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■ REVIEW ARTICLE

Innate Components of Music Perception

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ABSTRACT: Music plays a significant role in various celebratory occasions and is integral to the human experience. This article focuses on six components of music perception: pitch, melody and contour, harmony, timbre, structure, and temporal events. By examining studies on infant music perception, it becomes evident that these components are innately present rather than acquired through learning. The findings of this research contribute to a better understanding of these innate qualities and provide insights into human musicality and language development.

KEYWORDS: Behavioral and Social Sciences; Cognitive Psychology; Innate; Music Perception; Infants.

■ Introduction

Music floods our homes daily to provide comfort and joy. We sing each other happy birthday, exchange thoughts on the latest trending album, and listen to music on the car ride to work. Nevertheless, significant gaps exist in our understanding of how individuals process musical features and sounds (e.g., differentiate rhythm and pitch) despite the lack of formal musical training. Uncovering the cognitive components facilitating such qualities is essential in our understanding of human music cognition.

In the past, it was assumed that infants were incapable of processing auditory events.[1] It was believed that they could only decipher a single set of syllables or tones simultaneously. For example, as a result of such an assumption, in early auditory perception research, infants were often presented with the first sound in a sequence of sounds rather than the whole sequence as would otherwise be done in older people.[2]

This belief began to change in the late 1970s as the methodology for testing infants' auditory perception became more holistic. After introducing infants to complete sound sequences, it was found that infants could respond to contrasting melodic contours, which represent the trajectory of a musical phrase or melodic line. One investigation measuring cardiac activity in response to sounds showed that infants could recognize changes in tune inflections (i.e., changes in contour).[2] This experiment contradicted the previously held belief that infants could not decipher auditory sequences.

Moreover, in the 1980s, studies have shown that the structure of the melodic context can largely determine infants' perception of music.[2] This finding suggested that some melodic structures may be easier for infants to understand than others. This was crucial in establishing the importance of melodic context in infant music perception. Additional studies during this period have shown that infants group tones by proximity and intensity, allowing them to recognize beat direction, which helps in perceiving melody.[3,4]

In the 1990s, different reports suggested that infants might have higher music-processing abilities than adults. One study measuring how infants respond to music using head turns as an index demonstrated infants' ability to determine changes within multiple-scale contexts. In comparison, adults could only determine tuning changes within the context of scales in Western music.[5] This might be because they are related to culture-specific effects on the ability to recognize different musical components. Young infants might be less influenced by cultural conventions and expectations than adults who are more exposed and experienced. Additionally, during this time, it was noticed that infants show different responses to consonant (pleasant) vs. dissonant (unpleasant) music, much like adults.[6]

In the 21st century, there was also similar evidence suggesting that infants could outperform adults in recognizing subtle timing changes in both simple and complex metrical patterns (i.e., simple and complex patterns of the beats in music).[2] While adults could only discern timing changes in the context of simple metrical patterns characteristic of Western music, infants could discern timing changes in the context of simple and complex metrical patterns, as measured through looking times. However, infants, as they develop, seem to lose this ability, but remarkably can restore it after exposure to foreign music for a limited time (e.g., two weeks).[2] These findings illustrated that, during infancy, the sensitivity to different metrical patterns and the ability to learn foreign metrical patterns is higher than during adulthood.

Overall, research on music perception in infants has evolved dramatically during the past four decades, changing the thinking of infants' auditory abilities. This paper will review six components contributing to music perception: pitch, melody, harmony, timbre, form and structure, and temporal perception. These components overlap and interact to produce a comprehensive listening experience.

■ Methods

Relevant literature was found using Keywords in the Google Scholar database. Keywords included music perception, innateness, infants, prenatal, postnatal, preference, pitch, tempo, rhythm, beats, contour, harmony, melody, and structure. The

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exclusion criteria for this review limited the research to infants no older than 12 months. This restriction was put in place to ensure the study results reflected the behavior most characteristic of the infant closest to the time of birth.

Results

Pitch Perception:

Multiple studies have shown that infants and fetuses can distinguish high pitches from low at a very young age. In one investigation, 36 to 39-week-old fetuses were presented with musical notes of varying frequencies using a loudspeaker. Fetal heart rate was measured through Doppler cardiography. One group of fetuses was presented with two notes of the same pitch, serving as the experiment's control. The second group of fetuses was presented with two notes of differing pitch. The results showed that fetuses in the second group experienced a heart rate deceleration response to a change in pitch frequency, while the heart rates of fetuses in the control group stayed the same.[7] In another study, 5 to 8-month-old infants were trained to initiate a head-turn when presented with a pitch change. With higher pitch frequencies, infants were more sensitive to pitch changes.[8] In other words, the infants could detect the slightest change in pitch frequency at higher pitches and outperformed their adult counterparts. Additionally, when 6-month-old infants were presented with playing songs at different pitch levels, results showed that the looking time for the higher pitch range was longer than the lower pitch range.[2] Thereby, infants could discriminate against high and low pitches and demonstrate a preference for the higher pitch frequencies.

Perception of Melody and Contour:

Studies suggest that infants can detect contour changes within diatonic melodies (See Figure 1 A for an explanation of contour and Figure 1 B for an explanation of diatonic). 2 to 14-month-old infants were presented with lullabies and non-lullabies. Non-lullabies excluded the key characteristics of lullabies: simple melodies and rhythms, slower tempo, less accented, and lower arousal. In response to being presented with lullabies, infants experienced heart rate deceleration, decreased pupil dilation, and lower electrodermal activity.[9] These findings were not seen in non-lullabies. In a different investigation, 8 to 11- 11-month-old infants were presented with various contour-preserving and contour-violating transpositions of the same melody. Contour-preserving melody transpositions maintained the same contour throughout the changed melody. Contour-violating melody transpositions altered the contour between the original and changed melodies. The infants in the experiment were trained to turn when a new stimulus had been presented. The results showed that infants only responded (indexed by head-turns) to contour-violating transformations and not to contour-preserving ones.[10] A similar study showed that infants also demonstrate different responses (head-turns) to contour changes in diatonic and non-diatonic backgrounds.[11] This suggests that infants rely heavily on contour to detect musical transformations, and the musical context (e.g., diatonic vs. non-diatonic environments) is important for infants in recognizing contour changes.

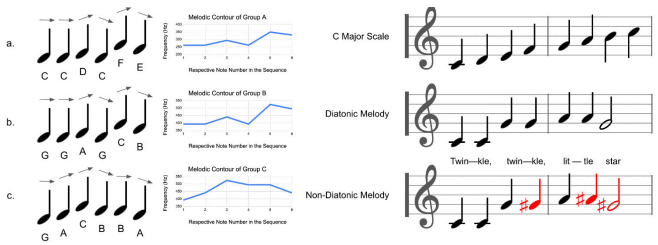

Figure 1: Contour and diatonic vs. non-diatonic melody. A. Contour represents the trajectory of a melodic line or musical phrase. It captures the shape of the melody. For example, Panel A shows three different groupings of the tune "Happy Birthday." The contour is depicted to the right of the notes in a line graph format. The X-axis represents the respective note number in the sequence. The y-axis represents the frequency of notes in Hz. Group A depicts the 'Happy Birthday' tune with the original notes and contour. Group B depicts the tune with different notes but the same contour as the original. Group C depicts the tune with different notes and different contours. **B.** A diatonic melody is composed of notes within the original scale. A non-diatonic melody contains a few notes that are outside the original scale. The panel shows the C Major scale and the melody of "Twinkle, Twinkle, Little Star" as a diatonic and non-diatonic melody in the key of C Major.

Harmonic Perception:

Evidence suggests that infants and newborns can recognize consonant and dissonant versions of melodies (pleasant vs. unpleasant songs). 1 to 3-day-old newborns were presented with consonant and dissonant musical excerpts. The brain activity of the newborns was recorded using a functional MRI. The results showed activity in newborns' inferior frontolateral cortex and Broca's area in response to dissonance.[12] This indicates that the ability to recognize consonant and dissonant melodies might be present with little to no prior music exposure. Another study presented 2-day-old newborns with consonant and dissonant Mozart Minuets. It was found that the looking times for the consonant Minuets were longer than the dissonant Minuets.[13] Similar studies were conducted on 2 to 4-month-old and 6-month-old infants, and the results stayed constant throughout. Looking times for consonant intervals and music were significantly longer than dissonant intervals and music.[6,14] Similarly, a study conducted on 4-month-olds showed that dissonant music was associated with motor movements, indicating discomforts such as shorter looking times and increased activity.[15] With infants display the opposite when presented with consonant musical structures, it can be inferred that infants prefer consonance over dissonance.

Processing of Timbre:

Timbre refers to the ability to differentiate sounds from different instruments. Although many studies test infants' perception of human voices, only a few investigate how infants perceive musical timbres. One investigation presented infants with two musicians playing different instruments in synchrony. Infants could only hear one of the two at a time via headphones. Measuring looking-time (i.e., how long they spend looking at the musicians), it was evident that infants rely significantly on the physical characteristics of instruments when discriminating musical timbres.2 During the study, infants could perceive the differences in timbre between a viola and a trombone. However, infants' ability to

distinguish between physically similar instruments (e.g., violin and viola) remains unclear. More studies are needed to determine whether the perception of musical timbre is innate in humans.

Perception of Music Form and Structure:

Previous reports showed that infants can detect changes in music or sound structure (e.g., recognize when a phrase is ending). In one study, infants aged 4½ to 6 months were presented with two different excerpts of Mozart's Minuets. The first excerpt contained pauses inserted at the end of phrases. The second excerpt contained pauses inserted in the middle of continuing phrases. Results showed that the infants oriented themselves to the speaker device for longer during the naturally cut-off segments (first excerpt).[16] A following investigation, using body orientation as a measure of music responsivity, found that infants were adept at noticing descending contour, pitch duration changes, and tempo changes to recognize the endings of phrases.[17] A similar study showed that infants react differently (indexed by head-turns) to different musical motifs while melodic and rhythmic features were kept the same.18 These findings suggest that infants might possess a basic understanding of music form and structure, allowing them to perhaps identify musical ideas in a composition.

Perception of Temporal Events:

Research on neonates and infants shows that they can recognize changes in temporal events, including tempo, rhythm, and meter. Neonates were presented with various rhythmic sequences. The EEG showed that violating the beat structure of the sequence elicited different brain responses in neonates.[19] In another study, indexed by head-turns, 6 to 11-month-old infants showed that they could identify altered tempo sequences within groups.[4] In a different study, infants display multiple behavioral responses to changing tempo and rhythm. 6 to 7-month-old infants were presented with play songs and lullabies. Play-songs contained more brilliant melodies and rhythms at a faster tempo, while lullabies contained more soothing melodies and rhythms at a slower tempo. The results of this experiment indicate that during lullabies, infants were most likely to focus their attention inwardly on themselves.[20] During play songs, however, results show that infants were more likely to focus their attention outwardly, often looking at their caregiver and displaying higher motoric arousal.[20] In addition to identifying altered tempo sequences, infants also indicated a predisposition for a specific metrical pattern: duple meter. A study on 9-month-old infants using head-turns showed that infants were most likely to detect musical changes through a duple meter.[21] These different behavioral and brain responses to changing tempos and rhythms indicate that infants and neonates can process different temporal events, especially those within duple meters.

Conclusion

This article reviewed various studies on infants' musicality and ability to process different musical components. The reviewed literature indicates that infants and fetuses elicit different brain responses, heart rates, and behavioral/visual cues in response to varying versions of a musical component. Even with little to no prior music experience, it was evident that infants can recognize differences in pitch, melody and contour, harmony, structure, and temporal events. This suggests that the ability to discern such components of music perception are largely innate rather than something that is acquired over time.

Such a finding could help support the introduction of music to infants in the early stages of development. Music components such as temporal perception are underlying mechanisms that aid in developing other cognitive abilities such as speech perception, memory, and social skills.[22] In addition, music perception and language might share common developmental features.[23] Therefore, exposure to music early on in life may benefit infants' cognitive growth and acquisition of language later in life.

However, it is important to note that there still needs to be more literature and methodology in testing infants for music perception abilities. The components of music perception we deem innate may not have developed specifically for music perception.[24] While evidence suggests that some components of music perception are specific adaptations to music rather than byproducts of the general auditory experience, such a conclusion still needs to be established and debatable.[25] The methodology or testing for infant musicality might also need further development and improvement. One particular question is whether CHT (Conditioned Head Turn) and HPP (Head-Turn Preference Procedure) are reliable measures to make conclusions about infants' responsivity to music, especially at a higher cognitive level (i.e., establishing music comprehension, taste, and preference).[1]

This article presented a focused review of infant musicality with a limited number of studies, which might have resulted in limitations to the conclusion and results. For example, the infants' rapid development during the prenatal and postnatal stages makes it hard to determine whether their music perception abilities have been acquired over time. One way to combat this limitation would have been to examine longitudinal studies on infant music perception to understand when each music perception ability is developed or lost during child development.[1] However, such studies do not exist at this time. Several areas remain to be reviewed and explored in the future in more comprehensive reviews or empirical studies. For example, innate music perception can be explored from an evolutionary perspective. This could provide insights into whether the ability to recognize different musical qualities gives us an evolutionary advantage or if this ability is a necessity rather than simply existing for pleasure.[19,25,26]

Another potential area of interest is to explore the cognitive implications of differences in music perception. For example, the link between music perception and pretend play—which often aids social development in a child—may be explored.[26] Another interesting sector to study would be music pleasure in congenitally deaf children with cochlear implants. The implants have poor pitch discrimination but good temporal resolution.[26] As a result, deaf children depend heavily on timing and rhythmic structure to recognize and enjoy music. Further research into this field may provide insights into the importance of timing in music. In conclusion, this review sug

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gests that the building blocks of music perception are innate. This was done by analyzing various studies on infant music perception.

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