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Bushra E. Rahman April 12, 2022

Frustration responses of single mothers to prolonged infant crying

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Abstract

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The purpose of this study was to investigate the factors informing frustration ratings among single and non-single mothers to the stressor of infant crying. Single mothers constitute a salient population in the U.S. and increased prevalence of common mental disorders, lack of social support, and higher likelihood of poverty make them more susceptible to mental and economic strain than other parents. Prolonged infant crying is a frustrating stimulus for parents and can act as a trigger for negative emotions and even infant abuse. Little is known regarding the role of single motherhood in the frustration response to infant crying, such as specific maternal psychosocial determinants as well as acoustic features and sex differences among the infant cry which could be contributing to this response. We hypothesized that single mothers would rate infant cries to be more frustrating and have increased reported psychological strain compared with non-single mothers. Furthermore, specific acoustic characteristics of the cries as well as the sex of the infant being male were also hypothesized to be associated with higher frustration ratings among mothers.

25 single ($x=29.11$, $SD = 5.52$) and 25 non-single ($x=31.69$, $SD = 8.23$) mothers of infants ages six months old or younger participated in this study. Following consent, each participant completed eight pre-task questionnaires which evaluated psychosocial qualities of perceived stress, postnatal depression, anxiety, financial strain, resilience, social support, emotion dyregulation, and positive and negative affect. Each mother then completed an on-line frustration rating task, containing 50 different 15-second cry videos of male and female infants shown in randomized order. The participant recorded her frustration rating on a 7-point Likert scale after each clip. The findings of this study show that frustration ratings did not differ between single and non-single mothers, and social support was the only psychosocial variable with an intergroup difference. However, mothers' frustration ratings were significantly associated with the duration of the stimulus, acoustic qualities of the cry (exphonations, intensity and shimmer) as well as negative affect. A significant effect of infant sex was also observed, where female infants received higher frustration ratings, indicating an aspect of the cry other than acoustics could be contributing to this perceived sex difference among mothers.

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I. Introduction and Background

The Growing Relevance of Single Motherhood in the U.S.

A single mother refers to a female parent who lives with and raises her child without a spouse or live-in partner. Common causes of single motherhood include divorce, break-up, partner death, or single-person adoption ("Single Mother Statistics," 2021). This demographic is is a salient population, as the U.S. has the highest rates of single-parent households in the world, with 23% of children under the age of 18 living with one parent and no other adult. This is more than three times the global rate of single parent households, which sits at 7% (Kramer, 2019). The prevalence of single parenthood in the past half-century can be attributed to declines in marriage, increases in divorce rates, as well as increases in nonmartial births (Livingston, 2018). In the U.S., 80.5% of single-parent families are headed by single mothers, and one third of these mothers live in poverty. Today, one in six children in the U.S. under the age of 18 (12.5 million) are being raised without a father ("Single Mother Statistics," 2021). Single parenthood is associated with higher incidence of poverty and financial strain. Of all single-parent households, those headed by a single mother have the lowest monthly income and are nearly four times as likely to be in a crisis category for poverty than single father households (Lu et al., 2019).

Mental Health in Single Mothers

Family-type is a well-documented predictor of mental health is family type, where higher incidence of common mental disorders such as anxiety, depression, and substance use disorder have been found among single mothers when compared to partnered mothers (Kim et al., 2018). For example, depression was significantly more common in single mothers at 29% compared to 15.7% among partnered mothers (Crosier et al., 2007). Depression onset among women was informed by poor self-esteem and lack of support, which are both significantly more common

feelings among single mothers (Brown & Moran, 1997). Chronic depressive episodes (lasting at least a year) were associated with financial hardship, for which singles mothers are also at greater risk (Brown & Moran, 1997). Among single mothers, risk factors for depression include young age, low income, residential instability, and high stress (Kim et al., 2018). Previous studies also indicate that single mothers face several daily obstacles including self-doubt, financial strain, physical and mental fatigue, solo decision-making, and social stigmatization (Crosier et al., 2007; Kim et al., 2018; Lindolm, 2016). These stressors, paired with a lack of social support and sustained care from a partner, have been shown to take a toll on single mothers' psychological functioning and impair their ability to successfully navigate their social spheres (Crosier et al., 2007; Hope et al., 1999; Lindolm, 2016).

Single mothers are nearly twice as likely to experience moderate to severe mental disability when compared with partnered mothers, and primary factors associated with poor mental health in single mothers are the presence of increased levels of financial hardship and perceived lack of social support (Crosier et al., 2007). The elevated psychological distress among single mothers due to financial strain can be explained by the fact that fewer single mothers have paid employment than married mothers (Hope et al., 1999). Within 2021, only half of single mothers were employed full-time all year long, 29% were jobless the entire year, and only 22% of them received unemployment benefits ("Single Mother Statistics," 2021). Additionally, single motherhood contains a host of unique obstacles. For example, parents of children with special needs are more likely to divorce, and as it is more common for mothers to receive custody, this responsibility falls almost entirely on the mother (Lindolm, 2016). Other inescapable challenges of single motherhood include sleep deprivation, inadequate self-care, ongoing conflict with an ex-partner, unstable support networks, history of abuse, and social stigma (Lindolm, 2016). On

the other hand, when provided with tools for promoting positive adjustment, single mothers can increase their positive functioning and coping, and can display traits such as resilience in the face of hardship (Taylor & Conger, 2017). Two important points of entry have been identified for intervention among single mothers: enhancing perceptions of social support and promoting internal strengths, such as optimism, self-efficacy, and self-esteem (Taylor & Conger, 2017). Highlighting these traits among single mothers through group support and intervention would be effective in offsetting the detrimental psychological outcomes of single motherhood.

Along with perception of limited partner support, maternal stress has also found to be closely related to lower ability to withstand frustration. When lack of partner support and low frustration tolerance are considered together, they predict a significant amount of maternal stress, where low frustration tolerance accounts for this variance in an incremental, stepwise method (Vidair et al., 2004). This suggests that the stress of single motherhood may also play a role in the susceptibility to other negative emotions, such as frustration.

Maternal Subjective Responses to Infant Crying

Prolonged infant crying in the early months of an infant's life has been studied extensively as a frustrating stimulus for parents. These cries can trigger negative emotions such as anger, frustration, or sadness, and may even lead to infant abuse (Barr et al., 2006). Mothers' emotional reactions to infant crying can be classified an infant-oriented, empathy/sympathy response or a mother-oriented, frustration/anxiety-inducing response to the crying (Leerkes & Qu, 2020). Infant-oriented response to infant crying among mothers has been associated with greater accuracy in determining infant distress, less negative beliefs about crying, and increased sensitivity to infant distress. Conversely, mother-oriented negative emotional response to infant crying consists of less accurate interpretation of infant distress cues and lower sensitivity to

infant distress (Leerkes, 2010; Leerkes, Supple, O'Brien, et al., 2015; Leerkes et al., 2016). It has also been determined that maternal frustration ratings increase as the duration of the cry progresses, although there exist individual differences in these frustration trajectories (Barr et al., 2014).

Unwanted, intrusive thoughts and impulses among caregivers typically arise from stressful stimuli, such as infant crying. Response to infant crying has also been found to be distinct among prepartum and postpartum mothers. One study determined that while nearly 25% of prepartum mother reported intrusive infant-related thoughts of harm after listening to prolonged crying, this statistic increased significantly to 44% among postpartum mothers (Fairbrother et al., 2019). Hostile emotions and urges to flee were more common in postpartum mothers. Furthermore, while mothers and fathers did not differ significantly in the likelihood of intrusive thoughts, women were more likely to report internalizing negative emotions associated with frustration than men. Therefore, while mothers were less likely to use external displays such as infant shaking, they may be more susceptible to strong feelings of frustration or anxiety (Fairbrother et al., 2019). In another study, where new mothers were randomly assigned to listen to infant crying and cooing and continuously rate their feelings of frustration, participants in the cry condition were more likely to report intrusive thoughts of harm as well as report higher level of frustration throughout the cry duration. These mothers also reported higher levels of post-test negative emotions and stronger urges to flee, but not stronger urges to soothe the infant (Fairbrother et al., 2015). Evidently, prolonged infant crying can be a trigger for negative emotions, high frustration levels, and personal distress among mothers, which could even predict intrusive infant-related thoughts of harm.

Postnatal depression is strongly associated with altered mother-infant interactions, namely lack of maternal responsiveness to infant cues (Esposito et al., 2017). Mothers diagnosed with depression were found to feed, rock, and touch their crying infants less than non-depressed mothers. Depressed mothers engaged in less caregiving during their infant crying, and only responded to cries at higher frequencies and which were 15 seconds or less (Esposito et al., 2017). This finding is pertinent to single mothers, who have significantly higher incidence of depression than non-single mothers (Crosier et al., 2007). Additionally, older, non-depressed mothers were most interactive with infants and engaged in more caregiving behaviors. This presents a distinct contrast from the typical demographics of single mothers, who are not only more likely to experience depression, but also have children at a median lower age than married mothers (Livingston, 2018).

Hypotheses 1 and 2:

Hypothesis 1: Single mothers will find infant cries to be more frustrating compared with non-single mothers.

Hypothesis 2a: Single mothers will score higher in postnatal depression, and this will *mediate* the association between single motherhood and increased frustration in response to infant crying.

Hypothesis 2b: Single mothers will score higher in perceived stress, and this will *mediate* the association between single motherhood and increased frustration in response to infant crying.

Hypothesis 2c: Social support will be a *moderating* variable for frustration ratings, so single mothers with strong social support will have lower frustration ratings to infant crying.

Hypothesis 2d: Single mothers will face more economic strain, and this will *mediate* the association between single motherhood and increased frustration in response to infant crying.

Cry Acoustics and Subjective Responses to Infant Crying

While infant crying is a known trigger for frustration and negative emotions, one can ask about the specific acoustic qualities of infant cries that contribute to frustration. Infantile colic, or perceived excessive amounts of infant crying has been long identified as triggering negative emotions and harmful thoughts among parents, however distinct acoustic features of the cry sound could also be strong predictors for why the cries may be perceived as particularly aversive and excessive (Zeskind & Barr, 1997). Crying has been referred to as a "biological siren", with the purpose of eliciting caregiving by alerting the parent of the needs and wants of the infant (LaGasse et al., 2005). The salience of the cry to a caregiver produces a visceral reaction which propels a strong sympathetic, or "fight or flight" response, where the caregiver reacts strongly and immediately. Therefore, the caregiver may either be compelled to soothe the infant to turn off the "siren", have a strong urge to flee and distance themselves from distressing stimuli, or tragically, resort to shaking or infant abuse to stop the crying (LaGasse et al., 2005). Infant crying creates a behavioral system between parent and infant, which operates at two levels: the features of the cry sources itself and the type of response it elicits among caregivers.

The perception and response of mothers to infant cries are influenced by sociodemographic characteristics and listener attitudes, alongside acoustic characteristics of the cry (Esposito et al., 2015). Factors such as infant age, maternal personality characteristics, maternal age, and pre-existing stresses all have a significant impact on how the listener perceives the infant cry. However, acoustic qualities and patterns of the cry also play a significant role in how they are perceived by the mother. Previous studies have consistently pointed to higher frequency, pitch, and energy as well as longer duration as triggers for high frustration among mothers (LaGasse et al., 2005; Green et al., 2011; Gustafson & Green, 1989). Phonation, or vocal vibrational patterns,

is also associated with frustration, specifically hyperphonation or extremely high-pitched cries and dysphonation, or turbulent cries (LaGasse et al., 2005; Gustafson & Green, 1989). Specifically, the production of expiratory phonations, or exphonations, have also been found to positively correlate with aversiveness ratings to infant crying (Richey et al., 2020).

Higher-pitched infant cries have been associated with both harsh and more sensitive caregiving responses among adults. While perception of higher-pitched infant crying as more urgent allows for more immediate and affectionate caregiving responses, an extreme increase in cry pitch is also a trigger for more irritated, negative, and even harsh parenting practices (Out et al., 2010). Therefore, abnormal cry acoustics, such as extreme increase in pitch could provoke harsh parenting behaviors in parents due to an increased frustration response (Out et al., 2010). In adult males, cry aversiveness judgements are positively correlated with increased duration of exphonations, as well as other acoustic characteristics of the cry, such as roughness, intensity, and shimmer, however these measures have not been studied in mothers (Richey et al., 2020).

Different cry patterns are perceived in distinct ways by mothers. Cries classified as screaming or yelling, which consisted of similar acoustic features such as higher fundamental frequency and overall energy, were perceived by mothers as reflecting a higher intensity of anger while the alternative classification of fussing and whining was thought to reflect increased intensity of sadness (Green et al., 2011). Infants may also alter acoustic features and patterns of their crying in response to psychological state of the mother. It was determined that infants of clinically depressed mothers cried as frequently and for equal durations as infants of non-depressed mothers, but at a higher and more restricted fundamental frequency range (Esposito et al., 2017). This may be explained as a behavioral adaptation in response to the mother, since

depressed mothers were less likely to engage in caregiving behaviors and responded only to cries at higher fundamental frequency and shorter duration (Esposito et al., 2017).

Hypothesis 3:

Hypothesis 3a: Increased duration of exphonations made by the infants will result in higher frustration ratings by mothers.

Hypothesis 3b: Infant cry features previously found to correlate with higher aversiveness rating, namely intensity and shimmer, will result in higher frustration ratings among mothers.

Sex Differences in Infant Cry Acoustics and Gender Perceptions

Male infants are more likely to be victims of infant abuse, namely Shaken Baby Syndrome or Abusive Head Trauma (SBS/AHT) than female infants. This suggests that frustration responses to infant crying may differ between male and female infants, which could be explained by sex differences in cry acoustics. Male infants might be perceived as more aversive and trigger more negative emotions, which in extreme cases, may elicit abuse. Male infants have been found to spend more time producing expiratory phonations than female infants, and this variable was positively correlated with aversiveness ratings made by adult males (Richey et al., 2020).

While previous literature on maternal response to infant crying does not explore differences based on infant sex, it has been found that mothers may hold gender biases when it comes to performance on certain tasks. When asked to predict the ability of their babies in crawling down a slope, mothers of female infants underestimated their performance while mothers of male infants overestimated, even though both infants had nearly identical levels of locomotor performance (Mondschein et al., 2000). Cultural norms and gender stereotypes, such as “boys shouldn’t cry” and “boys are more athletic” likely contribute to gender biases held by both mothers and fathers, which may be expressed implicitly in how they perceive their infants

(Thomassin, 2019; Richey et al., 2020). In some cases, however, parents are consciously aware of their role in establishing gender norms, particularly for sons. While households consisting of heterosexual fathers uphold standards for hegemonic masculinity among for their sons through their own personal endorsement, households consisting of single mothers or gay parents attempt to uphold these ideals without a consistent reference point for their son (Kane, 2006). This lack of a sustainable masculine model to emulate could manifest into enduring behavioral issues of boys living in single-mother households, as they have been found to have higher rates of externalizing behavior and are more likely to be suspended in school in comparison to boys of married parents (Hymowitz, 2020).

Mothers have also shown to react with gendered differences when it comes to vocal cues among infants. Mothers responded preferentially to girls crying both at birth and 44 weeks (Johnson et al., 2014). Additionally, infants may display differential behavior between their mother and father, especially in speech exposure and language acquisition. On average, infants preferentially respond to female adult speech, as mothers provide most language input and respond more readily to infant vocal cues (Johnson et al., 2014). As there exists gendered differences in mothers' perceptions of infant abilities and vocal cues, this may lead to sex differences in maternal frustration to infant crying.

Single mothers' behavioral response to stressful stimuli has not been explored in previous studies. Little is known regarding the significance of single motherhood in the context of frustration response. This study compares single vs. non-single mothers' frustration ratings when exposed to prolonged infant crying. Specifically, we aim to identify specific factors and mechanisms as well as characteristics of the infant cry stimuli that modulate the frustration responses of single mothers in comparison to partnered mothers. This study could have

implications for better understanding the unique challenges of single motherhood, and more importantly, how a lack of certain buffers for stressors associated with parenthood may impact parental responses, such as frustration.

Hypothesis 4:

Mothers will give higher frustration ratings to male infant cries compared to female infant cries.

II. Methods

Recruitment and Study Parameters

This study was conducted completely in an on-line format. 50 mothers with infants less than six months of age were recruited through physical flyers around Emory University campus and through a Facebook ad campaign posted under the Lab for Darwinian Neuroscience's Facebook page. The ad demographic was specified as single and non-single mothers with infants less than six months of age. The ad was posted across the United States for eight weeks. 25 single mothers and 25 mothers who had been in a stable relationship with a co-parent since the birth of their child were ultimately recruited.

This proposed allocation of participants is justified by an a-priori power analysis performed on data from a related study. The related study was a comparative analysis of the impact of economic problems on depression in single mothers vs. married mothers. The analysis was carried out with t-tests (Cohen's d=1.01 of CES-D score between single vs. non-single mothers). The mean and standard deviation was used from each group's response to the Center for Epidemiological Studies – Depression Scale (CES-D), which uses a 0-3 point scale for 20 items (MGH Center for Women's Mental Health, 2016). Given the lack of previous studies that used the same experimental design as ours, the Cohen's d, mean, and standard deviation values from this study were used in the power calculation. With the type-I error set to $\alpha=0.05$, the power analysis showed that a total of N=21 is required to provide 80% power for detecting a significant intergroup difference for risk factors which influence depression among single mothers (Kim et al., 2018). As this study considered intergroup differences in negative emotional responses, it was used as a model for our own study to investigate differential frustration

responses between single and non-single mothers. To account for data loss or other issues which could arise, 25 single and 25 partnered mothers were recruited for this study.

Upon completion of the study's consent form and preliminary demographic questions (relationship status, mother's race and birthdate, child's race and birthdate, sex of child, yearly household income, employment status, and hours worked per week), participants completed the following eight pre-task questionnaires: 1.) Perceived Stress Scale, a 12-item questionnaire which assesses the degree to which the respondent's life situations have been appraised as stressful in the past month (Cohen, 1988). 2.) Edinburgh Postnatal Depression Scale (EPDS), a 10-item scale developed to identify symptoms of depression among postpartum women (MGH Center for Women' Mental Health, 2016). 3.) State-Trait Anxiety Inventory (STAI), which is a psychological inventory to measure two distinct anxiety types. This study only utilized the State-Anxiety Inventory (Form Y-1), which consisted of 20 questions and measured state anxiety in the specific moment, rather than anxiety as a general personality trait (Carmin & Ownby, 2000). 4.) Family Economic Strain Scale, a 25-item scale measuring respondent's stress related to financial scarcity and the extent to which it pervades in providing for themselves and their family (Hilton & Devall, 1997). 5.) Brief Resilience Assessment Questionnaire, a 6-item scale to assess respondents' ability to recover from stressful life situation (Smith et al., 2008). 6.) Duke-UNC Functional Social Support Questionnaire, an 8-item scale measuring the strength of the individual's social support network (*FSSQ Duke-UNC Functional Social Support Questionnaire*, 2006). 7.) Emotion Dysregulation Scale, a 12-item scale measuring ability to regulate emotions based on questions related to emotional experiencing, cognition, and behavior (Powers et al., 2015). 8.) Positive and Negative Affect Schedule (PANAS), which are each a 10-item scale measuring positive and negative moods and emotions, in that specific moment of time (Watson

et al., 1988). All demographic and questionnaires responses were self-reported and completed before the online task, and then compared between single vs. non-single mothers.

On-line Task Creation and Collection of the Stimulus Set

The final portion of the study consisted of the on-line frustration-rating task. The program, PsychoPy's Builder Mode was used to construct the task. It was then uploaded to the online platform, Pavlovia, where the task was accessible via a URL. The task contained 50 different 15-second infant cry videos of male and female infants from a previous study which were stitched together. After each 15-second clip, a screen was displayed which asked the participant to record her frustration level using a 7-point Likert Scale. The question "How frustrating did you find that cry?" appeared on the screen after each cry and it was indicated that 1 corresponded to "not frustrated at all" and 7 corresponded to "extremely frustrated". There was an equal distribution of male and female infant videos with 25 of each, the order of male and female cry stimuli was randomly generated for each trial, and each infant was dressed in a white diaper to control for gendered biases in perception. The total duration of the task was approximately 15 minutes.

The task was completed on a Zoom call with the researcher. Each participant was instructed to have access to Google Chrome before agreeing to the Zoom call in order to install the extension "Sound Meter (Noise and Decibel)". To ensure that the stimuli were presented at a constant volume for each participant, they were sent a sample beforehand and asked to adjust their computer volume so the decibels on the meter read 42-48 dB when the video was played. They made note of this volume setting, as this is the same setting that should be used during the task. Each participant was asked to complete the task with headphones, and in a room without other noises or distractions. This was all done on the Zoom call, where the researcher able to

guide participants through this set-up. Once the volume was standardized, the participant could move on to the task, and the researcher was on stand-by on the call in case any issues arose. While the participant completed the task, the researcher kept their microphone and webcam muted. After each participant had successfully completed the consent forms, questionnaires, and the frustration ratings, they were compensated with a $20 Amazon E-gift card code.

The task also contained two attention probes to ensure the participant was focused for the duration of the task. Two of the infant videos displayed in the task contained a beeping sound in the last 5 seconds of the clip. The frustration rating screen instructed participants that if a beeping sound was heard, to type "0" rather than provide a frustration rating from 1-7. All participants whose data was analyzed in this study successfully completed both attention tests, indicating that they were attentive throughout the task. Data collected from three mothers was unable to be used in this study as one failed the attention test, another was distracted with her baby during the call, and another was unable to standardize her volume. Therefore, data were collected from a total of 53 participants to compensate for this loss and arrive at a final sample size of n=50.

The video stimulus set used for this study consisted of 25 male and 25 female infant videos. These were collected as an expansion of the stimulus set from a previous study which explored perception of infant cry aversiveness among adult men (Richey et al., 2020). The recruitment process for these videos began in January of 2020 through ads posted on Craigslist, where parents of infants six months or younger were targeted. After consenting, parents were provided with details for recording the video. These videos of the infant crying were recorded in the infant's home at what the parents judged to be peak cry intensity. The following instructions were provided for recording the video of the infant crying:

1.) The baby must be dressed in only a white diaper, and not wearing anything else.

2.) The baby should be laying with their back on a white blanket or sheet and the video background should only consist of the white background.

3.) The camera should be positioned approximately three feet above the crying infant.

4.) The baby should be centered in the video and all four of his/her limbs should be in the frame for the entire duration.

5.) The camera should be held as still as possible and there should be no background noise in the video.

6.) The video duration must be 40 seconds long.

After the parent sent a video of their infant crying which met the above criteria, they were compensated. The full stimulus set consisting of 50 standardized infant videos were collected by November of 2020.

After the complete infant video stimulus set was acquired, cries were analyzed acoustically. For each infant cry sample, Praat software was used to calculate each of the following values: mean pitch, maximum pitch, minimum pitch, frames voiced, harmonic to noise ratio, intensity, jitter, shimmer, and air energy. For all relevant analyses, the pitch floor was set to 250 Hz and the pitch ceiling was set to 2600 Hz. The mean, minimum, and maximum pitch are the average, minimum, and maximum pitch of the 40-second clip, respectively. Pitch is defined as “the perceptual correlate of periodicity in sound” (McDermott & Oxenham, 2008). The frames voiced are the number of frames within the sound clip, which is determined based on the power in a frame (Eager, 2015). The harmonic to noise ratio is the additive noise in the voice signal, and this quality can be expressed as the hoarseness of a voice (Yumoto et al., 1982). The intensity describes a measure of how the human ear perceived volume, where 0 dB is the

threshold of human hearing and a whisper is approximately 34 dB (Chepesiuk, 2005). Jitter indicates the variability or perturbation of fundamental frequency, which is "a mathematical quantity, referring to the lowest frequency harmonic of the speech sound wave" (*Voice 2. Jitter*, 2011; Weusthoff et al., 2013). Shimmer refers to the variability of the amplitude of the sound wave (Farrús and Ejarque, 2007). Lastly, air energy is defined as the sound energy once air has been accounted as the wave medium (*Sound…Get energy*, 2021). Bouts of expiratory phonations, inspiratory phonations, and pauses in each infant cry sample were determined using Audacity software. Audacity was used to zoom in and listen closely to individual segments of the audio sample, and mark occurrences of expiratory phonations, where the infant is breathing outwards while crying; inspiratory phonations, where the infant is inhaling while crying; and pauses, where the infant has momentarily suspended their crying.

The 50 videos that were collected and analyzed (25 male and 25 females) were used as the stimulus set for the on-line task on Pavlovia for this study. Infants averaged 71 +/- 37 days of age. The racial distribution of the infants in the videos were: 18 Caucasian, 9 African American, 4 Hispanic, 3 Asian, and the remaining were multi-racial (7 Caucasian and African American, 4 Hispanic and Caucasian, 2 Asian and Caucasian, 1 Hispanic and African American, 1 Native American and Hispanic, and 1 African American and Middle Eastern). To be uploaded onto PsychoPy and then Pavlovia, each infant video was trimmed to its first 15 seconds. Then, Clideo, a video formatting website was used to standardize each video to a .mp4 file type with dimensions of 1280x720.

Participant Descriptives

The participants for this study consisted of 50 mothers from across the U.S. who had infants that were six months old or younger (Mean Infant Age = 94.26 days, SD = 47.25). The

average age of all mothers who participated was 30.35 years old (SD = 7.00). The mean age of the 25 single mothers was 29.11 (SD = 5.52) and the mean age of the 25 non-single mothers was 31.69 (SD = 8.23). The self-reported racial distribution of single mothers was as follows: 11 Caucasian, 9 African American, 4 Hispanic, and 1 multi-racial mother (Caucasian and Hispanic). The self-reported race distribution of non-single mothers was: 18 Caucasian, 4 African American, 2 Asian, and 1 Hispanic. To be eligible to for the study, participants had to have a reliable Wi-Fi connection, access to a desktop computer or laptop, headphones, as well as Zoom and Google Chrome installed on their computer. They were also instructed to be in a quiet environment (such as a room with the door closed) while on the Zoom call with the researcher and while completing the on-line Pavlovia task.

Analysis

All statistical analyses were carried out using the Statistical Package for the Social Sciences (SPSS Version 28.0). The data which were analyzed included the participants' demographic information, scores on questionnaires, and frustration ratings from the infant crying stimuli. Depending on the hypothesis, statistical tests run on the sample included linear mixed-effects models (MIXED), PROCESS macro for SPSS to run mediation and moderation analyses, independent samples *t*-tests, and bivariate Pearson correlation. Each linear mixed-effect model's covariance structure was selected as compound symmetry. The analysis model used to test each hypothesis is listed below.

Hypothesis 1: *Single mothers will find infant cries to be more frustrating compared with non-single mothers*.

A linear mixed model (LMM) on SPSS was used to determine whether frustration ratings differed between both participant groups. The model included Single Motherhood as a between-subjects variable, and the video presentation sequence ("InfantOrder") and infant video identifier ("InfantID") as within-subjects variables. The fixed effect for Motherhood status and InfantOrder was estimated. The LMM also included a random effect for SubjectID, InfantID, and InfantOrder to account for variance across different participants, infant video, and presentation sequence.

Hypothesis 2a: *Single mothers will score higher in postnatal depression, and this will mediate the association between single motherhood and increased frustration in response to infant crying.*

This hypothesis was tested in two separate steps. First, an independent samples *t*-test was used to test for intergroup differences in postnatal depression, based on scores on the Edinburgh Postnatal Depression Scale (EPDS). Mothers' EPDS scores were specified as the test variable and motherhood status of the participant was inputted as the grouping variable. If this test was significant in the hypothesized direction, then the installed package, PROCESS v4.0 by Andrew F. Hayes, was used on SPSS to run a mediation analysis. In this model, the model was specified for mediation, frustration rating as the Y (outcome) variable, motherhood status as the X (predictor) variable, and participant scores on the EPDS was inputted as a mediator. The confidence intervals and number of bootstrap samples were left at their standard setting, which were 95 and 5000, respectively.

Hypothesis 2b: *Single mothers will score higher in perceived stress, and this will mediate the association between single motherhood and increased frustration in response to infant crying.*

This hypothesis was tested in the same way as Hypothesis 2a, with mothers scores on the Perceived Stress Scale inputted as the test variable for the independent samples *t*-test and then as a Mediator for the PROCESS macro mediation analysis. All other measures were kept the same.

Hypothesis 2c: *Social support will be a moderating variable for frustration ratings, so single mothers with strong social support will have lower frustration ratings to infant crying*.

This hypothesis was tested in two separate steps using an independent samples *t*-test for differences in Functional Social Support scores between single and non-single mothers, and then the PROCESS macro package was used to run a moderation analysis. For this model, the model number was specified as "1" for moderation, frustration rating as the Y variable, motherhood status as the X variable, and participant scores on the Functional Social Support Scale was inputted as a moderator. The confidence intervals and number of bootstrap samples were left at their standard setting, which were 95 and 5000, respectively.

Hypothesis 2d: *Single mothers will face more economic strain, and this will mediate the association between single motherhood and increased frustration in response to infant crying*.

This hypothesis was tested in the same way as Hypothesis 2a and 2b, using both an independent samples *t*-test and mediation analysis using PROCESS macro. Mothers' scores on the Family Economic Strain Scale were inputted as the test variable for the independent samples *t*-test and then as a Mediator for the PROCESS macro mediation analysis. All other measures were kept the same.

Hypothesis 3a: *Increased duration of exphonations made by the infants will result in higher frustration ratings by mothers.*

SPSS's linear mixed model (LMM) was used to determine if mothers' frustration ratings differed because of the expiratory phonations of the stimulus set. The model included sum of expiratory phonations of the infant cry stimuli ("SumEx") and the Subject ID as a between-subjects variable, and the video presentation sequence ("InfantOrder") and infant video identifier ("InfantID") as within-subjects variables. The fixed effect for SumEx was estimated. The LMM also included a random effect for Subject ID, InfantID, and InfantOrder to account for variance across different participants, infant video, and presentation sequence.

Hypothesis 3b: *Infant cry features previously found to correlate with higher aversiveness rating, namely intensity and shimmer, will result in higher frustration ratings among mothers.*

This hypothesis testing was also carried out using SPSS's linear mixed model (LMM). To investigate whether mothers' frustration ratings could be explained by acoustic characteristics which were previously found to be aversive, the model included SubjectID as a between-subjects variable. The cry samples' acoustic characteristics of Intensity and Shimmer as well as InfantOrder and InfantID were inputted as within-subjects variables in the model. The fixed effects for Intensity and Shimmer were estimated. A random effect for Subject ID, InfantID, and InfantOrder was also included.

Hypothesis 4: *Mothers will give higher frustration ratings to male infant cries compared to female infant cries.*

A linear mixed model (LMM) on SPSS was used to determine if frustration ratings differed based on infant sex. The model included Single Motherhood and sex of the infant shown in the crying stimuli ("InfantSex") as a between-subjects variable, and the video presentation sequence ("InfantOrder") and infant video identifier ("InfantID") as within-subjects variables. The fixed effect for Motherhood status and InfantSex was estimated. The LMM also included a random effect for SubjectID, InfantID, and InfantOrder to account for variance across different participants, infant video, and presentation sequence.

III. Results

For preliminary analysis of psychosocial profiles among the two study groups, independent samples *t*-tests were conducted for all questionnaires data. Single mothers (N=25) and non-single mothers (N=25) were compared on the nine questionnaires utilized in this study (Brief Resilience Scale, Edinburgh Postnatal Depression Scale, State-Trait Anxiety Scale, Perceived Stress Scale, Financial Economic Strain Scale, Duke-UNC Functional Social Support Scale, Emotional Dysregulation Scale, Positive Affect Schedule, and Negative Affect Schedule) (Table 1). Among all scales, only Functional Social Support differed between single and non-single mothers. Specifically, single mothers (M = 3.50, SD = 1.03) scored lower than non-single mothers (M = 3.95, SD = 0.85; $t(48) = 1.70$, one-sided p = 0.048). Means scale scores for each group are shown below in table 1.

Measure	Single Mothers' Scores (X +/- SD)	Non-Single Mothers' Scores (X +/- SD)	t	p
Frustration Rating	3.48 +/- 1.33	3.52 +/- 0.89	0.12	0.45
Brief Resilience Scale	3.42 +/- 1.11	3.42 +/- 0.82	-0.003	0.50
EPDS	9.60 +/- 6.10	9.40 +/- 5.40	-0.12	0.45
State Trait Anxiety	43.40 +/- 17.14	42.24 +/- 10.65	-0.29	0.39
Perceived Stress	18.20 +/- 8.50	17.48 +/- 7.21	-0.32	0.37
Financial Economic Strain	62.28 +/- 22.85	56.16 +/- 16.31	-1.09	0.14
Functional Social Support	3.50 +/- 1.03	3.95 +/- 0.85	1.70	0.05**
Emotion Dysregulation	46.64 +/- 22.42	46.88 +/- 19.54	0.55	0.29
PANAS Positive Affect	30.16 +/- 10.04	30.32 +/- 7.96	0.06	0.48
PANAS Negative Affect	19.44 +/- 10.99	18.20+/- 6.44	-0.49	0.31

Table 1: Mean Scale Scores and Independent Sample t-test Output for Non-Single vs. Single Mothers on all Nine Questionnaires

Hypothesis 1: *Single mothers will find infant cries to be more frustrating compared with non-single mothers*.

The linear-mixed effect model revealed that frustration ratings did not differ between single mothers (M = 3.48, SD = 1.33) and non-single mothers (M = 3.52, SD = 0.89). There was an effect of the order in which the stimulus was presented ($F(1, 2197.780) = 22.419$,

p<0.001), as well as an effect of the specific Infant ID (CS covariance estimate = 0.308, p<0.001). The parameter estimates for the fixed-effect variable InfantOrder was determined to be 0.009, so each infant cry stimuli presentation resulted in a positive change of 0.009 in the frustration ratings. A follow-up plot allowed visualization of this trend, where increased frustration ratings with each trial of the cry stimuli (Figure 1).

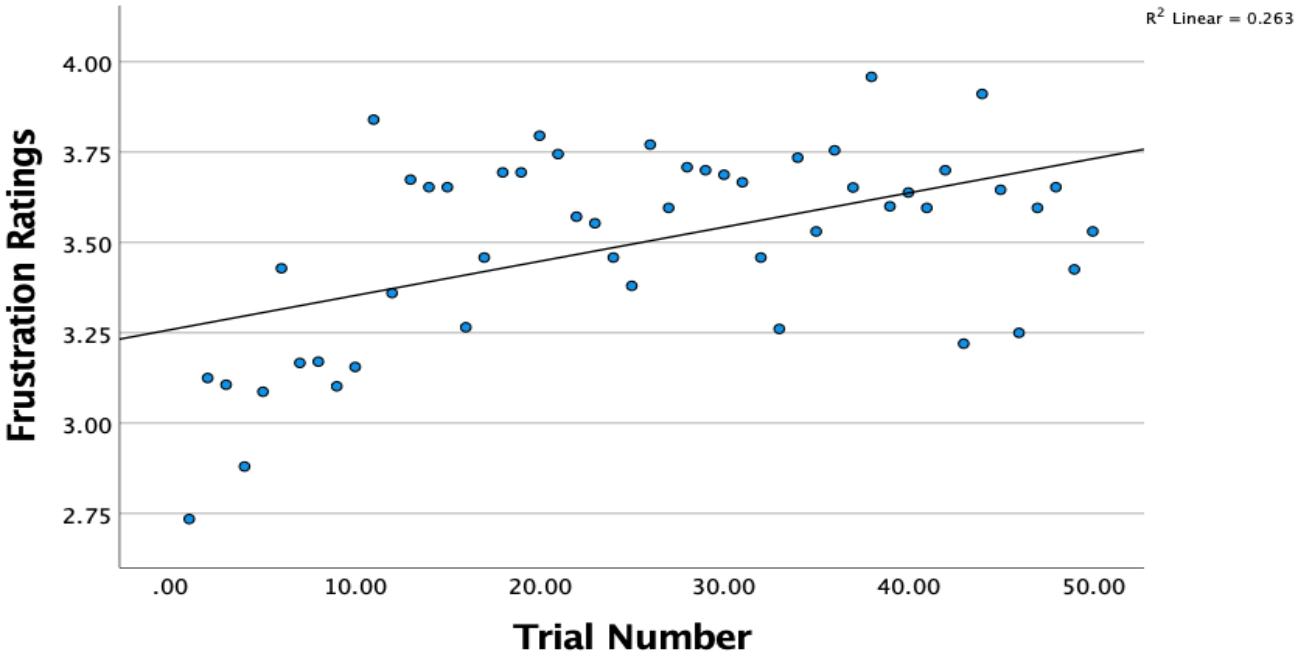

Figure 1: Average Frustration Ratings Across all Consecutive Trials (both Single and Non-single mothers)

Hypothesis 2a: *Single mothers will score higher in postnatal depression, and this will mediate the association between single motherhood and increased frustration in response to infant crying.*

Edinburgh Postnatal Depression Scale scores did not differ between single mothers (M = 9.60, SD = 6.10) and non-single mothers (M = 9.40, SD = 5.40) ($t(50) = -0.123$, one-sided p = 0.451). Therefore, the mediation analysis was not conducted.

Hypothesis 2b: *Single mothers will score higher in perceived stress, and this will mediate the association between single motherhood and increased frustration in response to infant crying.*

Perceived Stress scores did not differ between single mothers (M =18.20, SD = 7.21) and non-single mothers (M = 18.20, SD = 8.50) ($t(50) = -0.32$, one-sided p = 0.37). Therefore, the mediation analysis was not conducted.

Hypothesis 2c: *Social support will be a moderating variable for frustration ratings, so single mothers with strong social support will have lower frustration ratings to infant crying.*

As mentioned above, single mothers did have less social support than non-single mothers ($t(50) = 1.70$, one-side p = 0.048). A moderation analysis was then performed to determine whether this variable moderated the relationship between motherhood status and frustrating ratings.

The interaction between motherhood status and Functional Social Support Scale scores on the outcome variable, frustration rating, was not found to be statistically significant [B = -0.0537, 95% C.I. (-0.77, 0.67), p=0.67]. Therefore, perceived social support is not a moderator of the relationship between motherhood status and frustration ratings.

Hypothesis 2d: *Single mothers will face more economic strain, and this will mediate the association between single motherhood and increased frustration in response to infant crying.*

Financial economic strain did not differ between single mothers (M = 62.28, SD = 22.85) and non-single mothers (M = 56.16, SD = 16.31) ($t(50) = -1.09$, one-sided p = 0.14). Therefore, the mediation analysis was not conducted.

Hypothesis 3a: *Increased duration of exphonations made by the infants will result in higher frustration ratings by mothers.*

The linear mixed effects model revealed a positive association between frustration ratings and exphonations duration of the infant video stimuli ($F(1, 2267.83) = 24.31$, $p<0.001$), as well as from the participant's identification ("Subject"), which was found to have a significant effect (CS diagonal offset estimate = 0.609, $p<0.001$). The parameter estimate for SumEx was determined to be 0.14, where a positive increase of one in expiratory phonations of the infant changes the frustration rating given by the mother by 0.14. Thus, longer durations of expiratory phonations made by the infant resulted in higher frustration ratings among mothers.

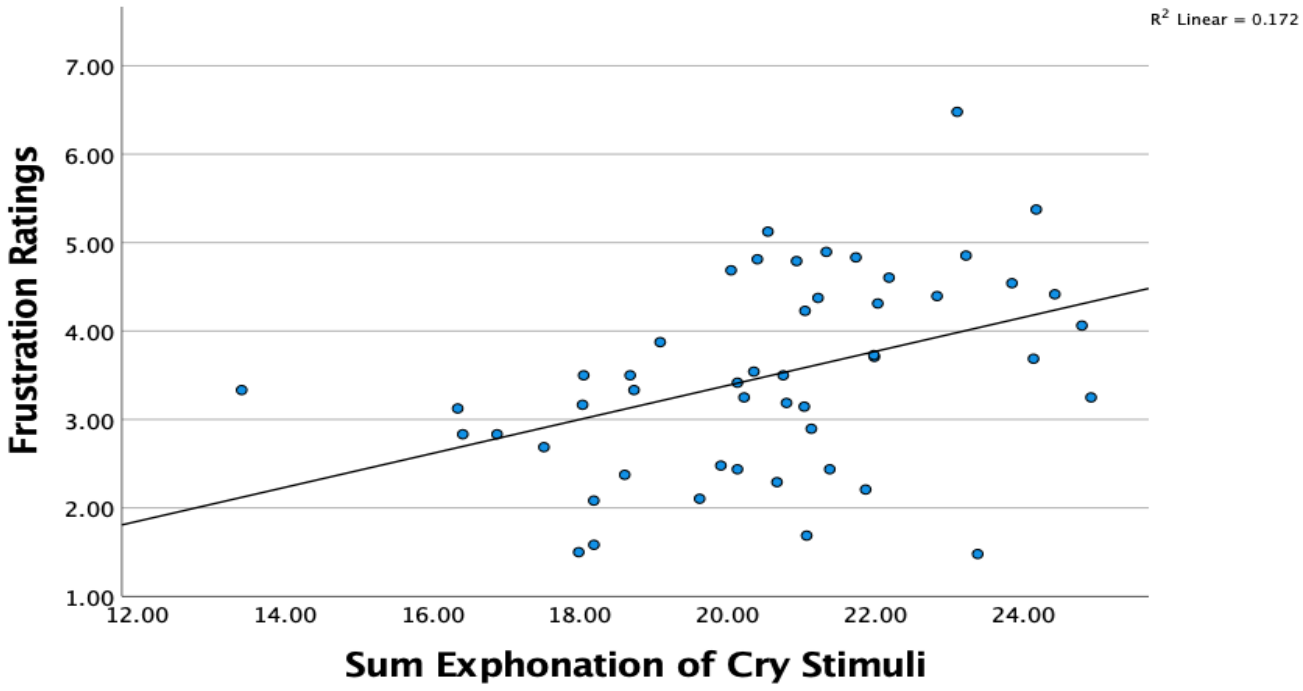

Figure 2: Model of Mothers' Frustration Ratings and Sum Exphonation of Infant Cry Samples

Hypothesis 3b: *Infant cry features previously found to correlate with higher aversiveness rating, namely intensity and shimmer, will result in higher frustration ratings among mothers.*

The linear-mixed effect model showed that the association between frustrations ratings and the cry acoustic features of intensity ($F(1, 2316.33) = 58.84$, $p<0.001$) and shimmer ($F(1, 2318.40) = 112.46$, $p<0.001$) were statistically significant. The parameter estimate for intensity and shimmer were 0.048 and 1.007, respectively. Each positive change of one within the intensity and shimmer caused a change of 0.048 and 1.007 in the mothers' frustration ratings. Therefore, higher intensity and shimmer of the cry sample resulted in higher frustration ratings across all mothers. The participant's identification ("Subject"), was also found to have a significant effect (CS diagonal offset estimate = 0.600, $p<0.001$).

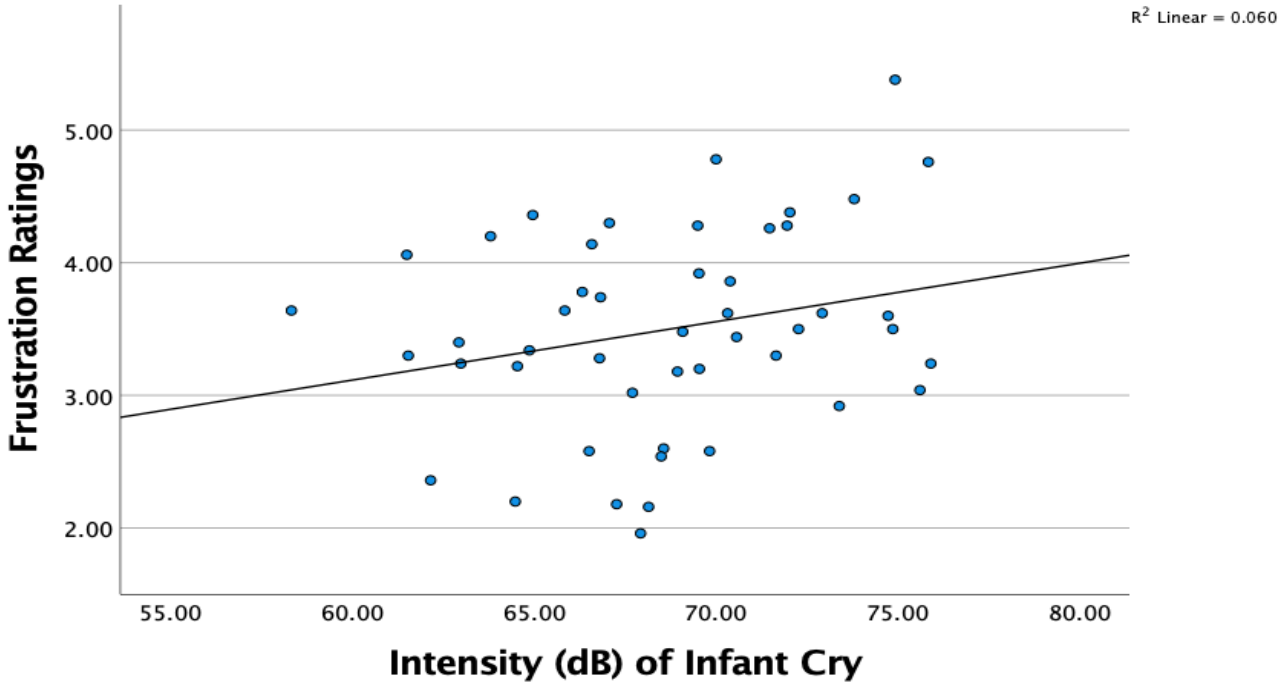

Figure 3: Model of Mothers' Frustration Ratings and Average Intensity of Infant Cry Samples

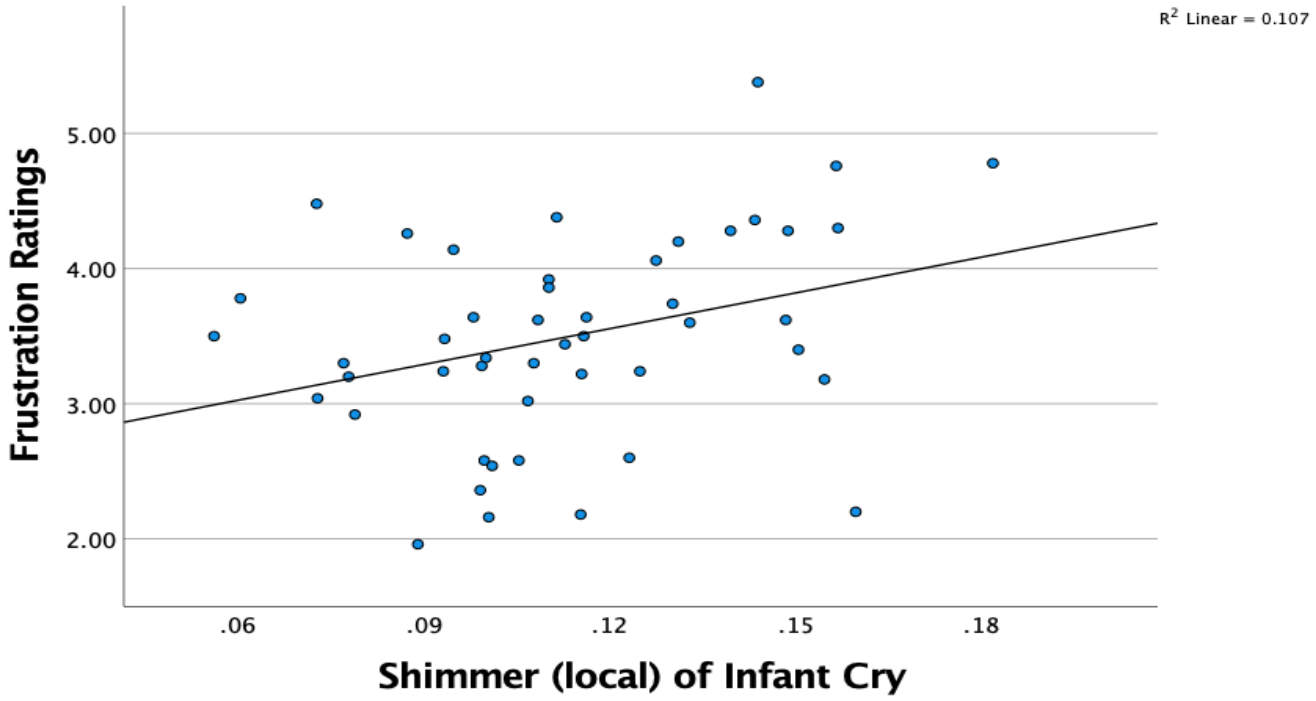

Figure 4: Model of Mothers' Frustration Ratings and Average Shimmer of Infant Cry Samples

Hypothesis 4: *Mothers will give higher frustration ratings to male infant cries compared to female infant cries*.

The linear mixed model indicated that infant sex was significantly related to frustration ratings ($F(1, 2320.158) = 31.437$, $p<0.001$). The parameter estimate for InfantSex was found to be -0.3008, with respect to male infants. Therefore, female infants received higher frustration ratings among mothers in comparison to male infants. The participant's identification number ("Subject") was found to have a significant effect (CS diagonal offset estimate = 0.596, $p<0.001$).

To further visualize the direction of the effect of infant sex on mothers' frustration ratings, we plotted average frustration ratings to male and female infants (Figure 5), which showed that, contrary to our hypothesis, female infants were rated as more frustrating.

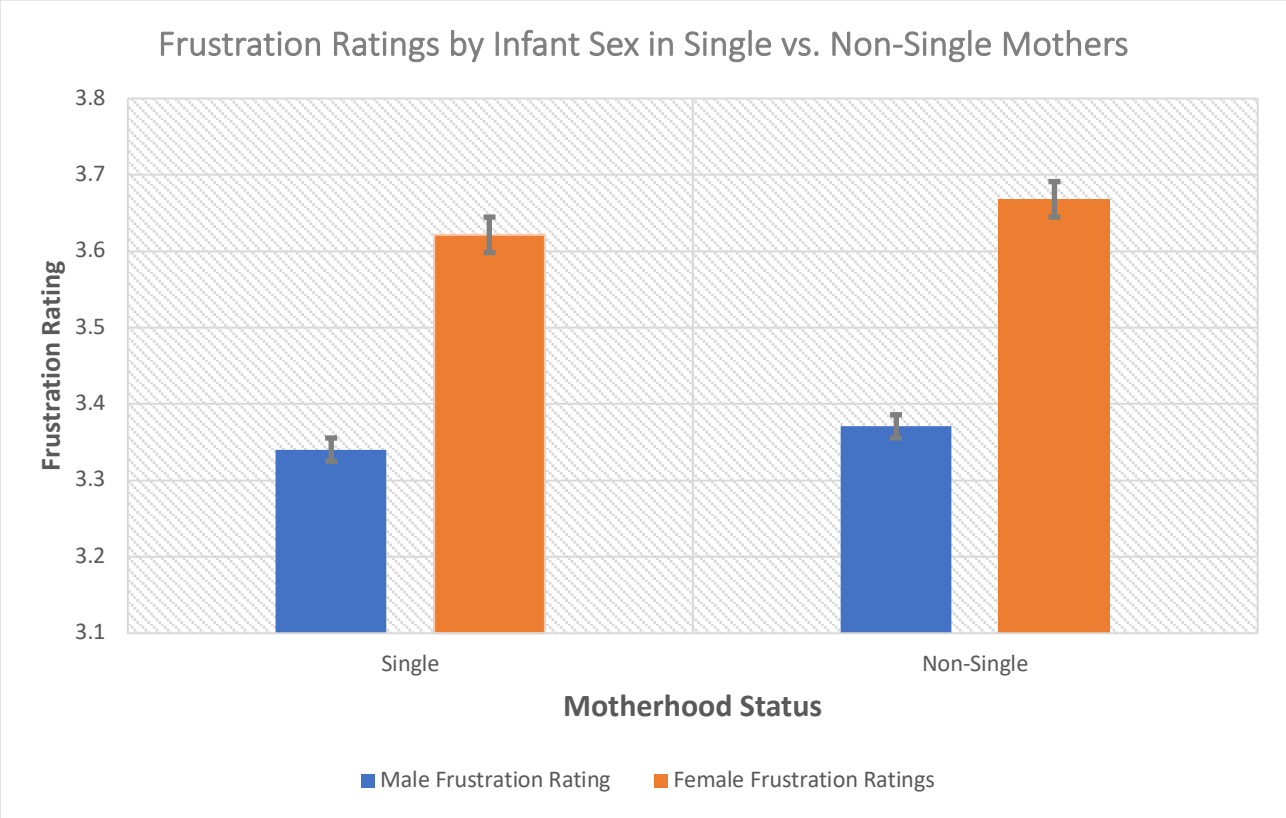

Figure 5: Bar chart of Frustration Rating Differences by Infant Sex of Single vs. Non-Single Mothers

Additional Exploratory Analyses

To further explore the data, Pearson's correlation tests were conducted between average frustration ratings across all mothers and all psychosocial questionnaires. Three of nine psychosocial questionnaires had a positive correlation with average frustration ratings. There was a positive correlation between State Trait Anxiety Scale scores ($r=0.424$, $n=50$, $p=0.002$), Perceived Stress Scale scores ($r=0.417$, $n=50$, $p=0.003$), and Negative Affect Schedule scores ($r=0.431$, $n=50$, $p=0.002$) with average frustration ratings.

		State Trait Anxiety	Perceived Stress	PANAS Negative
Average Frustration Rating	**Pearson Correlation**	0.424**	0.417**	0.431**
	Sig. (2-tailed)	0.002	0.003	0.002

Table 2: Significant Correlation Outputs between Psychosocial Questionnaire Scores and Mothers' Average Frustration Ratings

We also correlated average frustration ratings with all acoustic features of the cries. Four out of the five acoustic variables explored in this study had a positive correlation with average frustration ratings: expiratory phonation durations (r=0.306, n=48, p=0.035), local shimmer (r=0328, n=48, p=0.0.024), local dB shimmer (r=0.337, n=48, p=0.021), and dda shimmer (r=0.307, n=48, p=0.036). The two infant videos which were used as attention probes during the task were not included in this correlation analysis.

		Sum Exphonation	Shimmer (local)	Shimmer (local, dB)	Shimmer (dda)
Average Frustration Rating	**Pearson Correlation**	0.306*	0.328*	0.337*	0.307*
	Sig. (2-tailed)	0.035	0.024	0.021	0.036

Table 3: Significant Correlation Outputs between Cry Acoustic Qualities and Mothers' Average Frustration Ratings

A final linear-mixed effect model was created which contained all variables (both pertaining to participant psychosocial characteristics and acoustic qualities of the infant videos) that were correlated with participant's frustration ratings in the above bivariate analyses. Tests of collinearity were first completed on the three psychosocial variables and four acoustic characteristic variables, respectively.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	2.157	.463		4.663	<.001		
	StateTraitAnxiety	.000	.022	-.002	-.006	.995	.222	4.511
	Perceived Stress Scale	.037	.031	.260	1.201	.236	.356	2.811
	PANAS Negative Affect	.036	.025	.291	1.477	.147	.430	2.326

a. Dependent Variable: AvgFrustrationRating

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	StateTraitAnxiety	Perceived Stress Scale	PANAS Negative Affect
1	1	3.813	1.000	.01	.00	.00	.01
	2	.096	6.310	.61	.00	.01	.30
	3	.075	7.122	.13	.00	.44	.32
	4	.016	15.607	.26	1.00	.55	.38

a. Dependent Variable: AvgFrustrationRating

Table 4 and 5: Outputs from Multicollinearity Tests of Questionnaire Variables Correlated with Frustration Ratings

These tests indicated that multicollinearity was a concern for State Trait Anxiety Scale (Tolerance = 0.222, VIF = 4.511, Condition Index = 15.607, Variance Proportions = 1.00) and Perceived Stress scores (Tolerance = 0.356, Condition Index = 7.122, Variance Proportions = 0.55). While Table 4 did not indicate a multicollinearity problem for either, as the VIF values did not exceed a value of 10, the diagnostic outputs in Table 5 pointed to a potential issue of multicollinearity. The Condition Index being over 15 is an indicator of multicollinearity, which was seen in Dimension 4 of Table 5. A high Variance Proportion (over 0.5) confirms multicollinearity; therefore, State Trait Anxiety and Perceived Stress were concluded as having an issue of multicollinearity and excluded in the final linear-mixed effect model.

A collinearity analysis was also completed on the acoustic characteristic of the infant videos that were found to be correlated with average frustration ratings. These tests indicated

that multicollinearity was a concern when all Shimmer variables were included in the model (Shimmer, Shimmer local, and Shimmer dda), based on the same methodology described above (Shimmer: Tolerance = 0.035, VIF = 28.967, Condition Index = 69.728, Variance Proportions = 0.88; Shimmer local: Tolerance = 0.053, VIF = 18.929, Condition Index = 69.728, Variance Proportions = 0.83; Shimmer dda: Tolerance = 0.073, VIF = 13.743, Condition Index = 43.833, Variance Proportions = 0.83). As the different shimmer variables are nuanced ways of measuring similar acoustic qualities (variability of sound wave amplitude), it was expected that there would be multicollinearity problem when all four of its variables were considered in the model. So, only the general shimmer variable ("Shimmer") was added in the final linear-mixed effect model.

The linear-mixed effect model was then created with all variables correlated with frustration ratings that did not have a multicollinearity problem (Negative Affect Schedule scores, sum of expiratory phonations, and cry shimmer). The model contained frustration rating as the dependent variable, and the fixed effects of the three variables were estimated. The linear mixed model indicated that all three of these variables had a significant effect on the frustration ratings. So, when added to the same model, the total duration of expiratory phonations of infants ($F(1, 2348) = 49.62$, $p<0.001$), cry shimmer of the infant ($F(1, 2348) = 65.53$, $p<0.001$), and the reported negative affect of the mother ($F(1, 48) = 10.97$, $p = 0.002$) were all a significantly associated with frustration ratings. This further confirms that longer durations of expiratory phonations produced by the infant and cry shimmer have a significant positive effect on frustration ratings, and adds the component of the mothers' affect to the frustration rating. Thus, mothers' frustration ratings are significantly associated with acoustic qualities of the infant cry,

namely sum of expiratory phonations and shimmer, as well as higher levels of negative affect reported among mothers.

IV. Discussion

In this study, we hypothesized that due to increased sources of stress and lack of social support in their lives, single mothers would find newborn infant crying more frustrating than non-single mothers. This hypothesis was not supported, as there was no significant difference in frustration ratings between single and non-single mothers (Hypothesis 1). The study sample also did not find significant intergroup differences in the hypothesized mediators, namely postnatal depression, perceived stress, and economic strain (Hypotheses 2a, 2b, and 2d). There was a significant difference in perceived social support, where single mothers reported lower scores in the Functional Social Support scale. However, social support did not function as a moderator in the association between motherhood status and frustrating ratings (Hypothesis 2c).

Previous studies have noted a high prevalence of psychosocial stressors in single mothers' lives, namely higher levels of depression, anxiety, and economic hardship (Crosier et al., 2007; Hope et al., 1999; Kim et al., 2018). The absence of these effects in our study may be attributed to the fact that the study participants recruited were not a representative sample of single mothers. Furthermore, data on the number of children each mother had was not collected, which may have affected her frustration to infant crying. A mother with more children may be more habituated to infant crying, thereby report lower frustration ratings. Our study sample of single mothers may have had higher levels of mental and emotional well-being than the general population, and therefore did not experience increased psychosocial stress in comparison to non-single mothers, as previous studies suggest (Crosier et al., 2007; Lindolm, 2016). This could be explained by the process of recruitment for this study, where each mother had to respond to an online advertisement and express interest in involvement. This suggests that each mother who participated in the study not only had certain resources for connection with others, such as a

reliable Internet connection, a Facebook account, and previous experience with Zoom, but also had qualities such as proactivity and curiosity to pursue such research studies.

To assess the overall mental health of the sample of mothers in this study, the distribution of EPDS, Perceived Stress Scale, and State Trait Anxiety scores were examined in each group. A significant proportion of both single and non-single mothers had high scores on these scales. For EPDS scores, 32% of single and 32% of non-single mothers had scores which indicate a high possibility to probable instance of depression (12 or higher). 44% of single mothers and 40% of non-single mothers received scores of high State Trait Anxiety (45 or higher). On the Perceived Stress Scale, 72% of single mothers and 68% of non-single mothers received scores which signified moderate-high stress levels (14-40). Therefore, the study sample for single and non-single mothers both had roughly similar psycho-emotional profiles, so these characteristics did not differ between single and non-single mothers. Our findings also indicate that single mothers and non-single mothers endure roughly equal levels of psychosocial stress. This demonstrates that at least some single mothers have the capacity to be as mentally healthy as non-single mothers and do not face increased prevalence of psychosocial stressors that could translate to an increased perception of frustration.

Another explanation for the lack of intergroup differences in frustrating ratings could be the limited ecological validity of the experiment task. The stimuli of infant crying videos were chosen to simulate the experience of hearing one's own infant crying for a prolonged time period. However, the fact that these were pre-recorded stimuli of babies who were not their own and were shown in 15-second increments before the frustration rating screen appeared may have resulted in failure of the task to simulate the desired scenario and therefore the associated frustrating ratings. Furthermore, the participants were briefed on the task beforehand, so may

have been able to "brace" themselves for the frustrating stimuli, further contributing to their frustration ratings not being truly indicative of their frustration level to prolonged infant crying.

Regarding acoustic characteristics of the infant cry stimuli, sum of expiratory phonations made by the infant, as well as intensity and shimmer were all found to be associated with frustration ratings across all mothers (Hypothesis 3a and 3b). This finding is consistent with a previous study with fathers, where expiratory phonations correlated positively with ratings of aversiveness made by adult non-father males (Richey et al., 2020). The findings of this study add to this finding, demonstrating that increased infant exphonations lead to higher frustration ratings among mothers as well. Additional acoustic characteristics such as pitch and cry duration have also been found to mediate adults' response to infant crying (Dessureau et al., 1998). Amount of dysphonation has been found to highly correlate with adults' aversiveness ratings of infant cries (Gustafson & Green, 1989). Dysphonation has been identified as a marker of abnormality in infant cries, as it assesses deviations in pitch and intensity (Kheddache & Tadj, 2013). Therefore, it is probable that such cry variability might have been accounted for the in the shimmer analysis of this study, as shimmer measures amplitude variability of the sound. Specific to maternal response, a previous study has found that mothers' perception of negativity or irritability in their infant was positively correlated with fundamental frequency and negatively correlated to duration and phonation. In other words, mothers were less likely to perceive an infant as having an irritable temperament if they produced more phonations (Huffman et al., 1994). This suggests that an element of perception of the infant's temperament may also inform maternal response to infant crying, and therefore how frustrating mothers find the cry.

Maternal mental health issues, such as postpartum depression and anxiety have been strongly related to infant crying problems, such as excessive crying and infantile colic, and this

association has also been found to occur as early as pregnancy with crying problems seen in newborns (Ölmestig et al., 2021). Additionally, infants of depressed mothers have been found to cry at significantly higher fundamental frequency, which may be a behavioral adaptation since depressed mothers were less likely to engage in caregiving behaviors and responded only to cries at higher frequencies and which were 15 seconds or less (Esposito et al., 2017). Therefore, infant crying has been established as playing a strong role in mother-infant interactions – not only on the perception of frustration in response to acoustic features, but infant crying problems and higher fundamental frequencies of the cry could even be predictors for mental health disorders among mothers. Our study found that maternal negative affect and perceived stress were both positively correlated with frustration ratings among both single and non-single mothers. Negative affect of the mother was also significantly associated with frustration ratings given by the mother. Among adults, negative affect has been found to be related to higher rates of self-reported stress, poor coping skills, health complaints, and frequency of unpleasant events (Heinström, 2010). This explains how mothers with a higher score on negative affect were less likely to cope with the infant cry stimuli, resulting in a higher frustration rating. Therefore, the higher the level of negative affect within a mother, the higher her frustration level to infant crying.

Interestingly, negative behavior states in the mother not only impacts her frustration level in response to her infant, but also has been found to have lasting effects on the infant's behavior and emotion as well. Infant emotion regulation skills are shaped by early mother-infant interactions, and mother's emotional unavailability or dysregulation during this period (such as from depression) results in more frequent negative states among the infant as well (Field, 1994).

Additionally, maternal negative affect has been linked to infant behavioral issues, particularly childhood risk for anxiety problems (Brooker et al., 2016).

Our study showed that frustrating ratings differed by infant sex across both single and non-single mothers, with female infants given higher ratings in both groups (Hypothesis 4). Investigation of sex difference in infant cry perception is highly relevant, because in extreme cases, it can lead to infant abuse, such as Shaken Baby Syndrome (Barr et al., 2006). Male infants have been found to spend more time producing expiratory phonations, which was hypothesized to contribute to their increased vulnerability to abuse (Richey et al., 2020). Female infants have been found to produce more inspiratory phonations, which would further confirm that they produce fewer expiratory phonations than male infants, as crying consists of these two different types of phonations, along with pauses (Wermke et al., 2018). However, the infant videos used in this study did not have any significant differences in sum of expiratory phonations between male (M = 21.0082, SD = 1.963) and female infants (M = 20.9072, SD = 2.254) ($t(48)$ = 0.489, one-sided p =0.435), or any other acoustic quality. Therefore, it is important to consider what factors could be contributing to female infants receiving higher frustration ratings in this study, despite it being established that male infants are more likely to be the victims of infant abuse.

As stated above, the infant stimuli sample did not reveal any significant sex differences in acoustic qualities previously found to differ by infant sex, such as sum of expiratory phonations (Richey et al., 2020). This may point to another characteristic of the infant informing sex differences in frustration response, such as visual and interactive cues. Previous studies have reported increased parental feelings of protection and concern for physical harm for female infants (Block, 1976). Additionally, it has also been shown that it is important that mothers feel

reciprocal interaction and acknowledgment by their infant, as they reported experiencing decreased intense anger or feelings of abandonment towards their infant when they smiled or make frequent eye contact with them (Kurth et al., 2014). Female infants have been reported to maintain eye contact longer than male infants and continue to look longer at faces during 6 and 12 months of age (Leeb & Rejskind, 2004). Related to this increased engagement, mothers also play a significant role in providing language output to their infant and respond more readily to infant vocal cues than fathers (Johnson et al., 2014). Language acquisition and vocal cues are seen earlier among female infants than male infants (Adani & Cepanec, 2019). These factors may also result in mothers being preferential to female infants. Therefore, increased feelings of protection towards female infants, as well as their likelihood to participate in engaging behavior, such as smiling, eye contact, and vocal cues may act as a buffer. In other words, even if a female infant's cry is found to be more frustrating, an increased feeling of attachment and engagement between them and their caregiver could explain why they are less likely to be victims of infant abuse. A possible explanation for why this preference towards female infants (through lower frustration ratings) was not seen in this study could be because the experiment task did not include any aspects of social exchange, as the mother was instructed to simply listen and record her frustration level.

Furthermore, maternal reactions to infant distress have been seen to follow some unique patterns. For one, the emotion reaction of mothers to infant distress can be buffered when the mother had more infant-oriented goals (Leerkes, 2010). In other words, mothers reacted less sensitively to infant cries when they reported fewer negative emotions in response to the infant crying or were adept at detecting the source of infant distress (Leerkes, 2010). This finding was seen at play within this study, during the Zoom task call. At the end of the frustrating rating task,

the mothers were asked if they had any additional questions or comments about the study and five mothers (four non-single and one single) commented on how identification of the source of the infant's distress informed their frustrating rating. One mother said, "What made me more frustrated was that some of these cries were easy fixes to solve! I could tell few babies were just crying because they were cold – all they needed was a blanket!" Another mother calmly responded, "You could tell which ones just woke up from a nap and were a little cranky. They just needed to let it out." Thus, a unique feature of maternal perception to infant crying could be an innate ability to detect the source of discomfort, which affected the degree of sensitivity they exhibited towards the infant cry. This added focus to determine the source of the infant's distress along with the stronger attachment that mothers feel from female infants' visual cues could explain the findings of this study. As mothers have been found to be more responsive to infant vocal cues than fathers and feel more attached to female infants due to their increased reciprocal interaction, they may be finding the female infant cry to more frustrating simply because they are more responsive to it and would therefore be more affected by female infants (Kurth et al., 2014; Johnson et al., 2014). Furthermore, as female infants have been more associated with higher parental feelings of protection and mothers' infant response usually include some aspect of determination of the source of distress, mothers may also find female infants' cries more frustrating due to increased concern and a sense of urgency to address the female infants' need to protect her from a state of discomfort (Block, 1976).

The principle aim of this study was to identify specific behavioral, psychological, and social mechanisms, as well as characteristics of the infant cry stimuli that inform frustration responses of single mothers in comparison to partnered or non-single mothers. Little is known regarding the significance of single motherhood in the context of frustration response to

prolonged infant crying. This study did not find a significant difference in psychological distress, perception of financial hardship, or frustration level to infant crying between single and non-single mothers. The only variable which displayed a significant intergroup difference was perceived social support, however this did not inform frustration ratings among either group of mothers. Four factors were found to inform mothers' frustration response: sex of the infant (with females receiving higher frustration), the length of exposure to the cry, acoustic cry qualities (exphonation, intensity, and shimmer), and negative affect of the mother.

A logical direction for future research would be to look at gendered differences among infants in terms of facial expressions, movement, or physical appearance, as that was not an aspect considered in his study, but could be playing a role in adults', and particularly mothers', frustration response to infants crying. Additionally, the lack of differences of frustration ratings between single and non-single mothers in this study does not diminish the fact that this demographic continues to face unique obstacles in their daily lives. It is highly necessary that single mothers are provided with increased support networks and positive interactions with others. A study with survey results spanning 24 European countries indicate that the gap of perceived life satisfaction between single mothers and childless singles is substantially smaller than between single mothers and partnered mothers, but when residing in countries with supportive family policies and high levels of gender equality, single mothers reported equal levels of life satisfaction as childless singles (European Society of Human Reproduction and Embryology, 2017). This challenges the notion that single motherhood is a burden and inevitably reduces women's life satisfaction. From this understanding, more focused resources and practices can be implemented which better empower single mothers, such as more gender-equal policies and increased opportunities to build social support systems.

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