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**Title:** Categorizing the cries of infants with ASD versus typically developing infants: A study of adult accuracy and reaction time

**Authors:** Bornstein MH.\*, Costlow K., Truzzi A., Esposito G.\*

\*corresponding authors

<sup>1</sup> Child and Family Research, *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, Bethesda, USA

<sup>2</sup> Department of Psychology and Cognitive Science, University of Trento, Rovereto, TN, Italy

<sup>3</sup> Division of Psychology, School of Humanities and Social Sciences, Nanyang Technological University, Singapore

## Abstract

Background. The cries of children with Autism Spectrum Disorder (ASD) contain atypical acoustic features. The cries of typically developing infants elicit automatic adult responses, but little is known about how the atypical cries of children with ASD affect the speed with which adults process them. Method. We used a reaction time (RT) categorical task to analyze adults' categorization of typically developing cries, atypical (ASD) cries, mammalian animal cries, and environmental noise control sounds. 40 nonparent women ( $M$  age = 27 years) were instructed to categorize acoustic stimuli as human infant cries or non-human sounds as quickly as possible. Results. The RTs for correctly categorizing the cries of children with ASD ( $M = 831$ ms,  $SEM = 27$ ) were slower than RTs for typically developing child cries ( $M = 680$ ms,  $SEM = 6$ ) as well as mammalian animal cries (801ms,  $SEM = 11$ ) and environmental noise control sounds ( $M = 692$ ms,  $SEM = 10$ ). Conclusions. This difference may reflect difficulties in adults' perceiving and processing atypical cries of children with ASD, and the findings may have implications for the parent-child relationship and for the quality of care children with ASD receive.

**Keywords:** Cry; Infancy; Autism Spectrum Disorder; Typical development; Vocalizations; Reaction time

## Highlights:

- The cries of children with ASD contain atypical features such as higher f0.

- Adults are more accurate at categorizing TD cries as human than ASD cries.
- Adults are slower to categorize ASD cries compared to TD cries.
- Findings have implications for parent-child interactions and quality of child care.

## **Introduction**

Infant distress vocalizations (crying) are among the most biologically salient sounds, normally eliciting prompt and concerned adult responses. Infant cries are thought to have evolved as an adaptation to provide infants with caregiver attention, contact, and sustenance. As the infant's earliest form of vocal communication, crying plays an important role in the development of the parent-child relationship and secure attachment in the dyad (Ainsworth, 1969; Ainsworth, Blehar, Waters, & Wall, 2014; Bell & Ainsworth, 1972; Bowlby, 1969). The infant cry promotes maternal proximity, and human infants, like other mammalian infants, cry more when physically separated from their mothers (Bell & Ainsworth, 1972). The similarities in acoustic structure and in caregiver responses observed across vertebrates suggest that the production and processing of infant cries reflect a highly conserved system of social vocal behavior (Newman, 1985, 2007; Newman & Symmes, 1982). Considering the evolutionary significance of distress vocalization, it is expectable that adults will automatically respond to sounds they perceive as cries. However, less is known

about how adults perceive cries that fall outside the realm of typicality. Here, we studied adults' responses to cries of children diagnosed with Autism Spectrum Disorder (ASD). ASD is a prevailing problem in child development that affects social communication skills, so knowing more about adults' responses to the earliest communications of children with ASD is manifestly important.

ASD is a developmental disorder characterized by deficits in communication, social interaction, and repetitive behaviors (American Psychiatric Association, 2013). Although signs of ASD can be detected in the first year of life, retrospective and prospective studies report the strongest markers for differentiation of children with ASD from typically developing children are clear in the second year of life (Zwaigenbaum, Bryson, & Garon, 2013; Zwaigenbaum et al., 2009). Language development delays are a common symptom of ASD and are often one of parents' earliest concerns (Coonrod & Stone, 2004; De Giacomo & Fombonne, 1998). Differences in early vocal behavior have been found between children with ASD and typically developing (TD) children, as well as between high-risk (with a diagnosed ASD sibling) and low-risk children. Infants at high risk for ASD produce significantly fewer speech-like vocalizations, consonant types, and canonical syllable shapes than their low-risk peers (Oller et al., 2010; Patten et al., 2014; Paul, Fuerst, Ramsay, Chawarska, & Klin, 2011). Children diagnosed with ASD produce a larger proportion of syllables with atypical phonation than TD children (Sheinkopf, Iverson, Rinaldi, & Lester, 2012; Sheinkopf, Mundy, Oller, & Steffens, 2000). While interacting with their parents, children with ASD partake in fewer conversational turns, produce fewer

vocalizations, and are responded to less frequently by adults than TD children (Warren et al., 2010).

Even before their first words or utterances, however, infants who will be diagnosed with ASD show differences in communication through cry. Morphological characteristics of the infant cry, such as pitch and pause duration, shape adult responses to the cry. Fundamental frequency ( $f_0$ ), which is perceived as pitch, normally falls in the 300-600 Hz range for a healthy infant cry. Higher cry  $f_0$  often signals serious illness or low-fitness conditions in young infants, such as colic, lead exposure, low birth weight, and metabolic disorders (Furlow, 1997). Morley, Thornton, Cole, Fowler, and Hewson (1991) found that 67% of a “seriously ill” group of infants displayed a high pitched or moaning cry compared to only 1% of a “moderately ill” group; according to Morley et al., cry pitch is a better indicator of serious illness than respiration rate, temperature, pulse rate, and other commonly used symptoms. Abnormal cry  $f_0$  has also been observed in infants with ASD; compared to those of developmentally delayed (DD) and typically developing (TD) children, the atypical cries of children with ASD tend to have a higher  $f_0$  and shorter pauses (Esposito, del Carmen Rostagno, Venuti, Haltigan, & Messinger, 2014; Esposito, Nakazawa, Venuti, & Bornstein, 2012, 2013; Esposito & Venuti, 2010a, 2010b; Esposito, Venuti, & Bornstein, 2011; Sheinkopf et al., 2012). Developmental trajectories show that  $f_0$  decreases for TD and DD children between the first and second year but not for children with ASD (Esposito & Venuti, 2010a).

These atypical cry characteristics cause adults to perceive the cries of children with ASD differently from the cries of their TD peers. Adults in Western and Eastern settings (e.g., Italy and Japan) rate the cries of children with ASD as more distressed and distressing than the cries of TD children (Esposito & Venuti, 2010b; Esposito et al., 2011, 2012, 2013). Supporting this finding, the cries of children with ASD activate the left inferior frontal gyrus, the anterior insula, the thalamus, and other brain areas associated not only with parenting behaviors but also with the processing of aversive acoustic stimuli in adult listeners. The cries of children with ASD (relative to TD cries) also produce increased activity in brain regions associated with acoustic processing, suggesting that these atypical cries may represent acoustical signals that are more difficult to interpret (Venuti et al., 2012). In fact, parents of children with ASD are more likely to describe their children's cries as "unexpected" and "inexplicable" (Esposito & Venuti, 2008).

These differences in adult perception of ASD versus TD cries may have implications for the parent-child relationship. Functional magnetic resonance imaging (fMRI) reveals increased activity in the supplementary motor area (SMA), representing motor preparation for caregiver action in response to infant cries (Venuti et al., 2012). Using transcranial magnetic stimulation (TMS), Messina et al. (2015) found evidence for the automaticity of these motor responses, which occurred as early as 100 ms after cry presentation. These results were specific to natural TD infant cries, however, and did not hold when the  $f_0$  of the cry was manipulated. Because the cries of children with ASD are characterized by high  $f_0$ , it is expectable that ASD cries also differ in regard to

automaticity of adult responses compared to natural infant cries. However, no studies have explored how the special nature of atypical cries influences the facility with which adults interpret them.

Here, we analyzed how automatic the process of cry categorization is in adults for both typical (TD) and atypical (ASD) child cries. Using a reaction time (RT) categorical task, we instructed participants to categorize acoustic stimuli as “human infant cries” or “non-human sounds” as quickly as possible. We hypothesized that categorization of atypical (ASD) infant cries would be less automatic, as evidenced by longer RTs, than categorization of typical (TD) infant cries. We included two other kinds of sounds as well to isolate the specificity of any RT difference.

## **Methods**

### *Participants*

Forty nonparent right-handed women ( $M$  age = 26.96 years,  $SD$  = 4.70) were recruited as participants through a University database of volunteers and announcements posted on the University of Trento web site. We selected nonparent female participants because we wanted to avoid effects of previous parenting experience with infants and we wished to test the generality of preferences outside parenthood status. All participants were Caucasian Italian citizens with a college degree or above and had middle–high level socioeconomic status. No participants had a history of psychiatric disorders or

drug abuse. Informed consent was obtained from all participants. The study was conducted in accord with the ethical principles stated in the Helsinki declaration.

### *Materials*

#### *Stimuli*

Participants were presented with 320 total stimuli divided evenly into four categories presented randomly: typically developing infants' cries [TD Cry], atypically developing infants' cries (cries of children with ASD [ASD cry]), baby animal cries [Animal Cry], and environmental noise control sounds [Env. Noise]. Target stimuli were distress vocalizations (infant cries). Infant cries were extracted from home videos of 10 typically developing and 10 atypically developing infants, and baby animal cries and environmental noises were chosen from a database of sounds (details for the specific groups are provided below). Concerning infant cries, a research assistant, who was unaware of the purposes of the study and blind to children's group membership, gleaned video records of the two groups of children from home videos that had been made by parents when their children were 5 months of age. Videos included two groups of infants: ASD infants ( $n = 10$ , 5 boys and 5 girls) and TD infants ( $n = 10$ , 5 boys and 5 girls). All children were firstborns born between February 2003 and June 2004. Neither marital status (all of the women were married) nor maternal age differed between the two groups (ASD:  $M = 25.8$  years,  $SD = 4.2$ ; TD:  $M = 24.1$  years,  $SD = 5.1$ ;  $t(18) = .39$ ,  $p = .70$ ,  $d = 0.17$  ).

The assistant selected the first cry episode that occurred after a feeding if the mother did not intervene within 30 seconds from the beginning of the cry. To optimize and equate for sound quality and volume, and to ensure that the stimuli were representative of the typical range of infant vocalizations, only the first 5 s of infant vocalizations selected were used to create the experimental stimuli. Audio recordings of infant vocalizations were excluded if they contained background noise (e.g., adult talk, sounds from toys, or other environmental noise) that would interfere with acoustic analysis. To ensure that TD Cry and ASD Cry stimuli were representative of the typical range of cry sounds for typical and atypical groups, respectively, and to assess their acoustical characteristics, sounds were digitized and analyzed using Praat acoustic analysis software (Boersma & Weenink, 2005). We expected a higher fundamental frequency for ASD Cry compared to TD Cry (Esposito & Venuti, 2010a, 2010b; Esposito et al., 2011, 2012, 2013, 2014). From each 5-s cry stimulus, two different durations were extracted (250 ms and 500 ms). Specifically, each 250- or 500-ms segment was selected from different utterances within the 5-s cries and started right after a pause. Therefore, no segment included any pause, and each segment started at the beginning of an utterance. Different segments were extracted from different cry bouts and utterances.

Cry stimuli of less than 1 s duration were included to elicit faster reaction times and to exclude prosodic features. Cry prosodic features were excluded to focus on cry fundamental frequencies, which previous studies have shown to be one of the best predictors for adults' felt distress towards cries (Esposito et al.,

2013; Esposito, Nakazawa, Venuti, & Bornstein, 2015). The two stimulus durations were included for each stimulus class because the literature is not settled on which stimulus length is best for individuals to perceive infant cries.

*Typical cry stimuli [TD Cry].* Cries of typically developing children were extracted from home videos of children who were part of a longitudinal research project and did not present any cognitive concerns as confirmed by their Wechsler Preschool and Primary Scale of Intelligence-II (WPPSI-II; the reliability coefficients for the WPPSI-II U.S. composite scales range from .89 to .95; Wechsler, 1989) scores at age 4 years. The mean fundamental frequency of typical cry stimuli was 460.55 Hz ( $SD = 31.98$ ). The videos from which cries were extracted came from a pool of 120 videos previously recorded for a longitudinal study (recordings at 5, 13, 20 months of age). The experimenter contacted parents when their infant was 4 months old and they scheduled an appointment to record the video within 2 weeks of the infant turning 5 months of age. Selection criteria for the videos were (i) in the video there was a visible feeding (so we can be sure the baby is not crying because s/he is hungry); (ii) videos should contain at least one crying episode subsequent to the feeding; (iii) the mother was away from the baby (either in another room or out of sight); (iv), no environmental background noise (e.g., conversations or TV sounds) were to be heard in the videos.

*Atypical cry stimuli [ASD Cry]*. Cries of atypically developing children were extracted from retrospective home videos of infants later diagnosed with Autism Spectrum Disorder (ASD). The home videos belonged to a database of home videos collected at the University of Trento, which involved a total of 60 patients. Videos were collected at the time of the children's diagnostic assessment. Selection criteria from available videos were (i) videos should have a clear date to be sure to capture only infants within 2 weeks of turning 5 months old, (ii) in the video there was a visible feeding (so we can be sure the baby is not crying because s/he is hungry); (iii) videos should contain at least one crying episode subsequent to the feeding; (vi) the mother was away from the baby (either in another room or out of sight); (iv), no environmental background noise (e.g., conversations or TV sounds) were to be heard in the videos. Children between 36 and 40 months of age with ASD (1) received a clinical diagnosis from a child psychiatrist according to DSM-IV-TR criteria (APA, 2004), and (2) met the clinical diagnosis of ASD for the DSM-5 (APA, 2013), confirmed by (2a) the Autism Diagnostic Interview-Revised (ADI-R; a semi-structured, investigator-based interview for caregivers of individuals who may be ASD; ADI-R psychometric characteristics were excellent: both specificity and sensitivity are higher than 90%; Lord, Rutter, & Le Couteur, 1994) and (2b) the Autism Diagnostic Observation Schedule-Generic (ADOS-G; a semi-structured assessment of social interaction, communication, play, and imaginative use of materials for individuals who may have ASD; Lord et al., 2000). Children with ASD were free from other medical conditions (e.g., seizures, Fragile X syndrome) and had no

visual or hearing impairments. Their cognitive level was evaluated as average at the age of 4 years using the Griffiths Mental Development Scales (reliability of the administration is 90%; Griffiths, 1996; Hanson, 1982; Luiz, Barnard, Knoesen, & Kotras, 2004). The mean fundamental frequency of atypical cry stimuli was 529.76 Hz ( $SD = 37.88$ ), which was higher than TD cries ( $t(18) = 4.8$ ,  $p < .001$ ,  $d = 2.15$ ).

*Baby animal cry and environmental noise.* Animal stimuli included baby kitten, macaque, and sea-lion cries ( $f_0$  range = 320-550 Hz). Environmental control noises were formed from distressing domestic sounds, such as broken dishes ( $f_0$  range = 260-680 Hz). These domestic noises were included to assess participants' responses to distressing sounds that they might hear in the home, but differ from cry. Recordings were selected from different copyright free databases of animal vocalizations available from the internet.

### *Procedure*

Participants were asked to listen to the stimuli using headphones while focusing on a "+" sign on a light-green neutral background shown on a 42" LCD display (106 cm) placed 100 cm in front of the participants. A block design was applied where all 250 ms stimuli were presented together in the same block, and all 500 ms stimuli in a different block. Order of block presentation was counterbalanced across participants. Within each block, stimulus presentation was randomized. After each stimulus, participants were asked to categorize it as a human infant

distress vocalization or non-human sound as quickly as possible using two keys on the computer keyboard (the M and Z keys respectively). Participants were asked to press the Z key with the left index finger and the M key with the right index finger. Reaction times (RT) and accuracy (ACC) were recorded using the E-prime software. RTs were measured from the onset of the cry stimuli. No visual cue was given to prompt the response. Participants were asked to respond as fast and as accurately as possible as soon as the sound started. Participants were allowed to answer from the onset of the stimuli. After participants' responses, 1 s of silence preceded the presentation of the next stimulus. All sounds matched in overall loudness, and the volume was kept constant for presentations for all participants. All together the experimental session lasted about 10 minutes in mean, with a maximum length of 20 minutes. Non-response frequency was less than 0.5%. Non-response trials were excluded from the analysis.

## **Results**

Preliminary analysis resulted in no significant effect of stimulus duration on categorization; therefore, RT and ACC data for 250 ms stimuli and 500 ms stimuli were averaged [Table 1]. Univariate and multivariate distributions of dependent variable scores were examined for normality, homogeneity of variance, outliers, and influential cases (Fox, 1997). Because participants' RTs were not normally distributed (skewness = 2.12), a logarithmic transformation was applied and analyses were conducted on transformed RTs. In the analysis, only RTs for

correct answers were considered (Accuracy: ASD Cry = 64.5%; TD Cry = 94.0%; Animal Cry = 90.1%; Env. Noise = 97.6%,  $\chi^2(3, N = 40) = 7.8, p = .05, d = .98$ ); participants correctly categorized a higher percentage of TD cries as “human infant sounds” than ASD cries. An ANOVA with repeated measures and one factor (stimulus class) was calculated on RTs of the different stimulus classes: A significant main effect of stimulus emerged,  $F(3, 39) = 96.4, p < .001, \eta^2_p = .98$ . Tukey-HSD tests were carried out in post-hoc analyses to compare RTs across stimulus classes (ASD Cry – TD Cry = 151ms,  $p < .001, d = 2.31$ ; ASD cry – Env. Noise = 138ms,  $p < .001, d = 2.31$ ; ASD Cry - Animal Cry = 29.1,  $p = .54, d = 0.20$ ; TD Cry - Env. Noise = -12.2,  $p = .78, d = 0.09$ ; TD cry – Animal Cry = -122ms,  $p < .001, d = 2.31$ ; Env. Noise – Animal Cry = -152ms,  $p < .001, d = 2.31$ ). Fig. 1 shows that human TD infant cries were identified as human faster than animal infant cries; this comparison constitutes a manipulation check on the procedure. Participants were fastest in identifying TD cries as human and slowest in identifying ASD cries as human. Participants were even faster to identify environmental noise than ASD cry. No difference in RT was found between the ASD Cry and the Animal Cry.

## Discussion

The present study analyzed the automaticity of cry categorization in adult women for typical and atypical (ASD) infant cries. Atypical cries of infants with ASD have a higher  $f_0$  than TD cries; the higher mean  $f_0$  for the ASD Cry compared to the TD Cry in this study accords with that literature (Esposito &

Venuti, 2010a, 2010b; Esposito et al., 2011, 2012, 2013, 2014). Messina et al. (2015) found automatic adult motor responses to natural infant cries, but not for cries manipulated to have higher  $f_0$ . In line with this literature, we hypothesized that categorizing atypical infant cries as human would be less automatic, and thus take significantly more time, than categorizing typical infant cries. To test this hypothesis, we used a RT categorical task where participants were asked to categorize acoustic stimuli as human infant cries or non-human sounds as quickly as possible.

Supporting our main hypothesis, we found that participants were faster to correctly categorize TD Cries compared to the ASD Cries. The longer RTs associated with human atypical, as opposed to typical, crying could reflect difficulties in listeners' perception and cognitive processing of atypical cries. According to Venuti et al. (2012), the cries of children with ASD activate brain regions for complex, second-level acoustic processing in addition to regions for basic acoustic analysis. This result suggests that the cries of children with ASD (relative to TD cries) may be more difficult to process and interpret, leading to longer RTs to categorize atypical (ASD) cries. Participants in the present study also categorized the ASD Cries with only 64.5% accuracy compared to 94.0% for TD Cries, again supporting the literature on the "inexplicable" and "uninterpretable" nature of the atypical (ASD) cry (Esposito & Venuti, 2008; Venuti et al., 2012).

Participants had the slowest categorization RTs for ASD Cry and Animal Cry, with no significant RT difference between the two. It is possible that some

shared characteristic of the ASD and Animal Cry rendered these two stimuli more difficult to categorize than the TD Cry or Env. Noise. Research shows that human and non-human mammalian infant cries share a basic acoustic structure and similar cry characteristics, but larger mammals produce cries with a lower  $f_0$  (Newman, 2007). The Animal Cry and ASD Cry both have the same basic structure as the TD Cry with differences only in morphological characteristics ( $f_0$ ). Participants may therefore take longer to categorize Animal and ASD cries because they differ structurally from prototypical TD cries.

The task was to categorize the sound as human or not. It is therefore understandable that decision making for the Animal Cry took longer than the human TD cry but responding to and categorizing noise as not human was quick.

Further research is necessary to account for some limitations of this study and to elaborate the results. The present study provides new insights into cry categorization, but little is known about the brain mechanisms underlying this process or the causes of varying RTs. Future research should explore possible causes for the longer RTs for ASD and Animal Cry categorization. Although  $f_0$  has historically been considered the most influential acoustic characteristic of the infant cry, some studies have identified pause duration to be a more significant determiner of listeners' perceptions of cry (Esposito et al., 2013, 2015). Cry dysphonation, duration, and proportion of energy in various frequency bands also influence adult perceptions of cry (Gustafson & Green, 1989). Other characteristics such as  $f_0$  variability, hyperphonation, voiced phonation ratio, and number of utterances also affect adult cry perception (LaGasse, Neal, & Lester,

2005). The cry stimuli in the present study excluded pauses and cry prosodic features to focus more specifically on f0. Future research should therefore consider other morphological characteristics of the ASD Cry and the Animal Cry that may account for their longer categorization RTs.

Future research may also turn to neuroimaging methods to explore brain activity during cry categorization. The present study reported slower RTs for categorizing atypical (ASD) compared to typical (TD) infant cries, and neuroimaging methods may be used to determine the brain mechanisms related to this RT difference. Atypical (ASD) compared to typical (TD) infant cries elicit increased activity in brain regions for emotional, verbal, and prosodic processing, perhaps because atypical infant cries are more aversive and more difficult to interpret (Venuti et al., 2012). Future neuroimaging research might examine differential brain activity in these regions during a RT categorical task of typical (TD) and atypical (ASD) infant cries. Neuroimaging can also be used to determine whether less automatic RTs for categorizing cries of infants with ASD are associated with delayed motor responses to these cries. Messina et al. (2015) found evidence for automatic motor responses to typically developing, but not to manipulated (f0), infant cries. Future research might observe automatic motor excitation in response to cries of children with ASD, specifically, or cries with manipulated acoustic characteristics, apart from f0.

In lieu of naturalistic methods, future research may consider using cry elicitation procedures. The context of cry (i.e., pain-related versus non pain-related cries) affects cry characteristics (Sheinkopf et al., 2012), so it might prove

beneficial to control for context through cry elicitation methods. Finally, the small sample size of the present study needs to be considered when interpreting the results. Our study sample also consisted of non-parent females only. Indeed, it may be possible that testing mothers would show different RTs in response to stimuli due to their greater exposure to infant cry.

### **Implications**

Our findings may have select implications for the early detection of ASD and for early parent-child interactions. In accord with the literature, the cries of children with ASD used in our study had a higher mean  $f_0$  than TD cries (Esposito & Venuti, 2010a, 2010b; Esposito et al., 2011, 2012, 2013, 2014; Sheinkopf et al., 2012). If distress vocalization differences like this one between TD infants and infants with ASD can be detected, then the infant cry may be used as a marker to facilitate or corroborate early diagnosis of ASD. Although certain diagnosis is difficult before 2 years of age, infants later diagnosed with ASD have been identified with early markers in the first year of age, such as poor response to name, atypical eye contact, and reduced social smiling before 12 months of age (Koegel, Singh, Koegel, Hollingsworth, & Bradshaw, 2013; Zwaigenbaum et al., 2005). Atypical cries may be combined with other early markers to determine risk or to make earlier diagnoses.

If adults are slower to categorize atypical cries, as was found in this study, this feature of interaction could aggregate to affect the quality of care that children with ASD receive. Parents who have difficulty interpreting their children's cries may respond less immediately or less appropriately to such cries. For

example, Esposito and Venuti (2009) found that the mothers of 13 months-olds later diagnosed with ASD tended to vocalize in response to their infants' cries whereas mothers of TD infants tended to use non-vocal stimulation (e.g., patting or rocking) to soothe their infants. Mothers of children with ASD may vocalize more because they have a harder time interpreting their children's cries and determining an appropriate response. In this way, parents who are slower and less accurate at categorizing their infant's cries may respond differently to their infant's distress. As is known, parental responsiveness to distress is a basic and significant component of parent-infant interaction (Bornstein, 2015) and it may have potentially far-reaching effects on parent-child interactions for children with ASD.

This is not to suggest that an abnormal infant cry invariably leads to parental failings, such as withdrawal or infant maltreatment. The quality of parental care is related to a variety of infant, parent, and contextual factors in addition to the infant cry (Bornstein, 2016; Burgess & Draais, 1999). However, additional research is necessary to define the relation between infant cry and parental investment within this multifaceted context. Since parents seem to have more difficulty interpreting the cries of their young child with ASD, caregiver-infant interactions in these context may be hindered or difficult to build, resulting in long-term difficulties for both parties.

To counteract these possibilities, parents might monitor their children's development to look for early risk factors of ASD. Early intervention has been shown to lead to substantial improvement in the life conditions, autonomy, and

cognitive skills of children with ASD (Esposito & Venuti, 2008). Kuhl and Meltzoff (1996) proposed parent counseling to develop joint attention and communication in children with ASD by encouraging children to listen and make speech sounds (as cited in Paul et al., 2011, p.596). Warren et al. (2010) observed more adult input, conversational turns, and child vocalizations when participants with ASD were receiving intervention services compared to non-therapy time.

In conclusion, adults' accuracy and alacrity at assessing infant cries may influence the quality of caregiver input that TD children and children with ASD receive. Early interventions in parental responsiveness may be key in offsetting possible negative outcomes and jumpstarting development for children with ASD.

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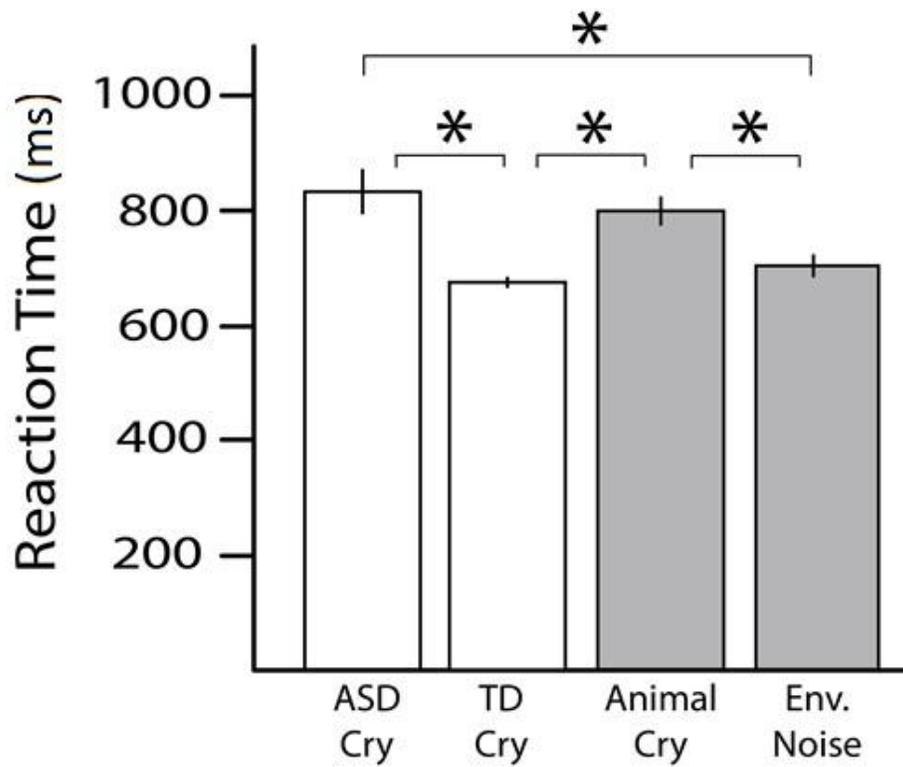


Figure 1. Means (SEMs) of participants' reaction times (in ms) to complete the categorization task for each stimulus type.

\*  $p < .001$

Word count: 4,428 words

RT	Mean (SD)	Min	Max	%Acc
Animal Cry	801.64(323.08)	245	2708	64.5
ASD Cry	830.65(435.03)	260	2864	94.0
TD Cry	680.12(300.30)	202	2985	90.1
Env. Noise	692.33(274.73)	235	2875	97.6

Table 1. Mean(SD) and range of participants' reaction time in response to different stimuli categories are reported in the table as well as the percentage of right responses (% Acc).