Toward a Developmental Psychology of Music

SANDRA E. TREHUB

Department of Psychology, University of Toronto at Mississauga, Mississauga, Ontario, Canada

ABSTRACT: Research on music perception has revealed numerous parallels between infants and adults, but these findings have had little influence on adult research. Studies of pitch memory in infants, children, and adults are presented to illustrate potential gains from a developmental approach. Although the prevailing wisdom is that absolute pitch processing dominates in early life until it is supplanted by relative pitch processing, recent research offers no support for that view. After a week of exposure to English folk melodies, infants remember the melodies, but they do not distinguish the original versions from transposed versions. Relative pitch processing dominates later on, but it does not occur at the expense of absolute pitch processing. For example, adults can identify the pitch level of familiar musical recordings in the context of foils that are pitch shifted by one or two semitones. Children 5–9 years of age can identify the pitch level of familiar recordings when the foils are pitch shifted by two semitones but not by one semitone. By contrast, Japanese children are successful in the context of one-semitone shifts. In short, a developmental approach can provide insights of comparable importance on many issues in music cognition.

KEYWORDS: pitch memory; absolute pitch; relative pitch; infants; children; adults

INTRODUCTION

In recent years, it has become clear that we begin life with predispositions for musical engagement.[1–4] The concern here is with receptive rather than productive abilities, the discrepancy between the two being considerably greater in music than in other domains such as language. For example, toddlers understand words well before they produce them, the lag being several months at the earliest stages of language acquisition.[5] The corresponding gap between receptive and productive abilities is considerably greater in music, often on the order of years rather than months.

INFANTS ARE INHERENTLY MUSICAL

The claim that infants are inherently musical[4] is based on their sensitivity to critical features of music. For example, they engage in relational processing of pitch[1,2]

Address for correspondence: Sandra E. Trehub, Department of Psychology, University of Toronto at Mississauga, Mississauga, Ontario, Canada L5L 1C6. Voice: 905-828-5415; fax: 905-569-4326.
Sandra.Trehub@utoronto.ca

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and temporal patterns,[6] which is essential for the appreciation of music. Specifically, they recognize the invariance of melodic patterns across changes in pitch level[7,8] and tempo.[9] Infants' detection of invariant pitch or rhythmic patterning does not reflect poor discrimination. On the contrary, they are sensitive to changes of a semitone or less in the context of multitone sequences.[10–12] Similarly, infants are sensitive to changes in temporal grouping,[9,13] meter,[14,15] tempo,[16] duration,[17] and timbre.[18]

ORIGINS OF CONSONANCE AND DISSONANCE

Infants are also sensitive to the consonance and dissonance of musical patterns.[19–21] They categorize intervals on the basis of their consonance and dissonance,[22] and they retain more fine-grained information from patterns with consonant intervals—melodic or harmonic—than from those with dissonant intervals.[20] Infants also exhibit rudimentary esthetic preferences for consonant over dissonant music. For example, 6-month-olds are more attentive while listening to Mozart minuets than to altered versions in which dissonant intervals replace many of the consonant intervals.[19] From as early as 2 months of age (earlier, no doubt, if we could test them), they prefer sequences of consonant, harmonic intervals to those with dissonant intervals.[23] By 4 months of age, they listen contentedly to European folk melodies, but they squirm, fuss, and turn away when presented with dissonant versions of those melodies.[21]

DOMAIN-GENERAL OR DOMAIN-SPECIFIC SKILLS?

These are but a few of the ways in which infants' processing of music or music-like patterns parallels that of adults. Can we assume that this preparation for music listening is uniquely human? Traditionally, relative pitch processing has been regarded as an exclusively human disposition, with absolute pitch processing being the *modus operandi* of nonhuman primates[24] and songbirds.[25] However, recent work by Wright and his associates[26] casts doubt on this widely held view. They trained rhesus monkeys to make nonverbal judgments of "same" or "different" on a series of trials involving novel melody pairs (i.e., new melodies presented on each trial). Subsequently, they tested these monkeys on other pairs in which the second melody was identical to the first (including its pitch level), transposed by one or two octaves (i.e., same melody at a different pitch level), or entirely different. Monkeys displayed a pattern of responses that one might expect from human listeners. They judged octave-transposed melodies as "same" when the melodies were tonal but as "different" when they were atonal. For example, "Happy Birthday" was recognizable in transposition (i.e., response of "same"), but randomly generated melodies were not (i.e., response of "different" for octave transpositions). On the one hand, these findings confirm the biological basis of relational processing in music. On the other hand, they indicate that relational pitch processing is not unique to human listeners but may be part of a heritage that is shared with many other species. Indeed, there is considerable evidence to support the contention that relational processing or perceptual invariance operates across age and species for pitch structure, spectral structure, and temporal structure.[27]

MOTIVATIONAL FACTORS

If species-specific predispositions do not account for the pattern processing that characterizes human music listening, they must account for the attraction to music from the earliest days of life,[28,29] for caregivers' universal disposition to sing to infants,[30,31] for young children's spontaneous music-making,[32,33] and for the worldwide prominence of music in cultural rituals.[34,35] Common threads across these diverse realms of activity include the emotional impact of music on listeners and practitioners[36–38] and the facilitation of social bonding.[31,39,40]

Music is highly effective in regulating or optimizing mood in listeners as diverse as infants,[29,41] adolescents,[42,43] and adults,[44] including those with psychotic tendencies[45] or late-stage dementia.[46] Aside from pharmacologic agents, music may be the most effective regulator of mood. As a result, it has been used extensively for lofty goals such as promoting physical or emotional well-being[47] and for less lofty goals such as influencing consumer behavior.[48] No doubt, the emotional impact of music and its ability to enhance social bonds have fueled the development of uniquely human musical behaviors.

THE GREAT DIVIDE: INFANTS AND ADULTS

Despite the fact that research on music perception has revealed intriguing parallels between infants and adults,[1,2,19] the infant findings have had little influence on adult research. The questions investigated with infants may seem elementary or obvious for adults. We know, for example, that adults encode consonant intervals more readily than dissonant intervals and that they prefer consonant to dissonant music, but we do not know *why* that is the case. The presumption is that music processing biases arise largely from extended exposure to culture-specific music,[49] but this presumption is incorrect in at least some respects. A related belief is that listening skills become increasingly refined or differentiated with increasing age and experience. At times, however, naïveté about cultural conventions leads infants to outperform adults on specific speech and music tasks. For example, infants exhibit more differentiated perception of some non-native speech contrasts,[50] melodic changes,[10] and atypical meters.[15] In short, developmental research can inform adult research by revealing the initial state of the organism, age-related changes in domain-general processing, and age- and experience-dependent changes in domain-specific processing.

A SAMPLE DEVELOPMENTAL AGENDA: ABSOLUTE AND RELATIVE PITCH PROCESSING

To illustrate potential gains from a truly developmental approach to music perception, consider the case of absolute pitch processing. The tiny minority of individuals (1 in 10,000) who possess absolute pitch (AP) can identify or produce isolated pitches in the absence of a reference pitch. Everyone else is thought to have very poor memory for absolute aspects of pitch.[51–53] Unique structural asymmetries or patterns of cortical activation have been identified in AP possessors,[54–56] but these differences may be a consequence of AP rather than its cause.

AP is generally attributed to early and prolonged musical training[57,58] acting in concert with genetic predispositions.[59,60] In one large sample of musicians, 40% who began lessons before age 4 had AP, in contrast to 26% who began at 4-6 years and 8% who began at 6–9 years.[57] For early lessons to result in AP, it may be necessary for training in note identification to precede the acquisition of relative pitch skills.[53] The prevalence of early training among AP possessors is consistent with a critical period for AP,[53,61] but the retrospective status of such information raises questions about its reliability. It is possible, for example, that parents of future AP possessors initiate musical training in response to their children's precocious musical interests or talents.[62] Beyond the uncertain early history of AP possessors is the typical incidence of earlier and more extensive training in musicians with AP compared to those without AP.[63] In principle, cumulative training along with enhanced quality of training could be as important as, or more important than, age of first lessons.

Views of AP and its acquisition have implications for the developmental course of pitch processing more generally. Takeuchi and Hulse,[61] among others,[64] consider absolute pitch processing as the dominant strategy in the preschool period, which could account for the relative ease of acquiring arbitrary pitch labels at that time. Saffran and her associates[65,66] go further, arguing that absolute pitch processing dominates from early infancy. By the end of the preschool period, however, children are thought to shift from absolute pitch processing to relative pitch processing.[61,66] One account of this shift implicates *unlearning* resulting from exposure to specific tunes in different keys.[53] Only AP possessors are thought to maintain absolute as well as relative modes of pitch processing. Just as relative pitch processing is thought to occur at the expense of absolute pitch processing,[53,61] AP possession is thought to have negative consequences for relative pitch processing.[63,67–69]

There are numerous problems with the proposed developmental timetable for absolute and relative pitch processing. For example, relative pitch processing is well documented in infancy,[1,2] but reliable evidence of absolute pitch processing in this period is lacking.[70] Claims of absolute pitch processing in infancy[65,66] are based on short-term memory for stimuli whose pitch relations are difficult for adults to remember. Ideally, questions regarding the priority of absolute or relative pitch processing should be settled with reference to long-term representations rather than short-term performance on novel materials.[70]

PITCH MEMORY IN INFANTS

Platinga and Trainor[71] examined infants' long-term retention of absolute and relative aspects of familiar melodies. They exposed 6-month-olds to one of two English folk tunes for 6 minutes daily over the course of 1 week. After the end of the familiarization phase (i.e., 1 day later), infants were able to distinguish the familiar tune from the unfamiliar tune, as reflected in greater attention to the novel tune. There was no indication, however, that infants remembered the original pitch level, because they accorded comparable attention to renditions in the original key and to those in a novel key (i.e., transposition of a perfect fifth). These findings are consistent with the priority of relative pitch processing in infancy. It is possible, however, that relational processing has priority for pitch but not for other dimensions of musical patterns. After comparable familiarization with one of two folk melodies, infants exhibited greater attention to renditions with novel tempo or timbre than to the original versions, which indicates that their memory for these melodies was tempo or timbre specific.[72] Studies such as these may underestimate infants' retention of pitch level because of relatively limited exposure to the "familiar" melodies. Perhaps infants would more readily remember the pitch level of their mothers' stereotyped performances of nursery songs.[29,73]

PITCH AND TEMPO MEMORY IN ADULTS

In general, adults with little or no musical training have reasonably good relative pitch, which enables them to recognize familiar tunes played at a novel pitch level and to detect pitch errors in performance.[74] Nevertheless, they perform at chance levels on conventional AP tests, which require identification or production of isolated pitches. Musicians without AP have comparable difficulties with isolated tones except when a reference tone is available, in which case they can capitalize on their knowledge of pitch intervals.[53]

In contrast to their poor memory for isolated pitches, adults exhibit surprisingly good memory for the pitch level of familiar musical materials. For example, mothers' repeated performances for infants (i.e., same songs on different occasions) are nearly identical in pitch level.[73] Consistency in pitch production is also evident in college students' repeated renditions of folk songs[75] and their attempts to sing along with imagined versions of favorite hit songs.[76] Their productions in the latter instance are within two semitones of the canonical recording. In these cases of song production, motor memory may play a substantial role, obscuring the independent contribution of pitch memory.

Schellenberg and Trehub[77] evaluated college students' recognition of the pitch level of instrumental excerpts from popular television programs: *E.R., Friends, Jeopardy, Law & Order, The Simpsons*, and *X-Files*. On each trial, participants heard two excerpts, one of which was shifted one or two semitones upward or downward by means of professional editing software that preserve the tempo and timbre. Students were required to identify the "real" version (first or second presented), that is, the one that matched the version heard on the television program in question. Performance significantly exceeded chance levels on one- and two-semitone shifts, with better performance on the latter (FIG. 1, Experiment 1). However, increasing exposure to pitch-shifted excerpts over the course of the test session reduced performance accuracy relative to that shown on the initial comparisons. Although the altered versions generated progressive interference with memory for the original details, adults still performed above chance levels. Other adults who were tested on the same task but with unfamiliar recordings (Experiment 2) performed at chance levels, ruling out the possibility of extraneous cues from the pitch-shifting manipulation.

These findings indicate that adults with minimal musical training remember the pitch level of music heard incidentally. Their ability to detect one-semitone shifts is noteworthy in view of the common occurrence of semitone errors in individuals with AP.[78] Musically untrained adults do not have deficient pitch memory, as alleged.[51,53] Instead, their memory for pitch rivals that of musicians as long as the test context features familiar, ecologically valid materials. It is clear, then, that listeners

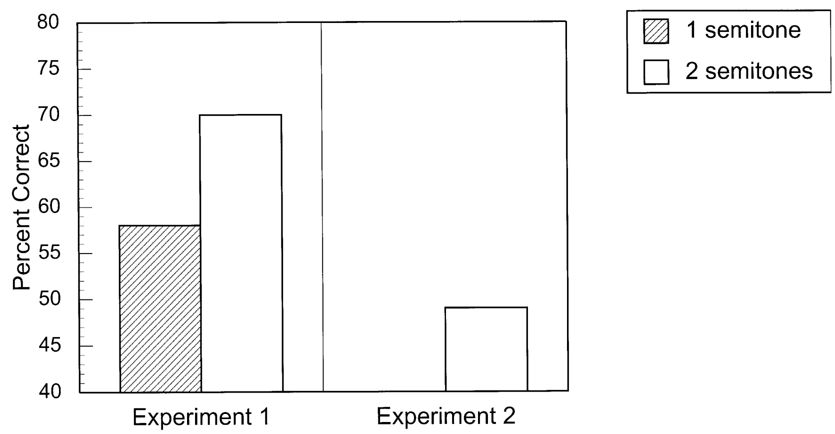

FIGURE 1. Adults' accuracy in identifying the pitch level of familiar (Experiment 1) and unfamiliar (Experiment 2) musical excerpts in the context of foils altered by one or two semitones. Chance level is 50%. Data from Schellenberg and Trehub.[77]

encode surface details of music, such as its pitch level, along with relational features such as melodic and temporal structure. Adults' identification of popular recordings from excerpts as brief as 100 ms[79] indicates that they encode timbral or spectral information as well. They encode comparable surface details from speech,[80] which enables them to recognize familiar voices.[81,82]

What about tempo? In ongoing research,[83] adults are being tested on their memory for the tempo of familiar musical excerpts. Test trials consist of the original excerpt paired with excerpts whose tempo is altered by 10% (faster or slower). On a separate occasion, participants are being tested on two-semitone pitch shifts involving the same excerpts. Performance to date reveals that adults can identify the original tempo, their accuracy being at least as good as that on two-semitone pitch shifts. Does recognition of these features depend on the complexity or engaging quality of the auditory patterns or merely on their familiarity? To provide answers to this question, participants in the tempo/pitch study are attempting to identify a conventional telephone dialtone—an unengaging but highly familiar stimulus—in the context of a pitch-shifted foil. Preliminary results reveal more accurate performance on the dialtone than on television theme music. This finding is consistent with exposure as the principal contributor to pitch memory, as is AP possessors' superior memory for pitches corresponding to white rather than black piano keys.[78,84]

PITCH MEMORY IN CHILDREN

The findings on pitch memory in adults are inconsistent with the view that relative pitch processing supplants absolute pitch processing in early childhood. Relative pitch processing may be the dominant or most relevant mode of musical processing in adulthood but, as noted, adults are clearly capable of encoding and retaining information about absolute pitch. It is likely that they can direct their attention to absolute or relative aspects of pitch, as necessary for the task at hand, just as they can focus on the content, voice quality, or prosody of a spoken message. There is no means of quantifying the relative efficiency of processing these various aspects of speech or music. We can ask, however, whether adults perform better or worse than children whose musical experience is much more limited. If increasing competence in relative pitch processing occurs at the expense of absolute pitch processing, as suggested,[53,61] then children, who are less efficient than adults in relative pitch processing, may outperform adults on memory tasks that depend on absolute aspects of pitch.

Such comparisons are currently in progress.[85] Children between 5 and 9 years of age are being tested on excerpts from the soundtracks of four television programs or movie videos that they watch regularly. The test procedure is the same as that used with adults except that the musical materials include vocal portions, as do most programs on the television diet of local children. Although the pitch-shifting manipulation does not have perceptible consequences with instrumental materials, it may generate subtle voice quality distortions, providing potential cues to the pitch change. Testing to date has revealed above-chance performance on two-semitone shifts but chance-level performance on one-semitone shifts and no age-related changes in performance (FIG. 2). Thus, there is no support for the view that children are better than adults at remembering the pitch level of familiar musical materials. On the contrary, they perform more poorly than adults in this respect. No doubt, these children have had less exposure than adults to music in general and, perhaps, to the musical excerpts in particular. Although older children have had the benefit of greater musical exposure than younger children, their experience in this regard does not seem to enhance their memory for the pitch level of familiar music. Tests of adults who are unfamiliar with this music will indicate whether vocal cues are responsible for children's success on the two-semitone shifts.

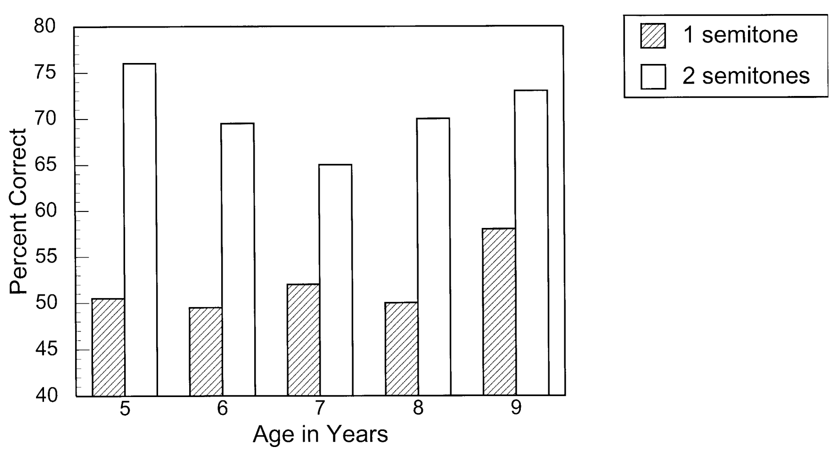

FIGURE 2. Children's accuracy in identifying the pitch level of familiar musical excerpts in the context of foils altered by one or two semitones. Chance level is 50%.

A parallel study is currently underway in Japan.[86] Japanese children provide an interesting comparison group because, on average, they have earlier and more extensive musical training than do North American children. Moreover, popular Japanese programs for children feature instrumental theme music in some cases and accompanied vocal music in others. The set of test materials includes four excerpts from programs that are familiar to each participant, two featuring instrumental themes and two featuring vocal-plus-instrumental themes. Results to date indicate that 5- and 6-year-old children perform above chance levels on one-semitone comparisons, and they perform no differently on instrumental than on instrumental-plus-vocal materials. In short, Japanese children are clearly superior to their North American peers in retaining the pitch level of familiar music. Information about their musical background is being examined with a view to identifying potential causal factors.

IMPLICATIONS OF DEVELOPMENTAL RESEARCH ON PITCH MEMORY

Findings from the research on pitch memory with infants, children, and adults offer little support for the conventional view that absolute pitch processing prevails in early life, being replaced by relative pitch processing sometime thereafter.[61,65,66] Instead, there is every reason to believe that absolute and relative pitch processing are operative from the beginning of life and that they remain so throughout life. What may differ as a function of age and musical experience are the specific circumstances that elicit one mode of processing rather than the other, creating the illusion that one mode functions in a dominant or exclusive manner.

Only musicians with AP are credited with dual processing. Obviously, they would be unable to function as musicians unless they had considerable expertise in relative pitch processing. Their identification of intervals[69] and keys[63] indicates that AP reduces processing efficiency on such tasks, but it does not impair accuracy. By the same token, non-AP musicians use absolute cues when making key judgments, and many of them have a single internalized reference tone such as A_4.[53] Even the untrained children and adults who identified the pitch level of television theme music[77,85,86] were making intuitive key judgments despite their ignorance of note names and the concept of key.

In the context of relatively unfamiliar materials, novice listeners remember a great deal more than global features or the “gist” of music. There are indications that they automatically encode surface features while listening to music[87] or speech.[80] Tests of explicit memory often imply that surface details fade with the passage of time, but their persistence is evident in implicit memory tasks.[80,87] The automatic processing of music-specific information (e.g., intervals) is also reflected in electrical activity in the brain.[88] In arguing for automatic processing of surface features in music, Dowling *et al.*[87] make the case with respect to interval processing. On the basis of the research presented here, that argument can be extended to absolute pitch processing in the context of music or speech.

If some form of absolute pitch processing is universal, then why is AP so rare? Perhaps it is because the defining criteria necessitate specialized knowledge of note names, which must be applied to decontextualized, essentially meaningless, tones. When AP occurs in the absence of early musical training, it is often associated with disability. For example, many blind school-age children develop AP after limited musical training.[89] Obviously, auditory cues play an important role in the lives of blind children, which may account for their disposition to attend carefully to absolute as well as relative aspects of pitch. AP also occurs with greater than expected frequency in individuals who are autistic[90,91] or developmentally delayed.[92,93] In cases of developmental delay or autism, deficits in cognitive flexibility may be relevant.[93] Very young children may have comparable generalization deficits, which may increase their "susceptibility" to AP.

Absolute pitch processing is but one of many skills for which a developmental perspective can yield important insights. Whether the questions of interest concern structural asymmetries in the brain, patterns of cortical activation, emotion, esthetic preferences, therapeutic interventions, cognitive consequences of musical training, or pedagogy, a developmental perspective has much to offer. Researchers engaged in these endeavors are invited to join the developmental enterprise.

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