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Original Article

Age-Related Changes in the Signal Value of Tears

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Abstract: Emotional tears may be uniquely human and are an effective signal of distress in adults. The present study explored whether tears signal distress in younger criers and whether the effect of tears on observers is similar in magnitude across the life span. Participants rated photographs of crying infants, young children, and adults, with tears digitally removed or added. The effectiveness of tears in conveying sadness and eliciting sympathy was greatest for images of adults, intermediate for images of children, and least potent for images of infants. These findings suggest that the signal value of tears varies with the age of the crier. The results may shed light on the functional significance of crying at different stages of human development.

Keywords: crying, distress vocalizations, emotional tears, emotion, facial expression

Introduction

Emotional tears are crucial for signaling distress in adult criers. Experiments in which tears have been digitally removed from photographs of adults' crying faces have shown that crying facial expressions are far less effective in communicating sadness and eliciting sympathy when tears are absent (Hendriks, Nelson, Cornelius, and Vingerhoets, 2008; Provine, Krosnowski, and Brocato, 2009). Although tears appear to be critically important for conveying information in adult facial expressions, the impact of tears on reactions to the emotional expressions of infants and children has not been methodically investigated.

Tears may not have the same signal value in infancy as they do in adulthood. Darwin noted that very young infants do not shed tears when crying (Darwin, 1872/1965). Others have confirmed that spontaneous tears in response to emotional provocation only emerge in the second or third month of life (Haering, 2001; Montagu, 1960), despite the competence of the lacrimal system to produce tears in response to physical irritants from birth (Apt and Cullen, 1964; Isenberg et al., 1998). The effectiveness of a newborn's crying

appears to be primarily dependent on the auditory component of crying rather than on tears (Owings and Zeifman, 2004). The sound of crying without any accompanying visual information has been shown to convey reliable information about an infant's health (Furlow, 1997; Wasz-Höckert, Michelsson, and Lind, 1985), identity (Gustafson, Green, and Clealand, 1994; Wiesenfeld, Zander-Malatesta, and DeLoach, 1981), and level of distress (Porter, Miller, and Marshall, 1986; Wolff, 1969). Human infant crying shares a conservative evolutionary history with the distress vocalizations of other mammalian young (Newman, 1985) and is believed to have evolved as an attachment behavior that functions to unite infant and mother when the infant is in need of care (Bowlby, 1969).

In comparison to infant crying, the function of adult crying and emotional tearing is less well understood. There are several notable differences between infant and adult crying. Adults cry in response to overwhelming physical and emotional pain but, unlike infants and young children, frequently seek privacy before crying (Becht and Vingerhoets, 1997; Vingerhoets, Cornelius, Van Heck, and Becht, 2000). The sound of crying, which is a powerful trigger of response in infancy, is either absent or stifled in adulthood. Additionally, most adult crying episodes are comprised merely of eyes welling up with tears (Vingerhoets et al., 2000). Changes in crying over the course of development suggest that, as crying comes under voluntary control, crying is suppressed in situations where emitting a signal of weakness or vulnerability could be detrimental (Zeifman, 2001a). In spite of these changes in the expression of crying from the infant period, some authors suggest that crying is a powerful attachment behavior in adulthood because adult crying typically elicits caring responses (Hendriks, Croon, and Vingerhoets, 2008; Hendriks and Vingerhoets, 2006).

Altruistic behavior, such as sympathizing with and assisting crying individuals, can be adaptive for the giver as well as the receiver (Batson and Shaw, 1991; Brown and Brown, 2006; Trivers, 1985). Helpers would be prone to exploitation, however, without a mechanism for resisting those who are not truly distressed. Likewise, identification of genuine need requires a mechanism for "seeing through" stoicism. Because tears are more difficult to suppress or feign than crying vocalizations and facial expressions, tears may guide the allocation of limited resources to those individuals who are genuinely in need of emotional support and can benefit most. Tears might therefore be more critical to evaluations of mature criers, who are more capable than young infants of both inhibiting crying and exaggerating need.

Numerous functions besides marshaling social support have been proposed for emotional tearing, including releasing harmful toxins (Frey and Langseth, 1985), signaling peaceful intentions (Hasson, 2009), and repelling sexual partners (Gelstein et al., 2011). Hasson (2009) argues that emotional tears signal appeasement because tears handicap signalers by blurring vision, thereby making aggressive and defensive actions difficult to execute. Gelstein and colleagues (2011) demonstrated that men who sniffed women's tears were less sexually aroused and had reductions in testosterone relative to men who sniffed saline, suggesting that tears may be a chemosignal or pheromone involved in mate choice. The precise function of emotional tears across the life span, thus, has not been fully resolved.

The current experiment was designed to explore the role tears play in judgments

about facial expressions across developmental stages. Because crying in infancy and early childhood is vocalized and the sound of crying is a source of considerable information, tears might be expected to play a lesser role in assessing infant distress than adult distress. In contrast to infant crying, most adult crying is inaudible and is merely tearing up (Vingerhoets et al., 2000). Older criers are also presumed to be more capable of voluntarily exaggerating or inhibiting distress than infants. Tears are therefore expected to play a more significant role in judgments of older criers. Further, if the function of tears is to signal need and draw others near, tears might be expected to have a greater influence on ratings of sadness than ratings of anger, an emotion which typically elicits avoidance rather than approach behavior (Marsh, Ambady, and Kleck, 2005).

The current study

The specific aim of the current study was to determine the effect of tears on the perception of, and hypothetical reactions to, crying faces in three distinct age groups: infants, children, and adults. Perceptions of sadness, sincerity, and anger on the part of different age criers were measured in response to crying faces with and without tears. It has been suggested that reactions to crying range from indulgent to abusive (Soltis, 2004). The present study, therefore, evaluated observers' sympathetic and hostile emotional reactions to crying, as well as self-reported likelihood of offering help, as a function of the presence or absence of tears. Our primary hypothesis was that tears would be most effective in communicating distress and eliciting sympathy in adult criers and least effective in infant criers. Secondly, we hypothesized that tears would have a greater impact on ratings of a crier's sadness and sincerity than a crier's anger.

Materials and Methods

Participants

Sixty-nine undergraduate students attending an elite liberal arts college in the northeastern United States participated in this study for partial course credit. Forty-three participants were female, 23 were male (two participants did not indicate a sex). Participants ranged in age from 18 to 21, with a mean age of 18.84 years ($SD = 0.92$). Seventy-four percent of participants were White, 3% Black, 6% Hispanic, 5% Asian, and 12% were of mixed race. One participant's responses were eliminated from analyses due to a substantial number of missing responses.

Selection of images

Photographs of crying individuals were downloaded from the internet using the search engine Google Images and entering the search terms "crying" and "tears" paired separately with men, women, adults, girls, boys, children, and infants. In order to facilitate comparisons between age groups and avoid conceptual overlap, we selected images of infants who appeared to be under 6 months of age, children who appeared to be between the ages of two and six years of age, and adults who appeared to be at least in their mid-twenties through middle age. Photographs were excluded if they depicted celebrities, if they appeared artificial or digitally altered in any way, if more than one person appeared in

the photograph, and if the photograph contained contextual information that could not be eliminated by cropping the photograph. The photographs represented individuals from a broad range of racial and ethnic backgrounds.

Age and gender classifications

In order to confirm age classifications and make certain males and female were equally represented, two research assistants who were unaware of the study's hypotheses were asked to classify each photograph as infant, child, or adult and as male or female. Through this procedure it became clear that age classifications were reliable for distinguishing between the three age categories, but the sex of young infants could not be reliably determined based on the photographs. As a result, five distinct groups were equally represented among the photos: men, women, boys, girls, and infants.

Alteration of images

Adobe Photoshop and Apple iPhoto were used to add, enhance, and remove tears from the photographs. Tears were added to the photographs of infants using Photoshop, since most images of infants did not initially contain visible tears. In order to make the tears appear as realistic as possible, photographs of older infants and toddlers that did contain tears were studied, and the position, color/tone, and shape of real tears was simulated in the altered images. The blemish-erasing tool in iPhoto was used to remove tears from adults' and children's faces. In some cases, tears that were present were further enhanced using Photoshop in order to increase their conspicuousness. Photographs were cropped so that the individual's face took up most of the frame and extraneous content was eliminated. The resulting images ranged in size from 2.5 x 2.5 inches to 3 x 4 inches, depending on the size and resolution of the initial photograph. The tearless and tearful versions of each crier's photo had precisely the same dimensions. Access to the entire set of original and digitally altered photos is available upon request.

Pilot testing of altered images

A pilot test was conducted to ascertain whether the digitally altered photographs were realistic looking. Twenty naïve participants were divided into two groups of ten, and each group was shown half of the altered photographs and half of the original photographs. Participants were told that the images were downloaded from the internet and therefore could have been digitally altered, and were asked to indicate how realistic or artificial each photograph was on a seven-point Likert scale, with one representing "not at all realistic" and seven representing "completely realistic." Any altered photograph that received a significantly lower authenticity rating than its original counterpart was discarded, as was any image, original or altered, that had an authenticity rating of less than five. From the remaining photographs, the four images in each of the five age and gender categories that received the highest overall authenticity ratings were selected for use in the experiment.

Order of presentation

Two separate sets of stimuli were created in order to present participants with one of two versions of the same photo, either with or without tears, and to avoid showing

individuals duplicates of the same face. Each set of 20 photographs contained four photos in each of the five distinct age and gender categories. Of the four photos in each category, two photos contained tears, and two photos did not contain tears. In order to avoid having photos of one age and gender designation concentrated toward the beginning or end of the experiment, the photos were first divided into sets, with each set containing one photo from each age and gender category. Within each set, the order of categories, the order of photos within each category, and the order of photos with and without tears, was determined using a random number generator. These procedures produced two sets of stimuli with the identical criers presented in the same order; the only difference between the two sets of stimuli was exactly which photographs contained tears and which did not. Both sets of stimuli contained an equal number of tearful and tearless photos (i.e., 10 each).

Procedure

Participants were tested by the same female experimenter either individually or in groups of up to three in a computer room on the college campus. Participants were seated approximately 12" from the 21.5-inch screen of a personal computer and instructed to perform ratings independently. Following consent, participants were randomly assigned to one of the two sets of stimuli. Participants viewed and rated photos online using software designed for this purpose. Each photo was displayed individually with its corresponding rating scales; participants proceeded to the next screen at their own pace. The entire procedure took approximately 30 minutes, at which time participants were fully debriefed. The study was approved by the Haverford College Institutional Review Board.

Measures

Participants first rated the extent to which they would describe the emotional expression of the individual displayed in the photograph as sad, sincere, and angry on a seven-point Likert scale, with 1 representing "not at all," 4 representing "somewhat," and 7 representing "extremely." Participants then rated their own level of sympathy and irritation on the same 7-point Likert scale. Finally, participants indicated whether they would attempt to comfort the individual in the photograph, leave the individual alone, or if they were unsure what they would do if they encountered the individual in the photograph and they were the only adult present. After completing ratings for all 20 photographs, participants provided general demographic information.

Manipulation check

The survey included an open-ended question asking whether any photographs in the experiments seemed odd or artificial. The question was repeated during the debriefing interview. None of the participants indicated awareness that some photos had been altered.

Data reduction and statistical analysis plan

Composite variables were created by averaging ratings on each dependent variable (i.e., sad, sincere, angry, irritated, and sympathetic) for photos falling into three age groups (infant, child, and adult) for each of the two experimental conditions (tears and no tears). For example, mean sadness ratings were computed for photos of infants with tears, infants

without tears, children (i.e., boys and girls) with tears, children without tears, adults (i.e., men and women) with tears, and adults without tears. For each dependent variable, a 2 (tears vs. no tears) x 3 (age: infant, child, or adult) repeated measures analysis of variance (ANOVA) was computed to test for main effects of tears and age, as well as their interaction. To test for sex of rater effects, mixed models were computed with tears and age as repeated measures and rater's sex as a between-subject factor.

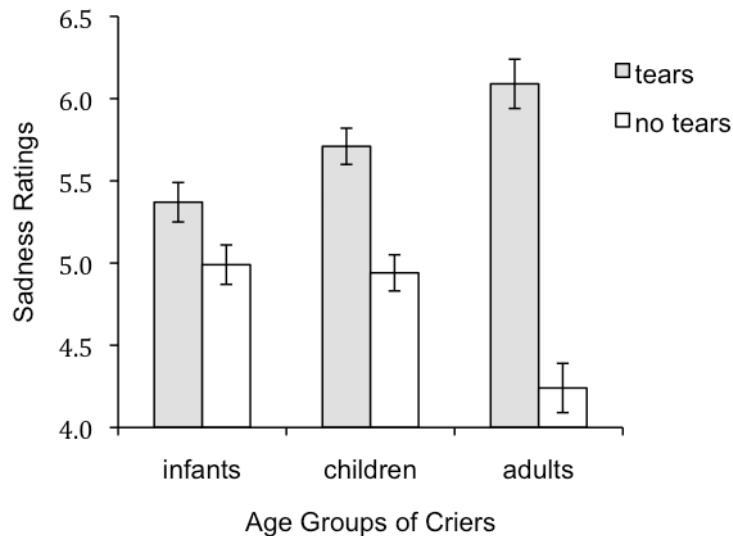
Because intervention ratings were categorical rather than continuous, ratings for intervention could not be averaged. Chi-square analyses were used to test whether the frequencies of the three responses (i.e., intervene to comfort, leave alone, or unsure) differed depending on the presence or absence of tears for each individual crier.

Results

Perception of emotional expressions: Sadness, sincerity, and anger

As predicted, there was a significant interaction between tears and age on sadness ratings, $F(2, 61) = 37.68$, $p < .001$. The difference between sadness ratings of faces with and without tears was greatest for adults, intermediate for children, and smallest for infants (see Figure 1). Faces with tears were perceived as significantly sadder than those without tears for all three age groups (all paired t s > 3.96 , p s $< .001$).

Figure 1. Mean sadness ratings for crying faces with and without tears as a function of crier's age group



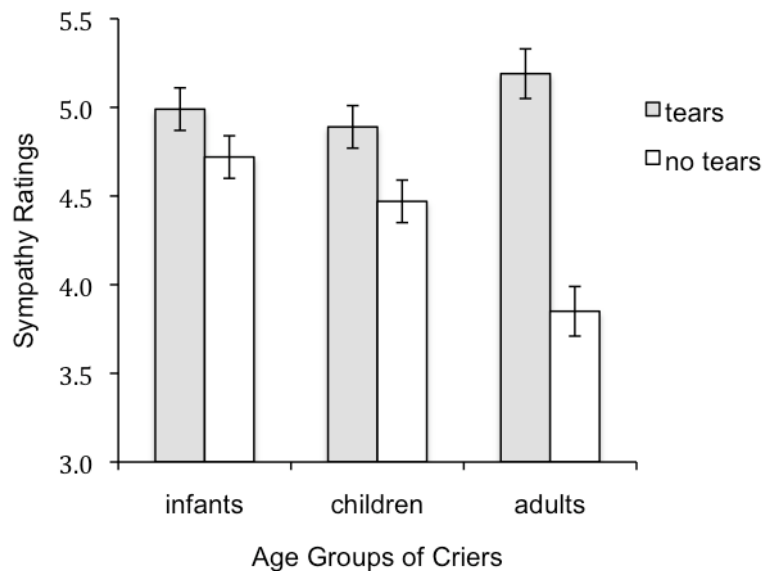
There was also a significant interaction between tears and age for sincerity ratings, $F(2, 65) = 4.11$, $p = .02$. Tears had a greater impact on judgments of sincerity with increased age of crier. Paired t -tests indicated that there was no difference between infant crying faces with and without tears in terms of the perception that infant criers were sincere, $t(67) = 1.21$, $p = .23$. For both children, $t(66) = 3.34$, $p = .001$, and adults, $t(67) = 5.09$, $p < .001$, tears significantly increased the sense that a crier was expressing a sincere emotion. There was no main effect of tears on the perception of anger of criers, $F(1, 66) =$

.31, $p = .58$, nor was there a significant interaction between tears and age on perceptions of anger, $F(2, 66) = 2.93$, $p > .05$.

Emotional reactions to crying faces: Sympathy and irritation

Tears increased sympathy ratings, $F(1, 66) = 93.89$, $p < .001$, as did younger age, $F(1, 66) = 6.74$, $p = .01$. However, these main effects were also qualified by a significant interaction, $F(2, 65) = 20.14$, $p < .001$. Tears had the greatest impact on sympathetic reactions to adult criers, a moderate impact on reactions to children, and the least impact on reactions to infant criers (see Figure 2). Tearful faces elicited significantly more sympathy than tearless faces in all three age groups (all paired t s > 2.34 , p s $< .05$).

Figure 2. Mean sympathy ratings for crying faces with and without tears as a function of crier's age group.



There was a significant main effect for tears, $F(1, 67) = 5.81$, $p = .02$, as well as for age, $F(2, 66) = 26.4$, $p < .001$, on irritation levels of participants, and no significant interaction between tears and age, $F(2, 67) = .96$, $p > .05$. Participants were more irritated by crying faces *without* tears ($M = 1.79$, $SD = .74$) than those with tears ($M = 1.66$, $SD = .74$), and were *less* irritated by the crying of adults ($M = 1.32$, $SD = .50$) than by the crying of children ($M = 1.94$, $SD = .99$) or infants ($M = 1.91$, $SD = .91$). Although irritation levels remained quite low especially in comparison to sympathy levels, the mean irritation levels in all cases represent values above “not at all” irritated, and contrasts between irritation in response to adults and the other two age groups were statistically significant, t s(68) > 5.33 , p s $< .001$.

Hypothetical responses to crying

Rates of hypothetical actions to comfort crying individuals were high overall, with average intervention rates of 83% for infant photos, 74% for children, and 25% for adults.

Chi-squares were computed for individual photos to see whether tears influenced participants' choices between three possible intervention options (i.e., comfort, leave alone, and unsure). For roughly a third of the photographs (7 out of 20 photos, or 35%), there was a statistically significant difference in rates of intervention in response to photos with tears and their matched controls without tears ($\chi^2s > 6.26$, $ps < .05$). In every case where there was a statistically significant difference between responses to tearful and tearless photos, the version of the photo with tears was the one associated with a higher rate of intervention to comfort the crying individual.

Effect of rater's sex

There were no main effects of rater's sex on any of the dependent measures with the exception of anger. Women gave criers higher anger ratings than men, $F(1, 63) = 4.38$, $p < .05$. This main effect was qualified by a significant interaction between rater's sex and crier's age, $F(2, 62) = 4.15$, $p < .05$. Compared to men, women viewed crying infants and children as higher in anger.

Discussion

The hypothesis that tears will have a more profound impact on the interpretation of facial expressions of distress in older criers compared to younger ones was confirmed. One possible reason tears are less useful for elaborating the meaning of the facial expressions of infants and children is that juvenile crying is predominantly an acoustic signal (Murray, 1979; Zeifman, 2001a). Audible crying decreases over the course of early development as children become capable of inhibiting vocalized crying and learn to gain proximity to caregivers through alternative, less costly, means (Barr, 1990a; Bell and Ainsworth, 1972; Gekowski, Rovee-Collier, and Carulli-Rabinowitz, 1983; Rebelsky and Black, 1972). As vocal signaling of distress becomes voluntarily suppressed, visual cues of distress, such as emotional tearing, may gain significance because they are reliable signs of distress and are not easily inhibited. This developmental progression of crying from a highly conspicuous auditory signal to a subtle visual signal is consistent with the idea that emotional expressions that come under voluntary control and are intentionally concealed have a tendency to be revealed through small yet detectable leaked cues (Cosmides and Tooby, 2000; Ekman, 1985).

The present findings suggest that tears communicate sadness and sincerity, but not anger. Tears also elicit sympathy, inhibit irritation among observers, and provoke interventions aimed at comforting criers. These findings are consistent with the theory that emotional tearing in adulthood is an attachment-relevant signal that functions to mobilize emotional support (Hendriks et al., 2008; Hendriks and Vingerhoets, 2006). These findings may also be seen as consistent with the appeasement-signaling view of emotional tearing (Hasson, 2009) because tears reduce irritation on the part of observers.

An unanticipated finding of the current study was that crying faces of infants and children were viewed as more irritating than those of adults, regardless of whether tears were present. Nonetheless, younger crying faces garnered high sympathy ratings and provoked high rates of hypothetical intervention. The paradoxical effects of infant and

child crying on listeners have been noted elsewhere (Barr, 1990b; Zeifman, 2001b). The current findings suggest that these paradoxical effects are elicited even without the acoustic element of crying, typically considered its most noxious feature (Murray, 1985; Owings and Zeifman, 2004).

A common explanation for the paradoxical effects of infant crying on listeners is that the aversive quality of infant crying underlies its effectiveness at recruiting actions aimed at stopping it (Owings and Zeifman, 2004). In this model, irritation typically leads to intervention. Higher levels of irritation in response to younger criers could also result from the fact that adults feel more physically compelled or socially obligated to respond to the cries of infants and young children compared to those of adults, leading to irritation. Hostile reactions to crying may thus be among the costs contributing to transformations in the deployment of distress signals across the life span (Zeifman, 2001a).

One limitation of the current study is the use of still photographs rather than audio-containing stimuli such as videotape. While the use of photographic stimuli allowed tears to be manipulated while holding other variables constant, it is not known whether tears would have the same impact on the dynamic facial expressions of individuals as it did in this experiment. Future studies should explore judgments about videotaped crying, with and without accompanying sound, and with and without visual images. This method would allow one to see whether the visual and acoustic elements of crying operate together in an additive fashion to communicate distress, or if one channel of communication is dominant over the other at certain points in development. Additional research on the expression and perception of crying at different stages of development and in diverse contexts will provide the field with a more complete understanding of the evolutionary significance of this behavior.

Emotional expressions and the co-evolved mechanisms to interpret them convey information about an individual's state to others (Cosmides and Tooby, 2000). In the case of infant crying, this exchange of information is beneficial to both parties involved in the communication because it ensures infant survival and parental reproductive success. For adult criers, providing information about one's weakness could either be advantageous or injurious, depending on the audience. Adults are therefore more circumspect than infants or children about crying, and can voluntarily inhibit or exaggerate outward expression of distress (Fridlund, 1994). Even when individuals deliberately mask emotions, however, involuntary cues emitted through voice, posture, or face, can provide accurate information about an individual's internal state (Ekman, 1985). Tears may increase in signal value with age because tears leak honest information that is otherwise suppressed.

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