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Lynnet Richey March 27, 2018

Sex and gender influences on adult male perception of infant cries

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An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
of the requirements of the degree of
Bachelor of Sciences with Honors

Department of Neuroscience and Behavioral Biology

2018

Abstract

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Male infants are abused more frequently than female infants. However, the cause of this disparity has yet to be investigated. Infant crying is known to be the primary trigger for abuse. As such, in this two-part study we examined the influences of infant sex, gender stereotypes, and sound qualities on the perceived aversiveness of infant cries. Adult male participants rated the perceived aversiveness of audio and video recordings of crying infants. In experiment one, only acoustic stimuli were used. In experiment two, video stimuli were used which included both the acoustic component of the infant's cry as well as infant gender cues in the form of clothing color (blue to suggest male, pink to suggest female). In half of the videos shown to each subject, the gender cue matched the sex of the child. In the other half of the videos, the cue and the infant's sex were discordant. Results from part one indicate that in the absence of visual stimuli or gender cues, male infant cries are more aversive than female infant cries. However, there was no difference between male and female infant cries for any measured objective sound characteristic. In experiment two, it was discovered that female infants who were suggested to be female to viewers were perceived as more aversive than females suggested to be male or males suggested to be either male or female. These results lead to the conclusion that perceived aversiveness is the result of a variety of interacting, occasionally opposing factors including sex-specific cry qualities and gender stereotypes. In addition, given that boys are abused more than girls, one can infer that other powerful factors are at play that modulate aggressive interactions with male and female infants. This study elucidates two factors that affect rates of infant aversiveness and emphasizes the need for future projects to clarify what other forces influence abuse rates.

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Abstract

Male infants are abused more frequently than female infants. However, the cause of this disparity has yet to be investigated. Infant crying is known to be the primary trigger for abuse. As such, in this two-part study we examined the influences of infant sex, gender stereotypes, and sound qualities on the perceived aversiveness of infant cries. Adult male participants rated the perceived aversiveness of audio and video recordings of crying infants. In experiment one, only acoustic stimuli were used. In experiment two, video stimuli were used which included both the acoustic component of the infant's cry as well as infant gender cues in the form of clothing color (blue to suggest male, pink to suggest female). In half of the videos shown to each subject, the gender cue matched the sex of the child. In the other half of the videos, the cue and the infant's sex were discordant. Results from part one indicate that in the absence of visual stimuli or gender cues, male infant cries are more aversive than female infant cries. However, there was no difference between male and female infant cries for any measured objective sound characteristic. In experiment two, it was discovered that female infants who were suggested to be female to viewers were perceived as more aversive than females suggested to be male or males suggested to be either male or female. These results lead to the conclusion that perceived aversiveness is the result of a variety of interacting, occasionally opposing factors including sex-specific cry qualities and gender stereotypes. In addition, given that boys are abused more than girls, one can infer that other powerful factors are at play that modulate aggressive interactions

with male and female infants. This study elucidates two factors that affect rates of infant aversiveness and emphasizes the need for future projects to clarify what other forces influence abuse rates.

Background

Infant crying is typically an adaptive behavior by which a child can shape parental responses to meet his or her needs (Soltis 2004). However, prolonged, inconsolable crying can frustrate caretakers and, in extreme cases, lead to abuse. One prevalent form of infant abuse is called Shaken Baby Syndrome (SBS) or Abusive Head Trauma (AHT). SBS is the result of cranial rotation or acceleration due to violently shaking a child (Castiglia 2001). Shaking is especially dangerous for infants due to their large brain to body ratio, lack of neural myelination, and minimal cranial support owing to underdeveloped neck musculature (Schub & Cabrera 2017).

As one might expect, the consequences of SBS are often dire, and can include: subdural or sub-arachnoid hematomas, retinal hemorrhages, psychomotor developmental delays, epilepsy, and cortical and subcortical atrophy leading to severe cognitive delays (Biron and Shelton 2005). A case report that followed the development of a one year old girl portrays the effects of SBS in a particularly poignant manner. After the abuse, the child was hospitalized due to a loss of consciousness and was found to have a severe subdural hematoma. She had surgery to limit the bleeding and was comatose for nearly a week. Months after the trauma, the child's lack of continued neurological growth became evident from cranial scans. Soon, the girl began to miss developmental milestones. Years after the trauma, the extent of the damage became clear: at age 6, she was unable to answer simple questions such as, are you a boy or a girl, to count beyond two, or to use the bathroom independently (Laurent-Vannier et al., 2009).

While this case illustrates the consequences of SBS for survivors, 18-25% of SBS victims die as a result of the trauma (Barr, 2012). Only 22% of victims escape acute sequela (Biron and Shelton 2005). Even fewer escape long term disabilities, which can appear after a prolonged

symptom-free period (Bonnier et al., 1995). The lack of immediate signs of abuse in less severe cases is a serious problem in SBS (Haviland and Russell 1997). Without noticeable signs, other caretakers cannot seek treatment for injuries inflicted upon the child or prevent further abuse. Even in cases where a child is brought to a physician after moderate abuse, SBS can still be missed, as it is challenging to diagnose. There are rarely external signs of abuse like bruises or bumps, and symptoms— fussiness, vomiting, unresponsiveness, and fever—are non-specific (Schub & Cabrera 2017). In fact, one study found that of children eventually diagnosed with Abusive Head Trauma, 31% had previously seen a physician who missed the abuse (Jenny et al., 1999). Given that the children in this study had repeated doctor's visits, these were likely more serious cases of AHT in which children displayed immediate severe symptoms. This diagnostic difficulty leads one to question how many cases of SBS occur that are never recognized.

Even given the cases missed due to a combination of the factors noted above and the reluctance of perpetrators to obtain treatment for victims, the reported incidence of SBS for 0-1 year old infants is approximately 30/100,000 births (Keenan et al., 2003; Minns et al., 2008). In addition, SBS is the most frequent cause of death or long term neurological injury resulting from child abuse (Blumenthal, 2002).

Given the inordinate toll SBS takes on the individual and society, extensive research has been focused on the cause of the infant-directed violence. Infant crying has been identified as the primary trigger. In fact, one study found that 5.6% of parents reported having smothered, slapped or shaken their baby at least once because of the child's crying (Reijneveld et al., 2004). Inconsolable crying, in particular, is a known trigger for abuse (Barr et al., 2014). This type of crying, in which the infant cannot be soothed, is common for the first two to four months of life, then decreases precipitously. SBS incidence follows a similar trajectory (Barr et al., 2006).

Interviews with abusers corroborate inconsolable crying as a trigger for violence. One aggressor stated that he was changing his child, presumably to stop the infant's crying. However, after being changed, the child would not stop sobbing. In response, he shook the infant once, and then again when the first episode did not fully suspend her cries (Biron and Shelton 2005). Unfortunately, this pattern of repeated shaking is not unusual. In many incidences, moderate shaking can stun a child, halting his or her weeping. This positively reinforces the shaking, and makes future abuse more likely. In a previously mentioned study focused on missed cases of abusive head trauma, during the period between the initial physician's visit and the diagnosis, which was an average of seven days in length, 28% of the infants suffered additional abuse (Jenny et al., 1999).

Given that crying is the primary trigger for abuse, efforts have been made to assist parents in coping with inconsolable infant crying. Most of these attempts focus on educating parents about crying as a stressor, and teaching them how to safely handle negative emotional responses to crying. One study revealed that a brief educational program resulted in significant increases in parental awareness regarding proper responses to infant crying (Barr, 2009). Another demonstrated a significant decrease in rates of abuse for those provided with information regarding SBS during their postpartum hospital stay (Dias et al., 2005). Such studies provide hope that education is a feasible method for reducing abuse. This improvement emphasizes the need for continued exploration of abuse triggers so that the information can be effectively communicated to parents.

One consistent finding in cases of SBS is that male infants are abused at higher rates than female infants, consistently accounting for 60-65% of reported AHT cases (Ludwig and Warman 1984; Starling, Holden, and Jenny 1995; Fanconi and Lips 2010; Starling et al., 2004). In this

study, we attempt to explain sex differences in rates of infant abuse by investigating differences between female and male infant cries and adult's reactions to them. One possibility is that there are acoustic differences between male and female infant cries or their accompanying behaviors. Another possibility is that gender stereotypes held by abusers affect how tolerant they are of male and female infant cries.

Parents, especially heterosexual fathers, are known to promote "traditional masculine" behavior in their sons (Kane 2016). While infants may not be expected to fulfill these desired behaviors yet, evidence suggests that sex stereotypes are placed on infants by parents, especially fathers, even 24 hours post-partum (Rubin et al., 1974). This nearly immediate typecasting could lead fathers to be more irritated by their son's excessive crying, as the behavior does not match stereotyped ideas that boys should not cry (Motro and Ellis 2017).

The fact that paternal figures in particular exaggerate gender stereotypes in their sons is notable, as abusers are typically fathers or male partners of the child's mother (Reijneveld et al., 2004). In fact, 70-90% of abuse can be attributed to male caretakers despite men typically providing less care than women (Schub & Cabrera 2017, Starling et al., 1995). Fathers are the most frequent abusers, accounting for 37% of reported SBS cases (Starling et al., 1995). However, one study found that mother's boyfriends and step-fathers committed a startling 23.6% of infant head trauma, a seemingly disproportionate percentage for their prevalence as caretakers (Starling et al., 1995). Compounding this evidence of disproportionate accountability is a study that examines rates of child abuse committed by boyfriends compared to the amount of time they spend as the child's caretaker. Results revealed that boyfriends commit 27 times more abuse than would be expected given their caretaking responsibilities.

This propensity for abuse by new partners of the child's mother can be linked to comparable behaviors in the animal kingdom. Many primate males will eliminate infants sired by previous dominant males, causing females to be able to breed again sooner (Lukas and Huchard 2014). Another relevant primate study noted the propensity for male spider monkeys to specifically eliminate male infants within their own social group, in theory to reduce later intra-group competition (Alvarez et al., 2015). These strategies lead to a greater likelihood that the male's genetic lineage will be passed on and a reduced chance that the male's status in the group will be challenged in the future.

A final risk factor for abuse is limited experience with infant care on the part of the abuser (Blumenthal 2002), suggesting that first-time parental figures would pose the greatest risk. To best mimic the situation of a first time, inexperienced father or boyfriend interacting with an infant, we chose to focus our study on men who have not yet had children.

Hypotheses

1) Given higher rates of abuse in male infants, men will rate male infant cries as more aversive than female infant cries, irrespective of clothing color.

2) Given higher rates of abuse in male infants, men will rate infants dressed in blue (assumed male gender) more negatively than infants dressed in pink (assumed female gender), irrespective of infant sex.

3) Sex and clothing color will interact such that men will rate male infants dressed in blue as most aversive.

4) Given the disparity in rates of abuse based on infant sex, auditory characteristics of infant cries will differ by sex.

5) Given the disparity in rates of abuse based on infant sex, subjects will be able to correctly identify the sex of an infant based on listening to its cry.

Methods

This study consisted of two experiments. The first used audio recordings of infant cries that were acquired in a previous experiment. The second experiment was conducted using newly acquired video stimuli.

Experiment One:

Thirty second audio clips of 1 to 3-month-old crying infants were recorded by experimenters or parents. A total of 26 clips, 13 from girls and 13 from boys, were recorded. All recordings were taken in the children's homes. Clips were later edited to 10 seconds to be used in this study.

41 men over the age of 21 who were not fathers were recruited to take part in this experiment. This demographic was chosen because they are inexperienced, a known risk factor for SBS, and because recruiting an adequate sample of new fathers or boyfriends was deemed infeasible in the allotted time. The participants had an average age of 26 years (SD = 7.95). The racial distribution of the sample was as follows: 19 White, 15 Asian, 6 African American, and 1 Latino.

E-prime was used for stimulus presentation. After hearing each infant cry stimulus, participants were asked to rate the cry for aversiveness on a 7-point likert scale. 10 second frog or bird call stimuli were inserted after every third cry to reduce habituation to the infant cries. After rating all 26 cries, subjects listened to all 26 cries again in a different order. This time, participants were asked to guess the sex of each infant they heard crying.

Experiment Two:

In the second experiment, we recorded videos of young (<3mo) infants from the Atlanta area. Videos were recorded at the child's home with the infant crying at what parents judged to be peak intensity. Videos were recorded using an iPhone 5s recorder from approximately one foot back and three feet above the infant. All infants were placed on a white blanket provided by experimenters. Each infant was recorded wearing both a blue and a pink outfit, colors we hoped viewers would associate with their gender (blue=boy, pink=girl). Twelve infants were recorded, yielding a total of 24 videos. Each video was later edited to a 30-second-long clip, a duration garnered from a previous SBS study (LaGasse, Neal and Lester 2005).

40 male non-fathers over the age of 21 were recruited to rate the videos. Again, this demographic was chosen to model inexperienced fathers or boyfriends. The participants had an average age of 26 years (SD = 5.94). The racial distribution of the sample was as follows: 22 White, 10 Asian, 4 African American, and 4 Latino.

E-prime was used for stimulus presentation. Each participant viewed twelve videos of infants crying and rated each video for aversiveness. 25% of the videos were male babies dressed in blue, 25% were male babies dressed in pink, 25% were female babies dressed in blue and 25% were female babies dressed in pink. Blue clothing was meant to suggest that the infants were male, while pink clothing should have suggested the infant was female. Each participant saw each infant once. Infant clothing color was counterbalanced across participants; each infant was seen in blue by half of the participants and in pink by the other half of the participants. Each infant cry stimulus was followed by a 30 second video of birds chirping, which was intended to reduce habituation to the infant cry stimuli. To assess the effectiveness of our clothing manipulation, we asked each subject after the completion of the experiment whether they assumed that infant clothing color indicated infant sex.

Analysis

All statistical tests were conducted using the statistical package for the social sciences (SPSS). For each variable, data beyond 3 times the interquartile range from the mean were treated as outliers and removed. $p<0.05$ was considered statistically significant.

Experiment One:

One subject's data was excluded due to an internet failure that led to partial data loss. For each of the rest of the participants (n=41), average aversiveness ratings for female infant cries (n=13) were subtracted from average aversiveness ratings for male infant cries (n=13). The difference scores across all 41 participants were then compared with zero using a one sample t-test. Cronbach's alpha was calculated for ratings of boys and ratings of girls as a within subject measure of rating consistency. In addition, the proportion of correct gender guesses was calculated for each subject. A one sample t-test was used to compare the values of all 41 participants to 0.5 (i.e., chance).

For each infant cry, Praat software was used to calculate values of the following characteristics: fundamental frequency (Fo), mean pitch, maximum pitch, minimum pitch, cry roughness, frames voiced, harmonic to noise ratio, and intensity. The Fo equates to the lowest frequency of a sound. Pitch, in contrast to Fo, includes all harmonics of a sound and changes with shifting volume of different harmonics (Gerhard 2003). If one is listening to musical instruments, Fo would be the note the instrument is playing. However, many instruments can play the same note but sound drastically different. This is largely an effect of the different harmonics, which are accounted for in the pitch of a sound. Roughness refers to amplitude modulations ranging from 30 to 150 Hz that typically induce unpleasant auditory percepts (Arnal

et al. 2015). As one might guess, frames voiced is a measure of the amount of time out of the total sound in which there is sound. Harmonics to noise ratio is a measure of the periodicity of a sound which has also been defined as hoarseness (Yumoto, Gould, Baer 1982). Finally, the intensity of a sound is a measure of volume (Green, Whitney, Potegal 2011). Independent sample t-tests were conducted to determine if these qualities differed between male and female infants. Each auditory characteristic was also tested for correlation with aversiveness ratings for each participant. The correlation values across all participants were then compared with zero using a one sample t-test.

Experiment Two:

Two subjects had incomplete data due to EPrime failures and were therefore excluded from analysis. For the remaining subjects (n=40), we tested for main effects of clothing color and sex, as well as their interaction on aversiveness ratings. Specifically, the average aversiveness score for infants dressed in pink (n=6) was subtracted from the average score for infants dressed in blue (n=6). At the group level, differences from all 40 subjects were compared with zero using a one sample t-test. In addition, the average score of female infants was subtracted from that of male infants for each subject, and differences from all 40 subjects were compared with 0 using a one sample t-test. A repeated measure analysis of variance (ANOVA) with infant sex and clothing color as within-subject variables was conducted to test for interactions between clothing color and sex. Follow-up t-tests were performed to explore the nature of significant interaction effects. Subject age, video order, and experience with infants were also included as between-subject variables. To account for inter-subject variation in how participants use the rating scale, we also repeated all analyses after dividing each subject's cry aversiveness scores by their average bird song aversiveness score. Infant experience was based on subject's

descriptions and was coded into the following categories: extensive experience (regular caretaking), moderate experience (occasional caretaking), minimal experience (interaction but no caretaking), or no experience. Information provided spanned the subject's lifetimes. Cronbach's alpha was also calculated for each group of videos to examine internal reliability.

As noted, after the completion of the experiment, we asked each subject whether they assumed that infant clothing color indicated infant sex. We used these responses to divide participants into two groups, those who said yes (n=24) and those who said no (n=16). A repeated measure analysis of variance (ANOVA) with infant sex and clothing color as within-subject variables was conducted for each group separately to test for interactions between clothing color and sex. In addition, follow-up t-tests were done to examine the nature of any interactions.

For each infant cry, Praat software was used to calculate the values of the following characteristics: fundamental frequency, intensity, and mean pitch. Independent sample t-tests were conducted to determine if these qualities differed among any of the groups of videos (Boys in Blue, Boys in Pink, Girls in Blue, Girls in Pink).

Results

Experiment One:

Male infant cries were rated as significantly more aversive than female infant cries (M-F mean=0.15, t(40)=2.27, p=0.03, d=0.24; Figure 1). Supplemental Figure 1 shows the mean scores for male infants and female infants for each subject. Cronbach's alpha was 0.95 for male infant ratings and 0.94 for female infant ratings, demonstrating high within subject reliability for ratings of males and females.

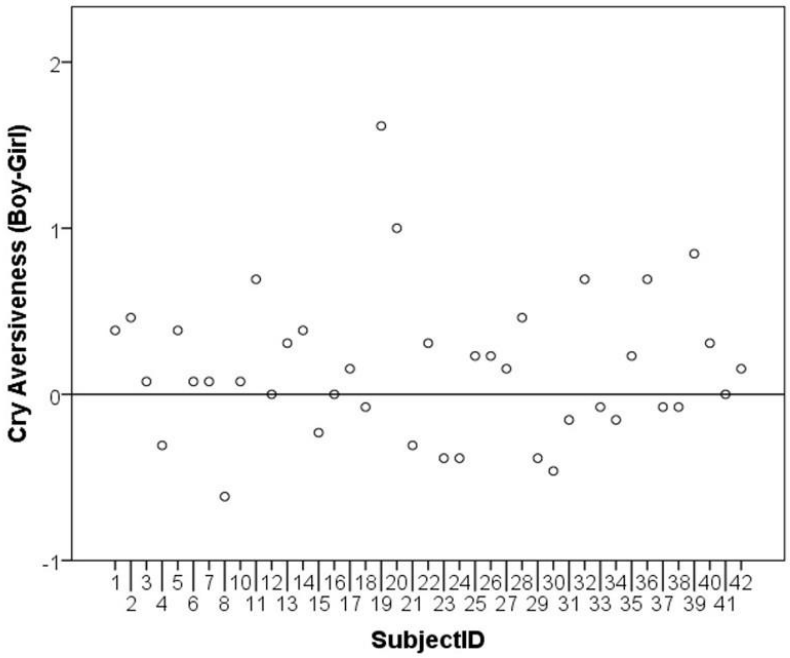

Figure 1: Effects of infant sex on aversiveness ratings. Each point on the graph represents the average aversiveness rating of female infants subtracted from the average aversiveness rating of male infants for one subject.

Figure 2 shows the data of a single subject to demonstrate the sex-based clustering of aversiveness responses.

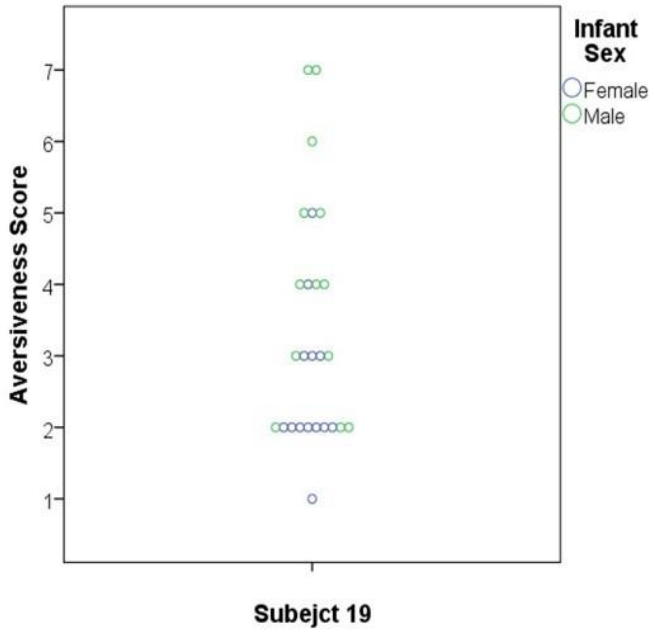

Figure 2: Aversiveness scores for each cry from subject 19. Male cries, labeled in green, are more common near the top of the graph while female cries cluster near the bottom.

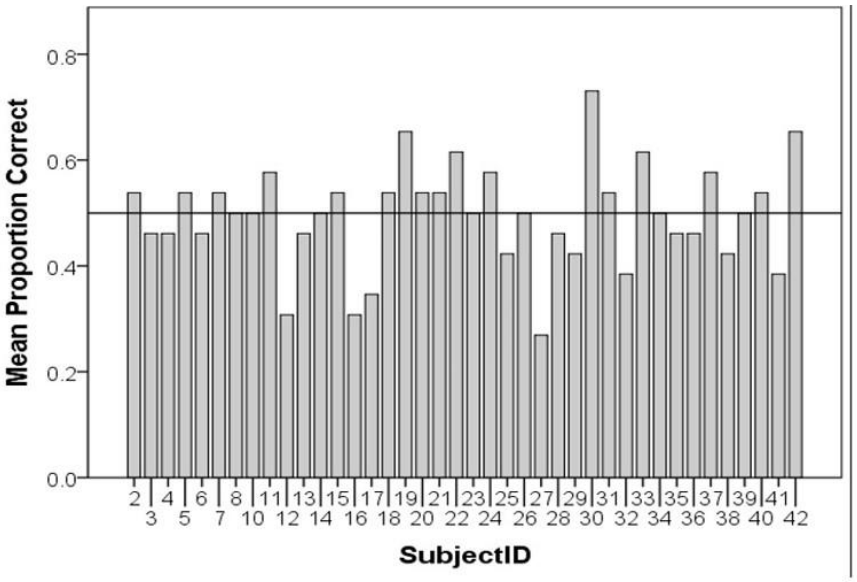

Figure 3: Measurement of correct guesses of infant sex. The bars indicate the mean proportion of correct guesses for each subject. The horizontal line indicates 0.5, or chance.

Despite male cries being rated as more aversive than female infant cries, participants were unable to distinguish male from female infant cries (Mean Proportion Correct=0.50, t(39)=-0.25, p=0.80), as shown in Figure 3.

Fundamental frequency, mean pitch, maximum pitch, cry roughness, intensity, and harmonics to noise ration all correlated significantly with aversiveness ratings (Figure 4). However, none of these variables differed significantly by infant sex (Figure 5).

Quality	mean r
Fundamental Frequency(Hz)	0.13***
Mean Pitch (Hz)	0.34****
Maximum Pitch (Hz)	0.12***
Minimum Pitch (Hz)	-0.01
Roughness (asper)	0.4****
Intensity (dB)	0.17****
Frames Voiced	0.07
Harmonics- Noise Ratio (dB)	0.23****

Figure 4: Correlations between aversiveness ratings and infant cry characteristics.
p<0.0001**** p=0.0001-0.001***
p=0.001-0.01** p=0.01-0.05*

Quality	Female n	Female Range	Female Mean	SE	Male n	Male Range	Male Mean	SE	p	t
Fundamental Frequency(Hz)	13	329-538	433.23	14.72	13	390-551	444.77	14.35	0.58	-0.56
Mean Pitch (Hz)	13	346.33-626.01	477.23	19.46	10	378.83-780.55	504.37	37.98	0.52	0.15
Maximum Pitch (Hz)	13	557.37-2590.12	1904.63	176.42	13	632.69-2593.06	1513.35	37.98	0.15	-0.65
Minimum Pitch (Hz)	12	249.99-259.40	252.88	0.82	13	249.86-252.64	250.63	0.25	0.019*	2.64
Roughness (asper)	13	3.25-4.62	3.85	0.09	13	2.88-4.34	3.71	0.12	0.37	0.92
Intensity (dB)	13	64.20-80.01	70.15	1.25	13	68.86-74.95	71.39	0.56	0.38	-0.91
Frames Voiced	13	0.53-0.79	0.66	0.021	13	0.50-0.89	0.67	0.03	0.73	-0.35
Harmonics- Noise Ratio (dB)	13	9.97-18.62	13	0.65	13	8.05-21.74	13.73	1.08	0.57	-0.58

Figure 5: Comparison of auditory characteristics by infant sex. For each variable, data beyond 3 times the interquartile range were treated as outliers and removed.

Experiment Two:

There was no main effect of infant sex on aversiveness ratings (Mean M-F=0.06, SE=0.09, t(39)=0.69, p=0.49, d=0.07; Figure 6A). However, aversiveness ratings did vary based on clothing color, with infants in pink rated as more aversive than infants in blue (Mean B-P=-0.25,

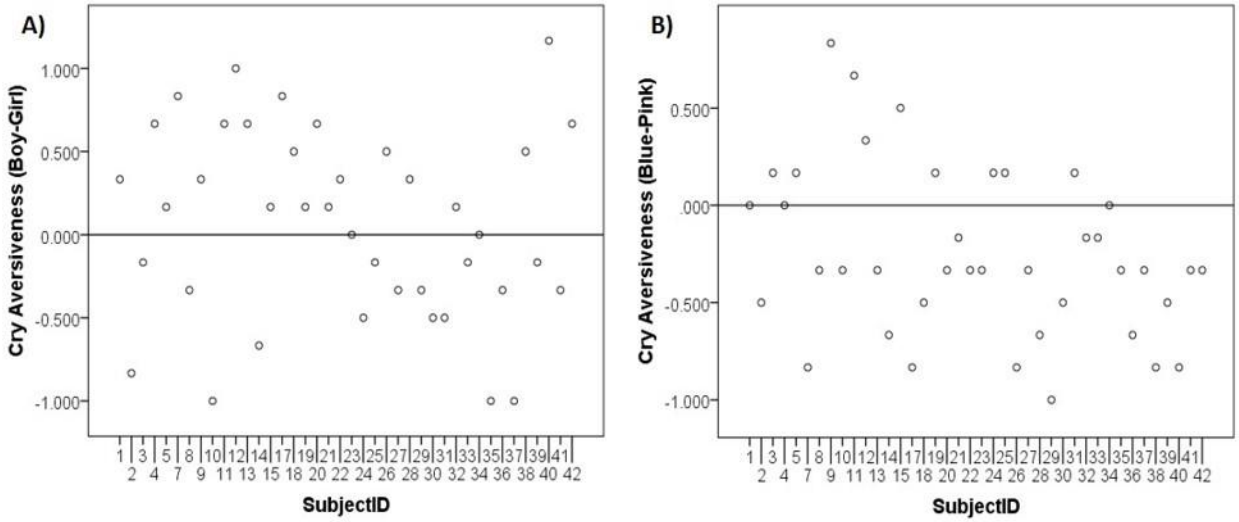

Figure 6: A) Sex and B) clothing color effects on aversiveness ratings. Each point shows the average rating of female infants subtracted from the average rating of male infants for a single subject.

SE=0.07, t(39)=-3.51, p=0.001, d=0.29; Figure 6B). The mean aversiveness scores for male infants and female infants for each subject are shown in Supplemental Figure 2. The mean scores of infants in blue and infants in pink for each subject are shown in Supplemental Figure 3.

There was also a significant sex by color interaction effect (p=0.001). Follow-up t-tests revealed that 1) when dressed in blue, male infants are rated as significantly more aversive than female infants (Mean M-F=0.36, SE=0.11, t(39)=3.14, p=0.003, d=0.40; Figure7A) and 2) female infants in pink were rated as more aversive than female infants in blue (Mean B-P=-0.54, SE=0.11, t(39)=5.15, p=0.8*10^-5, d=0.61; Figure 7B). No significant differences exist between girls and boys dressed in pink (Mean M-F=-0.23, SE=0.13, t(39)=-1.85, p=0.073, d=0.26; Figure7C), nor are there differences between ratings of boys in pink and boys in blue (Mean B-

P=0.05, SE=0.11, t(39)=0.47, p=0.64, d=0.06; Figure7D). None of the between subject variables were significant with (age p=0.68, order p=0.67, experience p=0.69) or without (age p=0.01, order p=0.58, experience p=0.36) normalization of ratings. Cronbach's alpha was 0.63 for males, 0.91 for females, 0.86 for infants in pink, and 0.85 for infants in blue indicating that there is reasonable within-subject reliability for each grouping.

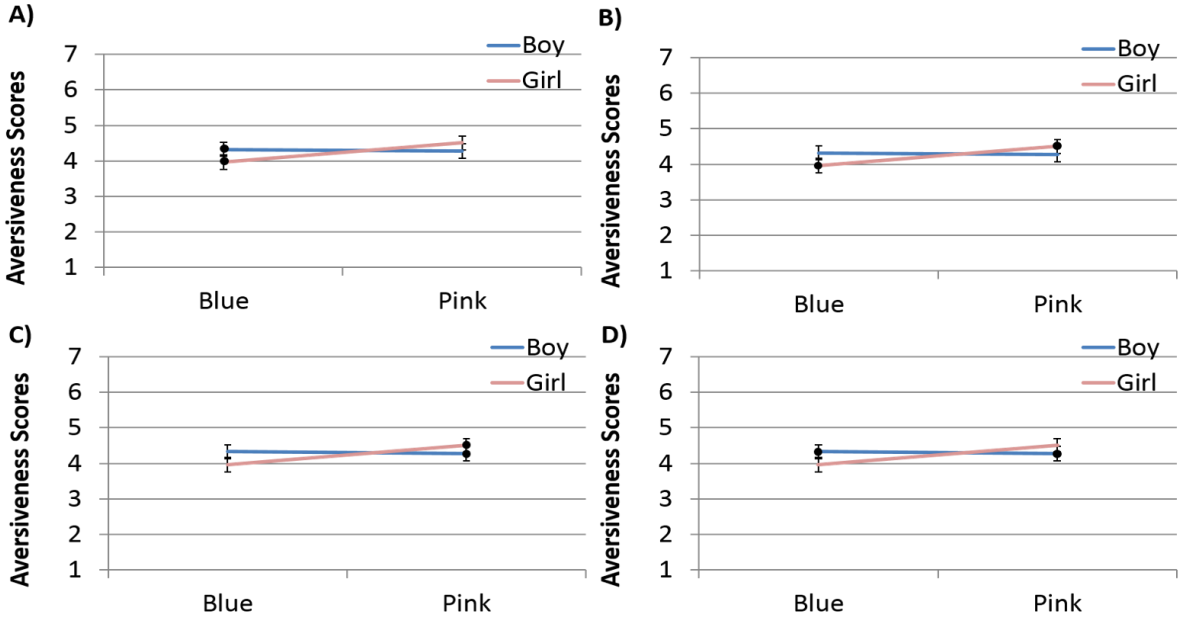

Figure 7: Sex and clothing color interaction on aversiveness ratings, with follow-up comparisons illustrated. Bold circles indicate groups being compared in each panel. A) in blue, male infants are rated as significantly different than female infants B) girls in pink are rated as significantly different than girls in blue C) no significant differences exist between girls and boys in pink, D) nor are there differences between scores of boys in pink or blue. Lines represent the mean aversiveness across subjects and error bars represent the standard error of the mean.

Separating participants based on whether they believed infant clothing related to the child's gender revealed interesting trends. For individuals who stated they believed clothing color was related to infant gender (yes group), infants in pink were rated as significantly more aversive than infants in blue (Mean B-P=-0.33, SE=0.08, t(23)=-4.12, p<0.000, d=0.36; Figure 8A). However, this was not the case for those in the no group (Mean B-P=-0.125, SE=0.12,

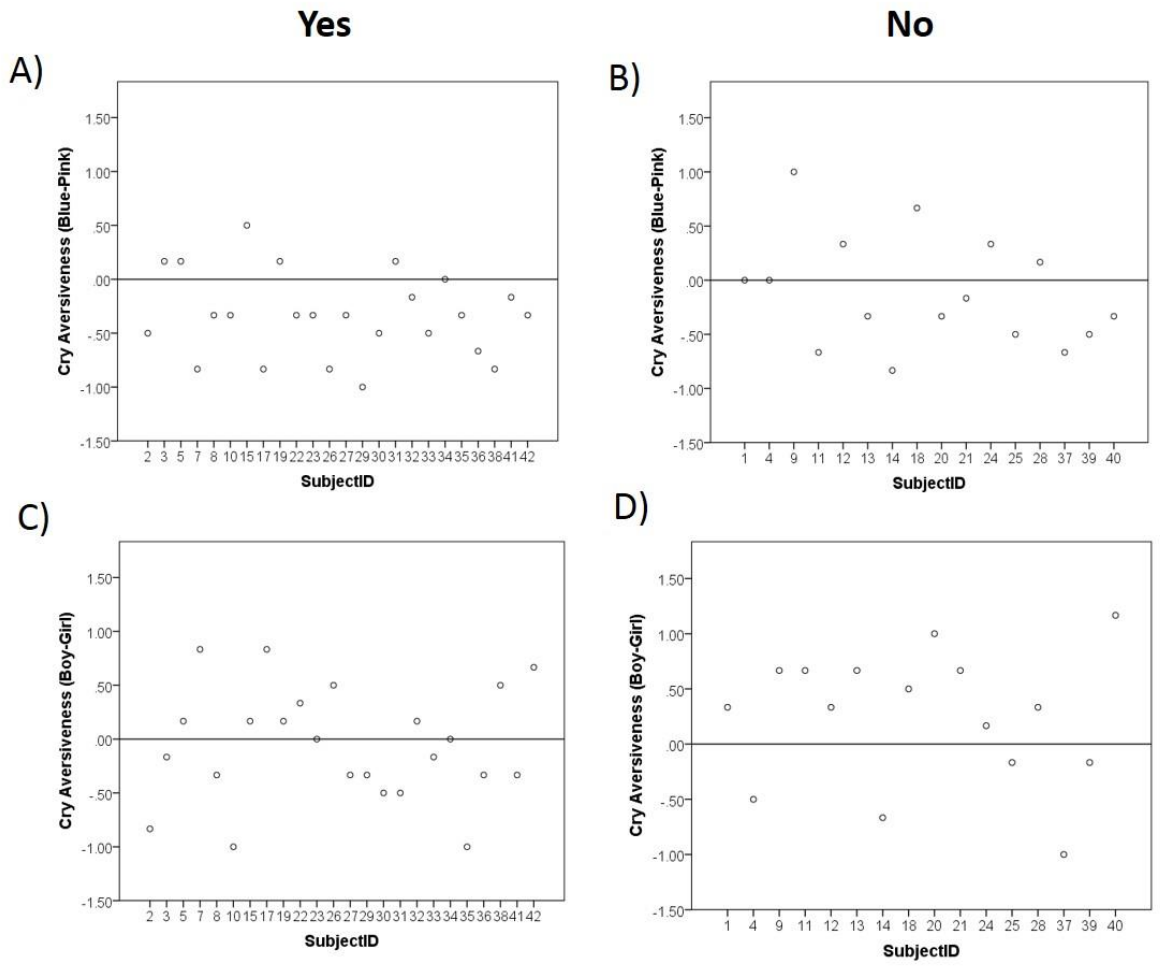

Figure 8: Main effects of infant sex and clothing color on aversiveness ratings as a function of whether participants equated clothing color with infant gender. For A and B, each point shows the average aversiveness score of infants in pink subtracted from the score of infants in blue for a single subject. For C and D, the points represent the average score of female infants subtracted from the average score of male infants for a single subject. Data are plotted separately for participants who did (A, C) or did not (B, D) equate clothing color with infant gender.

t(15)=-0.90, p=0.34, d=0.29; Figure 8B). In addition, the yes group showed no significant difference between the ratings of male and female infants (Mean M-F=-0.062, SE=0.11, t(23)=-0.59, p=0.56, d=0.07; Figure8C). However, there was a weak trend within the no group, with male infants rated as more aversive than female infants (Mean M-F=0.25, SE=0.15, t(15)=1.65, p=0.12, d=0.31, Figure8D). Figure 9 shows a side-by-side comparison of the results form experiment one and the sex rating results from the no group of experiment two (the result shown

in figure 8D). As shown, the graphs look quite similar.

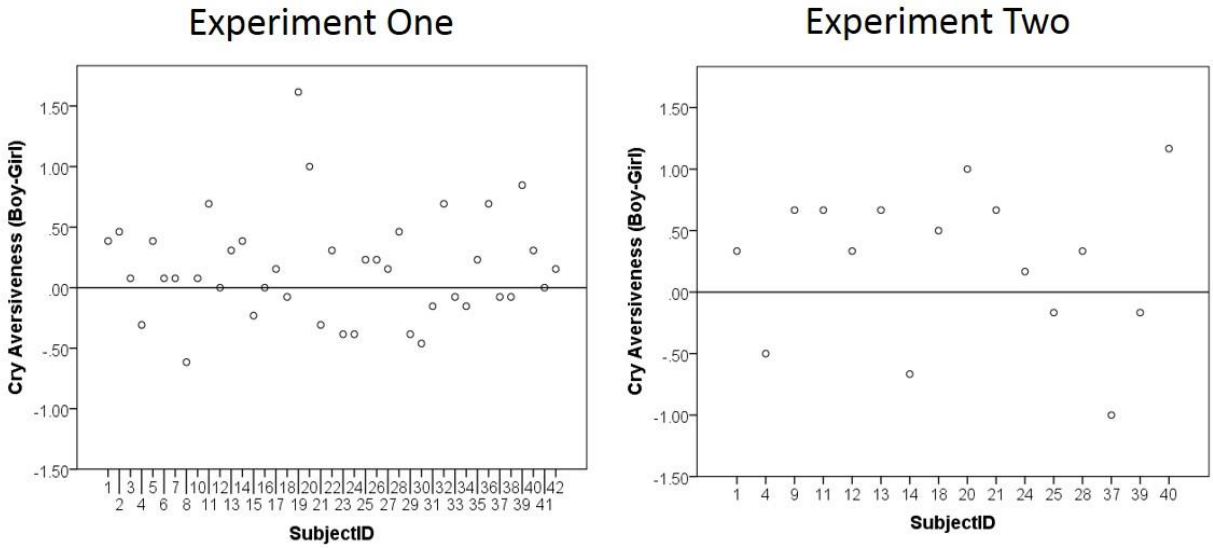

Figure 9: Comparison of aversiveness ratings in experiment one with the no group of experiment two. Each point on the graph represents the aversiveness ratings of female infants subtracted from those of male infants for one subject. The larger scattering or points above zero reflects the fact that male infants were rated as more aversive than female infants in both groups.

There was a significant interaction effect of color and sex for both the yes group (p=0.01) and the no group (p=0.03). For the yes group, follow-up t-tests revealed that 1) girls in pink were rated as more aversive than girls in blue (Mean B-P=-0.64, SE=0.12, t(23)=-5.17, p<0.00, d=0.69; Figure10A) and 2) when dressed in pink, female infants are rated as significantly more aversive than male infants (Mean M-F=-0.38, SE=0.16, t(23)=-2.43, p=0.02, d=0.41; Figure10B). No significant differences exist between boys in blue and boys in pink (Mean B-P=-0.01, SE=0.15, t(23)=-0.09, p=0.93, d=0.01, nor are there differences between the scores of female and male infants in blue (Mean M-F=0.25, SE=0.15, t(23)=1.62, p=0.12, d=0.26). For the no group, follow-up tests demonstrated that when dressed in blue, male infants are significantly more aversive than female infants (Mean M-F=0.52, SE=0.16, t(15)=3.18, p=0.01, d=0.66; Figure10C). No significant differences exist between girls in blue and girls in pink

(Mean B-P=-0.40, SE=0.19, t(15)=-2.13, p=0.05, d=0.46), boys in blue and boys in pink (Mean B-P=0.15, SE=0.15, t(15)=0.98, p=0.34, d=0.18), or boys and girls dressed in pink (Mean M-F=-0.02, SE=0.21, t(15)=-0.10, p=0.92, d=0.02).

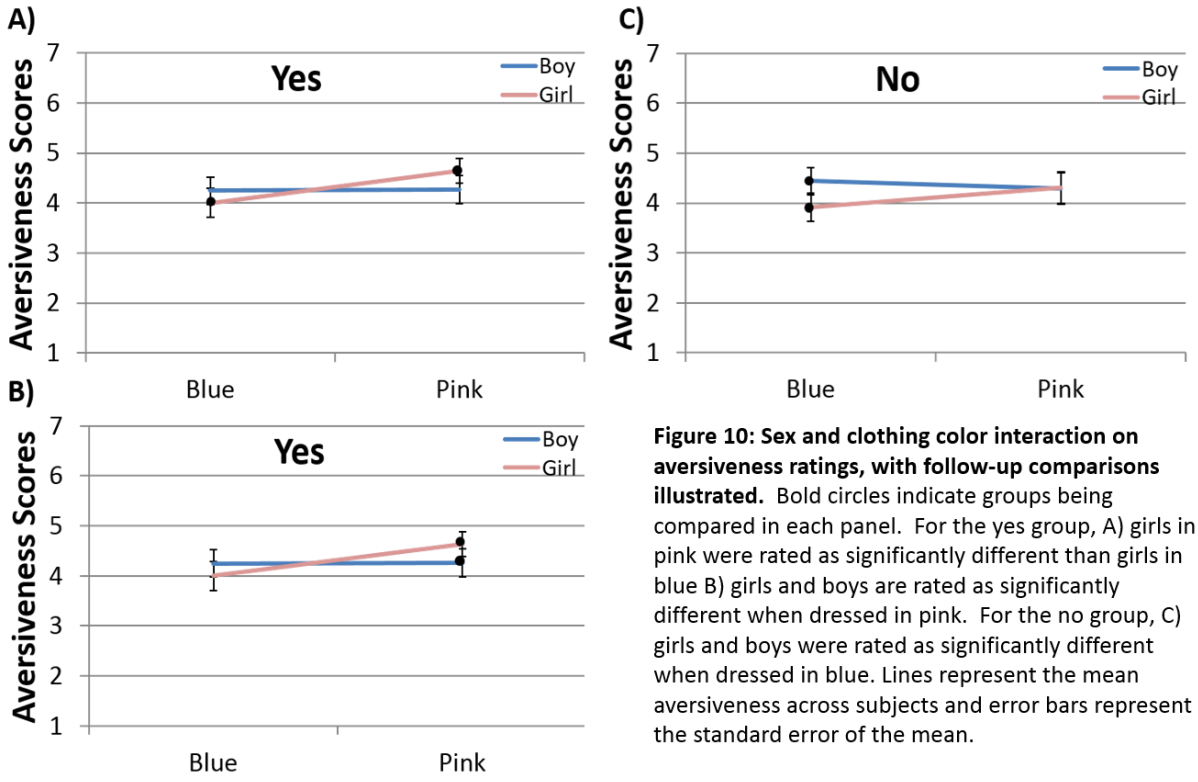

Figure 10: Sex and clothing color interaction on aversiveness ratings, with follow-up comparisons illustrated. Bold circles indicate groups being compared in each panel. For the yes group, A) girls in pink were rated as significantly different than girls in blue B) girls and boys are rated as significantly different when dressed in pink. For the no group, C) girls and boys were rated as significantly different when dressed in blue. Lines represent the mean aversiveness across subjects and error bars represent the standard error of the mean.

Independent t-tests revealed no significant differences in acoustic qualities based on video grouping or infant sex (Figures 11 & 12).

Quality	Range Females in Pink	Mean Females in Pink (SE)	Range Females in Blue	Mean Females in Blue (SE)	Range Males in Pink	Mean Males in Pink (SE)	Range Males in Blue	Mean Males in Blue (SE)	Range Females	Mean Femlaes (SE)	Range Males	Mean Males (SE)
Pitch (Hz)	329.90-378.35	356.33 (8.46)	289.31-324.21	358.95 (0.83)	296.04-403.45	356.81 (14.52)	278.31-373.83	342.23 (13.74)	324.21-389.32	357.64 (6.20)	278.31-373.83	349.5 (9.78)
Fo (Hz)	419-603	528.67 (26.99)	372-656	533.83 (38.19)	361-503	421.33 (21.97)	357-510	403.83 (22.84)	372.00-656.00	531.25 (22.31)	357.00-510.00	412.58 (15.33)
Intensity (dB)	47.11-64.23	55.43 (2.65)	51.89-62.26	51.64 (2.56)	51.89-62.26	55.76 (1.45)	55.40-59.82	57.08 (0.60)	42.65-61.74	53.53 (1.85)	55.40-59.82	56.42 (0.78)

Figure 11: Auditory cry qualities by video grouping and gender. For each variable, data beyond 3 times the interquartile range were treated as outliers and removed.

Contrast	df	t	p
Pitch FP – Pitch FB	5	-0.50	0.64
Pitch MP – Pitch MB	5	1.73	0.14
Pitch FP – Pitch MP	5	-0.02	0.98
Pitch FB – Pitch MB	5	0.94	0.39
Pitch F – Pitch M	5	0.44	0.68
Fo FP – Fo FB	5	-0.32	0.76
Fo MP – Fo MB	5	0.85	0.43
Fo FP – Fo MP	5	2.58	0.05
Fo FB – Fo MB	5	2.26	0.07
Fo F – Fo M	5	2.48	0.06
Intensity FP – Intensity FB	5	2.31	0.07
Intensity MP – Intensity MB	4	-1.18	0.11
Intensity FP – Intensity MP	5	-0.14	0.90
Intensity FB – Intensity MB	4	-1.99	0.22
Intensity F – Intensity M	4	-1.77	0.46

Figure 12: Pitch, fundamental frequency (Fo), and intensity measures between video groups and gender. The auditory characteristics of females in pink (FP), females in blue (FB), males in pink (MP), and males in blue (MB) were compared for each variable, as were overall male (M) and female (F) scores. For each variable, data beyond 3 times the interquartile range were treated as outliers and removed. $P<0.05$ was considered statistically significant.

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Discussion

Male infants are abused more frequently than female infants (Ludwig & Warman 1984; Fanconi & Lips 2010). However, the cause of this disparity has yet to be investigated. In this two-part study, we examine the influences of infant sex, gender stereotypes, and sound qualities on the perceived aversiveness of infant cries.

We found that based on auditory characteristics, male infant cries are rated as more aversive than female infant cries. This is demonstrated by the greater aversiveness of male cries in experiment 1, as well as by the trend in the sub-group of participants in experiment 2 who failed to recognize gender cues. Despite this, no single acoustic variable could be identified that both correlated with aversiveness ratings and differed by infant sex.

Despite the lack of acoustic differences by infant sex in experiment 1, a number of variables correlated strongly with aversiveness ratings. The strongest relationship was between aversiveness and cry roughness. Based on the r^2 value, roughness explains 16% of aversiveness ratings. This association is not surprising as roughness is known to occupy a unique niche within the acoustic world. Oscillations from 30-50 hertz are not used within speech, but are prevalent in distress calls. The unique nature of this quality is evident from the fact that humans can localize rough sounds faster than similar sounds with other oscillatory patterns, suggesting that this feature has evolved to immediately attract attention (Arnal et al. 2015). Thus, the aversive quality of roughness and its presence in infant cries is aligned with the function of these sounds: to attract and hold caretakers' focus. In addition to roughness, mean pitch (11.6%), maximum pitch (1.4%) fundamental frequency (1.7%), harmonics-noise ratio (5.3%), and intensity (2.9%) all account for significant variance in aversiveness ratings.

As in experiment 1, no acoustic variables differed by infant sex in experiment 2. However, there was a trend for female infants to have higher Fo than male infants ($p=0.06$). This is consistent with a previous report that found female infant cries to have a marginally higher Fo than male infant cries (Borysiak et al., 2017). In addition, Fo has previously been found to relate to the listener's level of distress, as has the proportion of sound to pause, here quantified by the harmonics to noise ratio (Esposito et al., 2015). Higher pitch is another important factor which has been associated with harsh caregiver responses (Out et al., 2010). This is in accord with our findings which indicate higher pitch was associated with higher aversiveness ratings. A final self-evident factor regarding cries that could spark abuse is the duration of the act (Gustafson and Green 1989). This factor was not addressed in our study as previous research has shown that the amount of crying does not differ by infant sex (Almli, Ball and Wheeler 2001), nor does the prevalence of colic (Fazil 2011).

When gender cues were combined with infant cry videos in experiment 2, the propensity for male cries to be judged more aversive was overwhelmed by the perception that infants dressed in pink were more aversive. However, this was only the case when the child actually was a girl. This is demonstrated by female infants in pink being rated as significantly more aversive than boys in pink or girls in blue, though only by the group of participants who assumed pink outfits indicated the infant shown was female. The fact that no acoustic differences were found between the video groups and that this trend only held for viewers who perceived gender cues suggests it is a real effect rather than a video sampling error. For boys, being perceived as male or female did not affect the aversiveness of their cries. It should be noted that in experiment two, Cronbach's alpha was 0.63 for males, indicating low internal reliability.

The finding that cries of girls are particularly aversive when they are dressed in pink is contrary to our hypothesis. Our initial assumption that male infant cries would be judged as more aversive was based on known stereotypes suggesting that males should not cry (Motro and Ellis 2017). However, perhaps other stereotypes are coming into play. One study which asked parents of young children to complete questionnaires regarding the femininity or masculinity of potential behaviors found that male children were expected to be loud and disruptive, while it was believed girls should remain quiet and still (Smith and Daglish, 1977). Perhaps this stereotype leads viewers to find it aversive when girls fail to conform by crying.

Infant cry studies have found that higher Fo cries are perceived as expressing more urgency (Lin et al., 2016). In addition, gender labeling studies indicate cries thought to be from a female infant are perceived as expressing more fear (Condry and Condry 1976). Thus, in combination, the slightly higher Fo of girl cries and the female label could make viewers perceive infant girls as more physiologically aroused, something known to spark larger stress responses in caretakers (Kurth et al., 2014).

In concert, the findings that the acoustics of male cries are more aversive but girls are perceived as more aversive when identified as female leads to the conclusion that abuse is sparked by an amalgam of factors. The increased aversiveness of male infant cries may play a role. However, the powerful influence of gender stereotypes can overwhelm this effect. In addition, while both likely impact abuse rates, their effect sizes are small (Study1 d=0.24; Study 2 Color d=0.29) indicating their influence is rather minimal. The higher aversiveness ratings for females dressed in pink suggests that there must be influential unexamined factors that explain why male infants are, in practice, abused more frequently.

One explanation is that abuse disparity by sex originates not from the reaction to infants when they are crying, but rather is related to the caretaker's relationship with the child when they are not crying. Specifically, infant-caretaker bonding could modulate parental responses to a frustrating child. This factor is of particular interest as studies suggest female infants engage in more social bonding activities then male infants from hours after their birth. Female infants more frequently orient to faces, spend more time making eye contact, and orient to voices more than male infants do in the first few days of life (Osofsky and O'Connell 1977; Hittleman and Dickes 1979, Connellan et al., 2000). These trends continue through the following months (Moss and Robson 1968). Given reports discussed below that reciprocal interaction is vital to caretaker-infant bonding, parents may form stronger bonds with daughters that more effectively counter negative emotions precipitated by the infant's crying.

Some mothers indicate that the perception of reciprocal interaction and intimacy was the factor that led them to feel that their child was more than a burden. One individual noted that when her infant started interacting, "I felt needed whereas before (he recognized me) I really didn't..." The study goes on to discuss a case in which parental bonding failed to occur, stating "The one brain-damaged infant in our study, who failed to smile or look at her mother, elicited intense anger and conscious wishes of abandonment" (Kurth et al., 2014). These quotes emphasize the importance for caretakers to feel acknowledged by their child. This bond and the positive emotions that result may make the frustrating times, when an infant refuses to cooperate or cries inconsolably, tolerable. This idea is fortified by reports that one factor that differs between abusive and non-abusive mothers is their reactions to their child's joy. While both groups were frustrated by infant cries, abusive mothers experienced less pleasure at their child's smiles (Frodi and Lamb 1980). This suggests that a vital component of abuse is the lack of

pleasurable associations with the infant, something that can be spurred by the absence of a caregiver-infant bond. Given the reliance of bond formation on reciprocal interaction and the increased propensity for such interactions in female infants, one can speculate that the decreased rate of abuse in female infants is partially due to a more intimate caregiver bond.

Additional evidence of parental bonding differences based on infant sex originates from language studies. These reports indicate that mothers converse with and make interpretations of the sounds of female infants more frequently than those of male infants (Clearfield and Nelson 2006**;** Johnson et al., 2014). This has been portrayed as a reflection of maternal stereotypes regarding appropriate interaction. However, another explanation for this occurrence could be that mothers possess a stronger bond to their daughters and thus feel a greater desire to respond to and understand them. A final indication of differential bond formation comes from parental self-reports. Parents report feeling warmer and physically closer to their daughters than to their sons (Block 1976).

While reciprocal bonding may be vital for all caregivers, it is possible that this interaction is especially important for step fathers or boyfriends. A study focused on the cause of increased child abuse by mother's boyfriends reported that many perpetrators said their abuse stemmed from feelings that the child was not recognizing or respecting them. One would think that these feelings would not apply to young infants. However, the study describes a case of a father who killed a 5-week old child for disobedience (Margolin 1992). Clearly, the reality of a child's abilities does not always come into play in caretaker responses to or perception of an infant. Another contributing factor to the disparity in abuse rate could be explained by gender labeling studies which find that cries thought to be from boys are rated as expressing more anger,

especially by men (Condry and Condry 1976; Lin et al., 2016). This perception could lead to more aggressive responses by caregivers who perceive the child as demanding and disrespectful.

A final infant sex based difference in parental interactions arises when examining protectiveness towards the child. When speaking about their daughters, parents indicate increased feelings of protectiveness and concern for physical harm. This is demonstrated through increased supervision and discouragement of rough play (Block 1976). Violent feelings can be tempered by awareness of the potential for infant harm, as noted by the success of educational protocols that reiterate to parents the hazards of shaking (Dias et al., 2005). Thus, acute awareness of the perceived fragility of baby girls could be yet another factor that restrains abusers from striking out at females as frequently as they do males.

Given the complex nature of most behavioral responses, it is no surprise that infant abuse is sparked by a variety of factors. The increased aversiveness of male cries may play a role. However, complex and varied sex stereotypes, infant-caregiver bonds, lack of caretaker education, and other yet-undiscovered factors must also contribute to create a situation in which abuse occurs. Teasing apart the contributing factors will require continued exploration. In particular, we hope to have the opportunity to examine viewer reactions to the auditory elements of the videos from experiment two in the same paradigm used in experiment one. This would allow the replication of the results from part one with a different sample of men and different cries. Additional acoustic analysis would also be beneficial, as identification of the factor or factors that make male infant cries more aversive would clarify results. In addition, a study examining father-infant bonds and differences in reciprocal interaction between male and female infants would allow the incorporation of attachment into assessments of abuse likelihood. Finally, repeating rating experiments with characteristics beyond just aversiveness (angry,

manipulative, etc.) could potentially shed light on the motivations that underlay sex differences in infant victimization.

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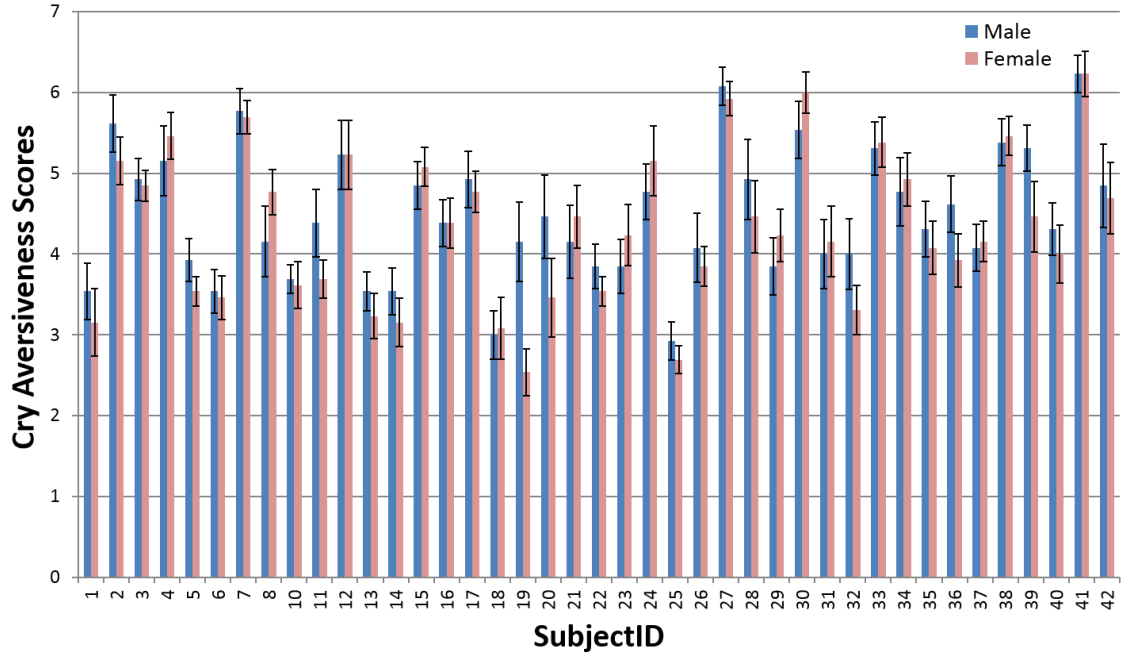
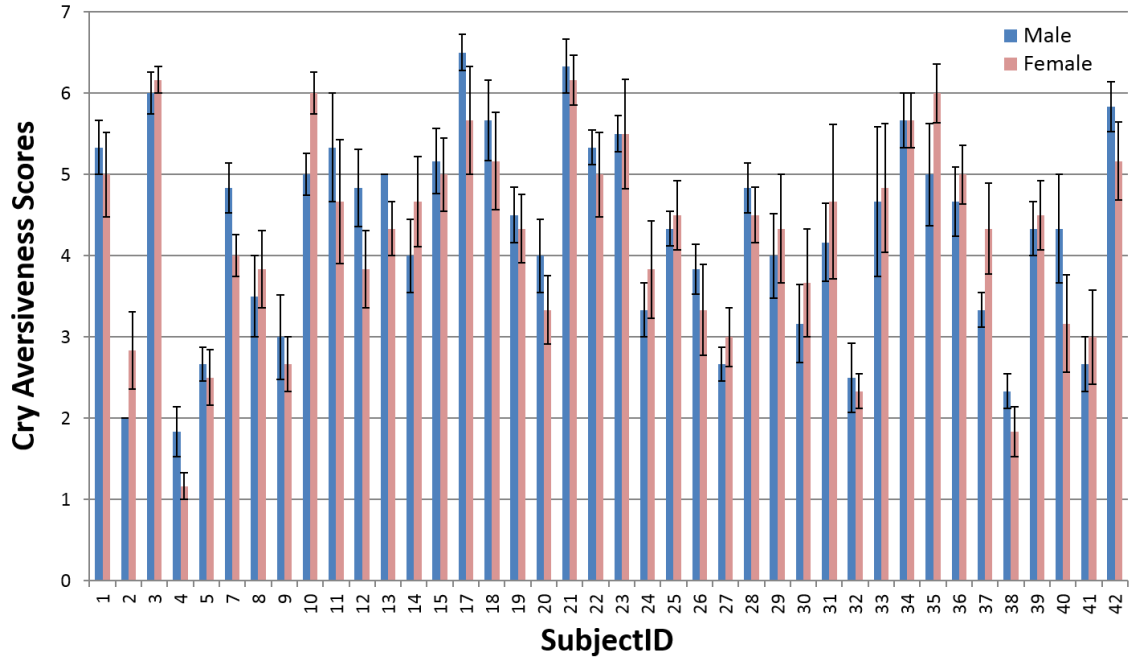
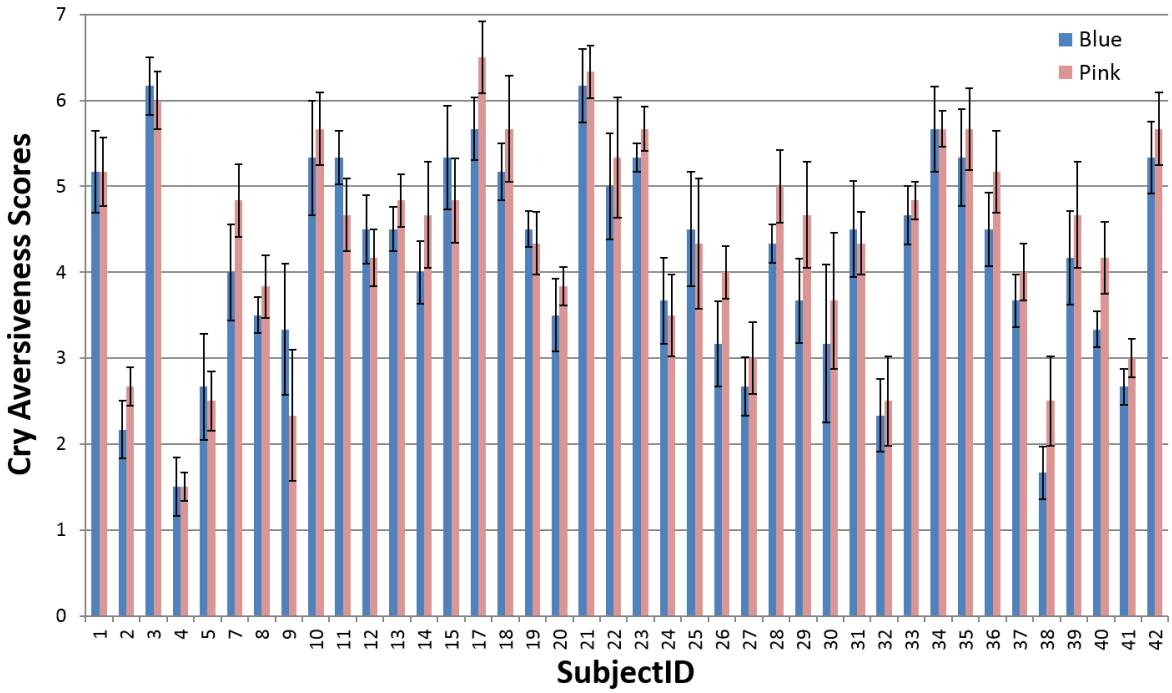
Supplemental Materials



Supplemental Figure 1: The average aversiveness score for male infants and female infants for each subject in experiment one. Error bars represent the standard error of the mean.



Supplemental Figure 2: The average aversiveness score for male infants and female infants for each subject in experiment two. Error bars represent the standard error of the mean.



Supplemental Figure 3: The average aversiveness score for infants seen in pink and infants seen in blue for each subject in experiment two. Error bars represent the standard error of the mean.