BRIEF REPORT

INFANTS PREFER HIGHER-PITCHED SINGING

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Female singers were recorded singing a song in a high and/or a low range. Infants preferred to listen to the higher-pitched versions, suggesting that infants' preference for infant-directed singing and speech is mediated in part by a preference for higher pitch.

A recent study showed that infants prefer to listen to infant-directed over non-infant-directed singing (Trainor, 1996). Although different performance styles are used to communicate different messages to infants, such as when it is time to calm down and sleep or when it is time to play (Rock & Trainor, in press), all types of infant-directed singing share certain characteristics. In comparison to non-infant-directed singing, infant-directed singing is higher in pitch, slower in tempo, and rendered in a more loving or emotionally engaging manner (Trainor, 1996; Trainor, Clark, Huntley, & Adams, 1997; Trehub & Trainor, in press; Trehub, Unyk, & Trainor, 1993; Trehub et al., 1997). Interestingly, infant-directed speech is also higher in pitch and slower in tempo than adult-directed speech (e.g., Fernald, 1991; Fernald & Kuhl, 1987; Papoušek, 1992). It is generally assumed that infants' preference for infant-directed over adult-directed speech is due in part to a preference for higher-pitched voices (e.g., Fernald, 1991; Fernald & Kuhl, 1987; Trehub & Trainor, 1990), although very few studies have addressed this issue directly. Fernald and Kuhl (1987) synthesized the pitch contours of infant-directed and adult-directed speech and found that infants preferred the former. It is not clear from this study, however, whether it was the exaggerated pitch contours or the overall higher pitch of the infant-directed speech samples that mediated infants' preferences. Patterson, Muir, and Hains (1997) reported that raising the voice of a stranger half an octave recruited infants' attention whereas lowering it half an octave did not. For mothers, infants' attention was heightened when the pitch was either raised or lowered (probably a novelty preference as the mother's voice is highly familiar), but the amount of smiling was greater when the pitch was raised than when it was lowered. In the research reported here, we tested directly whether

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infants prefer higher- over lower-pitched singing.

The stimuli in Experiment 1 were naturalistic non-infant-directed pairs of recordings from 4 women with semi-trained voices who were asked to sing a children's song of their choice. Digital recordings were made with CSRE (Computerized Speech Research Environment) software, Tucker-Davis Technologies hardware, and a Comptech 486 PC. The singers were initially asked to sing the song in the pitch range that was most comfortable for their voice. This rendition was not used. They were then instructed to sing the same song twice more at the same tempo. Two singers were asked to sing the song 3 semitones (where a semitone is 1/12 of an octave or the distance between any two adjacent notes on the piano) higher and then 4 semitones lower than their original version. The other two were asked to sing the song 3 semitones lower and then 4 semitones higher than their original version. The high and low versions were 7 semitones (or a perfect fifth) apart (starting pitches of the lower versions were 220, 204, 258, and 204 Hz), and according to Western musical theory (e.g., Aldwell, & Schachter, 1989) and studies of infants' perception of consonance (e.g., Schellenberg & Trainor, 1996; Trainor & Heinmiller, 1998; Trainor & Trehub, 1993; Trehub & Trainor, 1993), hearing two versions in succession that are a perfect fifth apart should sound natural and pleasant. Two of the songs ("Twinkle, Twinkle," "Itsy Bitsy Spider") were sung in a playful manner and two ("Jesus Loves Me," "Kumbaya") in a lullaby manner.

Each high and low song pair was matched for tempo (across the singers, tempos ranged from 1.24 to 1.72 beats/s) and to the extent possible, idiosyncratic features of individual singers' voices and style of singing. The songs were also matched for intensity, which ranged from 53 to 56 dB(A) across singers. To make sure that the song pairs were well matched, 4 adults rated each song pair as to whether the high or the low song was most pleasant on a scale from 1 (low song most pleasant) to 7 (high song most pleasant). The mean ratings per singer varied from 2 to 4.25, with a mean of 3.63. This is not significantly different from the neutral value of 4 ($p > .5$), and in any case, there was a non-significant trend for adults to find the low versions more pleasant, which works against the hypothesis that infants will prefer the higher versions. An additional 4 adults rated which song was most appropriate for infants on a scale from 1 (low most appropriate) to 7 (high most appropriate). In this case the means ranged from 3.25 to 5 across the singers, with a mean of 4.19. Again this is not significantly different from 4, $p > .6$.

Each infant was tested individually on the high/low song pair from one singer. Infants controlled how long they heard each version of the song pair through their looking behaviour. This difference in looking time was used as the measure of infants' preference. Four infants were tested on each song pair for a total of 16 infants (age range = 6 months, 3 days to 6 months, 16 days; 9 female, 7 male). The data from an additional 5 infants was not used due to fussiness or equipment failure. The digital sound files were presented with a Macintosh IIci computer containing an Audiomedia card and a Denon amplifier. The infant sat on his or her parent's lap in a sound attenuating chamber across from the experimenter. Both the parent and the experimenter listened to masking music through headphones so they were unaware of what the infant was hearing. The experimenter communicated to the computer through a custom built interface and button box. Two GSI loudspeakers were located on opposite sides of the infant and each sat on top of a box with a smoked plexiglas front so that it was not possible to see the toy that was located inside each box unless the lights inside the box were illuminated.

To begin a trial, the experimenter centered the infants' attention and pressed a button on the box. This signalled to the computer to flash the light in one of the toy boxes. When the infant turned his or her head to look at the toy and flashing light, the experimenter pressed a second button, which caused the

computer to leave the light on and play one version of the song pair. When the infant looked away from the toy, the experimenter released the button. When the infant looked away for at least 2 s, the trial ended with the computer turning off the light and sound. During testing, 20 trials of the high and low versions were presented in alternation through the loudspeakers on opposite sides of the infant. For half of the infants the high version was presented on their left and the low version on their right. Crossed with this factor, for half of the infants the low version was presented first and for half the high version was first.

Overall, infants looked significantly longer at the toy in order to listen to the high versions over the low versions, $t(15) = 1.94$, $p < .04$, where the dependent measure was the amount of time each infant listened to the high version divided by the amount of time the infant looked to both versions across the 20 trials (Figure 1, upper panel). Significant habituation occurred during the procedure, $t(15) = 5.12$, $p < .0001$, as average looking times decreased from 12.4 s ($SD = 4.8$) for the first 10 trials to 6.5 s ($SD = 1.2$) for the second 10 trials. Infants looked significantly longer in order to listen to the high version during the first half, $t(15) = 1.90$, $p < .04$, but not during the second half, $p > .27$. Analyses of variance with initial side (right/left), initial version (high/low), and song type (playsong/lullaby) as independent variables and proportion looking time as the dependent variable revealed no significant main effects or interactions involving these variables over the first 10 or the second 10 trials.

As predicted, infants preferred to listen to higher-pitched over lower-pitched singing. As these singing samples were closely matched on all other dimensions, this is a strong indication that the pitch of the voice probably plays a crucial role in infants' preference for infant-directed over non-infant-directed singing. One factor remains a potential problem, however. While using the same singer for the high and low versions largely eliminated stylistic variation between the pairs of songs, it is possible that singing higher than your most comfortable range has a different effect on the quality of the rendition than singing lower than your most comfortable range. Although the adult raters did not find the higher versions more pleasant or more appropriate for an infant than the lower versions, we decided that it was prudent to replicate these results in a second experiment. Four women, two with relatively low singing voices and two with relatively high singing voices, were asked to sing "Twinkle Twinkle" at their most comfortable range. All renditions were at a tempo of 1.5 beats/s. The four samples formed two high/low pairs, with starting notes of 205/300 Hz. and 203/345 Hz. As in Experiment 1, adult ratings of the relative pleasantness and appropriateness for infants of the high versus low samples tended to favored the low samples (mean of 3.0 for pleasantness and 3.6 for appropriateness).

Testing and data analysis of infants' preferences for the two high/low pairs were identical to those of Experiment 1. Sixteen infants (age range = 6 months, 1 day to 6 months, 30 days; 8 female, 8 male) were tested, half with one pair and half with the other pair of samples. The data from an additional 4 infants was not used due to fussiness or equipment failure. Again, there were no effects of initial side (right/left) and initial version (high/low) across either the first 10 or the second 10 trials. Overall, infants preferred to listen to the higher over the lower version, $t(15) = 2.26$, $p < .02$ (Figure 1, lower panel). Significant habituation occurred, as average looking times decreased significantly from the first to the second 10 trials, $t(15) = 2.48$, $p < .02$. Infants looked significantly longer in order to listen to the high version during the second half, $t(15) = 3.26$, $p < .003$, although not during the first half, $p = .19$.

Experiment 2 replicated the results of Experiment 1 with stimuli that were sung at the most comfortable range of the singers. Together, these experiments provide strong evidence that infants prefer to listen to higher- over lower-pitched singing. They also lend

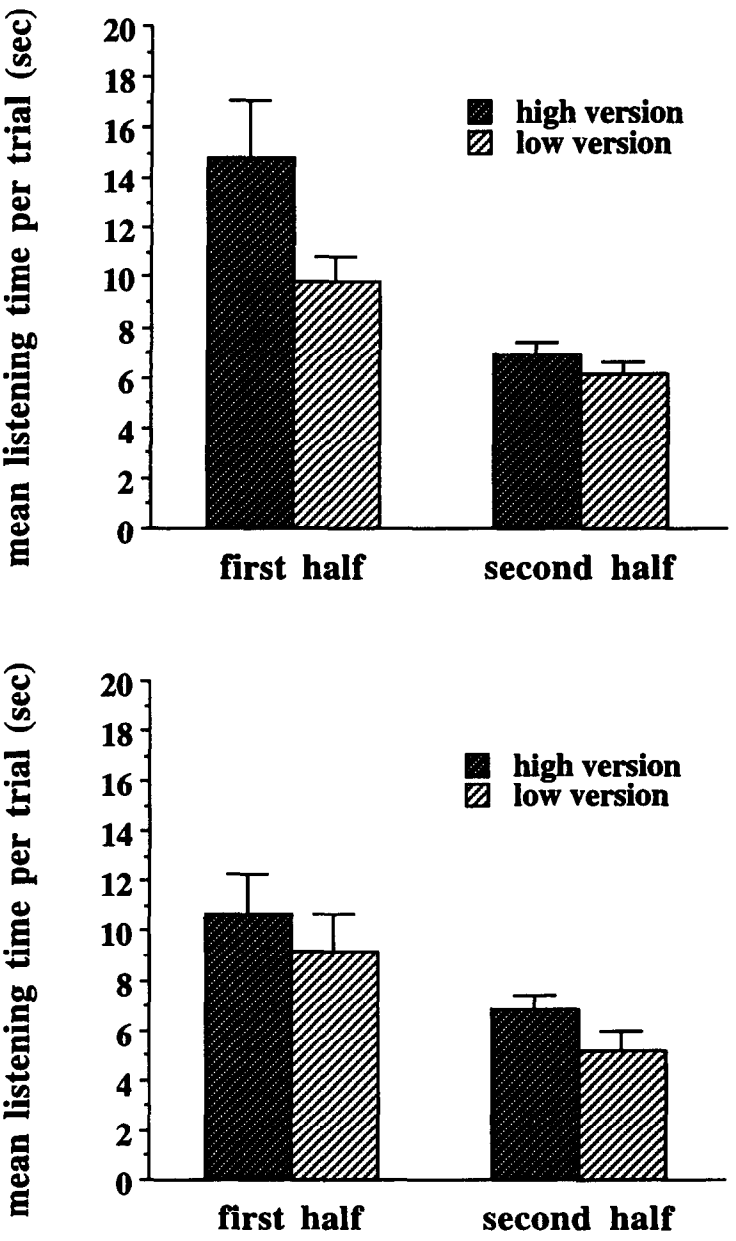

FIGURE 1
Mean listening times (and standard errors of the mean) for trials of high- versus low-pitched singing across the first 10 and second 10 trials for Experiments 1 (upper panel) and 2 (lower panel).

support to the view that infants' preference for infant-directed over adult-directed speech is also based in part on a preference for higher-pitched voices.

Why might infants prefer higher-pitched voices? One possibility is that infants are more familiar with women's than men's voices. Indeed, it appears that infants hear and

remember their mother's voice prior to birth (see DeCasper & Spence, 1991). However, higher frequency sounds are greatly attenuated by the mother's body, so a preference for lower-pitched voices might be predicted from prenatal experience. In contrast to this prediction, however, newborns show a preference for higher-pitched infant-directed over adult-directed speech (Cooper & Aslin, 1990) and at 1 month of age preferences seem to be based more on high-frequency spectral characteristics (that would not be transmitted well to the fetus) rather than fundamental frequency contour (Cooper & Aslin, 1994). Preferences arising from prenatal exposure may be specific to the mother's voice. Spence & Freeman (1996) found that newborns preferred low-pass filtered but not whispered versions of their mother's over a stranger's voice. Low-pass filtered versions should sound similar to what the fetus heard before birth. Whispered speech is missing the low-frequency energy and cues to pitch, so it should sound very different from what the fetus heard.

Thus, prenatal experience cannot easily explain infants' general preference for high-pitched voices. What about post-natal experience? From birth, infants are spoken to and sung to at relatively high pitches so it is possible that their preference arises from this experience. However, such an interpretation does not explain why caregivers universally address infants using high pitch levels. Singing and speaking to infants is generally thought of as a reciprocal interaction (e.g., Papoušek, 1993; Papoušek & PapoušekPapoušek, 1991). Caregivers address infants as they do at least in part because infants react positively. If infants cried when addressed in infant-directed speech, caregivers would soon modify their behaviour. Therefore, while experience likely plays some role in infants' preference for high-pitched voices, it seems unlikely that it is entirely based on experience.

The auditory system matures first for high frequencies (e.g., Bredberg, 1968; Olsho, Koch, Carter, Halpin, & Spetner, 1988; Trehub, Schneider, & Endman, 1980). It is possible that the preference for higher-pitched voices arises from the simple fact that infants are better able to hear higher voices. However, the singing samples presented in the present study, and most of infants' everyday experience, is with voices that are well above threshold, so all can be clearly heard. A more likely explanation is that infants prefer the timbre (i.e., voice quality) changes that inevitably accompany singing or talking at a higher pitch. It is difficult to control for timbre changes because the perception of timbre is not independent of the perception of pitch in adults (e.g., see Hirsh & Watson, 1996) and the perceptual relation between pitch and timbre has not been studied developmentally. In their study of infants' reactions to changes in the pitch of a speaking voice, Patterson et al. (1997) raised or lowered the frequency digitally, which results in a raising or lowering of the entire spectrum. This changes not only the fundamental frequency but the formant structure as well. In our study, the singers changed their pitch naturally, which results in an essentially constant formant structure, but which may have introduced more general timbre changes associated with voice range. Interestingly, a preference for higher voices emerged in both studies, suggesting that the effect may be independent of changes in timbre.

A final possibility for the origin of the preference for higher-pitched voices is a biologically-based tendency to associate certain sounds with certain emotional responses. Across species, as well as human cultures, low pitch appears to signal power and aggression whereas high pitch seems to signal friendliness and nonaggression (e.g., Morton, 1977). To apply consistently to the human case, it is likely that timbre must also be considered (Scherer, 1986); for example, a frustration type of anger seems to be expressed with high pitch (e.g., Frick, 1985). However, given the loving tone of voice that is typical of infant-directed speech and singing, a higher-pitched voice may be intrinsically more friendly and non-threatening, and hence more attractive, than a lower-pitched voice. The degree to

which infants' preference for higher- over lower-pitched voices is a result of familiarity, the sequence of maturation of low versus high frequency hearing, or biological predisposition needs to be explored in future studies.

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REFERENCES

Aldwell, E., & Schachter, C. (1989). *Harmony and voice leading* (2nd ed.). San Diego: Harcourt Brace Jovanovich.

Bredberg, G. (1968). Cellular pattern and nerve supply of the human organ of Corti. *Acta Oto-Laryngologica, 236* (Suppl.), 1–135.

Cooper, R. P., & Aslin, R. N. (1990). Preference for infant-directed speech in the first month after birth. *Child Development, 61,* 1584–1595.

Cooper, R. P. & Aslin, R. N. (1994). Developmental differences in infant attention to the spectral properties of infant-directed speech. *Child Development, 65,* 1663–1677.

DeCasper, A. J., & Spence, M. J. (1991). Auditorily mediated behavior during the perinatal period: A cognitive view. In M. J. S. Weiss, & P. R. Zelazo (Eds.), *Newborn attention: Biological constraints and the influence of experience* (pp. 142–176). Norwood, NJ: Ablex.

Fernald, A. (1991). Prosody in speech to children: Prelinguistic and linguistic functions. *Annals of Child Development, 8,* 43–80.

Fernald, A., & Kuhl, P. (1987). Acoustic determinants of infant preference for motherese speech. *Infant Behavior & Development, 10,* 279–293.

Frick, R. W. (1985). Communicating emotion: The role of prosodic features. *Psychological Bulletin, 97,* 412–429.

Hirsh, I. J., & Watson, C. S. (1996). Auditory psychophysics and perception. *Annual Review of Psychology, 47,* 461–484.

Morton, E. S. (1977). On the occurrence and significance of motivation-structural rules in some bird and mammal sounds. *American Naturalist, 111,* 855–869.

Olsho, L. W., Koch, E. G., Carter, E. A., Halpin, C. F., & Spetner, N. B. (1988). Pure-tone sensitivity of human infants. *Journal of the Acoustical Society of America, 84,* 1316–1324.

Papoušek, M. (1992). Early ontogeny of vocal communication in parent-infant interactions. In H. Papoušek, U. Jurgens, & M. Papoušek (Eds.), *Nonverval vocal communication.* (pp. 230–261). Cambridge: Cambridge University Press.

Papoušek, M. (1993, March). *Stages of infant-directed speech: Relation to stages in the infant's interactional vocal repertoire.* Poster presented at the Society for Research in Child Development, New Orleans.

Papoušek, H. & Papoušek, M. (1991). Innate and cultural guidance of infants' integrative competencies: China, The United States, and Germany. In M. H. Bornstein (Ed.), *Cultural Approaches to parenting.* (pp. 23–44). Hillsdale, NJ: Erlbaum.

Patterson, M., Muir, D. W., & Hains, S. (1997). *Infant sensitivity to perturbations in adult infant-directed speech during social interactions with mother and stranger.* Poster presented at the Society for Research in Child Development, New Orleans.

Rock, A. M. L., & Trainor, L. J. (in press). Distinctive messages in infant-directed playsongs and lullabies. *Development Psychology.*

Schellenberg, E. G., & Trainor, L. J. (1996). Sensory consonance and the perceptual similarity of complex-tone harmonic intervals: Tests of adult and infant listeners. *Journal of the Acoustical Society of America, 100,* 3321–3328.

Scherer, K. R. (1986). Vocal affect expression: A review and a model for future research. *Psychological Bulletin, 99,* 143–165.

Spence, M. J., & Freeman, M. S. (1996). Newborn infants prefer the maternal low-pass filtered voice, but not the maternal whispered voice. *Infant Behavior & Development, 19,* 199–212.

Trainor, L. J. (1996). Infant preferences for infant-directed versus non-infant-directed play songs and lullabies. *Infant Behavior & Development, 19,* 83–92.

Trainor, L. J., Clark, E. D., Huntley, A., & Adams, B. (1997). The acoustic basis of preferences for infant-directed singing. *Infant Behavior & Development 20,* 383–396.

Trainor, L. J., & Heinmiller, B. M. (1998). Infants prefer to listen to consonance over dissonance. *Infant Behavior & Development, 21,* 77–88.

Trainor, L. J., & Trehub, S. E. (1993). Musical context effects in infants and adults: Key distance.

Journal of Experimental Psychology: Human Perception and Performance, 19, 615–626.

Trehub, S. E., Schneider, B. A., & Endman, M. (1980). Developmental changes in infants' sensitivity to octave-band noises. *Journal of Experimental Child Psychology, 29,* 282–293.

Trehub, S. E., & Trainor, L. J. (in press). Singing to infants: Lullabies and play songs. *Advances in Infancy Research.*

Trehub, S. E. & Trainor, L. J. (1993). Listening strategies in infancy: the roots of language and musical development. In S. McAdams, & E. Bigand (Eds.), *Cognitive aspects of human audition* (pp. 278–327). London: Oxford University Press.

Trehub, S. E. & Trainor, L. J. (1990). Rules for listening in infancy. In J. Enns (Ed.), *The development of attention: Research and theory* (pp. 87–119). Amsterdam: Elsevier Science Publishers.

Trehub, S. E., Unyk, A. M., Kamenetsky, S. B., Hill, D. S., Trainor, L. J., Henderson, J. L., & Saraza, M. (1997). Mothers' and fathers' singing to infants. *Developmental Psychology, 33,* 500–507.

Trehub, S. E., Unyk, A. M., & Trainor, L. J. (1993). Maternal singing in cross-cultural perspective. *Infant Behavior & Development, 16,* 285–295.

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