the developmental changes of structural properties (e.g., fundamental frequency modulation and related variables) in spontaneous ("mitigated") cries follow a unidirectional program: One of the first building blocks of cry melody development is a simple rising-falling cry melody (melody = time function of the fundamental frequency). A first differentiation of spontaneous cries happens by a combination of these rising-falling melody patterns to pattern sequences created by a simple repetition or concatenation. The simplest form of complexification is a double-arc cry melody. Beyond duplications we also observed multiple repetitions within one cry to form ever more complex patterns (cries consisting of multiple-arc melodies).

Further refinement of laryngeal coordination and the mastering of tuning between the melody and resonance frequencies (Wermke et al. 2002b) during the first weeks of life provide several elementary abilities, which are at the disposal of other pre-speech vocalizations. A "training" process of this type is an important prerequisite for speech and language acquisition, especially for the acquisition of prosodic primitives.

A recent study investigating the melodies of 780 harmonic cries in 30 (14 male) healthy monozygotic twins[1] strongly supports the above mentioned developmental principles. The melodies were grouped into single-arc melodies and multiple-arc melodies and the frequency of occurrence displayed over the age of the infants (Fig. 1).

The most obvious tendency shown in Figure 1 is the nearly steady increase in the frequency of occurrence of complex (multiple-arc) melodies. This reveals a relatively continuous, unidirectional development from the early prevailing simple cry structures (single-arc-melody) to complex melodies. It is easy to understand that such developmental changes will influence the "classical" cry parameter. It could also be shown in this twin study that the synchronicity and the concordance in the melody development for monozygotic twins is much higher than that for unrelated pairs of subjects of the same sex and age from the same sample (Wermke 2002). The monozygosity, and hence the higher synchronicity of development, resulted in a much clearer manifestation of the universality of development than would have been the case in an average population. The melody changes sketched here are a strong argument for the relevance of the developmental aspects of human infants' cries important for evaluating recent attempts to illuminate the human infant cry from an evolutionary perspective. The described melody development probably reflects a specific signal function of human infants' cries that is at least as important from an evolutionary perspective as the functions summarized by Soltis.

The disparate and highly inconsistent values for cry parameters provided in the literature are not mainly a result of the different methods applied, as Soltis argues, but are, in our view, at least partially attributable to the fact that the majority of cry researchers did not adequately consider developmental changes of cry features. Hence, a reevaluation of the data in the cry literature under consideration of the now well-described developmental changes (including *reorganization phases*) might be helpful in resolving the paradoxes thematized by Soltis. Such a developmental perspective may have the potential to reveal the hidden consistency of the available cry data. This would clearly go beyond the signaling vigor hypothesis proposed. Note that we are not claiming that the model proposed by Soltis is inadequate, only that some of the data on which his interpretations are based are inadequate or insufficient for drawing the respective conclusions. The fact that the signal functions of the human infant cry have been shaped by a long evolutionary adaptation process also means that these signal functions are strongly related to the acoustic cry features. Yet exactly these sections in the target article are quite unsatisfying (sects. 4.1. and 4.3). Although referring to the lack of standardization in cry analysis and to some methodological controversies, Soltis implicates that we know the "normal infant cry characteristics" and moreover that we might be able to differentiate between "normal" and "abnormal" cry variables in individual infants. This is simply not valid. There has been invaluable work in this field over the last 40 years, but as long as cry researchers do not "correct" their cry scores with specific respect to the rapidly ongoing developmental processes during the first weeks of life, a cry-diagnosis will fail and we will not solve the controversies in the cry literature. It is not only the field of cry-diagnosis which suffers from the fuzziness of cry scores, but there is also an impact on the fields of research related to developmental biology, pre-speech development, child abuse, and infanticide.

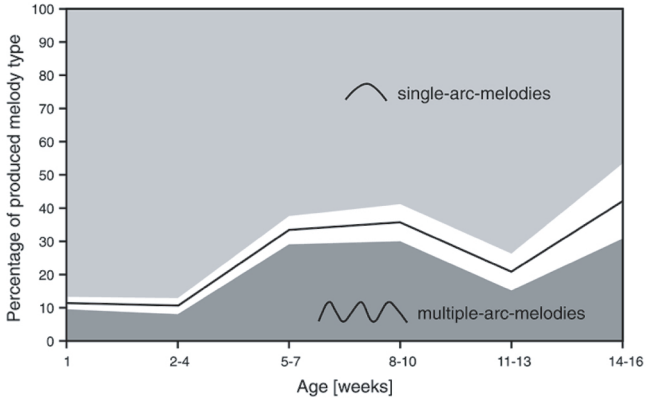


Figure 1 (Wermke & Friederici). Developmental changes of the relative frequency of occurrence of single-arc-melodies (upper part) versus multiple-arc-melodies (lower part) from all infants over the first 16 weeks of life (total amount of arc-like melodies: N=781; standard errors marked by the white region).

In our longitudinal studies, we strongly correlated all cry parameters to the age and the maturational state of the infant (e.g. Mende et al. 1990; Wermke 2002; Wermke et al. 1987; 1996; 2002a; 2002b; Lind & Wermke 2003) and obtained quite stable prognostic results as well as data consistency when retrospectively reanalyzing cry data under consideration of the developmental outcome of the children (first results: Wermke & Friederici 2004). We found that the relative percentage of multiple-arc melodies produced in cries during the first 14 weeks is a significant predictor of spontaneous word production performance at 18 months.

We fully agree with Soltis' prospect conclusion, that much remains to be learned about the signal functions of early infant crying. However, we strongly recommend an inclusion of structural developmental data before further testing any hypothesis.

NOTE

1. Spontaneous cries of the twins were recorded several times during their stay at the hospital. Recordings were repeated in six-week intervals (+/− 2 weeks) in the home environment. In total, 1,100 cry signals of infants between birth and the 16th week of life were investigated and cries containing large regions of subharmonics or noise were excluded from the melody analysis (N=386). The remaining 714 cry melodies could be assigned to melody types (single- vs. multiple-arc-melodies). Spectral analysis and melody computations were made using a CSL-Speech Lab 4300/ MDVP (Kay Elemetrics).

On the utility of an evolutionary approach to infant crying

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Abstract: Soltis' analysis of signal functions of young infants' cries stimulates testable questions regarding abuse, neglect, and infanticide. Nevertheless, his evolutionary perspective oversimplifies the cry event, and does little to promote developmental analysis of crying during infancy. Studies of the cry in its behavioral and developmental context are needed if we are to understand the proximate causes of optimal and suboptimal care.

https://doi.org/10.1017/S0140525X04400107 Published online by Cambridge University Press

Soltis' attempt to explain all communicative crying within the first three months of life from an evolutionary perspective is both interesting and problematic. The fact that this perspective can address data from several disciplines makes it an attractive tool for synthesizing a diverse and sometimes contradictory literature. Even so, the perspective carries the potential to oversimplify infant crying, and to lead research efforts away from understanding the cry's role in both domain-specific (social and communication) development and the overall development of the child. In this commentary, I argue that: (1) Soltis' focus on the cry sound obscures the richness of the cry event; (2) an evolutionary perspective does little to stimulate developmental analyses of crying; (3) consideration of the complexity of the cry event, and its development, are necessary for understanding parent-infant interaction, both optimal and suboptimal.

Soltis describes the cry's function in general terms, considering only its evolution as a vocal signal of infant health or "vigor." Furthermore, the context in which the cry occurs is characterized rather simply: either the context favors infant survival, or it does not. While this approach has generated questions about the proximate causes of abuse, neglect, and infanticide (target article, sect. 7, "Conclusions and prospects"), it oversimplifies the cry event, which includes temporal changes in acoustics, as well as visual cues about the infant's level of distress and, indeed, about whether he or she is crying at all.

Crying from healthy young infants has a complex acoustic structure that changes during a long cry bout (Green et al. 1998). Moreover, acoustic changes over time relate to adults' ratings of infant distress (Wood 2002), and the cry's "aversiveness" (Zeskind et al. 1985), in ways predicted by the graded signal view of crying. Soltis argues that when crying is persistent and acoustics are outside the normal range (i.e., when a child is unhealthy), caregivers could opt to provide suboptimal care. What would happen if a healthy child were regularly left to cry for long periods (e.g., in a busy household)? Would the acoustics of the child's long cry bouts become "abnormal" and so aversive that adults would provide suboptimal care? Analysis of parent-child interactions during long cry bouts would provide this information, whereas an evolutionary perspective that focuses on the cries of unhealthy infants may shed little light on such matters.

Crying occurs in concert with facial expressions and other behaviors, and Soltis' concentration on the sound itself obscures this observation. Two studies are relevant here. Green et al. (1995) presented nonparent adults with cries and noncry vocalizations from 3-month-old infants in both an audio-alone condition (just the sound), and an audio plus video condition (which showed the infant producing the sound). The adults were significantly better at correctly identifying cries from 3-month-olds when the sounds were paired with the video than when they were played alone. This was not true for noncry sounds. When the videotapes were edited so that cry faces were paired with noncry sounds, and vice versa, adults labeled noncry sounds that were paired with cry faces as cries. The visual information (facial expressions) thus took precedence over the auditory information (the sounds themselves). In another study, nonparents were able to use only the facial expressions of crying 3-month-olds to distinguish very distressed infants from those who were less distressed (Irwin 1999). These studies show that young infants' cries occur within the context of other behaviors, and that these behaviors may have as much or more influence on cry perception as the sound alone. It is therefore useful for researchers to consider the cry as a "multiply specified signal" (Irwin 1999), which includes the infant's sounds and facial expressions. Moreover, the existence of such cry complexity at 3 months of age suggests that developmental changes occurred earlier, a point Soltis' perspective does not address.

Little is known about the development of crying in healthy children, especially with regard to qualitative changes during infancy (Hopkins 2000). Where changes are documented, their underlying mechanisms are not well understood. An evolutionary perspective such as Soltis' does little to stimulate needed inquiry into infant cry development. Indeed, Soltis' discussion is limited to crying in the first 3 months because "At about 3 months of age, infants undergo a developmental shift in which crying becomes more differentiated, interactive, and intentional" (sect. 1, para. 3). If we assume that crying during the first 3 months serves only to maintain proximity to the caregiver, and to signal the infant's health, then we neglect an essential question: What qualitative changes occur in the cries of young infants, both healthy and unhealthy, and how do the changes affect adult-child interactions? There is evidence that crying undergoes changes during the first 3 months (beyond those associated with the "cry curve") that may reflect the beginnings of "differentiation" or reorganization of existing communicative behaviors.

In a longitudinal study, Hopkins and van Wulfften Palthe (1987) showed that fussing (a vocalization whose definition often overlaps with definitions of crying; Hopkins 2000) and cooing appeared at 6 weeks of age. Between 2 and 3 months, fussing and cooing became a new vocalization, "interrupted fussing," characterized by alternations between the two kinds of vocalizations. Thus, the components of crying were reorganized before the infants were 3 months of age. Interestingly, Hopkins (2000) noted that the alternations between fussing and cooing were accompanied by changes in facial expressions (cry faces during fussing, smiles during cooing). This observation indicates that crying in healthy children is a complex communicative event, even before the third month of life. Studies that consider the entire event (not only the sound) can provide insight into the changes in young infants' crying, and the mechanisms for the changes.

Soltis provides a provocative analysis of the possible signal functions of early infant crying. While his evolutionary perspective generates questions, it overlooks the complexity and development of the cry event. An understanding of optimal and suboptimal parent-infant interaction depends on consideration of the cry in its behavioral and developmental context. An evolutionary perspective does not promote such consideration.

ACKNOWLEDGMENT

I thank Dr. Susan A. Holt for helpful comments on this manuscript.

Colic and the early crying curve: A developmental account

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Abstract: The hypothesis that excessive early infant crying evolved to reduce the risk of withdrawal of parental care is disputed on the grounds that excessive infant crying is irritating and imposes fitness losses rather than gains. Alternative explanations for the early crying curve that take into account development on the part of the infant and the emerging infant-caregiver bond are proposed.

Soltis should be commended for a comprehensive review and novel synthesis of the early infant crying literature. His review highlights the fact that we cannot yet adequately explain the early crying curve or the prevalence of colic. The author's claim that the weight of the evidence favors the "signaling vigor" hypothesis over other explanations, however, seems to overlook inconsistencies with the data and plausible alternative explanations.

The main premise of the signaling vigor hypothesis, that infants cry to advertise their health and stave off neglect or infanticide, ignores the highly irritating quality of crying. The negative reaction of adults to even normal infants' cries is reflected in, among other things, the adjectives used in rating scales to describe cries (e.g., grating, annoying, sickly). As a result of these negative reactions, colic has at least short-term negative consequences for infants that, had they occurred over the course of human evolution, would

https://doi.org/10.1017/S0140525X04400107 Published online by Cambridge University Press