had their hands full – of their infants. Prior to the invention of baby slings, hominin mothers would have had to free their hands periodically from infant carrying in order to forage for food. A plausible way to do this would have been to put babies down, preferably nearby where they could be kept under surveillance.

Thus began the evolution of infant crying as an honest signal of need for reestablishing contact with the mother. In a sense, persistent infant cries compensated for the loss of little grasping hands and feet that once clung to mothers' bodies. Also, thus began a concomitant evolution of the special vocalizations of motherese, which functioned initially to sooth, appease, engage, and calm *distal,* complaining (as opposed to *proximal,* content) babies. In a sense, prosodic utterances became disembodied extensions of mothers' cradling arms, since a "squealing baby, in fact, can be stopped dead in its vocal tracks by a sudden stream of baby-talk" (Small 1998, pp. 145–46). For both mothers and babes, then, special vocalizations evolved in the wake of selection for bipedalism in response to reduction of the direct physical contact that was previously achieved by their ancestors' upper and lower extremities. Voices had come into their own!

Today, motherese forms a scaffold upon which language is acquired by maturing infants around the world, and I hypothesize that this was probably true during the emergence of protolanguage in the distant past (Falk 2004). Soltis' work raises the possibility that the signaling functions of early infant crying also played a significant role in the evolution of prelinguistic substrates in early hominins. As he notes, excessive infant crying with certain acoustic properties appears to constitute an honest signal of vigor that elicits nurturing responses in parents (and therefore increases fitness in both parents and offspring). Soltis therefore hypothesizes that colicky infants may, in fact, be relatively vigorous and that they signal this fact to their parents by persistent, intense, and more inconsolable crying that discourages parental withdrawal of support. On the other hand, Soltis suggests that, for unfit infants, it is pitch-related acoustic quality rather than the quantity of crying that triggers abusive responses in caregivers.

Higher overall tones (pitch) comprise an important acoustic feature of motherese, so it is interesting that infant cries of high and variable pitch are often perceived by adults as arousing or aversive (sect. 4.4 of the target article); that such cries can lead to differential allocation of parental resources (or infanticide); and that one study, at least, showed that infants whose mothers perceived their high-pitched cries as negative outperformed other infants on language tests at age 19 months (Lester et al. 1995). These nuggets from Soltis' target article suggest that cries with specific acoustic properties might have been preadaptive for the emergence of protolanguage and, if so, today's cries of colicky infants may specifically signal a sort of prelinguistic vigor. Do colicky babies grow up to have better verbal skills than non-colicky babies? I suspect this question (and the ones Soltis raises about their general fitness) could be addressed relatively easily by designing retrospective or (future) longitudinal studies. Meanwhile, it's clear that, from the moment of their births, human infants object to the insult of being separated from their mothers with persistent cries, while chimpanzee infants remain, for the most part, contentedly and silently attached to their mothers' bodies. The human neonatal pattern of excessive crying continues for several months (the extent varying with the degree of culturally determined physical contact between mother and infant), during which time babies' preference for ID as opposed to AD speech increases (Cooper et al. 1997). Crying then levels off precisely at the time ID speech is used most intensively (with 3- to 5-month old infants) (Stern et al. 1983). Soltis' research has convinced me that motherese and infant crying are two sides of the same coin, that both had long evolutionary histories, and that both may have been important factors during the evolution of prelinguistic substrates in early hominins.

Infant crying in hunter-gatherer cultures

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Abstract: By synthesizing evolutionary, attachment, and acoustic perspectives, Soltis has provided an innovative model of infant cry acoustics and parental responsiveness. We question some of his hypotheses, however, because of the limited extant data on infant crying among hunter-gatherers. We also question Soltis' distinction between manipulative and honest signaling based upon recent contributions from attachment theory.

Soltis innovatively synthesizes complementary aspects of the evolutionary, attachment, and acoustic literatures on infant crying in order to elucidate the adaptive function of infant crying, particularly excessive infant crying. Soltis' laudable model of early infant cry acoustics and parental response tendencies (sect. 4.6), is preceded by two general hypotheses, namely that: (1) infant cries characterized by high pitch, variable pitch, and biphonation are likely to be proximate causes of neglect, abuse, or infanticide; and (2) excessive "normal" crying (colic) honestly signals infant vigor and decreases the risk of neglect, abuse, or infanticide.

Both hypotheses assume that different types of crying affect the risk of neglect, abuse, or infanticide and that these forms of maltreatment were/are common in "premodern" or "traditional" cultures. Unfortunately, the majority of the cultures discussed in section 2.2 and Table 1 involve farmers, pastoralists, or urban industrialists. The case studies cited similarly involve farmers (e.g., Eipo), while research on the abuse or neglect of retarded and chronically ill infants was all conducted in urban-industrial cultures. We know little about abuse, neglect, and infanticide in hunter-gatherer cultures, especially in relation to infant crying. Neglect, abuse, and infanticide certainly exist (see Hill & Hurtado, 1992, for example), but the contexts, especially those surrounding cases in early infancy, are poorly understood. Hunter-gatherer societies may be particularly important for understanding the evolution of infant crying because the foraging way of life characterized most of human history. Hunter-gatherer infancy is characterized by constant holding/touching, frequent breastfeeding (often 4 times an hour), multiple care providers (fathers, siblings, other women, etc. – all very involved, in part, because infants are always held in hunter-gatherer communities), and infrequent crying (Hewlett et al. 2000; Konner, in press). Our own qualitative field observations of Aka and Bofi forager infants indicate that: (1) colic, as defined in the West, is rare or nonexistent; (2) caregivers do not get irritated with unusual or long crying bouts; and (3) young children as well as adults know how to soothe crying infants. Excessive and unusual crying occurs more frequently among the farming neighbors of the Aka and Bofi.

Soltis also assumes that parents alone decide the quantity and quality of care that infants receive (sects. 2 and 6), noting for example, that "parents can partition investment selectively among offspring as they choose" (sect. 2.3, para. 1). Throughout his discussion of signaling, Soltis implies that parents have complete control over the allocation of resources to infants (e.g., nursing, care, etc.) and does not consider care provided by other individuals. This sort of omission is appropriate if we assume that young infants are actually cared for all of the time by parents, as is often the case in the United States, but multiple-person caregiving is common in hunter-gatherer groups. In fact, approximately 40% of the care received by 1- to 4-month-old Aka and Efe forager infants comes from non-parental sources (Hewlett 1989; Tronick et al. 1987), often while parents are also present and caring for their in-

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fants simultaneously. For example, Konner (in press) reported that, although !Kung mothers are typically the primary caregivers, mothers alone accounted for only about half of the responses to fretting, whereas the majority (88%) of the frets elicited responses from both mothers and others simultaneously. Because !Kung infants were almost never alone with their mothers, other caregivers made substantial contributions to the quality, degree, and timing of responses to infant frets.

Noting the cooperative care patterns common among contemporary hunter-gatherers, Hrdy (in press) has proposed that humans evolved as cooperative breeders, and Ivey Henry et al. (in press) report that the amount of allocare received by Efe infants is the best predictor of infant survival. Cooperative breeding may reduce the cost of parenting in hunter-gatherers societies and thus reduce the actual levels of abuse and neglect in "traditional" cultures.

Soltis' second hypothesis assumes that normal crying universally peaks at six weeks of age, and again the extant data are limited. Data obtained on !Kung hunter-gatherers support the statement, although these data were collected in limited contexts (in-camp only, infant awake, mothers present) and Konner (in press) suggests considerable inter-cultural variability in forager crying patterns. Furthermore, if the sixth week peak is a human universal, then perhaps crying patterns should also be examined among nonhuman primates. If excessive crying at six weeks reduces the risk of infanticide, why doesn't it occur in higher primates or other animals in which infanticide occurs? Is this pattern uniquely human?

Whereas Soltis cites several studies documenting that specific cry acoustics lead to infant maltreatment in urban industrial cultures, we know of no acoustic studies conducted in forager or other small scale cultures. Our own qualitative observations suggest that this type of crying does not elicit maltreatment in forager cultures, however. Chronically ill infants may not survive, but caregivers continue to be indulgent and responsive rather than abusive or neglectful. Again, caregivers do not show the irritation and stress often described in urban industrial societies.

Finally, Soltis contrasts manipulative and honest signaling, suggesting that manipulative crying involves attempts to obtain care that is not physiologically needed. For example, an infant who is not very hungry may cry manipulatively for nursing, care, or proximity. This argument implies that attention, proximity, and care do not contribute to infant survival, but from an attachment perspective, one could argue that crying for proximity is an honest signal of need for the contact, which promotes attachment and may influence the quantity and quality of care received in the future. Crying for proximity is not necessarily manipulative, therefore, but may contribute to infant survival. Many scholars have noted that children's attachment behaviors (which include crying and proximity seeking) are responses to caregiving environments, and that these behaviors may enhance survival (Belsky 1997; Chisholm 1996; 1999; Lamb et al. 1984; Main 1990). Insecure attachment patterns (which include elevated levels of crying) may be facultative adaptations, because the patterns help infants with less responsive caregivers to gain more attention and care.

Despite these concerns, Soltis' model of early infant cry acoustics and parental responsiveness (sect. 4.6) is useful, and is likely to generate valuable field studies. The model is unique because it is multi-leveled and considers the joint and integrated influence of "infant and parental characteristics, household dynamics and economy, and the wider community and culture" (sect. 4.6, para. 4). Such holistic models often generate cross-disciplinary research and scholarship.

We agree with Soltis that early infant crying deserves more attention, and we appreciate his attempt to integrate data from diverse sources. More systematic analyses and data from hunter-gatherer cultures are needed in order to test and develop hypotheses about the evolution and adaptive function of early infant crying.

NOTE

Hillary N. Fouts and Michael E. Lamb are employed by a government agency and as such this commentary is considered a work of the U.S. government and not subject to copyright in the United States.

Is excessive infant crying an honest signal of vigor, one extreme of a continuum, or a strategy to manipulate parents?

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Abstract: An evolutionary account of excessive crying in young infants – *colic* – has been elusive. A study of mothers with new infants suggests that more crying is associated with more negative emotions towards the infant, and perceptions of poorer infant health. These results undermine the hypothesis that excessive crying is an honest signal of vigor.

Following Barr (1998a) and Lummaa et al. (1998), Soltis tentatively favors the argument that excessive infant crying is an honest signal of vigor, with more crying indicating higher infant quality (sect. 6.3). If that were the case, then mothers should have more positive emotions towards colicky infants. Yet many studies indicate otherwise. Although the casual pathways are not clear, there is a robust association between early infant temperament problems, including colic (Beck 1996), and postpartum depression (PPD). PPD, in turn, is robustly associated with reduced maternal care (Beck 1995). Mothers with PPD commonly think about harming their children, display fewer positive emotions and more negative emotions toward them, and are less responsive and sensitive to infant cues (Hagen 1999). Soltis himself notes that "Excessive infant crying is the most common clinical *complaint* of mothers with infants under three months of age" (sect. 5.1, para. 1, emphasis added).

My survey of 129 U.S. mothers with babies aged 3–32 weeks (see Hagen [2002] for details about other aspects of the study) included several maternal self-report items relevant to the excessive crying hypothesis (rated on a 7-point Likert scale):

- How much does your baby cry? (0=Never; 6=Constantly)
- How much in love are you with your baby?
- According to your doctor how healthy is your baby now?
- How much do you worry that your baby might have a problem of any kind?
- What is your "gut feeling" about the health of the baby?
- Has your baby had any health problems since the birth? (Yes/No)

The distributions of the variables were not normal, so non-parametric Spearman rank correlations (r_s) and a Mann-Whitney U test (Z) were computed. Descriptive statistics are reported in Table 1, results in Table 2 (all p-values two-tailed):

In each case, more infant crying was associated with lower levels of perceived infant health, more worry about health, and less positive emotions towards the infant, contrary to the vigor signaling hypothesis. The effects were small, and only significant for doctor rating of health and love for the baby. Because crying diminishes after 12–16 weeks, I re-ran the analyses for mothers with infants aged 3–12 weeks. There was little change in effect sizes, although now no results were significant, because of decreased sample size.

This study was not designed to examine infant crying, and no items assessed cry acoustics. It could therefore have been the case that cries with abnormal acoustics were confounded with excessive crying. Under the health signaling hypothesis, if the sample is biased towards infants in good health, that should tend to eliminate infants with abnormal cry acoustics, reducing the confound.

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