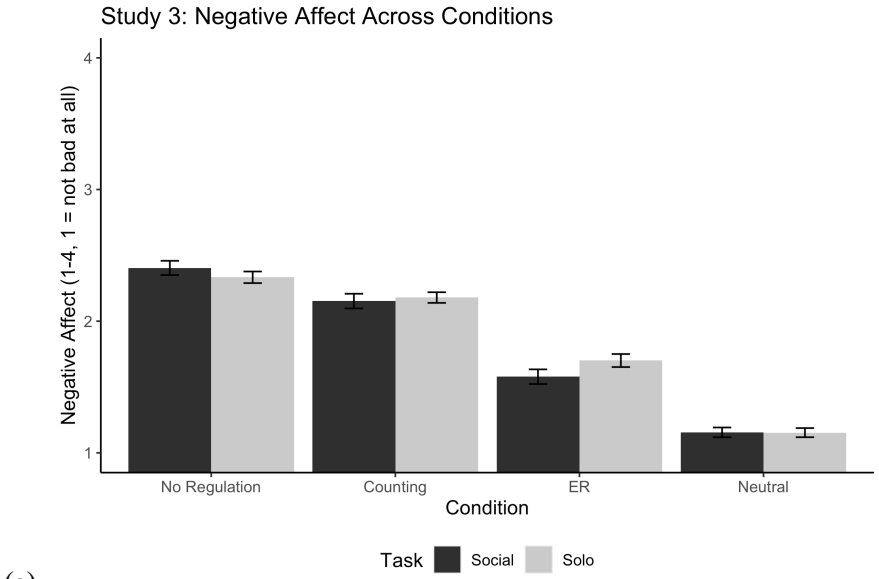


(a)

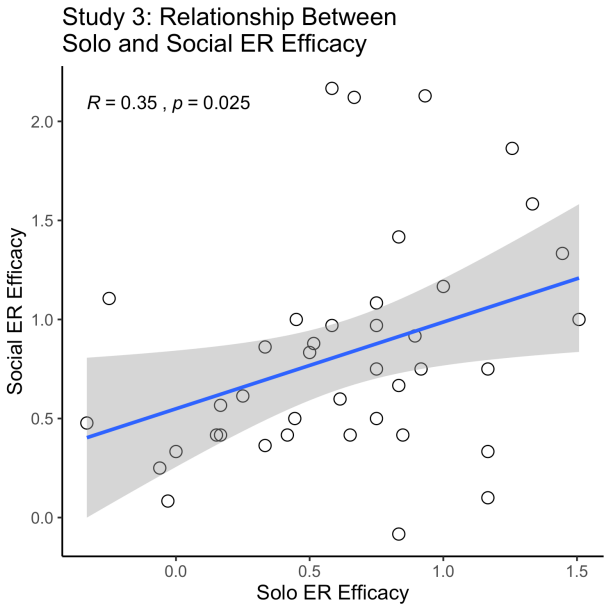


(b)

Figure 3. In study 2, **(a)** social emotion regulation (ER) was more effective than no regulation, $p < 0.0001$, and **(b)** there was no significant difference in negative affect for social ER trials that used reinterpretations generated by participants, and for those that used reinterpretations generated by the research team, $p = 0.75$.



(a)



(b)

Figure 4. In study 3, **(a)** there were no significant differences between the solo and social tasks for the no regulation, counting, and neutral conditions, but social emotion regulation (ER) was associated with lower negative affect than solo ER, $p < 0.0001$, and **(b)** social ER efficacy was correlated with solo ER efficacy, $p < 0.05$.

SUPPLEMENTAL MATERIALS

Reliability analyses for Study 1 and Study 2

We conducted two post-hoc analyses of the Study 1 data to examine whether 9 trials were sufficient for obtaining a reliable estimate of social reappraisal in Study 2. As the first analysis, we calculated the split-half reliability for the social ER condition from Study 1. We began by filtering the data for only the 18 social ER trials (negative-reinterpret-social), ordering the trials by stimulus image name, and assigning each trial an even or odd value (1-18). By ordering the trials in this way, we ensured that participants from each version of the task had the same even trials and odd trials (e.g. Image 003.png was categorized as an even trial for all participants who completed version 1). Next, we calculated participants' average negative affect on even trials, and their average negative affect on odd trials. Finally, we calculated the correlation between participants' average negative affect on even and odd trials, r = .74 (Lord & Novick, 1968). This value is reasonably high, providing confidence that administering 9 trials for each of the reinterpretation conditions of interest in Study 2 is sufficient for a reliable estimate of negative affect (Rudner & Schafer, 2001). While the odd-even splitting is a common approach for computing split-half reliability, this approach does not ensure that the data split into two parts are parallel or balanced (Chakrabartty, 2013). Thus, we followed up with a second reliability test for descriptive purposes.

For the second analysis, we examined the 18 social ER trials (negative-reinterpret-social) from Study 1 and calculated each participant's average negative affect using one less trial each time (i.e., average for 18 trials, 17 trials, 16 trials, etc.). Next, we calculated correlation coefficients for each participant's average negative affect using all 18 trials with their average negative affect using less trials (e.g., correlation between mean affect for 18 trials and mean affect for 17 trials, correlation between mean affect for 18 trials and mean affect for 16 trials, etc.). Results suggest

that with 9 trials, we still have relatively high reliability, $r = .88$, with the reliability dropping below an acceptable value at 5 trials, $r = 0.63$ (Supplemental Table 1).

Supplemental Table 1

Number of Trials Included in Comparison Mean	Correlation with 18 Trial Mean
3	0.2295201
4	0.4578911
5	0.6344222
6	0.7591528
7	0.8377344
8	0.8816504
9	0.8783361
10	0.9061898
11	0.9279366
12	0.9326546
13	0.9457340
14	0.9513833
15	0.9692663
16	0.9838442
17	0.9924504

CHAPTER 2: YOU CHANGED MY MIND: IMMEDIATE AND ENDURING IMPACTS OF SOCIAL EMOTION REGULATION

Abstract

As social creatures, our relationships with other people have tremendous downstream impacts on health and wellbeing. However, we still know surprisingly little about how our social interactions regulate how we think and feel through life's challenges. Getting help from other people to change how one thinks about emotional events – known as "social reappraisal" – can be more effective in down-regulating negative affect than reappraising on one's own, but it is unknown whether this regulatory boost from social support persists when people face the same events alone in the future. In a pre-registered study of 120 young adults (N = 60 same-gender dyads, gender split sample) involving in-lab emotion regulation tasks and a follow-up task online approximately 1 day later, we found that participants responded less negatively to aversive images that were socially regulated (i.e., reappraised with the help of a friend) both immediately and over time, as compared to images that had been previously solo regulated (i.e., reappraised on one's own) or not regulated (i.e., passively viewed). Interestingly, the regulatory boost from social support observed both in the lab and at follow-up was driven by women dyads. This work highlights one important mechanism explaining how support from others can facilitate emotional wellbeing: by changing peoples' lasting impressions of distressing events, interactions with others can help prepare them to cope with future exposure to those events on their own, underscoring how valuable others' perspectives can be when navigating ongoing emotional stressors.

Introduction

As social creatures, our relationships with other people have tremendous downstream impacts on health and wellbeing, often buffering us against the deleterious effects of physical and mental health challenges (Beckes & Coan, 2011; Berkman et al., 2000; Uchino et al., 2018). However, we still have limited knowledge about how our interactions with close others can shape how we think and feel through distressing situations (Niven, 2017; Reeck et al., 2016; Zaki & Williams, 2013). Recent research has demonstrated that changing how we think about negative events to change how we feel about them – known as cognitive reappraisal (Gross, 2015) – is a more effective emotion regulation strategy when a friend helps us change our perspective than when we try to rethink the situation on our own (Sahi, Ninova, & Silvers, 2021). In other words, a friend's perspective can help us change how we interpret negative events to cope with them more effectively. But what happens when we must face the same negative events later and our friend is not around to help? The present study examined whether people responded less negatively when re-encountering aversive stimuli that were previously socially regulated (i.e., reappraised with help) as compared to solo regulated (i.e., reappraised on one's own). Given prior mixed findings regarding gender differences in both social support and emotion processing (e.g., Neff & Karney, 2005; Shields et al., 2006), we tested this question in a gender-split sample of young adult same-gender friend pairs and assessed whether gender moderated social regulatory outcomes.

Immediate and enduring effects of reappraisal

Cognitive reappraisal has been shown to effectively down-regulate subjective (i.e., self-report), neural (e.g., amygdala responsivity) and physiological (e.g., autonomic arousal) responses to negative events as they are happening (Gross, 2015; Ochsner et al., 2004). It also has enduring effects such that individuals show reduced negative affect when re-encountering aversive stimuli

that were previously reappraised (i.e., up to 15 minutes later) (Erk et al., 2010; MacNamara, Ochsner, & Hajcak, 2011; Silvers, Shu, Hubbard, Weber, & Ochsner, 2015). Additionally, reappraisal seems to improve with practice, such that reappraising a stimulus multiple times, versus one time, is associated with better outcomes when passively encountering the stimulus again 1 week later (Denny, Inhoff, Zerubavel, Davachi, & Ochsner, 2015). Indeed, clinical treatment programs such as cognitive-behavioral therapy utilize reappraisal techniques over time to help individuals suffering from a range of psychopathologies (e.g., depression, anxiety, substance abuse) (A. Beck et al., 2005; Dimidjian & Davis, 2009).

While this emotion regulation strategy is helpful, it has limited benefits for some populations. For example, adolescents and depressed populations demonstrate lower attenuation of negative affect while actively reappraising than healthy adults, and exhibit little to no enduring effects of reappraisal when passively viewing stimuli again (Erk et al., 2010; Silvers et al., 2015). Recent research demonstrated that support from a friend can potentiate the efficacy of reappraisal (i.e., social reappraisal; Sahi, Ninova, & Silvers, 2021), highlighting social support as a potential mechanism for ameliorating emotion dysregulation. Some work suggests that social reappraisal can also have enduring effects, for example by reducing the impact of re-watching an upsetting video two days after reappraising with a partner (Nils & Rimé, 2012a).

If getting a friend's perspective can more effectively regulate one's emotions than trying to reappraise on one's own, it is possible that people will respond less negatively to socially regulated stimuli than solo regulated stimuli when re-encountering them in the future. We care deeply about other peoples' opinions and perspectives (Lieberman & Eisenberger, 2009), such that having a friend reframe distressing events might better facilitate lasting changes to our impressions of those events. This social regulatory process could illuminate one way that social interactions

enhance wellbeing: by changing our perspectives of negative events, our social interactions can prepare us to cope with future exposure to those events on our own. Systematic mapping of such self (i.e., on one's own) and social (i.e., with help from someone else) regulatory mechanisms also stands to improve future interventions aimed at improving emotional health and wellbeing.

Gender differences in emotion and social support

Prior research comparing social reappraisal to reappraising on one's own only examined women friend pairs (Sahi, Ninova, & Silvers, 2021). Existing research on gender differences in emotion and social support are very mixed, leaving open the possibility that gender might moderate social emotion regulation outcomes. Women are stereotyped to be more emotional than men (Shields, 2002), with some research suggesting that women display and report more emotions, and exhibit greater physiological arousal and neural responsivity to emotional stimuli (e.g., Bradley et al., 2001; Brody, 1997; Cahill et al., 2004). However, many additional studies have found no gender differences in these emotional reactivity metrics (e.g., Kelly et al., 2008; Vrana & Rollock, 2002). Regarding emotion regulation, and reappraisal more specifically, previous research shows no gender differences in reappraisal frequency (Gross & John, 2003), with some evidence that reappraisal might be less effortful for men (McRae et al., 2008). When it comes to relationships, women have been found to value social connection, intimacy, and emotional support to a greater extent than men who show a preference for shared activities (Duck & Wright, 1993; Felmlee, Sweet, & Sinclair, 2012; Fox, Gibbs, & Auerbach, 1985; Guimond, Chatard, Martinot, Crisp, & Redersdorff, 2006). However, research also suggests that while women may be more responsive to support needs than men, there are no differences in capacity for support (Neff & Karney, 2005). Thus, while women may be more likely to engage in supportive behaviors, it remains unclear how social emotion regulation may be differentially effective across genders.

The current study

In this pre-registered study of 120 young adults (N = 60 same-gender dyads), participants completed two in-lab emotion regulation tasks: a solo and social task. In these tasks, participants rated images that they (i) passively viewed (i.e., not regulated), (ii) solo regulated (i.e., reappraised on one's own), or (iii) socially regulated (i.e., reappraised with the help of a friend). Approximately one day later, they completed an online follow-up task from home where they passively viewed randomized images from each of these conditions again (i.e., with no cues) and rated them. We hypothesized that participants would respond less negatively to images that were socially regulated both immediately (i.e., in-lab) and over time (i.e., at follow-up), as compared to images that had been previously solo regulated or not regulated. We anticipated that these effects would be consistent across genders.

Method

All procedures were approved by the local IRB committee and informed consent was obtained from all participants. Our sample size, study design, and hypotheses were pre-registered prior to data collection. This pre-registration, alongside de-identified data and analysis scripts, are hosted on Open Science Framework (OSF; https://osf.io/a9jvf/; Sahi & Silvers, 2023).

Sample size. The rationale for our pre-registered sample size of 60 dyads is based on a power analysis that was conducted on previously published data (Sahi, Ninova, & Silvers, 2021a). Using the 'pwr' package (Champely, 2020) in R (R Core Team, 2022) with power of .8, a significance level of .05, and a Cohen's D of .53 derived from the existing dataset, we found that approximately 30 dyads would be sufficient to observe an immediate difference (i.e., during the task) between regulating emotions alone and regulating with help from others. Because we did not know what kind of effect size to expect for an enduring difference between these

conditions (i.e., at follow-up) or potential gender differences in these effects, we doubled the recommended sample size for a total of 60 dyads with 30 dyads for each gender.

Exclusion criteria. Participants individually completed email screenings to ensure their eligibility before coming to the lab. Prospective participants who had previously participated in a similar reappraisal study in the lab, were not proficient in English, reported having a developmental disability or neurological disorder, diagnosed behavioral or psychological issues, or uncorrected vision or hearing (i.e., characteristics that might interfere with ability to complete the task) were not enrolled in the study. Participants were between 18 and 39 years of age. Young adulthood is a time where friendships are particularly salient, shaping individuals' identities and appraisals of the world, making it an appropriate developmental period for our research questions (Arnett, 2015; Welborn et al., 2016). Participants were screened to ensure they had a same-gender friend they felt close to (i.e., at least a 6 on one of the following questions: (1) "How much support do you receive from this person on a regular basis?" and (2) "How significant is this relationship in your life?") to participate with.

Participants. Pairs of friends (N = 64 dyads, N = 128 participants) were recruited from the University of California campus through flyers, emails, and the university subject pool. Three dyads were excluded due to technical difficulties during the session, and one dyad was excluded due to difficulties understanding and completing the tasks, leaving a final sample of 60 dyads (N = 120 participants). Our sample was gender-split, such that we had an equal number of same-gender dyads that identified as women or men. Out of 120 participants, 5 participants did not report the details of their gender identity. Of those that reported, none reported a non-binary or gender non-conforming identity. One person reported that they did not identify with their sex assigned at birth. The mean age of this sample was 20.83 years, and the sample was

approximately 53% Asian, 13% White/Caucasian, 3% Hispanic/Latinx, and 3% Black/African American. The remaining participants identified as multiracial or another identity.

Social and solo emotion regulation tasks. We utilized the social and solo emotion regulation tasks from previously published research (Sahi, Ninova, & Silvers, 2021). Details of how these tasks were originally developed are included in Supplemental Materials ("Task Development"). The social and solo tasks included three conditions with 18 trials each: negative-regulate, negative-look, and neutral-look. In line with the original paradigm, there was no neutral-regulate condition, yielding an incomplete 2 (valence: negative vs. neutral) x 2 (cue: look vs. regulate) x 2 (task: solo vs. social) design with 6 conditions total. Each trial began with a cue (2 s). Across solo and social tasks, the "look" cue indicated that participants should look and let themselves respond naturally to the image. In the regulation condition of the solo task, the "reinterpret" cue indicated that participants should think about the image in a way that would reduce their negative emotional response to it (e.g., "They look upset with each other, but they can come to an agreement"). In the regulation condition of the social task, the "listen" cue indicated participants should listen to their friend reinterpreting the image. After the cue, participants saw a negative or neutral image (8 s for the solo task; 9 s for the social task to allow participants to see the image for 1 s before listening to the audio clip). After viewing the image and responding to it according to the cue, participants provided a negative affect rating (i.e., "How bad do you feel?") on a 4-point rating scale from "1 = not bad at all" to "4 = very bad" (3 s) (Figure 1A). A brief jittered fixation cross was included between each image and rating and between each trial. The solo and social tasks were presented in counterbalanced order, with trials from each condition randomized within the task.

The reinterpretations that participants heard during the listen trials were pre-recorded by their friends and spliced into the social emotion regulation task rather than read live. Importantly, these reinterpretations were read from a script that was generated in previous research for the purpose of standardizing the reinterpretations participants would listen to across dyads. These scripted reinterpretations have been shown to be no different from the kinds of reinterpretations participants use when regulating on their own in terms of how effectively they down-regulate negative affect on average (Sahi, Ninova, & Silvers, 2021). Participants were not informed that their friends were reading from a script.

At-home rating task. Building on this established paradigm, we created a follow-up task to be completed from home online approximately one day after the in-lab task. In this task, participants were re-presented with negative images they passively viewed, socially regulated, or solo regulated in the lab. Each participant saw all images from the corresponding version of the social regulation (social-negative-regulate) and solo regulation (solo-negative-regulate) conditions (18 images each) completed in the lab, as well as 18 images that were not regulated (9 from social-negative-look and 9 from solo-negative-look; selected to be roughly equivalent to the other conditions in terms of negative affect based on pilot study ratings – for details see Supplemental Materials: Task Development). These 54 trials would be presented in random order, each with an image and two questions: (i) "When you look at this image, how bad do you feel?" with a 4-point rating scale from "1 = not bad at all" to "4 = very bad" and (ii) "Have you seen this image before?" with a 5-point rating scale from "Very confident that I have seen this before" to "Very confident that I have not seen this before" (FeldmanHall et al., 2021). Importantly, there was no cue to look or reinterpret presented with these images at follow-up, such that participants were rating the images based on their natural responses to them at the time

(Figure 1B). Timing was not tightly regulated in this follow-up task to allow more flexibility in completing it from home (i.e., no auto-advancing of the trials in case distractions occurred), except that each trial was presented for a minimum of four seconds to allow some time to take in the image and prevent rapid click-throughs.

Questionnaires. We collected several measures relating to social and emotional tendencies and qualities, including measures of relationship quality (Inventory of Peer Attachment: Armsden & Greenberg, 1987), support-giving and compassion (Social Provisions Scale: Cutrona & Russell, 1987; 2-Way Social Support Scale: Shakespeare-Finch & Obst, 2011; Interpersonal Regulation Questionnaire: Williams et al., 2018; Dispositional Positive Emotions Scale: Shiota et al., 2006), mood and regulation (Mini-Mood and Anxiety Symptom Questionnaire: Casillas, & Clark, 2000; Perceived Stress Scale: Cohen et al., 1983; Emotion Regulation Questionnaire: Gross & John, 2003), childhood experiences (Childhood Trauma Questionnaire: Bernstein et al., 2003), and conformity/social desirability (Crowne & Marlowe, 1960; Steinberg & Monahan, 2007). We also included two unpublished scales, including an extended-emotion regulation questionnaire (including self and social regulation components) and an affect labeling questionnaire. Both participants completed the same set of questionnaires. These measures were collected for exploratory purposes and are only assessed here in relation to gender differences in social-emotional variables.

In-lab procedure. In each dyad that enrolled in the study, one participant was assigned as the "experiencer" and the other participant was the "helper." For dyads who signed up for the study directly (i.e., via email), participants were randomly assigned to their roles ($N = 46$, 52% women). For those who signed up via the university subject pool, the participant who signed up for the longer time slot was assigned to be the experiencer, with their friend as the helper ($N =$

14, 43% women). Although most participants were recruited directly (77%), we checked to ensure no important differences were observed in our results between these two methods of recruitment (see Supplemental Materials: Recruitment Differences). Upon arriving at the lab, the friend pairs were given their respective roles and consented by an experimenter together. Both participants were briefly walked through their tasks, including the in-lab and follow-up tasks for the experiencer, and the audio recording task for the helper. Then, they were separated for the remainder of the study.

Experiencer. First, the experiencer completed questionnaires. Next, they completed a brief training using Microsoft PowerPoint designed to prepare them for the social and solo emotion regulation tasks. As part of this training, experiencers saw sample negative images, talked through the different cues (i.e., look/reinterpret/listen), and practiced reinterpreting out loud. Experiencers were reminded that during the social task, the helpers would try to help them decrease their negative response to some of the images. After the training, experiencers completed the two tasks in E-Prime. In between the two tasks, they took a 5-minute break to watch a non-emotional distraction video (i.e., "How It's Made: Magnets"). After they completed the in-lab tasks, experiencers were asked about their perceptions of the study and reminded that they would receive an email the next day with a link to the follow-up task that resembled the in-lab task. Participants were not aware during the in-lab tasks that they would be viewing many of the same images again during the follow-up.

Helper. The helpers began by completing a brief relationship salience task where they were instructed to: "Take a moment to think about some memories that you have with the friend you came with today. When you are finished, please pick one memory and write a paragraph describing it." This task has been used in prior work to make a close other more salient when

they were not physically present (Guassi Moreira, Tashjian, Galván, & Silvers, 2018). After this task, the helper recorded 18 reinterpretations from the script generated by the research team (e.g., "That person will recover from the accident."). Each reinterpretation was one sentence and took about four seconds to read out loud. Helpers were instructed to read the reinterpretations in a natural way so that the reinterpretations of the images would feel helpful to their friend as they viewed negative images. After the helper completed the recordings, they filled out questionnaires. At the end of the study, helpers were asked about their perceptions of the study. Since the at-home rating task for experiencers would involve seeing the images from the in-lab emotion regulation tasks again, we asked the helpers not to disclose to their friends that they were reading the reinterpretations from a script until the experiencers finished this task approximately 1 day later. The helpers did not complete an at-home follow-up task.

Follow-up procedure. Twenty-four hours after the in-lab session, experiencers received a personalized link by email that took them to the at-home rating task in Qualtrics. Participants were told that they would view and rate negative images, including some of the images they saw in lab. In reality, they did not see any new images (i.e., all of the images in the at-home rating task were from the in-lab tasks). Participants were asked to complete the task in one sitting (approximately 10 minutes) in a private quiet place as soon as possible after receiving the link. Once they finished this task, we asked participants about their impressions of the follow-up task, and then informed them that their friends were reading from a script during the social emotion regulation task in the lab. We asked them whether they had discussed the scripted nature of the reinterpretations with their friend prior to the follow-up. 65% of participants responded 'No' (did not discuss the script with their friend), 17% said 'Yes', and 18% said 'Sort of' with an option to explain (e.g., they figured out the scripted nature of the study on their own). Participants were

provided with additional compensation for completing the follow-up. Participants completed the follow-up task approximately 39 hours on average (*SD* = 0.96, Range = 24 – 149 hours) after the in-lab session ended, and only 1 dyad did not complete the follow-up (*N* = 59).

Analyses. All analyses were conducted using the statistical software R (Version 4.1.2). We utilized linear mixed-effects models (i.e., multilevel regression models) with participant ID as the group level variable (i.e., trials nested within participants). Our models originally included version of the task (i.e., our pre-rated images were paired with different cues in each version of the task to check for baseline differences in images used across conditions) and which task participants completed first (solo vs. social) as predictors of no interest (*p*'s > 0.05).

Immediate effects of social emotion regulation. We first examined whether prior work in women demonstrating that social regulation was more effective than solo regulation (Sahi, Ninova, & Silvers) replicated in the current mixed-gender sample. In line with this previous work, we analyzed the data for this question in two stages: (i) as a manipulation check, we first tested whether negative images were associated with more negative affect than neutral images in the look trials; and (ii) we assessed whether cue (regulate vs. look), task (solo vs. social), and the interaction between them were associated with negative affect during the negative image trials. We followed up on significant interactions with Tukey-adjusted pairwise comparisons. We also analyzed whether social and solo regulation efficacy (the difference between negative-look and negative-regulate for each task) was associated within individuals by calculating the Pearson correlation coefficient between these difference scores.

Enduring effects of social emotion regulation. Since the follow-up task only had three conditions (unregulated negative images, solo regulated negative images, and socially regulated negative images), we tested whether condition shaped negative affect during the follow-up task,

with the social regulation condition as the reference group (i.e., social vs. solo regulation, social vs. no regulation). We followed up with Tukey-adjusted pairwise comparisons to assess differences between each pair of conditions. To clarify, these analyses investigated how the conditions differed from each other at follow-up (i.e., differences at the second timepoint), rather than how conditions changed from in-lab task to follow-up (i.e., changes across time).

Gender differences in social emotion regulation. For comprehensiveness, we first assessed baseline gender differences and found that men reported less negative affect than women when passively looking at negative images (see "Supplemental Materials: Gender Differences" for full analyses and results). Since baseline differences in emotional reactivity to negative images would equally affect the social and solo regulation conditions, and all conditions used different image sets, these findings would not affect our subsequent analyses (i.e., contrasting social regulation to the other conditions by gender).

Turning to our primary question regarding how gender may shape social emotion regulation outcomes, we tested for gender differences in the contrast between (i) social regulation versus no regulation, and (ii) social regulation versus solo regulation. In line with previous work (Sahi, Ninova, & Silvers, 2021), and as part of our planned analyses described above, we did not expect any differences across genders in response to the look-negative trials from the social and solo tasks. Thus, we used a condition variable with three levels – social regulation (negative-regulate-social), solo regulation (negative-regulate-solo), and no regulation (negative-look, including trials from both social and solo) to test these two contrasts for the in-lab tasks in a single model. The model included condition, gender, and the interaction between them as predictors of negative affect during the in-lab tasks. We similarly tested for potential gender differences at follow-up by using follow-up condition (i.e., socially regulated negative

images, solo regulated negative images, and unregulated negative images), gender, and the interaction between them as predictors of negative affect during the follow-up task. In both models, we set social regulation as the reference group for condition, and women as the reference group for gender.

Because the condition variables in these two models had 3 levels, these models would yield 2 main effects of condition (i.e., social regulation vs. no regulation for women, social regulation vs. solo regulation for women), 1 main effect of gender (the difference between men and women on average), and 2 interaction terms between condition and gender. Because we were interested in contrasting all conditions for both genders, we planned to follow up with Tukey-adjusted pairwise comparisons regardless of whether we found significant interaction terms for both models.

Exploratory associations between gender and relationship quality/social support variables. We explored gender differences in the relationship quality and social support questionnaires using point-biserial correlations (which yields the same *p*-values as independent samples t-tests) and followed up with exploratory analyses to see whether any of these social support variables might have explained our gender effects. We found that men reported lower relationship quality and social support in their relationships than women (Supplementary Table 1), but these associations did not statistically explain gender differences in the tasks (see full analyses and results under Supplementary Materials: Gender Differences).

Results

Manipulation check of negative versus neutral images.

Participants reported higher negative affect on average when passively viewing negative images (M = 2.44, SD = 1.00) versus neutral images (M = 1.11, SD = 0.39), b = -1.32, t(4115.19) = -61.72, p < .001, 95% CI = [-1.36, -1.28].

Social regulation was more immediately effective than solo regulation.

During the negative image trials (i.e., negative-look and negative-regulate for the social and solo tasks), participants reported significantly lower negative affect on the regulate trials (M = 1.65, SD = 0.80) than the look trials (M = 2.44, SD = 1.00), b = -0.85, t(4085) = -23.67, p < .001, 95% CI = [-0.92, -0.78]. There was no main effect of task (i.e., social vs. solo) on negative affect, b = -0.00, t(4085) = 0.08, p = .94, 95% CI = [-0.07, 0.07], but there was a significant interaction between cue and task, b = 0.13, t(4085) = 2.48, p = .01, 95% CI = [0.03, 0.23], such that participants reported lower negative affect on the regulation trials from the social task (M = 1.59, SD = 0.75) than the solo task (M = 1.71, SD = 0.83), z = -3.59, p < .001, but there was no difference between passively viewing the negative images from the social and solo tasks (i.e., the no regulation conditions from each task), z = -0.08, p = .94 (Figure 1C).

Social and solo regulation efficacy were correlated within individuals.

Social emotion regulation efficacy (the difference between average negative affect on negative-look-helper trials versus negative-regulate-helper trials) and solo emotion regulation efficacy (the difference between average negative affect on negative-look-solo trials versus negative-regulate-solo trials) were significantly correlated within individuals, r = 0.52, t(58) = 4.65, p < .001, CI = [0.31, 0.68], such that those who saw the greatest benefits from solo regulation, on average, also saw the greatest benefits from social regulation, on average.

Social regulation was more effective at follow-up than solo regulation.

In examining the effect of condition (unregulated negative images, solo regulated, or socially regulated – with the latter as the reference group) on negative affect during the follow-up task, we found a significant difference in negative affect between the images that had been previously socially regulated versus not regulated, $b = 0.24$, $t(3110) = 7.02$, $p < .001$, 95% CI = [0.17, 0.30], and those that had been previously socially regulated versus solo regulated, $b = 0.08$, $t(3110) = 2.45$, $p = .01$, 95% CI = [0.02, 0.15]. Pairwise comparisons additionally indicated a significant difference in negative affect between the images that had been previously solo regulated versus not regulated, $z = -4.56$, $p < .001$. Images that were not regulated in the lab were associated with the highest negative affect at follow-up ($M = 2.44$, $SD = 1.00$), followed by those that were solo regulated, ($M = 1.71$, $SD = 0.83$), and finally those that were socially regulated, ($M = 1.59$, $SD = 0.75$) (Figure 1D).

Social regulation was more effective than no regulation for both genders, but it was only more effective than solo regulation for women at both timepoints.

In examining whether gender moderated the effect of condition (i.e. social regulation, solo regulation, no regulation) on negative affect during the in-lab tasks, we found that social regulation was associated with significantly lower negative affect than solo regulation, $b = 0.24$, $t(4084.52) = 4.70$, $p < .001$, 95% CI = [0.14, 0.34], and no regulation, $b = 1.00$, $t(4084.34) = 22.80$, $p < .001$, 95% CI = [0.91, 1.08], with women as the reference group. There was no main effect of gender, $b = 0.05$, $t(81.01) = 0.42$, $p = 0.68$, 95% CI = [-0.17, 0.26], but there was a significant interaction between gender and social versus solo regulation, $b = -0.22$, $t(4084.39) = -3.07$, $p = .002$, 95% CI = [-0.36, -0.08], as well as between gender and social regulation versus no regulation, $b = -0.29$, $t(4084.37) = -4.71$, $p < .001$, 95% CI = [-0.41, -0.17].

For women, social regulation was associated with less negative affect than solo regulation, $z = -4.70$, $p < .001$, and solo regulation was associated with less negative affect than no regulation, $z = 17.21$, $p < .001$ (social versus no regulation: $z = -22.80$, $p < .001$). Meanwhile for men, both social and solo regulation were more effective than no regulation (respectively: $z = -15.98$, $p < .001$; $z = -15.57$, $p < .001$), but there was no difference between social and solo regulation, $z = -0.36$, $p = .93$ (Figure 2A).

In examining whether gender moderated the effect of condition (i.e., socially regulated images, solo regulated images, no regulation) on negative affect during the follow-up task, we found that socially regulated images were associated with significantly lower negative affect than solo regulated images, $b = 0.13$, $t(3108.38) = 2.74$, $p = .006$, 95% CI = [0.04, 0.23], and unregulated images, $b = 0.26$, $t(3108.09) = 5.36$, $p < .001$, 95% CI = [0.16, 0.35]. There was no main effect of gender, $b = -0.04$, $t(67.66) = -0.28$, $p = 0.78$, 95% CI = [-0.31, 0.23], nor was there a significant interaction between gender and either contrast (social versus solo: $b = -0.10$, $t(3108.22) = -1.43$, $p = .15$, 95% CI = [-0.23, 0.04]; social versus unregulated: $b = -0.04$, $t(3108.06) = -0.63$, $p = 0.53$, 95% CI = [-0.18, 0.09]). However, because we were interested in the contrasts between all conditions for both genders, we proceeded with Tukey-adjusted pairwise comparisons.

For women, socially regulated images were associated with less negative affect than solo regulated images, $z = -2.74$, $p = .02$, and solo regulated images were associated with less negative affect than unregulated images, $z = -2.62$, $p = .02$ (social versus no regulation: $z = -5.36$, $p < .001$). Meanwhile for men, both social and solo regulated images were more effective than unregulated images (respectively: $z = -4.57$, $p < .001$; $z = -3.82$, $p < .001$), but there was no difference between social and solo regulation, $z = -0.75$, $p = .73$ (Figure 2B).

Discussion

Changing how one thinks can change how one feels about emotional events, both in the moment and over time. Getting help from other people to change how one thinks can potentiate the efficacy of this strategy in the moment, but prior work had not examined whether these relative gains persisted when re-encountering negative events on one's own. In the present study, we found that participants responded less negatively to images that were socially regulated (i.e., reappraised with the help of a friend) both immediately and at follow-up, as compared to images that had been previously solo regulated (i.e., reappraised on one's own) or not regulated (i.e., passively viewed). These findings provide critical insight into how other people can shape the way we think and feel to help us cope with re-occurring stressors.

Social emotion regulation has enduring effects.

Building on previous work demonstrating that solo regulation can have lasting effects on how we respond to negative events (Erk et al., 2010; MacNamara et al., 2011; Silvers et al., 2015), and that social emotion regulation can be more immediately effective than solo regulation (Sahi, Ninova, & Silvers, 2021), we showed that social emotion regulation can have more enduring effects than solo regulation. Thus, the benefits of such social support are not just a short-term fix for emotional distress: these effects can last to help us navigate future situations on our own. These findings build on prior theoretical and empirical work on the regulatory roles of close relationships, including attachment research (Mikulincer & Shaver, 2019), suggesting that our interactions with close others may enhance our abilities to navigate negative emotions independently.

We demonstrated that the effects of social emotion regulation endured approximately 1 day later, but it will be important to assess whether these effects persist beyond this time frame.

In line with work looking at the effects of emotion regulation training over time (Denny, 2020), and research showing that reappraisals of stressors can be contagious in social contexts (Oveis, Gu, Ocampo, Hangen, & Jamieson, 2020), it is possible that in everyday life social reappraisals get reenforced across multiple interactions, potentially extending the enduring impacts of social emotion regulation. Notably, reappraisals can also up-regulate negative affect by reinforcing negative interpretations of stimuli (e.g., MacNamara et al., 2011), underscoring how social regulation has the power to diminish or enhance wellbeing in a context-dependent way.

Social emotion regulation may provide a greater boost in women than men.

Social regulation was more effective both immediately and at follow-up than no regulation for both genders, but social regulation was only more effective than solo regulation for women. Exploratory analyses (see Supplemental Materials) suggested that although there were significant gender differences in relationship quality and social support, they did not account for gender-related task differences. Prior work has shown less engagement of cognitive control regions (e.g., prefrontal cortex) with greater decreases in brain regions associated with emotional responding (e.g., amygdala) during reappraisal in men as compared to women (McRae et al., 2018), suggesting that reappraisal might be less effortful for men. If solo regulation is easier for men, they may benefit less than women from the regulatory "boost" offered by social support. Women have also exhibited more positive-refocusing and activation in reward-related regions (e.g., ventral striatum) during reappraisal than men (McRae et al., 2008), which may suggest that rewarding experiences like getting support from a close other (Lieberman & Eisenberger, 2009) benefits women more than men. Future research can unpack how gender differences in emotion socialization across development, or other individual differences (Sahi et al., 2022), shape social emotion regulation

processes, as beliefs about social roles can affect how people experience, communicate, and regulate emotions in relationships (Felmlee et al., 2012; Shields et al., 2006).

Limits on generalizability

Young adulthood presents a ripe developmental period for examining social influences, particularly from friendships, on emotion (Arnett, 2015). However, this demographic feature of our sample limits the generalizability of our findings; future research can examine other ages and relationship types to assess potential variability in social emotion regulation effects. Although we built on the existing literature to assess gender differences between same-gender dyads, we did not assess mixed-gender dyads or non-binary individuals, which may allow us to further tease apart whether our gender effects could be driven by the gender of the support-giver or support-receiver, or other relationship dynamics. Our sample was predominantly from two racial/ethnic groups on a college campus: Asian and White (53% and 13%, respectively; 66% total). Future research in more diverse samples can help identify possible effects of factors like identity, cultural norms, or socioeconomic status.

Conclusions

Our social relationships are critical for navigating stress and negative emotions. We replicated recent research demonstrating that getting help from friends to reframe negative stimuli is more effective than trying to reframe alone (Sahi, Ninova, & Silvers, 2021), and extended this work to show that these effects last: socially regulated stimuli are perceived less negatively than solo regulated stimuli approximately one day later. These findings indicate that by changing our lasting impressions of distressing events, our friends can help us better contend with those events in the future when we face them on our own. Such work demonstrates how social relationships can shape emotion regulation processes, and underscores how valuable others' perspectives can

be when making sense of emotional experiences. Finally, we found that gender can shape social emotion regulation processes and provided several avenues for unpacking this association in future work. Collectively, these findings inform social, developmental, and clinical research aimed at unpacking social influences on cognitive and affective states, as well as research aimed at developing interventions for emotion dysregulation.

Figures

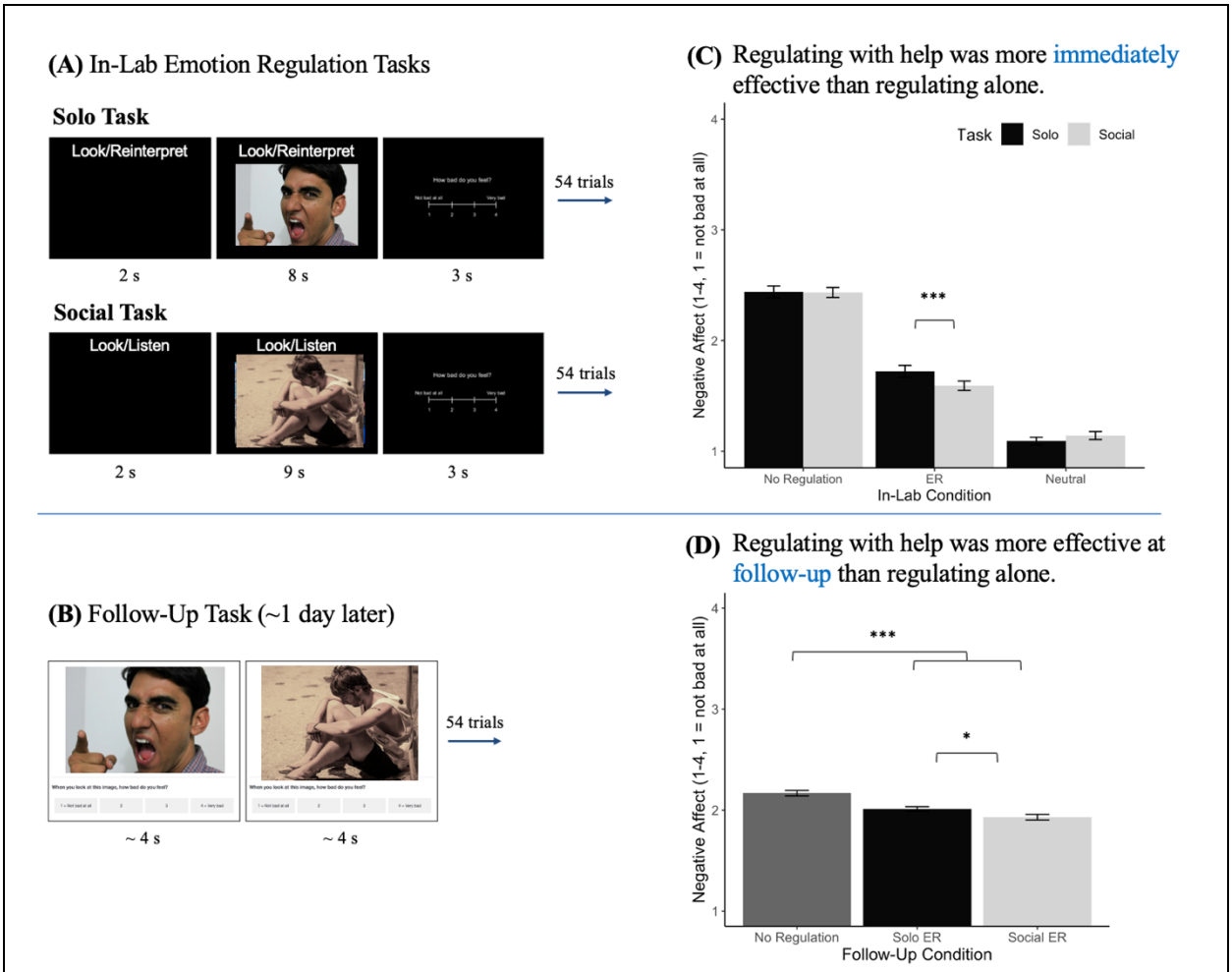


Figure 1. We used the "solo" and "social" emotion regulation (ER) tasks from previously published work (Sahi, Ninova, & Silvers, 2021). **(A)** The solo task began with a 2 s cue to "look" or "reinterpret" followed by an image presentation for 8 s, and a rating screen for 3 s. The social task followed a similar procedure, except that instead of seeing a cue to "reinterpret" they saw a cue to "listen" and the image was presented for 1 s before the audio clip played (9 s total). **(B)** The follow-up task was administered online at home approximately 1 day later. This task randomly presented images that were previously presented in the solo or social tasks, including images that were reinterpreted or passively viewed, with a rating scale (no cue). **(C)** We found that regulating with help was associated with lower negative affect during the in-lab tasks than reappraising alone, $p < .001$. **(D)** We additionally found that regulating with help was associated with lower negative affect at follow-up than reappraising alone, $p = .01$, and that both forms of regulation (i.e., solo and social) were associated with lower negative affect at follow-up than images that were not regulated in the lab, $p < .001$. *Note*: the images shown in this figure, taken from the Open Affective Standardized Image Set (Kurdi, Lozano, & Banaji, 2017), are samples not used in the actual task. $p < .05$ = *, $p < .01$ = **, $p < .001$ = ***

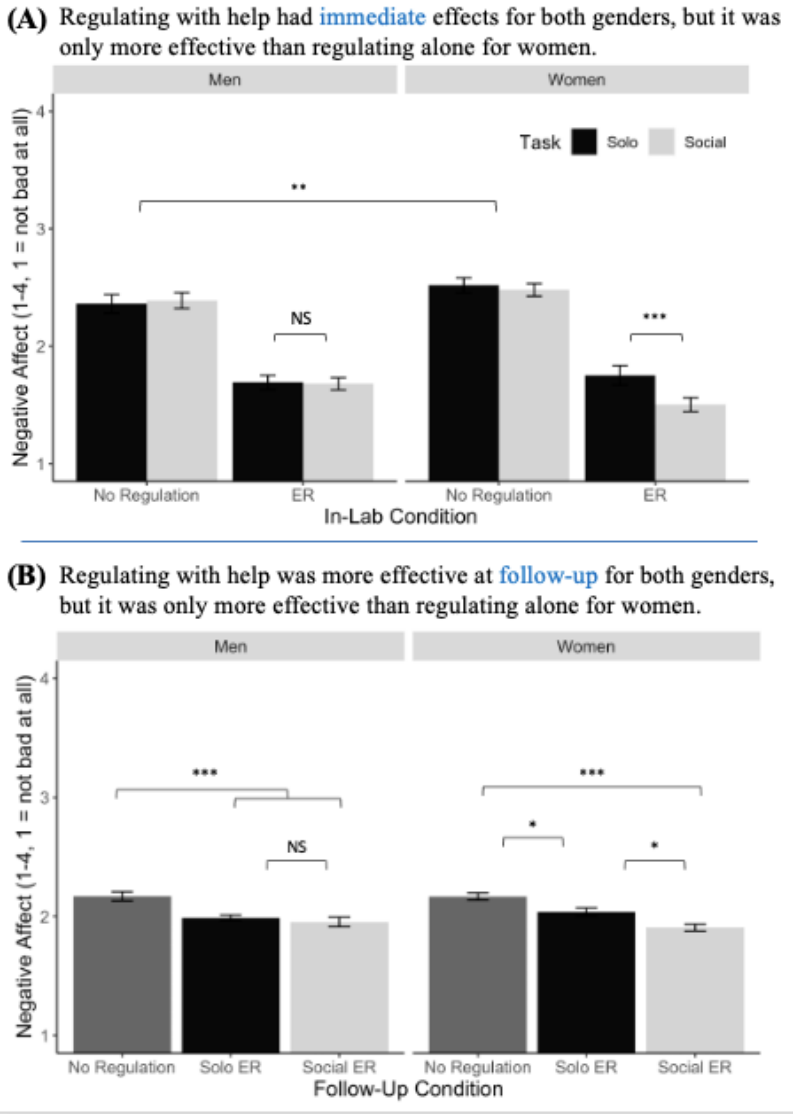


Figure 2. In exploring gender differences associated with social emotion regulation (ER) outcomes, we found that **(A)** regulating with help (i.e., social ER) was effective in down-regulating negative affect for both genders during the in-lab tasks, $p < .001$, but it was only associated with lower negative affect than regulating alone (i.e., solo ER) in women, $p < .001$. Additionally, men reported lower negative affect during the no regulation conditions (i.e., passively viewing negative images) than women on average, $p = .004$. Consistent with the in-lab pattern, **(B)** we found that regulating with help was effective in down-regulating negative affect for both genders at follow-up, $p < .001$, but it was only associated with lower negative affect than regulating alone at follow-up in women, $p < .05$. $p < .05$ = *, $p < .01$ = **, $p < .001$ = ***

SUPPLEMENTAL MATERIALS

Task Development

The social and solo emotion regulation tasks used in this study were derived from previous work (Sahi, Ninova, & Silvers, 2021). In this work, researchers drew visual stimuli that were social in nature (involved other people) from the International Affective Picture System (Lang et al., 2008), the Open Affective Standardized Image Set (Kurdi et al., 2017), and from freely available online sources. These negative and neutral images were rated on Amazon Mechanical Turk (mTurk), alongside reinterpretations meant to decrease the negative affect people felt in response to the images. A total of 72 negative images and their associated reinterpretations were distributed into four image sets – each with 18 images – that were balanced in terms of average negative affect and reinterpretation efficacy. Alongside 36 neutral images that were distributed into two image sets, these six image sets were used to create four versions of the tasks that counterbalanced image sets across the social and solo tasks (e.g. version 1 solo task: negative image set 1 – reinterpret, negative image set 2 – look, neutral image set 1 – look; version 1 social task: negative image set 3 – reinterpret, negative image set 4 – look, neutral image set 2 – look). Negative images and their associated reinterpretations are available on the online repository for the original paper (https://osf.io/94ecj/).

Recruitment Differences

To ensure no important differences between were observed in our results between our two methods of recruitment (i.e., flyers and university subject pool), we tested whether recruitment method moderated the effect of task (social vs. solo) on negative affect during the regulation conditions (i.e., negative-reinterpret). We found no main effect of recruitment method, $b = 0.07$, $t(71.82) = 0.62$, $p = .54$, a significant main effect of task, $b = 0.08$, $t(2009) = 2.37$, $p =$

.02, and a significant interaction between recruitment method and task, $b = 0.18$, $t(2008) = 2.43$, $p = .02$, such that there was a greater estimated difference between the social and solo regulation tasks amongst those recruited from subject pool, $t(2009) = -4.09$, $p < .001$, as compared to those recruited via flyers, $t(2009) = -2.37$, $p = .02$. This difference is one of magnitude (i.e., there was a greater estimated difference between our primary conditions of interest for those recruited from subject pool), but not of direction (i.e., social regulation was consistently significantly associated with less negative affect than solo regulation). We also checked to see whether gender was associated with recruitment method using Pearson's chi-squared test, and found no association, $\chi^2(1) = 0.09$, $p = .76$.

Gender Differences

Baseline emotional reactivity. We examined whether gender moderated emotional reactivity by using image type (negative vs. neutral), gender, and the interaction between them to predict negative affect during the look trials. We found (in line with our manipulation check) that neutral images were associated with lower negative affect than negative images, $b = -1.42$, $t(4114.16) = -2.85$, $p < .001$, 95% CI = [-1.47, -1.36], that men reported lower negative affect on average ($M = 1.70$, $SD = 0.96$) than women ($M = 1.85$, $SD = 1.05$), $b = -0.24$, $t(66.06) = -2.85$, $p = .006$, 95% CI = [-0.41, -0.08], and that there was a significant interaction between image type and gender, $b = 0.19$, $t(4114.20) = 4.34$, $p < .001$, 95% CI = [0.10, 0.27], such that there was no gender difference for neutral images, $z = 0.69$, $p = 0.49$, but women reported higher negative affect when passively looking at negative images ($M = 2.56$, $SD = 1.00$) than men ($M = 2.32$, $SD = 0.99$) on average, $z = 2.85$, $p = .004$.

These results cohere with existing research suggesting baseline gender differences in emotional reactivity (e.g., Bradley et al., 2001; Brody, 1997; Cahill et al., 2004). However, this

literature is mixed, and underscores the need to parse whether this reactivity is due to reporting differences or subjective differences in emotional experiences. Future work on social emotion regulation can incorporate additional measures of emotional reactivity beyond subjective self-report to assess whether the effects of social emotion regulation are consistent across self-report and other biological or physiological indices of emotional experience.

Emotion regulation capacity. We examined whether gender moderated emotion regulation generally by using instruction (look vs. reinterpret), gender, and the interaction between them to predict negative affect during the negative trials. In line with our findings thus far, we found that reinterpreting was associated with lower negative affect than passively looking at negative images, $b = -0.88$, $t(4086.16) = -24.49$, $p < .001$, 95% CI = [-0.95, -0.81], and that men reported lower negative affect on average than women during the negative trials, $b = -0.25$, $t(65.26) = -2.33$, $p = .02$, 95% CI = [-0.45, -0.04]. We also found a significant interaction between instruction and gender, $b = 0.18$, $t(4086.26) = 3.61$, $p < .001$, 95% CI = [0.08, 0.28], driven by differences in negative affect when passively looking at the images, $z = 2.33$, $p = .02$. In line with prior work demonstrating regulatory benefits across genders (e.g., Gross & John, 2003; McRae et al., 2008), regulating (averaging across social and solo regulation) was more effective than looking at the negative images for both women, $z = 24.49$, $p < .001$, and men, $z = 19.27$, $p < .001$.

Associations between gender & relationship questionnaires. We explored the association between gender and relationship quality and social support variables using point-biserial correlations. Variables of interest included the Inventory of Peer Attachment (i.e., trust, communication, and alienation subscales), the Two-Way Social Support Scale (i.e. receiving emotional support, giving emotional support, receiving instrumental support, and giving

instrumental support subscales), the Social Provisions Scale (i.e. guidance, reassurance of worth, social integration, attachment, nurturance, and reliable alliance subscales), the Interpersonal Regulation Questionnaire (negative-tendency, negative-efficacy, positive-tendency, and positive efficacy subscales), and the Dispositional Positive Emotions Scale (i.e. a measure of compassion). *P*-values are adjusted for multiple comparisons (18 tests total) using the False Discovery Rate (FDR) method.

We found that men reported lower trust, $r = -.40$, adjusted $p < .001$, and quality of communication, $r = -.43$, adjusted $p < .001$, on the Inventory of Peer Attachment. They also reported receiving, $r = -.26$, adjusted $p = .02$, and giving, $r = -.23$, adjusted $p = .04$, less emotional support, as well as receiving, $r = -.25$, adjusted $p = .02$, and giving, $r = -.23$, adjusted $p = .04$, less instrumental support on the Two-Way Social Support Scale. Finally, they reported a lower tendency to share positive events on the Interpersonal Regulation Questionnaire, $r = -.15$, adjusted $p = .03$. No other associations were significant (see Supplementary Table 1).

Since gender shaped the immediate and enduring effects of social vs. solo regulation on negative affect, and gender was moderately associated with the trust and communication subscales of the Inventory of Peer Attachment (IPPA), we checked to see whether the effects of gender on the immediate and enduring effects of social emotion regulation held even when controlling for these relationship quality variables. Thus, in line with our original analyses, we ran two models for each timepoint (in-lab and follow-up): condition, gender, the interaction between condition and gender, and either the trust or communication subscale of the IPPA as predictors of negative affect. None of the signficant terms in the original models changed when controling for relationship quality, such that the main effects of condition and the interaction terms between condition and gender were still signficant for the in-lab task, and the main effects

of condition were still signficant for the follow-up task (p's < .01). There was no change in the pattern of results obtained from pairwise contrasts, such that social regulation was more effective than not regulating in both genders both in-lab and at follow-up, but social regulation was only more effective than solo regulation for women at both timepoints. These analyses suggest that the differences between men and women observed during the tasks was not attributable to relationship quality differences.

Supplementary Table 1: Association Between Gender and Social Support Variables

Scale	*r*	Adjusted *p*
Inventory of Peer Attachment		
Trust	-0.40	< .001
Communication	-0.43	< .001
Alienation	-0.01	0.95
Two-Way Social Support Scale		
Receiving Emotional Support	-0.26	0.02
Giving Emotional Support	-0.23	0.04
Receiving Instrumental Support	-0.25	0.02
Giving Instrumental Support	-0.23	0.04
Social Provisions Scale		
Guidance	-0.14	0.16
Reassurance of Worth	-0.16	0.14
Social Integration	-0.15	0.16
Attachment	-0.12	0.24
Nurturance	-0.18	0.11
Reliable Alliance	-0.16	0.14
Interpersonal Regulation Questionnaire		
Negative-Tendency	-0.14	0.16
Negative-Efficacy	-0.15	0.16
Positive-Tendency	-0.25	0.03
Positive-Efficacy	0.02	0.91
Dispositional Positive Emotions Scale	-0.20	0.11

Note. We explored the association between gender and social support variables using point-biserial correlations. Negative correlation values (*r*) indicate that men had lower scores on these scales. *P*-values are adjusted for multiple comparisons (18 tests total) using the False Discovery Rate (FDR) method.

CHAPTER 3: IT'S HOW YOU SAY IT: A ROLE OF VOCAL PITCH IN REGULATING OTHERS' EMOTIONS

Abstract

Supportive interactions with close others can help change the way that people think about their negative experiences and thereby facilitate emotion regulation processes in the face of stressors. However, there is considerable variability in how individuals communicate during supportive interactions. Acoustic features of verbal speech inform how people perceive both the speaker and content of messages, but little is known about how features like vocal pitch shape affective outcomes during social support. Using a Bayesian statistics approach, we examined the role of support giver pitch on their friend's affective response in three existing datasets (N_1 = 40 dyads; N_2 = 40 dyads; N_3 = 60 dyads; all same-gender dyads) where participants recorded scripted reinterpretations (i.e., reappraisals) of aversive stimuli to help a friend regulate negative emotion. We found cumulative evidence that higher support giver pitch was associated with lower negative affect in the friend during the task, as well as some evidence that higher support giver pitch during social emotion regulation was associated with how positively the friend viewed their relationship with the support giver more generally. These samples consisted primarily of women, but preliminary results indicate that higher support giver pitch may not be beneficial in men dyads. This research demonstrates how tone of voice contributes to regulating others' emotions, highlighting the acoustic features of verbal communication as a promising frontier for future multidimensional socio-affective research aimed at improving social support and emotion regulation processes.

Introduction

Social support plays a critical role in mental and physical health, often facilitating recovery from negative life events and buffering against the harmful effects of everyday stressors (Beckes & Coan, 2011; Berkman et al., 2000; Uchino et al., 2018). Despite a well-established body of research on the benefits of social support, limited empirical research has identified specific mechanisms that allow supportive interactions to shape the way that people think and feel through everyday challenges (Niven, 2017; Reeck et al., 2016; Zaki & Williams, 2013). Increasingly, researchers are examining how people effectively regulate each other's emotions — a process called social emotion regulation (or interpersonal emotion regulation). One social emotion regulation strategy that has been shown to have both immediate and enduring effects on emotional reactivity involves helping to change how someone else thinks about emotional events to change the way they feel about them (Sahi, Ninova, Silvers, 2021; Sahi et al., 2023; Nils & Rimé, 2012). However, the mechanisms underlying this social regulatory process remain poorly understood, including how inter- and intra-personal variability in the way that people communicate during social support interactions contribute to affective outcomes.

Socioemotional attributes of vocal expression

While we have a limited understanding of the role of prosody — or tone of voice — in how people regulate each other's emotions, there is considerable research that aims to unpack the 'forms' and 'functions' of emotional prosody in social contexts more broadly (Pisanski et al., 2016; Pell & Kotz, 2021; Bryant, 2021). Such work indicates that listeners are highly attuned to the emotional valence and intensity of auditory stimuli (Liu et al., 2012; Paulmann & Kotz, 2008; Paulmann et al., 2013; Sauter & Eimer, 2009). Listeners use auditory cues to not only draw conclusions about the content being communicated, but also to form judgments about speakers

themselves, including, for example, judgements about their warmth, competence, confidence, persuasiveness, and trustworthiness (Scherer, London, & Wolf., 1973; O'Connor & Barclay, 2017; Wu, Ching, & Chen, 2023; Oksenberg, Coleman, & Cannell, 1986). Thus, listeners make inferences about the meaning and value of vocal communications that are informed by new and existing perceptions of the speaker.

One prominent feature of vocal expression that has been widely-studied is fundamental frequency (F0) — a measure of vocal fold vibration that is perceived as pitch (i.e., the "highness" or "lowness" of a speaker's voice; Hartmann, & Hartmann, 2013; Pisanski et al., 2016). Pitch is the most salient paralinguistic cue of human speech (Titze, 1994), reliably communicating information about a speaker's biological traits (e.g., sex, age, size; Kreiman & Sidtis, 2011), as well as socially relevant traits (e.g., warmth, competence; Oleszkiewicz et al., 2017) and affective states (e.g., valence, arousal; Liuni et al., 2020). Higher speaker pitch has been associated with high-arousal emotions such as anger, fear, and happiness, whereas lower speaker pitch is associated with low arousal emotions like sadness and even mental health disorders like depression (Pell et al., 2009; Yang, Fairbairn, & Cohn, 2012). Humans are attuned to such acoustic variability in emotional expression, such that people can recognize emotions from vocal cues in "nonsense speech" resembling their native language, with F0 being a key discriminant signal between broad emotion types (Pell et al., 2009). Within the positive emotion umbrella, meta-analytic work suggests that higher pitch is associated with more "epistemological emotions" (i.e., emotions related to existing or new knowledge) such as amusement and interest, as compared to emotions such as contentment or admiration (Kamiloğlu, Fischer, & Sauter, 2020), highlighting the nuance with which auditory cues — like other nonverbal cues (e.g., facial expressions) — communicate emotional information.

Importantly, auditory signals are thought to shape the behavioral responses of listeners, in ways that can be adaptive for the listener, the speaker, or both (Seyfarth et al., 2010; Rendall, Owren, & Ryan, 2009). A prime example of how auditory signals can adaptively support both the speaker and listener is in the context of early caregiving relationships where parents speak to their infants using "infant-directed speech" (i.e., "baby talk"). Such vocal modulation, which involves using higher pitch amongst other acoustic properties, communicates caregivers' positive affect, promotes social bonding between the caregiver and infant, and facilitates enhanced attention and learning in infants (e.g., cognitive and emotional development) (Werker & McLeod, 1989; Grieser & Kuhl, 1988; Trainor, Austin, & Desjardins, 2000; Saint-Georges et al., 2013; Cox et al., 2022). Thus, acoustic features of verbal expression can help the speaker increase the salience of their message to adaptively guide the listener's behavior, while simultaneously communicating affection and facilitating closeness between the speaker and listener (Bombar & Littig, 1996).

A growing body of work demonstrates that people can and do intentionally modulate their voices, particularly when attempting to shape another person's thoughts and behaviors (Pisanski et al., 2016). Thus, it is likely that speakers (intentionally or unintentionally) modulate their voices in social support contexts where their goal is to alter the affective state of the listener. When considering the context of social emotion regulation, it is plausible that one might try to use their voice to express positive arousal, or use a warm and assuring tone to comfort the listener — all of which have been associated with using higher pitch (Kamiloğlu, Fischer, & Sauter, 2020; Hughes et al., 2014; Oleszkiewicz et al., 2017). Such vocal modulation may improve social support outcomes by convincing the listener that a stimulus is less negative than it appears, effectively shaping the listener's cognitive and affective experiences by reorienting them towards the stimulus. In line with the literature on infant-directed speech, these non-verbal cues may

additionally serve to facilitate social bonding between the speaker and listener during social support, potentially contributing to relationship satisfaction over time.

Possible sex or gender differences in the acoustic features of social emotion regulation

Males have lower pitch on average than females (Rendall et al., 2005), but males and females tend to modulate their voices similarly when sharing the same communicative goal.[1] At the same time, there are subtle differences in the extent to which they modulate their voices that could be driven by their specific goals, their average pitch ranges, or both. For example, parents — regardless of sex — increase their pitch when speaking to infants (Fernald et al., 1989; Niwano & Sugai, 2003), but mothers seem to use greater pitch variability in addition to higher pitch when speaking to young children, and use this altered speech pattern with children longer than fathers (i.e., as children get older, fathers stop using "baby talk" earlier than mothers) (Broesch & Bryant, 2018).

Importantly, gender differences in emotion socialization or other features of social relationships can impact social emotion regulation mechanisms and associated acoustic features (Felmlee et al., 2012; Shields et al., 2006). Indeed, some research indicates gender differences in how individuals communicate with their same-gender friends and opposite-gender romantic partners: whereas women were more likely to use high pitch speech with their same-gender friends than men, both women and men used high pitch speech with their opposite-gender romantic partners (Bombar & Littig, 1996). Such work suggests that the gender of the speaker, the gender

[1] In mating contexts, people will sometimes exaggerate sex-typical voice patterns to increase their attractiveness when appealing to the opposite sex such that men lower their pitch and women raise their pitch. In this context, speakers may share the broad goal of appearing attractive, but their more specific goals differ (i.e., appearing masculine or feminine).

of the listener, and the relationship between them all contribute to how individuals modulate their voices. Thus, it is possible that there are gender differences in how pitch affects social emotion regulation outcomes.

Current investigation

In the current investigation, we examined the role of support giver pitch on social emotion regulation in three existing datasets ($N_1 = 40$ dyads; $N_2 = 40$ dyads; $N_3 = 60$ dyads; all same-gender) where participants recorded scripted reinterpretations (i.e., reappraisals) of aversive stimuli to help a friend reduce their negative emotion (Sahi, Ninova, & Silvers, 2021; Sahi et al., 2023). We applied Bayesian statistics to take a graded inference approach to investigating how the support giver's pitch during this social emotion regulation task — indexed by mean F0 across each trial — shaped the listener's trial-by-trial negative affect (i.e., accounting for both within- and across-speaker variation). To examine how speaker pitch generalized to relationship outcomes in everyday life, we tested whether average support giver pitch during social emotion regulation (i.e., speaker pitch averaged across all trials) was associated with the listener's self-reported relationship satisfaction.

Study 1 was treated as an exploratory dataset, after which we pre-registered our hypotheses for studies 2 and 3 on Open Science Framework (OSF; https://osf.io/vakn3/).[2] We expected higher support giver pitch to be associated with better social emotion regulation outcomes (i.e., lower negative affect in the listener during the task) and greater relationship satisfaction (i.e., higher score on a self-reported measure of peer attachment). Importantly, studies 1 and 2 only sampled women dyads, whereas study 3 used a gender-split sample of same-gender dyads (i.e., half women-

[2] The study 2 dataset had already been collected at the time of pre-registration, and data collection for study 3 had just begun.

women dyads, half men-men dyads). While this feature of the datasets limits assessments of gender-related effects, we attempted to gain some preliminary insight into this question by testing whether gender moderated the association between pitch and social emotion regulation and relationship outcomes in study 3.

Method

Use of published data. In this research, we used three datasets that have been analyzed in previous manuscripts. The behavioral data utilized here are freely available on OSF. Data from studies 1 and 2 are from a published manuscript (studies 1 and 3 from https://osf.io/3qn47/; Sahi, Ninova, & Silvers, 2021) and data from study 3 is from a pre-printed manuscript currently undergoing peer review (https://osf.io/a9jvf/, Sahi et al., 2023). The audio data utilized in this research have not been previously analyzed. Since we cannot fully de-identify this data, the raw audio data is not publicly shared. However, the acoustic features (e.g., F0 mean) derived from this data for the present research questions are shared publicly on OSF (https://osf.io/vakn3/).

Sample size. The number of dyads and social emotion regulation trials per dyad for these existing datasets (N_1 = 40 dyads, 18 trials each; N_2 = 40 dyads, 12 trials each; N_3 = 60 dyads, 18 trials each) were determined based on the expected effect sizes when comparing the efficacy of social (i.e., with help) and solo (i.e., on one's own) emotion regulation (Sahi, Ninova, & Silvers, 2021; Sahi et al., 2023), and not for testing the present research questions. Thus, it was unknown whether these existing datasets would be adequately powered to detect associations between support giver pitch and regulatory outcomes. We account for this limitation through our analytic choices, described in an upcoming section.

Exclusion criteria. Participants individually completed email screenings for all studies to ensure eligibility. Prospective participants who had previously participated in a similar reappraisal

study in the lab, were not proficient in English, were not between 18-39 years old, reported having a developmental disability or neurological disorder, diagnosed behavioral or psychological issues, or uncorrected vision or hearing (i.e., characteristics that might interfere with ability to complete the task) were not enrolled in the studies. Only women were enrolled in studies 1 and 2, whereas study 3 enrolled a gender-split sample of same-gender dyads.

Participants. Participants for these studies were friend pairs that reported having a close relationship, recruited from the university campus through flyers, emails, and subject pool. For study 1, the mean age was 19.4 years, and the sample was approximately 55% Asian, 24% White/Caucasian, 10% Latinx/Hispanic, and 2% Black/African American. For study 2, the mean age was 21 years, and the sample was approximately 50% Asian, 29% White/Caucasian, 30% Latinx/Hispanic, and 10% Black/African American. For study 3, the mean age was 20.83 years, and the sample was approximately 53% Asian, 13% White/Caucasian, 3% Latinx/Hispanic, and 3% Black/African American. Participants for all three studies were grouped into gender categories based on their gender identities rather than sex assigned at birth. For studies 1-2, the samples were all women, including 1 person who was assigned male at birth. For study 3, the sample was gender-split, including 1 person who was assigned female at birth (see Table 1 for summary of demographic and sample characteristics).

Social emotion regulation task.

Experiencer. The social emotion regulation task completed by the experiencers (i.e., the listeners) included three conditions: negative-listen, negative-look, and neutral-look (study 1: 18 trials each; study 2: 12 trials each; study 3: 18 trials each). The focus of our analyses was the "listen" trials of the social emotion regulation task wherein people heard their friend reinterpreting the content of negative stimuli. Each trial began with a cue to look or listen (2 s). The "look" cue

indicated that participants should look and let themselves respond naturally to the image. The "listen" cue indicated participants should listen to their friend reinterpreting the image. After the cue, participants saw a negative or neutral image (9 s). After viewing the image and responding to it according to the cue, participants provided a negative affect rating (i.e. "How bad do you feel?") on a 4-point rating scale from "1 = not bad at all" to "4 = very bad" (3 s) (Figure 1). A brief jittered fixation cross was included between each image and rating and between each trial. There were four versions of the task such that image sets were counterbalanced across conditions.

While our analytic focus was the "listen" trials, in all three studies, the experiencers also completed a solo emotion regulation task where they would regulate their own responses to negative images instead of receiving help from their friend. Study 3 also included a follow-up task one day later where participants rated images that they viewed or regulated in the social or solo tasks in the lab. Additional details for these tasks are described in the existing manuscripts (Sahi, Ninova, & Silvers, 2021; Sahi et al., 2023).

Helper. The helpers in these studies (i.e., the support givers) recorded reinterpretations of negative images from scripts generated for the original research studies (https://osf.io/h32q8/). There were four different scripts, corresponding to the four different image sets for each version of the task. Recordings for all three studies were created on the same PC computer using a Logitech H390 Wired Headset with a noise-canceling microphone and OceanAudio Version 3.6 (an audio recording software). Each reinterpretation was one sentence and took four to eight seconds to read out loud (e.g. "That person will recover from the accident"). Helpers were instructed to read the reinterpretations in a natural way so that they would be helpful to the friend as they viewed the negative images. Thus, all helpers for each corresponding version of the task read the same reinterpretations, but they were free to read them in any way they wanted to support their friend.

These reinterpretations were spliced into the social emotion regulation task for the listen trials, rather than read live (to control timing and prevent technical issues). Experiencers were not informed that the helpers were reading from a script until the end of the study.

Audio data cleaning procedure. For all three datasets, pitch extraction was performed using 'PraatR' (Albin, 2014), an R package that allows the user to execute a full list of 'Praat' commands within the R environment. Praat is an open-source computer software commonly used for analysis, synthesis, and manipulation of vocal features in human phonetics research (Boersma & Weenink, 2020).[3] We used the Praat function "To Pitch…", an auto-correlation technique optimized for speech, to extract F0 values for each clip (Boersma, 1993; Weenink, 2018; Boersma & Weenink, 2020).

Manual inspection for each recording was performed in the Praat window to detect and correct misidentified pitch values after completing pitch processing. Extreme pitch points (both high and low) that were outside of the speaker's pitch range were flagged by viewing the spectrogram while listening to the audio. Such values are likely caused by changes in breathing between utterances or noises from the recording environment (e.g., "creaky" voices; Klatt & Klatt, 1990; Wright, et al., 2019). For extreme values that had strong proxies, we replaced the extreme values with alternative values suggested by Praat (see example in Supplemental Figure 1; Gerhard, 2003; Styler, 2013). For extreme values that had no appropriate alternative matches, we removed these points using the "unvoice" function in Praat (Chow & Brown, 2018; see example in Supplemental Figure 2). We were conservative in our removal of extreme pitch values to preserve

[3] It is worth noting that the application of Praat has also been adopted by animal researchers (Charlton, Reby, & McComb, 2007; Charlton, Whisson, & Reby, 2013).

expected variability in acoustic patterns across and within speakers in natural speech.[4] Two trials total were removed from the dataset because these files could not be processed (i.e., no pitch value; see Supplemental Table 1).

We saved processed F0 data for each recording in units of semitone and Hertz. Semitone is a standardized acoustic measure that allows for better comparison across speakers with varying pitch ranges (Grieser & Kuhl, 1988; Hunte & Titze, 2010; Shute & Wheldall, 2010), including variability in pitch introduced by age, sex, body weight, and perceived social power (Barsties, 2013; Aung & Puts, 2020; Whalen & Levitt, 1995; Hellermann, 2003). Given that semitone is a standardized measure of pitch, and is arguably a better representation of perceived changes in pitch than Hertz (Grieser & Kuhl, 1988; Hellermann, 2003), we chose to use semitone as the unit of measurement for our analyses. We took a "whole sentence approach" to our analysis such that we calculated global measures of F0 in semitone, including F0 mean, minimum, maximum, range, and standard deviation across each audio clip (Paeschke, Kienast & Sendlmeier, 1999).

Variables.

Trial-by-trial pitch. Our measure of trial-by-trial acoustic pitch was the support giver's mean F0 in semitone across each audio clip.

Average speaker pitch. We averaged across trials for each speaker to assess average speaker pitch during social emotion regulation.

Social emotion regulation outcome. Our social emotion regulation outcome was the listener's trial-by-trial self-reported negative affect (on a scale of 1 to 4, 1 = not at all bad; 4 = very

[4] We replaced extreme F0 values with alternative values suggested by Praat in less than 1% of the trials for studies 1 and 2, and less than 2% of the trials for study 3. We removed unmatched extreme values on about 20% of the trials for studies 1 and 2, and about 30% of the trials for study 3.

bad) during the listen trials of the social emotion regulation task. Hearing their friends reinterpret the negative stimuli was an effective regulatory strategy (Sahi, Ninova, & Silvers, 2021), so these data exhibited a left skew such that participants mainly selected 1 or 2 (i.e., the lowest end of the 1 - 4 scale). Thus, these data, which had natural ordered categories, were treated as ordinal data in analyses.

Relationship quality. All three studies included a subjective measure of relationship quality — the Inventory of Peer Attachment (IPPA) — that was modified to focus the questions on the participant's partner in the study (i.e., their friend) rather than how they frame friends in general. The IPPA includes three subscales summed for a total score: trust (e.g., "I trust my friend"), communication (e.g., "When we discuss things, my friend cares about my point of view"), and alienation (e.g., "My friend doesn't understand what I'm going through these days") (α_1 = 0.86; α_2 = 0.84; α_3 = 0.97; Armsden & Greenberg, 1987). We used this measure as our assessment of how the listener perceived their relationship with the support giver in general (i.e., outside of the lab).

Analyses.

Bayesian statistics. We took a Bayesian parameter estimation approach to analyzing our research questions across three samples. This approach involves estimating parameter values by updating prior beliefs about the model parameters (i.e., prior distribution) with new evidence (i.e., observed data) using a likelihood function to yield a posterior distribution (McElreath, 2020). Rather than using *p*-values to assess whether an effect is meaningfully different from zero (i.e., no effect), Bayesian statistics allows for a graded inference approach to assess whether evidence accumulates in support of a proposed association across datasets (Spiegelhalter et al., 1994). Since we were working with multiple datasets with the same methodology and similar populations, we

were able to use the posterior from study 1 as a meaningful prior in subsequent studies. In other words, we could use new evidence from studies 2 and 3 to "update" what we learned from study 1 to make a cumulative assessment about the parameters of interest.

Bayesian statistics takes more of a probabilistic approach to statistical analysis than null-hypothesis testing. These analyses do not utilize *p*-values, but one can still assess the direction and strength of parameters in Bayesian models by evaluating the sign (i.e., +/-) and width of the credible interval associated with each parameter. A credible interval is the Bayesian analog of a confidence interval: it falls to the left of, right of, or overlaps with zero to indicate how likely a parameter is to be meaningfully different from zero. The highest density interval (HDI) is a type of credible interval that summarizes the range of most credible values of the parameter, such that the width of the HDI indicates certainty in the parameter estimate (Kruschke, 2011; Kruschke, 2018). 89% HDIs are recommended for interpreting results from Bayesian models, since the more extreme values in posterior distributions using a 95% interval are thought to be less stable (Krusche, 2014). Nonetheless, because 89% intervals are less conservative than 95% intervals (i.e., lower likelihood of containing zero), we report both in our results.

Regression models. For our first research question — whether support giver's pitch was associated with the listener's negative affect during social emotion regulation — we used ordinal logistic multilevel regression models with the listener's trial-by-trial negative affect (i.e, an ordinal variable) as the outcome and support giver's trial-by-trial pitch (i.e., a continuous variable) as the predictor. We nested trials within dyads, and used a random intercept and fixed effects. We used the 'brms' package in R for these models (Bürkner, 2018). This trial-by-trial (i.e., mixed-effects regression) approach allowed us to account for variation across dyads, as well as within-speaker differences in pitch – or variability in how the support giver modulated their pitch across trials.

For our second research question — whether support giver's pitch during social emotion regulation was associated with the listener's relationship satisfaction — we used linear regression models with the listener's relationship satisfaction (i.e., IPPA score; a continuous variable) as the outcome and average support giver pitch across social emotion regulation trials as the predictor variable. We used the "rstanarm" and "bayestestR" packages in R for these models (Goodrich et al., 2020; Makowski, Ben-Shachar, & Lüdecke, 2019). We followed up on our second research question with exploratory analyses assessing the association between average support giver pitch and the three subscales of listener relationship satisfaction (i.e., trust, communication, alienation), included in Supplementary Materials (Supplemental Table 2).

For both research questions, we used the same models across studies 1 and 2 (i.e., women only samples), but for study 3 (i.e., mixed-gender sample) we additionally included gender as a main effect and moderator of pitch.

Prior selection and sensitivity analyses in study 1. When using Bayesian statistics, one ideally has some information about the parameter they are estimating from prior literature on the topic. However, it is also possible to use Bayesian statistics without information about the prior by using a non-informative or weakly informative prior to conduct analyses. When using a weakly informative prior, one can designate an interval for the effect of interest that excludes values that would be unreasonable based on the scale of the variables or other existing knowledge. In Bayesian statistics, it is common to perform sensitivity analyses to examine the effect of choosing different priors (e.g., non-informative, weakly informative, and informative priors) on the results. Such sensitivity analyses can demonstrate the reliability of an effect and are linked to features of the sample, such as sample size (e.g., smaller datasets tend to be more sensitive to prior selection) (Krushke, 2021).

In study 1, we had no estimate of the parameters from existing research, so we ran our models with three different priors. For our first research question, the predictor variable (i.e., support giver's trial-by-trial pitch) ranged from approximately 4 to 22 semitones and the outcome variable (i.e., listener negative affect) ranged from 1 to 4 points. Given these ranges, we did not expect the pitch parameter to be greater than 1 or less than -1. Thus, we used (1) a flat prior (i.e. uninformative prior); (2) a weakly informative prior using a normal distribution, mean of 0, and standard deviation of 0.33 such that 99% of values for the parameter estimate were expected to fall between -1 and +1; and (3) another weakly informative prior with a narrower interval using a normal distribution, mean of 0, and standard deviation of 0.25 such that 99% of values for the parameter estimate were expected to fall between -0.75 and +0.75. We found that the results for study 1 were not sensitive to the prior we selected (i.e., the results did not meaningfully change when using different priors), so we chose to build on the second model using a weakly informative prior (i.e., full report of sensitivity analysis is provided under Results; see Supplemental Table 3 for summary).

For our second research question, the predictor variable (i.e., support giver average pitch across trials) ranged from approximately 7 to 16 semitones and the outcome variable (i.e., listener friendship satisfaction) ranged from 85 to 123 points. Given these ranges, we did not expect the pitch parameter to be greater than 9 or less than -9. Thus, we used (1) a flat prior (i.e. uninformative prior); (2) a weakly informative prior using a normal distribution, mean of 0, and standard deviation of 3 such that 99% of values for the beta coefficient were expected to fall between -9 and +9; and (3) another weakly informative prior with a narrower interval using a normal distribution, mean of 0, and standard deviation of 2 such that 99% of values for the coefficient were expected to fall between -6 and +6. As with the first research question, results for study 1

were not sensitive to the prior we selected, so we chose to build on the second model using a weakly informative prior (i.e., full report is provided under Results; see Supplemental Table 4).

Use of informative priors for pitch parameters in studies 2-3. We used the posterior for the pitch estimate from study 1 as an informative prior for this estimate in study 2, and used the posterior for pitch from study 2 (which contained information from studies 1 and 2) as an informative prior for this variable in study 3. Thus, with each additional study, we made a cumulative assessment of the nature of our effects. To assess how sensitive results from study 2 and 3 were to prior selection, we also tested these models with less informative priors (i.e., wider intervals).

Importantly, we set the reference group for gender in study 3 as women since studies 1 and 2 were conducted in n and mean-centered the pitch variable to aid in interpretation of the gender variable. Thus, we were able to use an informative prior for the pitch variable in study 3, despite the mixed-gender sample, because the estimate for pitch in this study represented the association between pitch and the outcome variable *for women*. Meanwhile, the estimate for gender in this model represented the effect of gender on the outcome variable *holding pitch at its mean*.

Use of weakly informative priors for gender terms in study 3. We had little prior information regarding possible gender effects in these models. Thus, for the first research question (i.e., the association between speaker pitch and listener negative affect during social emotion regulation) we used a weakly informative prior for the gender term with a normal distribution, mean of 0, and standard deviation of 0.33, and used an uninformative prior for the interaction term between pitch and gender. For the second research question (i.e., the association between average speaker pitch during social emotion regulation and listener relationship satisfaction), we expected men to have lower relationship satisfaction on average (as captured by the IPPA) than women in

this sample (Sahi et al., 2023). Thus, we used a weakly informative prior for gender with a normal distribution, mean of -1 (indicating that men were expected to have lower relationship satisfaction than women), and a standard deviation of 10, and used a weakly informative prior for the interaction term with a normal distribution, mean of 0, and a standard deviation of 10. Given the expected association between gender and pitch based on existing literature (Hellermann, 2003; Hunte & Titze, 2010), we checked for multicollinearity in the study 3 models. Gender and pitch were moderately correlated across models, *r's* < 0.5, but this correlation was not sufficiently high to raise concerns regarding multicollinearity.

Results

Was support giver pitch associated with social emotion regulation outcomes?

Study 1. In testing the association between support giver pitch and social emotion regulation outcomes in the listener in study 1, we used three different priors to test the sensitivity of our results to the prior we selected. The results of our analyses were consistent when using the flat prior (i.e., uninformative prior; *b* = -0.13, SD = 0.05, OR = 0.88, 89% HDI [-0.21, -0.04], 95% HDI [-0.24, -0.03]), a weak prior (i.e., normal(0, 0.33); *b* = -0.13, SD = 0.05, OR = 0.88, 89% HDI [-0.21, -0.04], 95% HDI [-0.23, -0.02]), and a weak prior with a more narrow interval (i.e., normal(0, 0.25); *b* = -0.12, SD = 0.05, OR = 0.89, 89% HDI [-0.21, -0.04], 95% HDI [-0.22, -0.03]). We chose to maintain the posterior from the model using the weak prior (i.e., normal(0, 0.33)) as the prior for subsequent analyses. According to this model, for every one unit increase in the support giver's pitch, the odds of the listener reporting lower negative affect increased by 12%. The HDI was to the left of (i.e., negative parameter) and non-overlapping with zero, and had a relatively narrow width (i.e., 0.17 points), indicating some confidence in this effect.

Study 2. Using the posterior from study 1 as an informative prior (i.e., normal(-0.13, 0.05)) for the pitch variable in study 2, higher support giver pitch was once again associated with lower negative affect in their friend during the task, b = -0.10, SD = 0.04, OR = 0.90, 89% HDI: [-0.17, -0.04], 95% HDI [-0.18, -0.03]. For every one unit increase in support giver's pitch, the odds of the listener reporting lower negative affect increased by 10%. As in study 1, the HDI was to the left of and non-overlapping with zero, and the HDI was narrower than in study 1 (i.e., 0.13 points), indicating increasing confidence in this effect.

When using a slightly less informative prior (i.e., doubling the interval: normal(-0.13, 0.10)), our results were relatively consistent, b = -0.08, SD = 0.05, OR = 0.92, 89% HDI: [-0.17, 0.00], 95% HDI [-0.19, 0.01], but the effect was smaller and the HDI overlapped with zero.

Study 3. Because study 3 used a gender-split sample, we built on the model from studies 1 and 2 to include gender as a main effect and moderator. We used the posterior from study 2 as an informative prior (i.e., normal(-0.10, 0.04)) for the mean-centered pitch parameter (with women as the reference group for gender), used weakly informative priors for gender (i.e., normal(0,0.33)) and a flat prior for the interaction term. We found that higher support giver pitch was once again associated with lower negative affect in their friend during the task, b = -0.08, SD = 0.03, OR = 0.92, 89% HDI: [-0.13, -0.02], 95% HDI [-0.14, -0.01], in women (i.e., holding gender constant). In women, for every one unit increase in helper's pitch, the odds of the target having lower negative affect increased by 8%. As in study 2, the HDI for pitch was to the left of and non-overlapping with zero, and the HDI was narrower than in study 2 (i.e., 0.11 points), indicating increasing confidence in this effect.

The main effect of gender had a positive parameter but the HDI was fairly evenly distributed over zero, b = 0.16, SD = 0.42, OR = 1.17, 89% HDI: [-0.50, 0.82], 95% HDI [-0.66,

0.98], suggesting a low likelihood that gender shaped listener negative affect during the task. The interaction between gender and pitch had a positive parameter and the HDI was nonoverlapping with zero, *b* = 0.13, SD = 0.07, OR = 1.14, 89% HDI: [0.02, 0.24], 95% HDI [0.00, 0.26]. While there was a negative association observed between pitch and social emotion regulation outcomes for women, there was a small positive association between pitch and social emotion regulation outcomes for men, *b* = 0.05, SD = 1.05, OR = 0.92, 89% HDI: [-0.05, 0.15], 95% HDI [-0.06, 0.17], with an HDI that crossed zero.

When using a slightly less informative prior (i.e., widening the interval: normal(-0.10, 0.08)), the parameter for pitch was still negative but weaker, *b* = -0.05, SD = 0.05, OR = 0.95, 89% HDI: [-0.13, 0.02], 95% HDI [-0.14, 0.04], with an HDI that overlapped with zero. The parameter for gender was stronger but the HDI was still spread across zero, *b* = 0.37, SD = 0.41, OR = 1.45, 89% HDI: [-0.28, 1.01], 95% HDI [-0.44, 1.18]). The interaction term was relatively consistent across models, *b* = 0.14, SD = 0.07, OR = 1.15, 89% HDI: [0.02, 0.25], 95% CI [0.00, 0.28], such that while we observed a negative association between pitch and social emotion regulation outcomes for women, there was a positive association between pitch and social emotion regulation outcomes for men, *b* = 0.09, SD = 0.05, OR = 1.09, 89% HDI: [0.01, 0.17], 95% HDI [-0.02, 0.19], with an HDI that did not cross zero.

Summary. To summarize, when using a weakly informative prior in study 1 and subsequently using strong priors in studies 2 and 3, we found accumulating evidence for a negative association between support giver pitch and listener negative affect during the social emotion regulation task (study 1: *b* = -0.13, SD = 0.05, OR = 0.88, 89% HDI [-0.21, -0.05], 95% HDI [-0.23, -0.02]; study 2: *b* = -0.10, SD = 0.04, OR = 0.90, 89% HDI: [-0.16, -0.04], 95% HDI [-0.18, -0.03]; study 3: *b* = -0.08, SD = 0.03, OR = 0.92, 89% HDI: [-0.13, -0.02], 95% HDI [-0.14, -

0.01]) *in women* (Supplemental Table 3). While the parameter estimate gets smaller across the three studies, the HDI also gets narrower, indicating increasing certainty in the estimate (Figure 2A). Based on our analyses in study 3, there does not seem to be a main effect of gender on listener negative affect during the task, but there is evidence for an interaction between pitch and gender on listener negative affect during the task such that increasing support giver pitch is associated with lower odds of negative affect in women, but associated with no change or possibly higher odds of negative affect in men.

Our results across these three studies were gradually more sensitive to the prior, such that the prior made no difference in the results in study 1 (i.e., parameter estimates and HDIs were consistent), made some difference in the results in study 2 (i.e., parameter estimate shrunk and HDI contained zero), and made a more notable difference in the results in study 3 (i.e., parameter estimate shrunk in magnitude and HDI crossed zero) (Supplemental Table 3). This pattern of decreasing certainty in the results aligns with the power of each sample: while study 1 was the best powered of the three (i.e., N_1 = 39, with around 18 trials each), study 2 had a smaller trial number per dyad (i.e., N_2 = 39, with around 12 trials each), and study 3 had the lowest power for each gender group (i.e., N_3 = 29 women dyads and 30 men dyads, with around 18 trials each).

Was support giver pitch during social emotion regulation associated with relationship outcomes?

Study 1. In testing the association between average support giver pitch during the task and listener relationship satisfaction in study 1, we used three different priors to test the sensitivity of our results to prior selection. The results of our analyses were relatively consistent when using a flat prior (i.e., uninformative prior; b = 1.61, SD = 0.66, 89% HDI [0.58, 2.64], 95% HDI [0.34, 2.92]), a weak prior (i.e., normal(0, 3); b = 1.52, SD = 0.63, 89% HDI [0.54, 2.48], 95% HDI [0.29,

2.72]), and a weak prior with a narrower interval (i.e., normal(0, 2); b = 1.44, SD = 0.62, 89% HDI [0.43, 2.37], 95% HDI [0.22, 2.63]). As with the first research question, we chose to maintain the posterior from the model using the weak prior (i.e., normal(0, 3)) as the prior for subsequent analyses. According to this model, for every one unit increase in the support giver's average pitch across social emotion regulation trials, the listener's relationship satisfaction increased by 1.52 points. The HDI for this parameter was to the right of and non-overlapping with zero, and was around 2 points wide, suggesting some confidence in a positive association between support giver pitch during the task and listener relationship satisfaction.

Study 2. Using the posterior from study 1 as an informative prior (i.e., normal(1.52, 0.63)) for study 2, higher support giver pitch during the task was once again associated with higher listener relationship satisfaction, b = 1.17, SD = 0.42, 89% HDI [0.54, 1.89], 95% HDI [0.33, 1.98]. For every one unit increase in the support giver's average pitch across social emotion regulation trials, the listener's relationship satisfaction increased by 1.17 points. As in study 1, the HDI was to the right of and non-overlapping with zero, and the HDI was narrower (closer to 1 point wide) than in study 1, indicating increasing confidence in this positive parameter.

When using a slightly less informative prior (i.e., doubling the interval: normal(1.52, 1.26)), the parameter estimate became weaker, b = 0.97, SD = 0.53, 89% HDI: [0.16, 1.84], 95% HDI [-0.11, 2.03], but the HDI remained to the right of and non-overlapping with zero. Thus, there was cumulative evidence across the two studies in support of a positive association between support giver pitch during the task and listener relationship satisfaction.

Study 3. Because study 3 used a gender-split sample, we built on the model from studies 1 and 2 to include gender as a main effect and moderator. We used the posterior from study 2 as an informative prior (i.e., normal(1.17, 0.42)) for the mean-centered pitch parameter (with women as

the reference group for gender), and used weakly informative priors for gender and the interaction term (i.e., normal(-1,10) and normal (0,10), respectively). In this model, higher support giver pitch during the task was associated with higher listener relationship satisfaction, b = 0.75, SD = 0.38, 89% HDI [0.20, 1.41], 95% HDI [0.02, 1.48], in women (i.e., holding other variables in the model constant). For every one unit increase in the support giver's average pitch across social emotion regulation trials in women, the listener's relationship satisfaction increased by 0.75 points. As in study 2, the HDI for this parameter was to the right of and non-overlapping with zero, and the HDI was about the same width (around 1 point) as in study 2.

There was a negative association between the dyad's gender and listener relationship satisfaction, b = -4.39, SD = 4.17, 89% HDI: [-11.06, 2.29], 95% HDI [-12.56, 3.79]. Although the HDI for this parameter overlaps with zero and is quite wide (around 13 points), the majority of the HDI is to the left of zero, suggesting that men may have lower relationship satisfaction on average than women (holding pitch at its mean). The interaction term was negative, b = -0.93, SD = 0.84, 89% HDI: [-2.30, 0.29], 95% HDI [-2.54, 0.81], but the HDI contained zero with a relatively narrow spread (under 3 points) suggesting low likelihood that there was an interaction between these variables.

When using a slightly less informative prior (i.e., widening the interval: normal(1.17, 0.84)), the parameters were directionally consistent (i.e., the same signs). However, the parameter for pitch was much weaker and the HDI for pitch now overlapped with zero, b = 0.04, SD = 0.62, 89% HDI: [-0.94, 1.06], 95% HDI [-1.20, 1.26]. The parameter for gender was stronger and the HDI for this term remained entirely to the left of zero, b = -7.06, SD = 4.64, 89% HDI: [-15.46, -0.64], 95% HDI [-15.82, 2.48]. The HDI for the interaction term remained negative and more evenly spread across zero in this model, b = -0.15, SD = 0.96, 89% HDI: [-1.57, 1.48], 95% HDI

[-2.05, 1.82]. Collectively, these results indicate that the estimates in this model, especially for pitch and gender, are sensitive to prior selection, and that we have weak evidence for a main effect of pitch on relationship satisfaction for women in the third sample. Given that the sample size is smaller in study 3 for each gender than in studies 1 and 2 (i.e., $N = 29$ women and $N = 30$ men in study 3, as compared to $N = 39$ women in studies 1 and 2), it is unsurprising that these analyses are more sensitive to prior selection than the previous studies.

Summary. To summarize, when using a weakly informative prior in study 1 and subsequently using strong priors in studies 2 and 3, we found accumulating evidence for a positive association between average support giver pitch during social emotion regulation and listener relationship satisfaction (study 1: $b = 1.52$, SD = 0.63, 89% HDI [0.54, 2.48], 95% HDI [0.29, 2.72]; study 2: $b = 1.17$, SD = 0.42, 89% HDI [0.54, 1.89], 95% HDI [0.33, 1.98]; study 3: $b = 0.75$, SD = 0.38, 89% HDI [0.20, 1.41], 95% HDI [0.02, 1.48]) *in women*. While the parameter estimate becomes smaller across the three studies and is notably weaker by study 3, the HDI also gets narrower, indicating some confidence in a positive association between the variables (Figure 2B). Based on our results and the relatively small number of men sampled (only in study 3), it is unclear whether a similar association is present in men, and we have no evidence for an interaction between pitch and gender on relationship satisfaction.

Our results across these three studies were gradually more sensitive to the prior, such that the prior made little difference in the results in study 1 (i.e., parameter estimates and HDIs were consistent), made some difference in the results in study 2 (i.e., parameter estimate shrunk but HDI relatively consistent), and made a notable difference in the results in study 3 (i.e., parameter estimates changed drastically and HDIs shifted) (Supplemental Table 4). This pattern of increasing sensitivity to the prior across each study is expected based on the use of stronger priors in studies

2 and 3, and the power of each sample: while studies 1 and 2 were similarly powered for linear regression (i.e., N_1 = 39, N_2 = 39), study 3 had less power for each gender group (i.e., N_3 = 29 women dyads, 30 men dyads).

Discussion

Social support is a critical ingredient to mental health and successful relationships and is often expressed vocally. However, limited research has examined the paralinguistic cues that confer effective social support and promote relationship satisfaction. We sought to examine how acoustic mechanisms — specifically vocal pitch — might facilitate supportive interactions when a speaker tried to help change how their friend thought about negative stimuli to help them regulate their emotions. Using a Bayesian statistics approach, we found consistent evidence across three datasets that higher support giver pitch was associated with lower negative affect in the listener during a social emotion regulation task. We also found evidence of a positive association between average support giver pitch during social emotion regulation and listener relationship satisfaction, although these associations were more sensitive to prior selection.

Higher support giver pitch was associated with better social emotion regulation outcomes

Acoustic properties of speech have been associated with speakers' perceived social traits, as well as information about their affective states, which collectively shape listeners' perceptions and behaviors. Thus, our finding that higher support giver pitch was associated with lower negative affect in the listener during social emotion regulation was likely driven by a combination of how the listener perceived the speaker as a support giver and the content of their support. Higher pitch has been associated with greater warmth, particularly in women speakers (Oleszkiewicz et al., 2017), suggesting that support givers in these studies may have been modulating their voices to communicate sincerity and kindness (i.e., features associated with warmth) to their friend. Such

vocal modulation might increase the efficacy of social support by increasing the salience of the speaker as a support giver (i.e., their availability and willingness to provide emotional support). Higher pitch has additionally been associated with greater speaker confidence, particularly in ambiguous circumstances (Scherer, London, & Wolf, 1973), as well as greater persuasiveness (for example, as indexed by lower refusal rate during telemarketing; Oksenberg, Coleman, & Cannell, 1986). Thus, in addition to communicating their own availability to the listener, support givers who use higher pitch during social emotion regulation might increase the believability of their messages. It might be particularly important for support givers to use a confident and persuasive tone when reframing affective stimuli to change someone else's emotional response. Finally, higher pitch has also been associated with greater positive arousal (Kamiloğlu, Fischer, & Sauter, 2020), which in the context of this paradigm might help support givers emphasize their positive reinterpretations of the stimuli (e.g., "It's not that bad!").

While our findings do not directly speak to these mechanisms, existing work on the social functions of higher pitch suggest that support givers might have modulated their voices to communicate greater warmth, confidence, and positive arousal to help regulate their friend's emotions during the task. Importantly, it remains unknown whether the effect of pitch on social emotion regulation outcomes in these studies was driven by differences in speakers' natural acoustic patterns (e.g., their average speaking pitch), how they modulated their voices for the task (e.g., changes from their baseline pitch), or both. In other words, is providing effective regulatory support a matter of how one uses their voice, having a naturally supportive voice, or both? While we used multilevel modeling to capture between-person and within-person variation in acoustic frequencies, future research can measure speakers' baseline acoustic frequencies (i.e., in a non-support context) to gain more insight into how much people modulate their voices when providing

support, and whether some people have voices that are more naturally conducive to effective support provision than others.

Mixed evidence for association between support giver pitch and relationship satisfaction

We observed mixed evidence for an association between support giver pitch and listener relationship satisfaction, making it difficult to draw strong conclusions about this set of findings. If pitch plays a role in effective social support provision, and receiving social support from a friend improves relationship satisfaction, then it is possible that those who use their voices more effectively during social support will be seen more favorably by their friends. However, it is unknown whether the support givers in the present studies modulate their voices when supporting their friends outside of the lab in the same way as they did during these lab experiments.

It is also possible that vocal synchronization is more important for relationship satisfaction than vocal modulation on its own. The literature on infant-directed speech underscores the interactive nature of this process whereby infants and caregivers synchronize their vocal patterns across interactions to facilitate enhanced bonding and learning (Saint-Georges et al., 2013). Similar synchronization has also been observed in clinical settings where clinicians lower their pitch when working with depressed patients (Scherer et al., 2014), highlighting the reciprocal nature of verbal and non-verbal communication. Thus, future research can clarify these findings by using more naturalistic paradigms where speakers and listeners can more freely interact, allowing us to assess how the listener's tone influences the speaker's tone, and vice versa, and how such synchronization processes might relate to relationship quality.

Possible gender differences in the association between pitch and social emotion regulation

Study 3 provided preliminary insight into whether gender might moderate associations between vocal pitch and social emotion regulation processes. While support giver pitch was

consistently associated with social emotion regulation outcomes in women (in studies 1, 2, and 3), study 3 indicated that higher speaker pitch was associated with no change in or possibly even worse social emotion regulation outcomes in men. Importantly, we cannot assess whether these gender differences are driven by how men modulate their voices during social support, how men perceive pitch variability in men speakers, or both. However, this preliminary finding builds on existing literature demonstrating that women are more likely than men to use affectionate speech patterns involving higher pitch with their same-gender friends (Bombar & Littig, 1996). Such gender differences in vocal communication could be rooted in differences in how men and women perceive their relationships with their same-gender friends, in line with existing work showing that women value intimacy and emotional support in their same-gender friendships to a greater extent than men (Felmlee et al., 2012). Recent findings using the study 3 dataset also showed that women experienced a greater regulatory boost from social support than men (Sahi et al., 2023), demonstrating that gender may play an important role in social emotion regulation mechanisms and outcomes.

At the same time, however, research suggests that men use high-pitch speech with their opposite-gender romantic partners to the same extent as women (Bombar & Littig, 1996), suggesting that men may modulate their voices similarly to women when providing support *to women*. Given that social traits like warmth are associated with femininity (Lehr, Tan, & Ysseldyke, 2009), it is possible that some men avoid using a warm tone with same-gender friends, but are more likely to use it in relationships with different social expectations or norms, for example with their children or romantic partners (Bombar & Littig, 1996; Broesch & Bryant, 2018). Future research can start to identify how gender shapes vocal modulation during social support by studying mixed-gender dyads, and assessing these acoustic patterns during social

support across different dyad types, including caregiving relationships, romantic relationships, and even in group settings.

Future directions: The role of context

A critical future direction for this line of research is to consider other social emotion regulation contexts. We looked at a single emotion regulation strategy (i.e., social reappraisal) using a controlled paradigm (i.e., reinterpretation-style reappraisal), demonstrating that vocal features play a role in social emotion regulation outcomes. However, it is unlikely that higher pitch will uniformly improve social emotion regulation outcomes. For example, in cases when a support giver chooses to validate rather than reinterpret another person's feelings of loss, they might lower their pitch to communicate that they resonate with the listener's affective state. Thus, the listener's affective state and the support giver's social emotion regulation strategy selection likely both shape the support giver's vocal modulation. Thus, it is important for future research to examine pitch and other acoustic features in different social support contexts to establish a more comprehensive view of the acoustic features of social emotion regulation processes.

There are many factors in addition to pitch that contribute to social emotion regulation efficacy, including verbal content (e.g., the perspective offered), the emotional context (e.g., the intensity and type of emotional stimuli), and individual preferences (e.g., the type of support people prefer to receive) that would be informative to examine in conjunction with acoustic variability (Sahi et al., 2022). The present studies controlled for many of these factors, for example by scripting the content of the reappraisals across dyads, and restricting feedback to audio recordings (i.e., no visual or physical cues such as facial expressions or affective touch) to isolate the effect of acoustic pitch. Future research can build on this work with more naturalistic paradigms

or observational datasets in large samples to help shed light on how different communicative mechanisms work in tandem to regulate listeners' cognitive and affective states.

Finally, age and cultural context have been shown to play important roles in emotional experiences, expression, social relationships, and even acoustic norms, suggesting that there is likely some variability in the role of acoustic features like pitch in regulating others' emotions in different populations (Bryant, 2022; Leipold, Abrams, & Menon, 2022). Our research was conducted in young adult friend pairs — a key developmental period for examining social influences on emotion (Arnett, 2015) — but we may see different effects of pitch on social emotion regulation across the lifespan. Future research in ethnically and linguistically diverse samples can help identify possible effects of factors like identity and cultural norms on vocal expression, and how such features might intersect with gender norms to shape social emotion regulation behavior.

Conclusions & broader implications

Social support is critical for emotional wellbeing, but we still have a limited understanding of how people regulate each other's emotions. In order to unpack the mechanisms and outcomes of social emotion regulation processes, it is critical to assess how different streams of information — including linguistic and paralinguistic cues — contribute to regulatory outcomes. In the present research, we demonstrated a role of support giver's vocal pitch in regulating their friend's emotions during in-lab social emotion regulation tasks, holding constant the content of their verbal communications. Adopting a multimodal approach to studying social emotion regulation processes can improve how we develop therapeutic mechanisms for emotion dysregulation and help improve the quality of social support that we provide and receive in everyday life more broadly. Such fine-grained research on vocal communication in social support contexts has implications for social, developmental, educational, and organizational domains, and can even be applied to improve the

quality of human-computer interactions in an increasingly technological world (Lim & Okuno, 2014). In sum, this work adopts a novel approach to studying social emotion regulation processes, providing insight into how people effectively communicate to support others and highlighting vocal communication as a promising frontier for future socio-affective research.

Figures

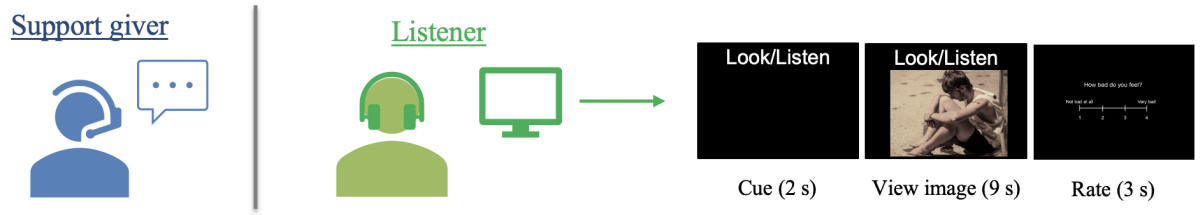


Figure 1. We analyzed the data from social emotion regulation tasks administered in three separate samples in previous work (Sahi, Ninova, & Silvers, 2021; Sahi et al., 2023). The listener in these studies completed a computerized task that began with a 2 s cue to "look" or "listen" followed by an image presentation for 9 s, and a rating screen for 3 s. During the look trials, participants passively viewed negative or neutral images, and during the listen trials they heard their friend — the support giver — reinterpreting the content of the negative image they were viewing to help them regulate their emotional response to it (e.g. "He is resting and will recover"). Our analyses focused on the listen trials of the task. *Note*: The image shown in this figure, taken from the Open Affective Standardized Image Set (Kurdi, Lozano, & Banaji, 2017), is a sample not used in the actual task. Graphics are from Microsoft Powerpoint.

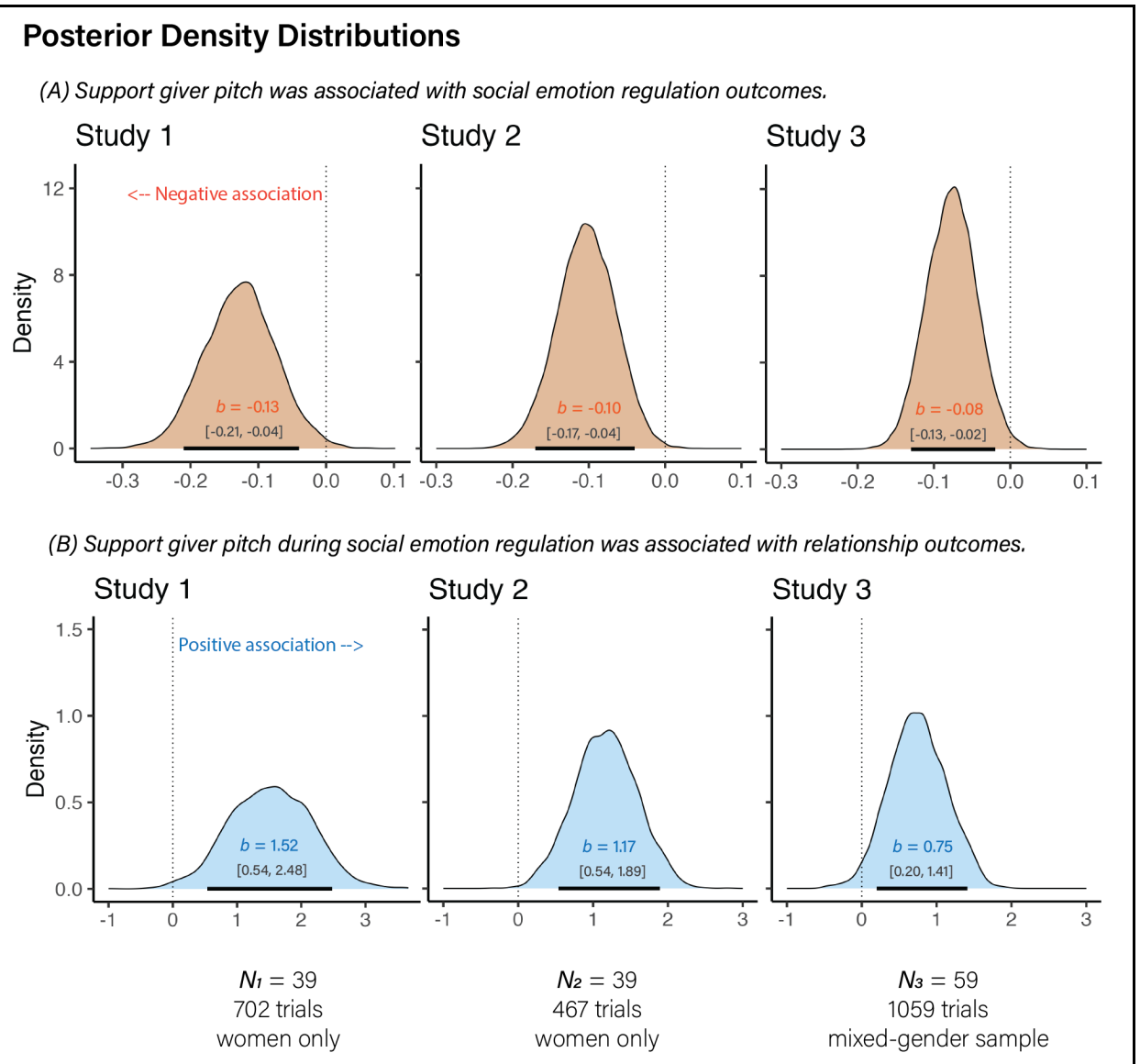


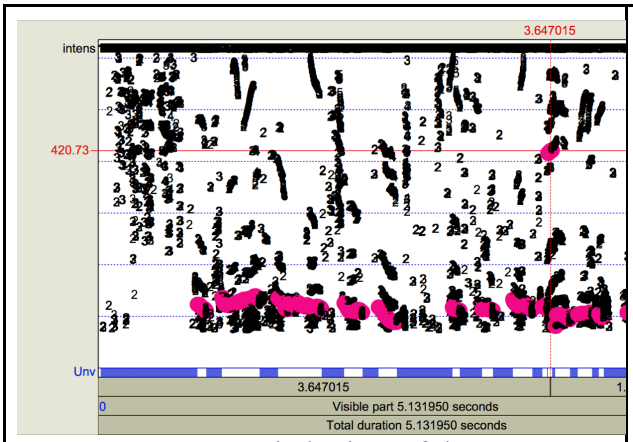
Figure 2. With Bayesian statistics, rather than looking for a significant *p*-value, we can assess the direction and strength of an effect by observing the shape and position of the posterior density distributions, shown above. The black horizontal bars on each plot represent the 89% highest density interval (HDI). **(A)** For the first research question, the HDIs for all three studies are to the left of and non-overlapping with 0, indicating a negative association between support giver pitch and listener negative affect during social emotion regulation. **(B)** For the second question, the HDIs for all three studies are to the right of and non-overlapping with 0, indicating a positive association between support giver pitch during social emotion regulation and listener relationship satisfaction. For both research questions, the HDI becomes narrower with each study, indicating that we have greater certainty in the parameter.

Tables

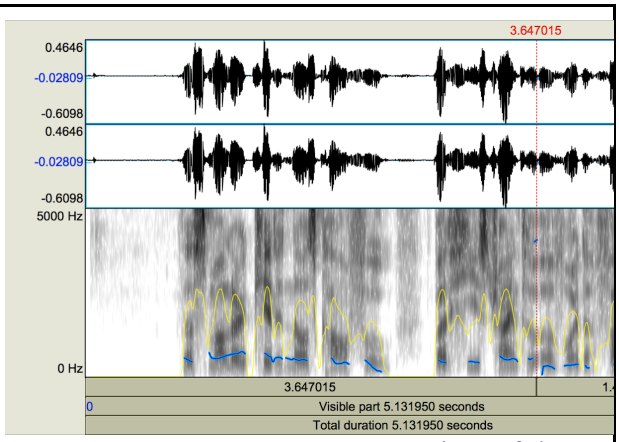
Table 1. Demographic and sample characteristics for each study			
	Study 1	**Study 2**	**Study 3**
Age	*M* = 19.4 (18 - 24)	*M* = 21 (19 - 27)	*M* = 20.83 (18 - 31)
Sex/Gender	Women only	Women only	Gender split
Racial/ethnic groups	55% Asian 24% White 10% Latinx/Hispanic 2% Black 9% Multiracial/another identity	32.5% Asian 27.5% White 25% Latinx/Hispanic 10% Black 5% Multiracial/another identity	53% Asian 13% White 3% Latinx/Hispanic 3% Black 28% Multiracial/another identity
Pitch Range in Semitones	Trial-level: 4 - 22 Person-level: 7.47 - 15.64	Trial-level: 2 - 18 Person-level: 7.98 - 15.33	Trial-level: -2 - 20 Person-level: -0.94 - 14.43
Note. Mean age and age range of the sample are provided for each study. Participants for all three studies were recruited based on their gender identities rather than sex assigned at birth. We provide pitch ranges at the trial-level (mean fundamental frequency values across individual trials) and person-level (mean fundamental frequency values across individual speakers, averaged over trials) in semitones.			

SUPPLEMENTAL MATERIALS

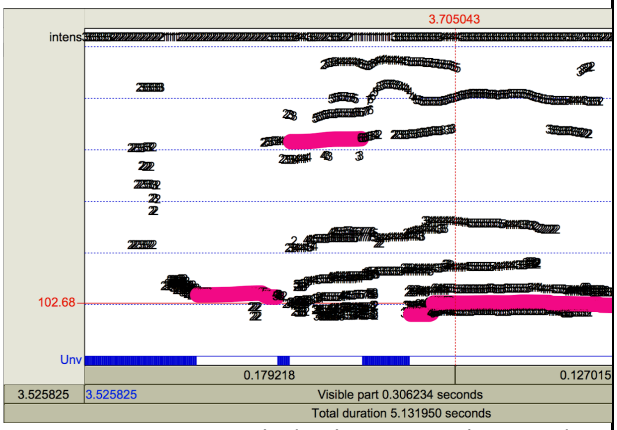
Supplemental Figures



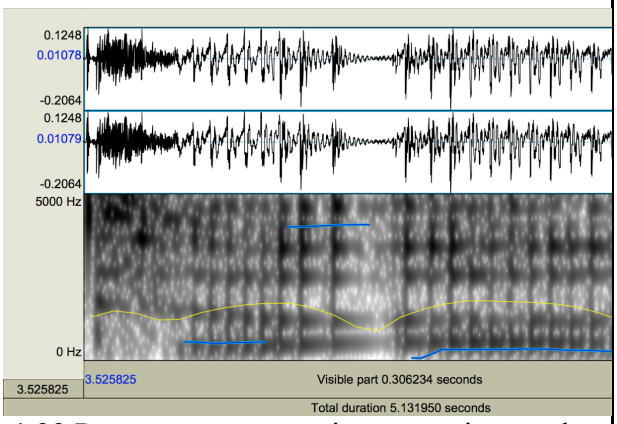
1.1 Praat pitch view of the sentence



1.2 Praat spectrogram view of the sentence

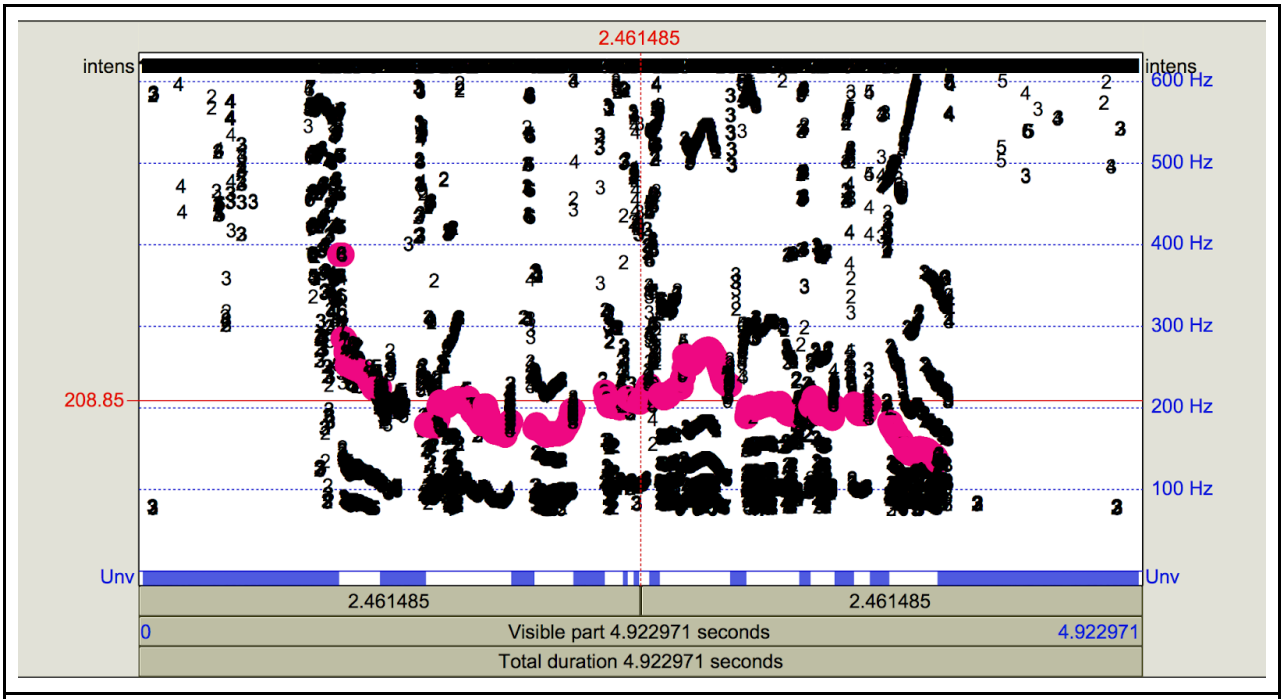


1.12 Praat pitch view centering on the F0 values required inspection and/or correction



1.22 Praat spectrogram view centering on the F0 values required inspection and/or correction

Supplemental Figure 1. Examples of F0 values (between 400Hz-500Hz) in different Praat viewing windows. The pitch points illustrated here are not random noises from the environment and have alternative matches. We use the Praat function "octave down" two times (x2) to bring the values back to the normal range. In this recording, the speaker (*male*) was saying "*the smaller kid knows kung fu but he's trying to avoid a fight* ".



Supplemental Figure 2. An example of removed F0 values (between 300Hz-400Hz) in the Praat window. The pitch points illustrated here are positioned in the beginning of a utterance - they are artifacts of breathing and do not contain meaningful pitch value. In this recording, the speaker (*female*) was saying "*she is doubting herself, but her brother is there to help her through it*".

Supplemental Tables

Supplemental Table 1. Sample sizes after audio data cleaning procedure

	Study 1	**Study 2**	**Study 3**	**Study 3 - Women**	**Study 3 - Men**
Original datasets	$N_1 = 40$ 18 trials each	$N_2 = 40$ 12 trials each	$N_3 = 60$ 18 trials each	$N_{3\text{-}W} = 30$ 18 trials each	$N_{3\text{-}M} = 30$ 18 trials each
After audio cleaning	$N_1 = 39$ 702 trials total	$N_2 = 39$ 467 trials total	$N_3 = 59$ 1059 trials total	$N_{3\text{-}W} = 29$ 522 trials total	$N_{3\text{-}M} = 30$ 537 trials total

Note. In each study, 1 dyad was lost due to incorrect data storage or unusable audio data files. In studies 2 and 3, 1 trial each was removed during data cleaning because these files could not be processed (i.e., no pitch value). Note: there were a few missing trials in the original datasets, such that most but not all dyads had 12-18 trials each.

Supplemental Table 2: Association between average support giver pitch and listener relationship satisfaction broken down by subscales

IPPA Subscale	Study 1	Study 2	Study 3
Trust	$r_{pitch,t\|c,a}$ = -0.11	$r_{pitch,t\|c,a}$ = -0.02	$r_{pitch,t\|c,a}$ = 0.20 Women: 0.25 Men: 0.26
Communication	$r_{pitch,c\|t,a}$ = 0.33	$r_{pitch,c\|t,a}$ = 0.28	$r_{pitch,c\|t,a}$ = 0.03 Women: -0.52 Men: -0.37
Alienation	$r_{pitch,a\|t,c}$ = 0.12	$r_{pitch,a\|t,c}$ = -0.10	$r_{pitch,a\|t,c}$ = -0.11 Women: 0.03 Men: 0.07

Note. We ran semi-partial correlation tests to see which subscale of the Inventory of Peer Attachment (IPPA) might be driving the association between support giver pitch and listener relationship satisfaction. We were not looking for significant associations here, but simply wanted to compare the magnitude and direction of correlation values for each subscale, reported above. In studies 1 and 2, speaker pitch had the strongest association with the communication subscale of the IPPA, after accounting for the association between pitch and the other IPPA subscales. In study 3, however, speaker pitch had the strongest association with the trust subscale of the IPPA, after accounting for the association between pitch and the other IPPA subscales. We ran the semi-partial correlation tests in Study 3 separately for men and women as well. To aid in interpreting these results, please note that men had lower relationship satisfaction on average than women, r = -0.52, p < .001.

Supplemental Table 3: Sensitivity analysis for association between support giver pitch and social emotion regulation outcomes.

Prior	Parameter estimate	89% HDI
Study 1		
flat prior	*b* = -0.13, SD = 0.05	[-0.21, -0.04]
normal(0, 0.33)	***b* = -0.13, SD = 0.05**	**[-0.21, -0.04]**
normal(0, 0.25)	*b* = -0.12, SD = 0.05	[-0.21, -0.04]
Study 2		
normal(-0.13, 0.05)	***b* = -0.10, SD = 0.04**	**[-0.17, -0.04]**
normal(-0.13, 0.10)	*b* = -0.08, SD = 0.05	[-0.17, 0.00]
Study 3		
normal(-0.10, 0.04)	***b* = -0.08, SD = 0.03**	**[-0.13, -0.02]**
normal(-0.10, 0.08)	*b* = -0.05, SD = 0.05	[-0.13, 0.02]

Note. When using a weakly informative prior in study 1 and subsequently using strong priors in studies 2 and 3 (rows flagged in yellow), we found accumulating evidence for a positive association between support giver pitch and listener negative affect during the task in women. Our results across these three studies were gradually more sensitive to the prior, such that the prior made no difference in the results in study 1 (i.e., parameter estimates and HDIs were consistent), made some difference in the results in study 2 (i.e., parameter estimate shrunk and HDI contained zero), and made a more notable difference in the results in study 3 (i.e., parameter estimate shrunk in magnitude and HDI crossed zero). *Note*: Study 3 was the only model of the three that contained additional predictors (i.e., gender and an interaction term).

Supplemental Table 4: Sensitivity analysis for association between average support giver pitch and relationship outcomes.

Prior	Parameter estimate	89% HDI
Study 1		
flat prior	*b* = 1.61, SD = 0.66	[0.58, 2.64]
normal(0, 3)	***b* = 1.52, SD = 0.63**	**[0.54, 2.48]**
normal(0, 2)	*b* = 1.44, SD = 0.62	[0.43, 2.37]
Study 2		
normal(1.52, 0.63)	***b* = 1.17, SD = 0.42**	**[0.54, 1.89]**
normal(1.52, 1.26)	*b* = 0.97, SD = 0.53	[0.16, 1.84]
Study 3		
normal(1.17, 0.42)	***b* = 0.75, SD = 0.38**	**[0.20, 1.41]**
normal(1.17, 0.84)	*b* = 0.04, SD = 0.62	[-0.94, 1.06]

Note. When using a weakly informative prior in study 1 and subsequently using strong priors in studies 2 and 3 (rows flagged in yellow), we found accumulating evidence for a positive association between average support giver pitch during social emotion regulation and listener relationship satisfaction in women. Our results across these three studies were gradually more sensitive to the prior, such that the prior made little difference in the results in study 1 (i.e., parameter estimates and HDIs were consistent), made some difference in the results in study 2 (i.e., parameter estimate shrunk but HDI relatively consistent), and made a big difference in the results in study 3 (i.e., parameter estimates changed drastically and HDIs shifted). *Note*: Study 3 was the only model of the three that contained additional predictors (i.e., gender and an interaction term).

DISCUSSION

Decades of research have shown how important social support is for our health and wellbeing, often buffering us against the harmful effects of physical and mental health challenges (Beckes & Coan, 2011; Berkman et al., 2000; Uchino et al., 2018). While it's clear that social support influences emotion regulation processes – or how people manage their emotional experiences – we have limited knowledge about how our interactions with close others can regulate the way that we think and feel through life's challenges (Niven, 2017; Reeck et al., 2016; Zaki & Williams, 2013). This dissertation zooms in on the intersection between social support and emotion regulation, a process we describe as "social emotion regulation" (Sahi, Ninova, & Silvers, 2021; Sahi, et al., 2022; Sahi et al., under review; Sahi, Eisenberger, & Silvers, in revision). In other words, how do people lend a hand in regulating our emotions? What are the mechanisms involved in social emotion regulation, and how do the outcomes of social emotion regulation compare to regulating on one's own?

Extensive work has examined the mechanisms and outcomes of cognitive reappraisal, an emotion regulation strategy that involves changing how one thinks to change how they feel about emotional stimuli. Such work has found that cognitive reappraisal is effective, enduring, and can be trained through practice, making it a good target for developing emotion dysregulation interventions (Gross, 2015; Ochsner et al., 2012; Denny, 2020). In daily life, we often get help changing how we think from the people around us, but limited research has examined how reappraisal unfolds in a social context. We developed a novel social emotion regulation paradigm building on existing cognitive reappraisal paradigms to compare how people regulate on their own versus with help from a friend. This paradigm involved listening to a friend reinterpret the content of negative images to help down-regulate negative affect during the task. We conducted four

studies using iterations of this paradigm to begin uncovering the mechanisms and outcomes of social emotion regulation.

Summary of findings

In Paper 1, we examined how regulating alone (i.e., using reappraisal independently to change one's emotional response) compared to regulating with help from a friend (i.e., listening to a friend reappraise stimuli to help change one's response). We found that regulating with help from a friend was more effective than regulating on one's own. We additionally tested alternate explanations for our findings, and ruled out the possibility that social emotion regulation was more effective than regulating on one's own due to a difference in the quality of reinterpretations, or due to a mere buffering effect. In sum, we found that social help selectively potentiated the efficacy of emotion regulation in friend pairs. Together, these results provide insight into how social relationships can directly lend a hand in implementing emotion regulation strategies: getting a friend's perspective when trying to rethink a negative event is more powerful than rethinking it on your own (Sahi, Ninova, & Silvers, 2021).

These results highlight social support as a potential pathway for ameliorating emotion dysregulation, especially in populations that struggle to implement cognitive emotion regulation strategies like reappraisal. However, there were two important open questions to clarify and extend these results. First, it is possible that getting help from others to regulate emotions might create an over-dependence in regulation processes, such that the effects of social emotion regulation are limited to when a social support figure is available to help. This suggestion is in line with existing work demonstrating that parents who engage in overzealous attempts to downregulate their children's emotions (i.e., "accommodation") can unintentionally exacerbate their children's anxiety (Norman, Silverman, & Lebowitz, 2015). Second, thus far we examined these processes

in women only, leaving open the possibility that gender differences in emotions and social relationships could impact social emotion regulation outcomes (Shields, 2002).

Thus, Paper 2 replicated the methods from Paper 1 in a mixed-gender sample with the addition of a follow-up study administered from home around one day after the in-lab tasks. In the follow-up task, participants passively viewed the stimuli from the in-lab tasks again and rated them. We found that participants responded less negatively to aversive images that were socially regulated (i.e., reappraised with the help of a friend) both immediately and over time, as compared to images that had been previously solo regulated (i.e., reappraised on one's own) or not regulated (i.e., passively viewed). Interestingly, while social emotion regulation effectively down-regulated negative affect in women and men, the regulatory boost from social support observed both in the lab and at follow-up was driven by women dyads. These findings build on prior theoretical and empirical work on the regulatory roles of close relationships, including attachment research suggesting that representations of attachment figures can become internalized over time to support emotion regulation processes (Mikulincer & Shaver, 2019). This work demonstrates that interactions with close others can help prepare people to cope with future exposure to those events on their own, underscoring how valuable others' perspectives can be when navigating ongoing emotional stressors (Sahi et al., 2023).

Across studies, participants only heard their friend's voice over headphones during the task, controlling for visual (e.g., facial expressions) and sensory (e.g., physical touch) cues that likely contribute to social emotion regulation processes. We additionally controlled for the content of what support givers said across dyads by scripting the reinterpretations of the images. However, we encouraged participants to speak in any way that would be helpful to their friends while offering social regulatory support. Thus, support givers varied in how they delivered the reinterpretations,

prompting us to investigate how acoustic features of vocal communication impacted social emotion regulation outcomes. In Paper 3, we used a Bayesian statistics approach to examine this question in three existing datasets from Papers 1 and 2 and found cumulative evidence that higher support giver pitch was associated with lower negative affect in the friend during the task, as well as evidence that higher support giver pitch during social emotion regulation was associated with how positively the friend viewed their relationship with the support giver more generally. Preliminary results looking at gender differences indicated that higher support giver pitch may not be beneficial in men dyads. This research demonstrates how "tone of voice" contributes to regulating others' emotions, highlighting the acoustic features of verbal communication as a promising frontier for future multidimensional socio-affective research aimed at improving social emotion regulation processes.

Implications and future directions

Collectively, these three papers shed light on *how* we help others regulate their emotions. We show that getting support in regulating emotions can be more effective than regulating on one's own, and that such support can linger when we're alone to facilitate self-regulation processes. We show that auditory signals like vocal pitch can facilitate social emotion regulation and relationship satisfaction. Consistent gender differences in these findings demonstrate the importance of assessing the role of relationship expectations and emotion socialization in social emotion regulation mechanisms. Relatedly, it will be important for future research to consider individual differences in social support preferences. In separate research, we found evidence that variability in how people choose to provide social support to others shapes how they feel receiving different types of support (Sahi et al., 2022). Thus, future research unpacking why individuals

respond differently to social regulatory support will be critical in understanding how this process works, and what drives its efficacy in different circumstances.

A critical future direction for this line of research is to consider other social emotion regulation contexts. In these studies, we looked at a single emotion regulation strategy (i.e., social reappraisal) using a controlled paradigm (i.e., reinterpretation-style reappraisal of impersonal stimuli) in friend pairs. In Paper 1, we showed that reappraising with help from a stranger was more effective than not regulating at all, but we have yet to compare reappraising with help from a stranger to reappraising with help from a friend, leaving open the question of how relationship type affects social emotion regulation outcomes. Some work has shown that when receiving support from a stranger about autobiographical stressors, people prefer to be validated than to receive reappraisal support (Sahi et al., 2022), since validation tends to offer more immediate relief than reappraisal (Nils & Rimé, 2012b). Such work demonstrates how the nature of emotional stimuli, relationship between the support giver and receiver, and regulatory goals can impact the outcomes of social emotion regulation and the relative efficacy of different support strategies. Thus, future research can compare different social regulatory strategies across a variety of emotional and relationship contexts.

It is also important to consider limitations on the generalizability of our samples. Young adulthood presents a ripe developmental period for examining social influences, particularly from friendships, on emotion (Arnett, 2015). Future research can examine other age groups to assess how social emotion regulation mechanisms might change across the lifespan. We are currently conducting research using functional magnetic resonance imaging in adolescents and young adult friend pairs to start probing the developmental mechanisms possibly contributing to social emotion regulation processes from a neural and behavioral perspective. Additionally, although we assessed

gender differences between same-gender dyads, we did not assess mixed-gender dyads or non-binary individuals, which may allow us to further tease apart whether our gender effects could be driven by the gender of the support-giver or support-receiver, or other relationship dynamics. Our samples were predominantly from two racial/ethnic groups on a college campus: Asian and White (53% and 13%, respectively; 66% total). Future research in diverse samples can help identify possible effects of factors like identity, cultural norms, or socioeconomic status.

Emotion regulation is a critical ingredient for health, well-being, and social functioning. However, the vast majority of research on emotion regulation has examined it in a social vacuum, despite the fact that in everyday life individuals frequently regulate their emotions with help from other people. The present collection of studies sought to compare the efficacy of a paradigmatic emotion regulation strategy, cognitive reappraisal, across intrapersonal and interpersonal contexts. In doing so, we aimed to build on (a) theoretical frameworks suggesting that emotion regulation strategies are implemented and effective across such contexts, and (b) empirical research suggesting that social relationships can play an important role in supporting emotion regulation processes through social buffering (e.g., "mere presence" effects) and social scaffolding (e.g., emotion modeling or explicit instructions to regulate). This dissertation sheds light on the mechanisms and outcomes of social emotion regulation processes and illuminates several avenues for future research to unpack the cognitive, neural, developmental, and acoustic mechanisms involved in effective social regulatory support. This line of research is highly informative across domains of psychology, education, and organizations, with implications for the development of human-computer interactions. Ultimately, this work promotes greater collective social and emotional wellbeing through enhanced emotional intelligence in how we understand ourselves, each other, and the bonds between us.

REFERENCES

Apple, W., Streeter, L. A., & Krauss, R. M. (1979). Effects of pitch and speech rate on personal attributions. *Journal of personality and social psychology, 37*(5), 715.

Albin, A. (2014). PraatR: An architecture for controlling the phonetics software "Praat" with the R programming language. *Journal of the Acoustical Society of America, 135*(4), 2198.

Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review*, Vol. 30, pp. 217–237. https://doi.org/10.1016/j.cpr.2009.11.004

Armsden, G. C., & Greenberg, M. T. (1987). The inventory of parent and peer attachment: Individual differences and their relationship to psychological well-being in adolescence. *Journal of Youth and Adolescence*, *16*(5), 427–454. https://doi.org/10.1007/BF02202939

Arnett, J. J. (2015). Emerging Adulthood: The Winding Road from the Late Teens through the Twenties. In *Emerging Adulthood: The Winding Road from the Late Teens through the Twenties*. https://doi.org/10.1093/acprof:oso/9780195309379.001.0001

Aung, T., & Puts, D. (2020). Voice pitch: a window into the communication of social power. *Current opinion in psychology*, *33*, 154-161.

Ayduk, Ö., & Kross, E. (2010). From a Distance: Implications of Spontaneous Self-Distancing for Adaptive Self-Reflection. *Journal of Personality and Social Psychology*, *98*(5), 809–829. https://doi.org/10.1037/a0019205

Barsties, B., Verfaillie, R., Roy, N., & Maryn, Y. (2013). Do body mass index and fat volume influence vocal quality, phonatory range, and aerodynamics in females?. *CoDAS, 25*(4), 310–318. https://doi.org/10.1590/s2317-17822013000400003

Beck, A., Emery, G., & Greenberg, R. (2005). *Anxiety disorders and phoblas: A cognitive*

perspective. Basic Books.

Beck, A. T., Steer, R. A., & Carbin, M. G. (1988). Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. *Clinical Psychology Review*, *8*(1), 77–100. https://doi.org/10.1016/0272-7358(88)90050-5

Beckes, L., & Coan, J. A. (2011). Social baseline theory: The role of social proximity in emotion and economy of action. *Social and Personality Psychology Compass*, *5*(12), 976–988. https://doi.org/10.1111/j.1751-9004.2011.00400.x

Berkman, L. F., Glass, T., Brissette, I., & Seeman, T. E. (2000). From social integration to health: Durkheim in the new millennium. *Social Science and Medicine*, *51*(6), 843–857. https://doi.org/10.1016/S0277-9536(00)00065-4

Bernstein, D. P., Stein, J. A., Newcomb, M. D., Walker, E., Pogge, D., Ahluvalia, T., … Zule, W. (2003). Development and validation of a brief screening version of the Childhood Trauma Questionnaire. *Child Abuse and Neglect*, *27*(2), 169–190. https://doi.org/10.1016/S0145-2134(02)00541-0

Boersma, P. (1993). Accurate short-term analysis of the fundamental frequency and the harmonics-to-noise ratio of a sampled sound. *Proceedings of the Institute of Phonetic Sciences, 17*: 97–110. University of Amsterdam. https://www.fon.hum.uva.nl/archive/1993/Proc17Boersma.pdf

Boersma, P. & Weenink, D. (2020). Praat: doing phonetics by computer (6.1.16) [Computer program]. https://www.fon.hum.uva.nl/praat/

Bombar, M. L., & Littig Jr, L. W. (1996). Babytalk as a communication of intimate attachment: An initial study in adult romances and friendships. Personal Relationships, 3(2), 137-158.

Bowlby, J. A. (2002). *Secure Bases: Parent-Child Attachment and Healthy Human Development*.

Basic Books.

Bradley, M. M., Codispoti, M., Sabatinelli, D., & Lang, P. J. (2001). Emotion and Motivation II: Sex Differences in Picture Processing. *Emotion*, *1*(3), 300–319. https://doi.org/10.1037/1528-3542.1.3.300

Brans, K., Van Mechelen, I., Rimé, B., & Verduyn, P. (2014). To share, or not to share? Examining the emotional consequences of social sharing in the case of anger and sadness. *Emotion*, *14*(6), 1062–1071. https://doi.org/10.1037/a0037604

Brewin, C. R., Andrews, B., & Valentine, J. D. (2000). Meta-analysis of risk factors for posttraumatic stress disorder in trauma-exposed adults. *Journal of Consulting and Clinical Psychology*, *68*(5), 748–766. https://doi.org/10.1037/0022-006X.68.5.748

Brody, L. R. (1997). Gender and emotion: Beyond stereotypes. *Journal of Social Issues*, *53*(2), 369–393. https://doi.org/10.1111/j.1540-4560.1997.tb02448.x

Broesch, T., & Bryant, G. A. (2018). Fathers' infant-directed speech in a small-scale society. Child Development, 89(2), e29-e41.

Bryant, G. A. (2021). The evolution of human vocal emotion. Emotion review, 13(1), 25-33.

Bryant, G. A. (2022). Vocal communication across cultures: theoretical and methodological issues. Philosophical Transactions of the Royal Society B, 377(1841), 20200387.

Buhle, J. T., Silvers, J. A., Wage, T. D., Lopez, R., Onyemekwu, C., Kober, H., … Ochsner, K. N. (2014). Cognitive reappraisal of emotion: A meta-analysis of human neuroimaging studies. *Cerebral Cortex*, *24*(11), 2981–2990. https://doi.org/10.1093/cercor/bht154

Cahill, L., Uncapher, M., Kilpatrick, L., Alkire, M. T., & Turner, J. (2004). Sex-related hemispheric lateralization of amygdala function in emotionally influenced memory: An fMRI investigation. *Learning and Memory*, *11*(3), 261–266. https://doi.org/10.1101/lm.70504

Campbell-Sills, L., & Barlow, D. H. (2007). Incorporating emotion regulation into conceptualizations and treatments of anxiety and mood disorders. In *Handbook of emotion regulation.* (Vol. 2, pp. 542–559). https://doi.org/10.1016/0022-4596(78)90152-4

Casillas, A., & Clark, L. A. (2000). The Mini Mood and Anxiety Symptom Questionnaire (Mini-MASQ). *Poster Presented at the 72nd Annual Meeting of the Midwestern Psychological Association*. Chicago, IL.

Chakrabartty, S. (2013). Best Split-Half and Maximum Reliability. *IOSR Journal of Research & Method in Education (IOSRJRME)*, *3*(1), 01–08. https://doi.org/10.9790/7388-0310108

Champely, S. (2020). *pwr: Basic Functions for Power Analysis*.

Charlton, B. D., Reby, D., & McComb, K. (2007). Female perception of size-related formant shifts in red deer, Cervus elaphus. *Animal Behaviour, 74*(4), 707-714.

Charlton, B. D., Whisson, D. A., & Reby, D. (2013). Free-ranging male koalas use Size-related variation in formant frequencies to assess rival males. PLoS One, 8(7), e70279.

Chow, I., & Brown, S. (2018). A musical approach to speech melody. *Frontiers in Psychology*, *9*, 247.

Coan, J., Schaefer, H., & Davidson, R. (2006). Lending a hand of the neural response to threat. *Psychological Science*, *17*(12), 1032–1039. https://doi.org/10.1111/j.1467-9280.2006.01832.x

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. In *Journal of Health and Social Behavior*. Retrieved from www.mindgarden.com

Cox, C., Bergmann, C., Fowler, E., Keren-Portnoy, T., Roepstorff, A., Bryant, G., & Fusaroli, R. (2022). A systematic review and Bayesian meta-analysis of the acoustic features of infant-directed speech. Nature Human Behaviour, 1-20.

Crowne, D. P., & Marlowe, D. (1960). A new scale of social desirability independent of psychopathology. *Journal of Consulting Psychology*, *24*(4), 349–354. https://doi.org/10.1037/h0047358

Cutrona, C. E., & Russell, D. W. (1987). The provisions of social relationships and adaptation to stress. *Advances in Personal Relationships*, Vol. 1, pp. 37-67. Retrieved from https://www.researchgate.net/publication/271507385

Davis, M. H. (1983). A mulitdimensional approach to individual differences in empathy. *Journal of Personality and Social Psychology*, *44*(1), 113–126. https://doi.org/10.1037/0022-3514.44.1.113

Denny, B. T. (2020). Getting better over time: A framework for examining the impact of emotion regulation training. *Emotion*, *20*(1), 110–114. https://doi.org/10.1037/emo0000641

Denny, B. T., Inhoff, M. C., Zerubavel, N., Davachi, L., & Ochsner, K. N. (2015). Getting over it: Long-lasting effects of emotion regulation on amygdala response. *Psychological Science*, *26*(9), 1377–1388. https://doi.org/10.1177/0956797615578863

Dimidjian, S., & Davis, K. J. (2009). Newer Variations of Cognitive-Behavioral Therapy: Behavioral Activation and Mindfulness-based Cognitive Therapy. *Current Psychiatry Reports*, *11*, 453–458.

Domitrovich, C. E., Greenberg, M. T., Cortes, R., & Kusche, C. A. (2005). *The Preschool PATHS Curriculum*.

Doré, B. P., Morris, R. R., Burr, D. A., Picard, R. W., & Ochsner, K. N. (2017). Helping others regulate emotion predicts increased regulation of one's own emotions and decreased symptoms of depression. *Personality and Social Psychology Bulletin*, *43*(5), 729–739. https://doi.org/10.1177/0146167217695558

Duck, S., & Wright, P. H. (1993). Reexamining gender differences in same-gender friendships: A close look at two kinds of data. *Sex Roles*, *28*(11–12), 709–727. https://doi.org/10.1007/BF00289989

Echterhoff, G., Higgins, E. T., & Levine, J. M. (2009). Shared Reality: Experiencing Commonality with others' Inner States about the World. *Perspectives on Psychological Science*, *4*(5), 496–521. https://doi.org/10.1111/j.1745-6924.2009.01161.x

Eisenberg, N., Hofer, C., Sulik, M. J., & Spinrad, T. L. (2014). Self-regulation, effortful control, and their socioemotional correlates. In *Handbook of emotion regulation* (pp. 157–172). Retrieved from https://psycnet.apa.org/record/2013-44085-010

Eisenberger, N. I., Master, S. L., Inagaki, T. K., Taylor, S. E., Shirinyan, D., Lieberman, M. D., & Naliboff, B. D. (2011). Attachment figures activate a safety signal-related neural region and reduce pain experience. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(28), 11721–11726. https://doi.org/10.1073/pnas.1108239108

English, T., Lee, I. A., John, O. P., & Gross, J. J. (2017). Emotion regulation strategy selection in daily life: The role of social context and goals. *Motivation and Emotion*, *41*(2), 230–242. https://doi.org/10.1007/s11031-016-9597-z

Erk, S., Mikschl, A., Stier, S., Ciaramidaro, A., Gapp, V., Weber, B., & Walter, H. (2010). Acute and sustained effects of cognitive emotion regulation in major depression. *Journal of Neuroscience*, *30*(47), 15726–15734. https://doi.org/10.1523/JNEUROSCI.1856-10.2010

Eysenck, H. (1968). Eysenck personality inventory. *San Diego: Educational and Industrial Testing Service.* Retrieved from https://pdfs.semanticscholar.org/5d0d/6989c00196692690507114dea8d1a4704505.pdf

FeldmanHall, O., Montez, D. F., Phelps, E. A., Davachi, L., & Murty, V. P. (2021). Hippocampus

guides adaptive learning during dynamic social interactions. *Journal of Neuroscience*, *41*(6), 1340–1348. https://doi.org/10.1523/JNEUROSCI.0873-20.2020

Felmlee, D., Sweet, E., & Sinclair, H. C. (2012). Gender Rules: Same- and Cross-Gender Friendships Norms. *Sex Roles*, *66*(7–8), 518–529. https://doi.org/10.1007/s11199-011-0109-z

Fernald, A., Taeschner, T., Dunn, J., Papousek, M., de Boysson-Bardies, B., & Fukui, I. (1989). A cross-language study of prosodic modifications in mothers' and fathers' speech to preverbal infants. Journal of child language, 16(3), 477-501.

Fox, M., Gibbs, M., & Auerbach, D. (1985). Age and gender dimensions of friendship. *Psychology of Women Quarterly*, *9*(4), 489–502. https://doi.org/10.1111/J.1471-6402.1985.TB00898.X

Friesen, A. P., Lane, A. M., Devonport, T. J., Sellars, C. N., Stanley, D. N., & Beedie, C. J. (2013, September). Emotion in sport: Considering interpersonal regulation strategies. *International Review of Sport and Exercise Psychology*, Vol. 6, pp. 139–154. Routledge. https://doi.org/10.1080/1750984X.2012.742921

Garrido-Vásquez, P., Pell, M. D., Paulmann, S., & Kotz, S. A. (2018). Dynamic facial expressions prime the processing of emotional pros- ody. Frontiers in Human Neuroscience, 12. https://doi.org/10.3389/ fnhum.2018.00244

Gee, D. G., Gabard-Durnam, L., Telzer, E. H., Humphreys, K. L., Goff, B., Shapiro, M., … Tottenham, N. (2014). Maternal buffering of human amygdala-prefrontal circuitry during childhood but not during adolescence. *Psychological Science*, *25*(11), 2067–2078. https://doi.org/10.1177/0956797614550878

Gerhard, D. (2003). *Pitch extraction and fundamental frequency: History and current techniques* (pp. 0-22). Regina, SK, Canada: Department of Computer Science, University of Regina.

Goldin, P. R., & Gross, J. J. (2010). Effects of mindfulness-based stress reduction (MBSR) on emotion regulation in social anxiety disorder. *Emotion*, *10*(1), 83–91. https://doi.org/10.1037/a0018441

Goodrich B, Gabry J, Ali I & Brilleman S. (2020). rstanarm: Bayesian applied regression modeling via Stan. R package version 2.21.1 https://mc-stan.org/rstanarm.

Grieser, D. L., & Kuhl, P. K. (1988). Maternal speech to infants in a tonal language: Support for universal prosodic features in motherese. *Developmental Psychology, 24*(1), 14–20. https://doi.org/10.1037/0012-1649.24.1.14

Gross, J. J. (1998a). Sharpening the Focus: Emotion Regulation, Arousal, and Social Competence. *Psychological Inquiry*, *9*(4), 287–290. https://doi.org/10.1207/s15327965pli0904_8

Gross, J. J. (1998b). The emerging field of emotion regulation: An integrative review. *Review of General Psychology*, Vol. 2, pp. 271–299. https://doi.org/10.1037/1089-2680.2.3.271

Gross, J. J. (2015). Emotion Regulation: Current Status and Future Prospects. *Http://Dx.Doi.Org/10.1080/1047840X.2014.940781*, *26*(1), 1–26. https://doi.org/10.1080/1047840X.2014.940781

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348–362. https://doi.org/10.1037/0022-3514.85.2.348

Gross, J. J., Richards, J. M., & John, O. P. (2006). Emotion Regulation in Everyday Life. In *Emotion regulation in couples and families: Pathways to dysfunction and health.* (pp. 13–35). https://doi.org/10.1037/11468-001

Grossmann, I., & Kross, E. (2010). The Impact of Culture on Adaptive Versus Maladaptive Self-Reflection. *Psychological Science*, *21*(8), 1150–1157.

https://doi.org/10.1177/0956797610376655

Guassi Moreira, J. F., Tashjian, S. M., Galván, A., & Silvers, J. A. (2018). Parents Versus Peers: Assessing the Impact of Social Agents on Decision Making in Young Adults. *Psychological Science*, *29*(9), 1526–1539. https://doi.org/10.1177/0956797618778497

Guimond, S., Chatard, A., Martinot, D., Crisp, R. J., & Redersdorff, S. (2006). Social comparison, self-stereotyping, and gender differences in self-construals. *Journal of Personality and Social Psychology*, *90*(2), 221–242. https://doi.org/10.1037/0022-3514.90.2.221

Hartmann, W. M., & Hartmann, W. M. (2013). Pitch (pp. 137-144). Springer New York.

Hazan, C., & Shaver, P. (1987). Romantic love conceptualized as an attachment process. *Journal of Personality and Social Psychology*, *52*(3), 511–524. https://doi.org/10.1037/0022-3514.52.3.511

Hellermann, J. (2003). The interactive work of pro*sody in the IRF exchange: Teacher repetition in feedback moves.* Language in Society, 32(1), 79-104. doi:10.1017/S0047404503321049

Hughes, S.M. et al. (2014) The perception and parameters of intentional voice manipulation. J. Nonverbal Behav. 38, 107–127

Hunter, E. J., & Titze, I. R. (2010). Variations in intensity, fundamental frequency, and voicing for teachers in occupational versus nonoccupational settings. *Journal of speech, language, and hearing research: JSLHR, 53*(4), 862–875. https://doi.org/10.1044/1092-4388(2009/09-0040)

Inagaki, T. K., & Eisenberger, N. I. (2012). Neural correlates of giving support to a loved one. *Psychosomatic Medicine*, *74*(1), 3–7. https://doi.org/10.1097/PSY.0b013e3182359335

Kawachi, I., & Berkman, L. F. (2001). Social Ties and Mental Health. In *Journal of Urban Health: Bulletin of the New York Academy of Medicine* (Vol. 78).

Kamiloğlu, R. G., Fischer, A. H., & Sauter, D. A. (2020). Good vibrations: A review of vocal expressions of positive emotions. Psychonomic bulletin & review, 27, 237-265.

Karpf, A. (2006). The human voice: How this extraordinary instrument reveals essential clues about who we are. Bloomsbury Publishing USA.

Kelly, M. M., Tyrka, A. R., Anderson, G. M., Price, L. H., & Carpenter, L. L. (2008). Sex differences in emotional and physiological responses to the Trier Social Stress Test. *Journal of Behavior Therapy and Experimental Psychiatry*, *39*(1), 87–98. https://doi.org/10.1016/j.jbtep.2007.02.003

Keltner, D., & Haidt, J. (1999). Social functions of emotions at four levels of analysis. *Cognition and Emotion*, *13*(5), 505–521. https://doi.org/10.1080/026999399379168

Kilpatrick, D. G., Koenen, K. C., Ruggiero, K. J., Acierno, R., Galea, S., Resnick, H. S., … Gelernter, J. (2007). The serotonin transporter genotype and social support and moderation of posttraumatic stress disorder and depression in hurricane-exposed adults. *American Journal of Psychiatry*, *164*(11), 1693–1699. https://doi.org/10.1176/appi.ajp.2007.06122007

Klatt, D. H., & Klatt, L. C. (1990). Analysis, synthesis, and perception of voice quality variations among female and male talkers. *The Journal of the Acoustical Society of America*, *87*(2), 820–857. https://doi.org/10.1121/1.398894

Kovacs, M., & Lopez-Duran, N. L. (2012, April). Contextual emotion regulation therapy: A developmentally based intervention for pediatric depression. *Child and Adolescent Psychiatric Clinics of North America*, Vol. 21, pp. 327–343. NIH Public Access. https://doi.org/10.1016/j.chc.2012.01.002

Kreiman, J., & Sidtis, D. (2011). Foundations of voice studies: An interdisciplinary approach to voice production and perception. Hoboken: Wiley-Blackwell. Retrieved from http://eu.wiley.com/WileyCDA/WileyTitle/productCd-0631222979.html

Kross, E., Ayduk, O., & Mischel, W. (2005). When asking "why" does not hurt: Distinguishing rumination from reflective processing of negative emotions. *Psychological Science*, *16*(9), 709–715. https://doi.org/10.1111/j.1467-9280.2005.01600.x

Kross, E., & Grossmann, I. (2012). Boosting wisdom: Distance from the self enhances wise reasoning, attitudes, and behavior. *Journal of Experimental Psychology: General*, *141*(1), 43–48. https://doi.org/10.1037/a0024158

Kruschke, J. (2014). Doing Bayesian data analysis: A tutorial with R, JAGS, and Stan. Academic Press.

Kurdi, B., Lozano, S., & Banaji, M. R. (2017). Introducing the Open Affective Standardized Image Set (OASIS). *Behavior Research Methods*, *49*(2), 457–470. https://doi.org/10.3758/s13428-016-0715-3

Lakens, Daniel. (2017). Equivalence Testing With TOSTER – Association for Psychological Science – APS. Retrieved August 13, 2020, from https://www.psychologicalscience.org/observer/equivalence-testing-with-toster

Lakens, Daniël, McLatchie, N., Isager, P. M., Scheel, A. M., & Dienes, Z. (2020). Improving Inferences about Null Effects with Bayes Factors and Equivalence Tests. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences*, *75*(1), 45–57. https://doi.org/10.1093/geronb/gby065

Lang, P., Bradley, M., & Cuthbert, B. (2008). *International affective picture system (IAPS): affective ratings of pictures and instruction manual. University of Florida, Gainesville*.

Lehr, C. A., Tan, C. S., & Ysseldyke, J. (2009). Alternative schools: A synthesis of state-level policy and research. Remedial and Special Education, 30(1), 19-32.

Leipold, S., Abrams, D. A., & Menon, V. (2022). Mothers adapt their voice during children's adolescent development. Scientific Reports, 12(1), 951.

Lieberman, M. D., & Eisenberger, N. I. (2009, February 13). Pains and pleasures of social life. *Science*, Vol. 323, pp. 890–891. American Association for the Advancement of Science. https://doi.org/10.1126/science.1170008

Lim, A., & Okuno, H. G. (2015). A recipe for empathy: Integrating the mirror system, insula, somatosensory cortex and motherese. International Journal of Social Robotics, 7, 35-49.

Liu, T., Pinheiro, A. P., Deng, G., Nestor, P. G., McCarley, R. W., & Nizni- kiewicz, M. A. (2012). Electrophysiological insights into processing nonverbal emotional vocalizations. Neuroreport, 23, 108–112.

Liuni, M., Ponsot, E., Bryant, G. A., & Aucouturier, J. J. (2020). Sound context modulates perceived vocal emotion. Behavioural processes, 172, 104042.

Lord, F. M., & Novick, M. R. (1968). *Statistical theories of mental test scores*. Reading MA : Addison-Welsley Publishing Company [13].

MacNamara, A., Ochsner, K. N., & Hajcak, G. (2011). Previously reappraised: The lasting effect of description type on picture-elicited electrocortical activity. *Social Cognitive and Affective Neuroscience*, *6*(3), 348–358. https://doi.org/10.1093/scan/nsq053

Makowski, D., Ben-Shachar, M., & Lüdecke, D. (2019). bayestestR: Describing Effects and their Uncertainty, Existence and Significance within the Bayesian Framework. *Journal of Open Source Software, 4*(40), 1541. doi:10.21105/joss.01541

Master, S. L., Eisenberger, N. I., Taylor, S. E., Naliboff, B. D., Shirinyan, D., & Lieberman, M.

D. (2009). A picture's worth: Partner photographs reduce experimentally induced pain. *Psychological Science*, *20*(11), 1316–1318. https://doi.org/10.1111/j.1467-9280.2009.02444.x

McElreath, R. (2015). Statistical rethinking: A Bayesian course with examples in R and Stan. Chapman and Hall/CRC.

McElreath, R. (2020). Statistical rethinking: A Bayesian course with examples in R and Stan. Chapman and Hall/CRC.

McRae, K., Ochsner, K. N., Mauss, I. B., Gabrieli, J. J. D., & Gross, J. J. (2008). Gender differences in emotion regulation: An fMRI study of cognitive reappraisal. *Group Processes and Intergroup Relations*, *11*(2), 143–162. https://doi.org/10.1177/1368430207088035

Mikulincer, M., & Shaver, P. R. (2019). Attachment orientations and emotion regulation. *Current Opinion in Psychology*, Vol. 25, pp. 6–10. https://doi.org/10.1016/j.copsyc.2018.02.006

Morris, A. S., Criss, M. M., Silk, J. S., & Houltberg, B. J. (2017). The impact of parenting on emotion regulation during childhood and adolescence. *Child Development Perspectives*, *11*(4), 233–238. https://doi.org/10.1111/cdep.12238

Morris, A. S., Silk, J. S., Steinberg, L., Myers, S. S., & Robinson, L. R. (2007). The role of the family context in the development of emotion regulation. *Social Development*, *16*(2), 361–388. https://doi.org/10.1111/j.1467-9507.2007.00389.x

Morris, R. R., Schueller, S. M., & Picard, R. W. (2015). Efficacy of a web-based, crowdsourced peer-to-peer cognitive reappraisal platform for depression: Randomized controlled trial. *Journal of Medical Internet Research*, *17*(3). https://doi.org/10.2196/jmir.4167

Neff, L. A., & Karney, B. R. (2005). Gender differences in social support: A question of skill or responsiveness? *Journal of Personality and Social Psychology*, *88*(1), 79–90.

https://doi.org/10.1037/0022-3514.88.1.79

Nils, F., & Rimé, B. (2012). Beyond the myth of venting: Social sharing modes determine the benefits of emotional disclosure. *European Journal of Social Psychology*, *42*(6), 672–681. https://doi.org/10.1002/ejsp.1880

Niwano, K., & Sugai, K. (2003). Maternal accommodation in infant-directed speech during mother's and twin-infants' vocal interactions. Psychological reports, 92(2), 481-487.

Niven, K. (2017). The four key characteristics of interpersonal emotion regulation. *Current Opinion in Psychology*, Vol. 17, pp. 89–93. https://doi.org/10.1016/j.copsyc.2017.06.015

Niven, K., Garcia, D., van der Löwe, I., Holman, D., & Mansell, W. (2015). Becoming popular: Interpersonal emotion regulation predicts relationship formation in real life social networks. *Frontiers in Psychology*, *6*(SEP), 1452. https://doi.org/10.3389/fpsyg.2015.01452

Niven, K., Holman, D., & Totterdell, P. (2012). How to win friendship and trust by influencing people's feelings: An investigation of interpersonal affect regulation and the quality of relationships. *Human Relations*. https://doi.org/10.1177/0018726712439909

Niven, K., Totterdell, P., & Holman, D. (2009). A classification of controlled interpersonal affect regulation strategies. *Emotion*, *9*(4), 498–509. https://doi.org/10.1037/a0015962

Niven, K., Totterdell, P., Stride, C. B., & Holman, D. (2011). Emotion Regulation of Others and Self (EROS): The development and validation of a new individual difference measure. *Current Psychology*, *30*(1), 53–73. https://doi.org/10.1007/s12144-011-9099-9

Norman, K. R., Silverman, W. K., & Lebowitz, E. R. (2015). Family Accommodation of Child and Adolescent Anxiety: Mechanisms, Assessment, and Treatment. *Journal of Child and Adolescent Psychiatric Nursing*, *28*(3), 131–140. https://doi.org/10.1111/jcap.12116

O'Connor, J. J., & Barclay, P. (2017). The influence of voice pitch on perceptions of trustworthiness across social contexts. *Evolution and human behavior, 38*(4), 506-512.

Ochsner, K. N., & Gross, J. J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences*, *9*(5), 242–249. https://doi.org/10.1016/j.tics.2005.03.010

Ochsner, K. N., Ray, R. D., Cooper, J. C., Robertson, E. R., Chopra, S., Gabrieli, J. D. E., & Gross, J. J. (2004). For better or for worse: Neural systems supporting the cognitive down- and up-regulation of negative emotion. *NeuroImage*, *23*(2), 483–499. https://doi.org/10.1016/j.neuroimage.2004.06.030

Oleszkiewicz, A., Pisanski, K., Lachowicz-Tabaczek, K., & Sorokowska, A. (2017). Voice-based assessments of trustworthiness, competence, and warmth in blind and sighted adults. Psychonomic bulletin & review, 24, 856-862.

Oksenberg, L., Coleman, L., & Cannell, C. F. (1986). Interviewers' voices and refusal rates in telephone surveys. *Public Opinion Quarterly, 50*(1), 97-111.

Oveis, C., Gu, Y., Ocampo, J. M., Hangen, E. J., & Jamieson, J. P. (2020). Emotion Regulation Contagion: Stress Reappraisal Promotes Challenge Responses in Teammates. *Journal of Experimental Psychology: General*. https://doi.org/10.1037/xge0000757.supp

Ozer, E. J., Best, S. R., Lipsey, T. L., & Weiss, D. S. (2003). Predictors of posttraumatic stress disorder and symptoms in adults: A meta-analysis. *Psychological Bulletin*, Vol. 129, pp. 52–73. American Psychological Association Inc. https://doi.org/10.1037/0033-2909.129.1.52

Paeschke, A., Kienast, M., & Sendlmeier, W.F. (1999). *F0-contours in emotional speech*. https://www.internationalphoneticassociation.org/icphs-proceedings/ICPhS1999/papers/p14_0929.pdf

Pauw, L. S., Sauter, D. A., van Kleef, G. A., & Fischer, A. H. (2018). Sense or sensibility? Social

sharers' evaluations of socio-affective vs. cognitive support in response to negative emotions. *Cognition and Emotion*, *32*(6), 1247–1264. https://doi.org/10.1080/02699931.2017.1400949

Paul-Christian Bürkner (2018). Advanced Bayesian Multilevel Modeling with the R Package brms. *The R Journal, 10*(1), 395-411. doi:10.32614/RJ-2018-017

Paulmann, S., Bleichner, M., & Kotz, S. A. (2013). Valence, arousal, and task effects in emotional prosody processing. Frontiers in Psychology, 4, Article 345. https://doi.org/10.3389/fpsyg.2013.00345

Paulmann, S., & Kotz, S. A. (2008). Early emotional prosody perception based on different speaker voices. Neuroreport, 19, 209–213.

Pell, M. D., & Kotz, S. A. (2021). Comment: The Next Frontier: Prosody Research Gets Interpersonal. *Emotion Review*, *13*(1), 51–56. https://doi.org/10.1177/1754073920954288

Pell, M. D., Paulmann, S., Dara, C., Alasseri, A., & Kotz, S. A. (2009). Factors in the recognition of vocally expressed emotions: A comparison of four languages. Journal of Phonetics, 37(4), 417-435.

Pietrzak, R. H., Johnson, D. C., Goldstein, M. B., Malley, J. C., Rivers, A. J., Morgan, C. A., & Southwick, S. M. (2010). Psychosocial buffers of traumatic stress, depressive symptoms, and psychosocial difficulties in veterans of operations enduring Freedom and Iraqi Freedom: the role of resilience, unit support, and postdeployment social support. *Journal of Affective Disorders*, *9*(3), 74–78. https://doi.org/10.1016/s0084-3970(10)79345-2

Pisanski, K., Cartei, V., McGettigan, C., Raine, J., & Reby, D. (2016). Voice Modulation: A Window into the Origins of Human Vocal Control? *Trends in Cognitive Sciences*, *20*(4), 304–318. https://doi.org/10.1016/j.tics.2016.01.002

R Core Team. (2022). R: A language and environment computing. *R Foundation for Statistical*

Computing. Vienna, Austria. Retrieved from https://www.r-project.org/

Rasmussen, E. E., Strouse, G. A., Colwell, M. J., Russo Johnson, C., Holiday, S., Brady, K., … Norman, M. S. (2019). Promoting preschoolers' emotional competence through prosocial TV and mobile app use. *Media Psychology*, *22*(1), 1–22. https://doi.org/10.1080/15213269.2018.1476890

Ray, R. D., Ochsner, K. N., Cooper, J. C., Robertson, E. R., Gabrieli, J. D. E., & Gross, J. J. (2005). Individual differences in trait rumination and the neural systems supporting cognitive reappraisal. *Cognitive, Affective and Behavioral Neuroscience*, *5*(2), 156–168. https://doi.org/10.3758/CABN.5.2.156

Reeck, C., Ames, D. R., & Ochsner, K. N. (2016). The social regulation of emotion: An integrative, cross-disciplinary model. *Trends in Cognitive Sciences*, Vol. 20, pp. 47–63. https://doi.org/10.1016/j.tics.2015.09.003

Rendall, D., Kollias, S., Ney, C., & Lloyd, P. (2005). Pitch (F 0) and formant profiles of human vowels and vowel-like baboon grunts: The role of vocalizer body size and voice-acoustic allometry. The Journal of the Acoustical Society of America, 117(2), 944-955.

Rendall, D., Owren, M. J., &Ryan, M. J. (2009). What do animal signals mean? Animal Behaviour, 78, 233–240. https://doi.org/10.1016/j. Anbehav.2009.06.007

Rimé, B. (2009). Emotion elicits the social sharing of emotion: Theory and empirical review. *Emotion Review*, *1*(1), 60–85. https://doi.org/10.1177/1754073908097189

Rimé, B. (2012). Beyond the myth of venting: Social sharing modes determine the benefits of emotional disclosure. *Article in European Journal of Social Psychology*, *42*(6), 672–681. https://doi.org/10.1002/ejsp.1880

Rudner, L. M., & Schafer, W. D. (2001). Reliability. Retrieved August 12, 2020, from ERIC

Digest. website: https://www.ericdigests.org/2002-2/reliability.htm

Russell, D. W. (1996). UCLA Loneliness Scale (Version 3): Reliability, Validity, and Factor Structure. *Journal of Personality Assessment*, *66*(1), 20–40. https://doi.org/10.1207/s15327752jpa6601_2

Sahi, R., Ninova, E., & Silvers, J. (2020). Social Reappraisal Studies. Retrieved from osf.io/94ecj

Sahi, R. S., & Silvers, J. A. (2023). Social Reappraisal Study: Enduring Effect. Retrieved from OSF website: osf.io/a9jvf

Sahi, Razia S., Ninova, E., & Silvers, J. A. (2021). With a little help from my friends: Selective social potentiation of emotion regulation. *Journal of Experimental Psychology: General*. https://doi.org/10.1037/xge0000853

Sahi, Razia S, He, Z., Silvers, J. A., & Eisenberger, N. I. (2022). One Size Does Not Fit All: Decomposing the Implementation and Differential Benefits of Social Emotion Regulation Strategies. *Emotion*. https://doi.org/10.1037/emo0001194

Sahi, R. S., Gaines, E. M., Nussbaum, S., Lee, D., Lieberman, M., Eisenberger, N. I., & Silvers, J. (2023). You changed my mind: Immediate and enduring impacts of social emotion regulation. Retrieved from psyarxiv.com/q2m34

Saint-Georges, C., Chetouani, M., Cassel, R., Apicella, F., Mahdhaoui, A., Muratori, F., ... & Cohen, D. (2013). Motherese in interaction: at the cross-road of emotion and cognition?(A systematic review). PloS one, 8(10), e78103.

Sauter, D. A., & Eimer, M. (2009). Rapid detection of emotion from human vocalizations. Journal of Cognitive Neuroscience, 22, 474–481.

Scherer, K. R., London, H., & Wolf, J. J. (1973). The voice of confidence: Paralinguistic cues and audience evaluation. Journal of Research in Personality, 7(1), 31-44.

Scherer, S., Hammal, Z., Yang, Y., Morency, L. P., & Cohn, J. F. (2014, November). Dyadic behavior analysis in depression severity assessment interviews. In Proceedings of the 16th International Conference on Multimodal Interaction (pp. 112-119).

Schwarzer, R., Diehl, M., & Schmitz, G. (1999). *Self-regulation scale*.

Seyfarth, R. M., Cheney, D. L., Bergman, T., Fischer, J., Zuberbühler, K., & Hammerschmidt, K. (2010). The central importance of informa- tion in studies ofanimal communication. Animal Behaviour, 80, 3– 8. https://doi.org/10.1016/j.anbehav.2010.04.012

Shakespeare-Finch, J., & Obst, P. L. (2011). The development of the 2-way social support scale: A measure of giving and receiving emotional and instrumental support. *Journal of Personality Assessment*, *93*(5), 483–490. https://doi.org/10.1080/00223891.2011.594124

Sheppes, G. (2014). Emotion regulation choice: Theory and findings. *Handbook of Emotion Regulation*, 126–139.

Sheppes, G., Scheibe, S., Suri, G., Radu, P., Blechert, J., & Gross, J. J. (2012). *Emotion Regulation Choice: A Conceptual Framework and Supporting Evidence*. https://doi.org/10.1037/a0030831

Shields, S. A. (2002). *Speaking from the Heart: Gender and the Social Meaning of Emotion*. https://doi.org/10.2307/3341953

Shields, S. A., Garner, D. N., Di Leone, B., & Hadley, A. M. (2006). Gender and Emotion. *Handbooks of Sociology and Social Research*, 63–83. https://doi.org/10.1007/978-0-387-30715-2_4/COVER

Shiota, M., Keltner, D., psychology, O. J.-T. journal of positive, & 2006, undefined. (2006). Positive emotion dispositions differentially associated with Big Five personality and attachment style. *Taylor & Francis*, *1*(2), 61–71.

https://doi.org/10.1080/17439760500510833

Silvers, J. A., Shu, J., Hubbard, A. D., Weber, J., & Ochsner, K. N. (2015). Concurrent and lasting effects of emotion regulation on amygdala response in adolescence and young adulthood. *Developmental Science*, *18*(5), 771–784. https://doi.org/10.1111/desc.12260

Somerville, L. H. (2013). The teenage brain: Sensitivity to cocial evaluation. *Current Directions in Psychological Science*, Vol. 22, pp. 121–127. https://doi.org/10.1177/0963721413476512

Sorokowski, P., Puts, D., Johnson, J., Żółkiewicz, O., Oleszkiewicz, A., Sorokowska, A., ... & Pisanski, K. (2019). Voice of authority: professionals lower their vocal frequencies when giving expert advice. Journal of Nonverbal Behavior, 43, 257-269.

Spiegelhalter, D. J., Freedman, L. S., & Parmar, M. K. (1994). Bayesian approaches to randomized trials. Journal of the Royal Statistical Society: Series A (Statistics in Society), 157(3), 357-387.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. (1983). State-Trait Anxiety Inventory for Adults Sampler Set Manual, Instrument and Scoring Guide. *Consulting Psychologists Press, Inc. Mind Garden, Inc.*, 0–78. https://doi.org/10.1037/t06496-000

Steinberg, L., & Monahan, K. C. (2007). Age Differences in Resistance to Peer Influence. *Developmental Psychology*, *43*(6), 1531–1543. https://doi.org/10.1037/0012-1649.43.6.1531

Styler, W. (2013). Using Praat for linguistic research. *University of Colorado at Boulder Phonetics Lab.*

Torre, J. B., & Lieberman, M. D. (2018). Putting Feelings Into Words: Affect Labeling as Implicit Emotion Regulation. *Emotion Review*, *10*(2), 116–124. https://doi.org/10.1177/1754073917742706

Trainor, L. J., Austin, C. M., & Desjardins, R. N. (2000). Is infant-directed speech prosody a result of the vocal expression of emotion?. Psychological science, 11(3), 188-195.

Troy, A. S., Ford, B. Q., McRae, K., Zarolia, P., & Mauss, I. B. (2017). Change the things you can: Emotion regulation is more beneficial for people from lower than from higher socioeconomic status. *Emotion*, *17*(1), 141–154. https://doi.org/10.1037/emo0000210

Uchino, B. N., Bowen, K., de Grey, R. K., Mikel, J., & Fisher, E. B. (2018). Social support and physical health: Models, mechanisms, and opportunities. *Principles and Concepts of Behavioral Medicine: A Global Handbook*, 341–372. https://doi.org/10.1007/978-0-387-93826-4_12

Uusberg, A., Taxer, J. L., Yih, J., Uusberg, H., & Gross, J. J. (2019). Reappraising reappraisal. *Emotion Review*, *11*(4), 267–282. https://doi.org/10.1177/1754073919862617

Vrana, S. R., & Rollock, D. (2002). The role of ethnicity, gender, emotional content, and contextual differences in physiological, expressive, and self-reported emotional responses to imagery. *Cognition and Emotion*, *16*(1), 165–192. https://doi.org/10.1080/02699930143000185

Weenink, D. (2018). Speech Signal Processing with Praat. URL: https://www.fon.hum.uva.nl/david/LOT/sspbook.pdf

Welborn, B. L., Lieberman, M. D., Goldenberg, D., Fuligni, A. J., Galván, A., & Telzer, E. H. (2016). Neural mechanisms of social influence in adolescence. *Social Cognitive and Affective Neuroscience*, *11*(1), 100–109. https://doi.org/10.1093/SCAN/NSV095

Werker, J. F., & McLeod, P. J. (1989). Infant preference for both male and female infant-directed talk: A developmental study of attentional and affective responsiveness. *Canadian Journal*

of Psychology / Revue canadienne de psychologie, 43(2), 230–246. https://doi.org/10.1037/h0084224

Williams, W. C., Morelli, S. A., Ong, D. C., & Zaki, J. (2018). Interpersonal emotion regulation: Implications for affiliation, perceived support, relationships, and well-being. *Journal of Personality and Social Psychology*, *115*(2), 224–254. https://doi.org/10.1037/pspi0000132

Whalen, D. H., & Levitt, A. G. (1995). The universality of intrinsic F0 of vowels. *Journal of phonetics*, *23*(3), 349-366.

Wright, R., Mansfield, C., & Panfili, L. (2019). Voice quality types and uses in North American English. *Anglophonia*. doi: https://doi.org/10.4000/anglophonia.1952

Wu, H. X., Li, Y., Ching, B. H. H., & Chen, T. T. (2023). You are how you speak: The roles of vocal pitch and semantic cues in shaping social perceptions. *Perception*, 52(1), 40-55.

Yang, Y., Fairbairn, C., & Cohn, J. F. (2012). Detecting depression severity from vocal prosody. IEEE transactions on affective computing, 4(2), 142-150.

Zaki, J., & Williams, C. (2013). Interpersonal emotion regulation. *Emotion*, *13*(5), 803–810. https://doi.org/10.1037/a0033839

Zuberbühler, K. (2009). Survivor signals: the biology and psychology of animal alarm calling. Advances in the Study of Behavior 40, 277– 322. https://doi.org/10.1016/s0065-3454(09)40008-1