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The Effects of Arousal Induction on Infants' Tempo Preferences

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THE EFFECTS OF AROUSAL INDUCTION ON INFANTS' TEMPO PREFERENCES

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Abstract

Previous research has demonstrated that infants have a natural preference to listen to fast temporal sequences over intermediate temporal sequences (Steffler, 2012, unpublished thesis). The present study seeks to explore whether or not infant tempo preferences are context-dependent, specifically examining the effect of arousal levels on tempo preferences. In the current study, 6- to 8-month-old infants' preference for tempo was evaluated using a head-turn preference procedure, following an arousal induction phase, in which the infants' environment was altered with the aim of lowering their physiological arousal. Infants showed a significant 3-way interaction between side of presentation, first stimulus presentation, and tempo.

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Introduction

Music is a universal mode of communication that has been utilized across cultures and generations to convey and stimulate emotions in both adults (Cupchik, Rickert & Mendelson, 1982) and young children (Trainor & Trehub, 1992). Infants experience music at an early stage of life as a means of communication and arousal regulation (Trainor, 1996). Generally, lullabies and playsongs are the most common styles of music employed by caregivers (Trehub & Schellenberg, 1995). Traditionally, lullabies have been implemented as a way of calming and soothing infants, whereas playsongs have been used to arouse and stimulate infants (Trehub & Trainor, 1998). Tempo, which is defined as the rate of events in time (McAuley, 2010), is one performance-based feature of music that differentiates lullabies and playsongs. Essentially, tempo communicates the speed at which an underlying beat is played in a musical composition (Conrad, Walsh, Allen & Tsang, 2011). Lullabies are typically sung at a slow tempo and are thought to decrease arousal levels, while playsongs are usually sung at a faster tempo and are thought to increase arousal levels (Shenfield, Trehub, & Makata, 2003). While a number of studies have indicated that the tempo of a musical composition has the ability to adjust arousal levels (Holbrook & Anand, 1990; Husain, Thomas, & Schellenberg, 2002), the reciprocal effect, that arousal levels could determine tempo preference, has not yet been investigated in infants.

The theory of the zone of optimal processing for tempo provides an important theoretical explanation regarding the acquisition of temporal discrimination. This theory postulates that there is a personal affinity for particular tempi which maximizes tempo discrimination (Drake, Jones, & Baruch, 2000). According to the theory, the auditory system is designed in such a manner that temporal sensitivity in adults is greatest at an intermediate

level (Drake et al., 2000). This level ranges between 300 and 800-ms IOI (interonset interval) (Fraisse, 1957). The zone of optimal processing has also been attributed to infant auditory preferences, generating an association between sensitivity to tempo and temporal preference. This theory provides two possible theoretical accounts to explain infant sensitivity to tempo. The first hypothesis contends that infants and children have the same intermediate zone of temporal processing as adults, and thus perform best when discriminating between tempos at 300 - 800-ms IOI (Baruch & Drake, 1997). The second hypothesis predicts that the zone of optimal processing slows with age (Baruch, Panissal-Vieu, & Drake, 2004). Thus, younger children and infants should be better at temporal discriminations for faster tempi than adults (Baruch et al., 2004).

Baruch and Drake (1997) tested tempo discrimination in 2- and 4-month-old infants to determine whether the zone of optimal tempi was the same for adults and infants. Using a habituation/dishabituation paradigm, infants were presented with isochronous tone sequences of 100, 300, 600 and 1500-ms IOI with a ±15% tempo change. Results revealed that both age groups exhibited tempo discrimination for the intermediate tempo (600-ms IOI), but showed no discrimination for very fast (100-ms IOI) or very slow (1,500-ms IOI) tempi (Baruch & Drake, 1997). These findings support the first hypothesis, which suggested that the zone of optimal tempi for infants is the same as adults. However, the findings of Baruch and Drake (1997) conflict with the results of Drake et al., (2000). Drake et al.'s (2000) finding illustrated that there was a shift in optimal tempo sensitivity with increased age. These results are consistent with the latter hypothesis, which proposed that the optimal zone slows with age.

A study conducted by Baruch, Panissal-Vieu, and Drake (2004) examined tempo preferences in adults, children, and infants. In this study, pairs of isochronous sound sequences varying in tempo (from 100- to 1,500-ms IOI) were recorded to measure adult tempo preferences. Similar to the study conducted by Baruch and Drake (1997), it was found that adults showed the highest preference for intermediate tempo. The results found that both 6- and10-year-olds showed a preference for the faster tempo, however older children generally preferred slower sequences (Baruch et al., 2004). Furthermore, no systematic tempo preferences for fast or slow tempo were observed in 4-month-old infants (Baruch et al., 2004). These findings further demonstrated that tempo preferences change across development. It is clear from the above studies that additional research is required to explain these conflicting results and to try and determine if there are other variables that impact infant preferences for different tempi.

Recently, a study conducted by Steffler (2012, unpublished thesis) investigated infants' sensitivity to tempo. A classic head-turn preference procedure was employed to test 16 6- to 7-month-old infants. The stimuli consisted of two songs containing the same musical melodies. The speed at which the melody was played varied between a fast and an intermediate tempo version. The fast tempo version contained 200 beats per minute (bpm) and the slow tempo version contained 140 bpm. The results demonstrated that infants showed a strong preference for fast temporal sequences over intermediate temporal sequences. Steffler (2012) concluded that infants are optimally sensitive to faster temporal sequences. These findings are consistent with results from past research, which suggested that the younger the participants, the faster their preferred tempi (Drake et al., 2000). This study differed however, from the studies previously discussed, as it focused on investigating infant

sensitivity to tempo during one specific developmental period (6- to-7-months). However, the above study and previous research has not addressed or focused on whether or not infant tempo preferences are affected by the environment in which the music is heard. The present study expanded on the study conducted by Steffler (2012) by not only observing infant tempo preference, but also examining the environmental influences during which time the music was played.

To determine whether pitch was dependent on the affective context in which infants listened to music, Tsang and Conrad (2010) explored the effects of song type on infant pitch preferences for lullabies and playsongs. High and low pitch versions of four foreign children's songs were recorded for each of the songs. The study found that 6- and 7-month-old infants preferred low-pitched over high-pitched versions of the lullabies and high-pitched over low-pitched versions of the playsongs, indicating that the affective nature of the music impacted infant pitch preferences. Based on their findings, Tsang and Conrad (2010) concluded that infant preferences for pitch are context-dependent. In a similar study, Conrad, Walsh, Allen, and Tsang (2011) analyzed the role of context on infant tempo preferences in playsongs and lullabies. Playsongs are usually fast in tempo, whereas lullabies generally have slower tempi. It is plausible that tempo, in addition to pitch, is a performance feature of music that conveys affective information to the infant during infant-directed singing. Twenty-four 6- to 7-month-old infants' natural preferences for tempo were measured using a head-turn preference procedure. The stimuli consisted of the same four foreign children's songs used by Tsang and Conrad (2010). However, pitch was held constant and the tempo of each song was manipulated. A fast- and slow-tempo version was recorded for each song, with the two versions differing in tempo by approximately 25% (Conrad et al., 2011). Results

revealed a context-dependent tempo preference for playsongs, but researchers were unable to demonstrate context-dependent preferences for tempo with the lullabies. Conrad et al., (2011) proposed that the lack of preference in the lullaby condition may have been due to an inappropriate use of tempo range. To examine whether infants have a generalized preference for faster tempi, Steffler (2012) presented infants with two tempi, both faster than the tempi used by Conrad et al., (2011). Based on Steffler's results, it is plausible to conclude that the lack of an observed preference for the slow lullaby tempi used in Conrad et al., (2011) was because the tempo used was too slow for infant listeners to process. These studies did not specifically manipulate the environment in which the infants were placed, but focused on manipulating the type and tempo of music played. To date, it is unclear how infant tempo preferences are affected by the environment in which they listen to the music.

Numerous studies have investigated the effect of temporal speed and its impact on arousal levels in adults. Balch and Lewis (1999) observed the effects of tempo on mood and arousal. Results revealed that only arousal was influenced by tempo. No effect of tempo on mood was found. These findings demonstrated that tempo manipulation induced changes in arousal. Similarly, Husain, Thompson, and Schellenberg (2002) investigated the relationship between tempo and arousal levels for undergraduate students. The results demonstrated the impact that tempo manipulations had on arousal. Specifically, fast tempo music was found to induce higher arousal levels, while slow tempo music was found to induce lower arousal levels. However, very little research has investigated the reverse; the impact of arousal levels on tempo preference.

Holbrook and Anand (1990) examined the impact of arousal levels on tempo preferences in adults. The authors proposed the 'sympathic hypothesis', which argued that

tempo preference shifted depending on general arousal levels. This theory postulates that when arousal levels are low, the natural rate of preferred tempo for a particular piece of music would be slow and when arousal levels are high, the preferred tempo for that same musical piece would increase (Holbrook & Anand, 1990). The researchers tested the theory by manipulating prior situational arousal. Participants were split into two conditions: low arousal and high arousal. The results indicated encouraging support for the sympathic hypothesis, which predicted a shift in preferred tempi due to an increase or decrease in situational arousal. This theory suggested that the natural rate of preferred tempo depended on the context in which the listening experience occurred. Thus, the results of this study can be used to predict that highly aroused infants would prefer faster tempi, whereas infants with lower arousal levels would prefer slower tempi (Berlyne, 1971; North & Harhreaves, 2008). The present study was designed to research whether or not these predictions are true in infants as well.

Additional research has examined a more direct measure of physiological arousal by investigating the relationship between exercise and tempo preference. Karageorghis, Jones, and Low (2006) examined the relationship between exercise heart rate and music tempo preference. They believed that during physical activity there would be stronger preferences for fast tempo, due to increases in physiological arousal (Karageorghis et al., 2006). Undergraduate participants walked on a treadmill at three different exercise intensities while listening to music with different tempi. Results revealed an interaction between exercise intensity and music tempo, such that as the intensity of the workout increased, arousal levels increased. Participants reported a preference for fast tempo music as work intensity increased, thus further supporting the notion that tempo preference is context-dependent.

Taken together, the literature suggests that adult tempo preferences are context-dependent. However, to our knowledge, there has been no conclusive research demonstrating whether infant tempo preferences are affected by situational context. Therefore, a logical extension to the currently available research is to establish whether the notion of a generalized fast tempo preference during infancy is plausible, or if infant preferences for tempo differ depending on the context in which they are heard. In the present study, we attempted to reduce the infant's arousal levels prior to measuring their natural preferences for tempo and predicted that the arousal induction would alter the infant's tempo preference.

The current study focused on which factors influenced infants' optimal temporal processing. Following an arousal induction, a head-turn preference procedure was used to test 6- to 8-month-old infants' tempo preference. We hypothesized that infants would show a listening preference for slower tempi when their arousal levels were reduced. Therefore, during testing, if infants showed a preference for intermediate tempo over fast tempo, this would indicate that an arousal induction, preceding the musical listening experience, resulted in a shift in preferred tempi. Thus, we proposed that situational context plays a major role in infant tempo preference. Overall, the present study sought to contribute to the emerging literature on the origins of infants' sensitivity to tempo.

Method

Participants

Fourteen 6- to 8-month-old infants (mean age = 7.6 months, range = 6.3 - 8.9 months; 9 boys, 5 girls) participated in this study. Participants were recruited via telephone from the developmental research participant database, maintained by the Department of Psychology at

Western University. At the time of the testing, all the infants were healthy and had no reported history of prior ear infections or family history of hearing impairments.

Apparatus

The experiment took place in a quiet testing room. The overhead lights in the laboratory were off throughout the entire study and a table lamp positioned behind the infant in the corner of the room was the only source of light. The wattage of the bulb in the lamp was 100W. Each infant was seated facing forward on the caregiver's lap, directly across from the experimenter at a distance of 1.5 m. A computer keyboard was used to record the infant's head turning behaviour and was hidden from the infant behind a small podium. A pair of sound speakers (Bose 201-V), which played the audio stimuli, were located on top of two cabinets, situated to the left and right side of the infant. Each cabinet was positioned 90 cm on either side of the chair upon which the caregiver and infant were seated. The cabinets contained a standard 13-in CRT computer monitor that displayed the visual stimuli. Both computer screens were oriented at a 90 degree angle from the infant, with the centre of the screen approximately at the infant's eye level. Both the caregiver and experimenter wore headphones throughout the experiment and listened to masking music to ensure they had no influence on the infant's head-turning behaviour.

All sound stimuli were played at a comfortable listening level by a Macintosh G4 computer, which was connected to a Yahama amplifier/receiver, and in turn, connected to the two sound speakers. A Macintosh G4 computer, with customized software, was located in an adjoining room and controlled the trial presentations and recorded the looking times.

Stimuli

Arousal Induction Stimuli

A short children's story entitled "Where is Petey Nutter?" was recorded by a female researcher in a quiet laboratory room. It is an unpublished children's story, therefore unfamiliar to all the participants. The story was 2 minutes and 51 seconds in length.

Testing Stimuli

A fast- and intermediate- tempo version of the same musical melody was used in the present study (Steffler, 2012). The melody contained no words or lyrics; it was comprised of 16 notes, and was written in a major mode with a piano timbre. The fast tempo version was 200 bpm, and the intermediate tempo version was 140 bpm.

Procedure

There were two stages during this study: the Arousal Induction Phase and the Testing Phase. In the Arousal Induction Phase, the mother and infant were brought into the dimly lit laboratory room. The infant sat facing forward on the caregiver's lap. Once the infant and mother were seated, the mother was informed that a short recording of a children's story would begin to play when the researcher left the room. Once the recording finished, the researcher returned to the room and the Testing Phase began.

During the Testing Phase of the study, infants were tested individually in a head-turn preference procedure. The infant remained seated on the caregiver's lap, with the experimenter sitting directly across from the infant. Each trial began with the experimenter pressing a key on the keyboard (hidden from the infant) when the infant was attentive and facing forward. Once the trial had been initiated, a visual stimulus of Mickey Mouse flashed on the computer monitor (either on the right or left side of the infant) to attract the attention

of the infant and serve as a directional cue to orient the infant to the auditory stimuli. When the infant looked to the flashing monitor, the experimenter pressed a button on the keyboard which started a timer for the looking-time behaviour to be recorded by the computer (in seconds). During this time, one of the song stimuli began to play and Mickey Mouse stopped flashing, but remained on the screen. When the infant looked away (45 degree head turn) for at least 2 s, the trial ended. The experimenter then released the key, which terminated both the musical stimuli and visual display. The next trial consisted of the alternative version of the auditory stimulus and occurred on the opposite side. The same visual display (i.e., Mickey Mouse) was presented on both sides of presentation. The fast- and intermediate-tempo trials alternated until the infant completed 20 trials in total. Infants were counterbalanced for both side of presentation (ie., half started on the left side and the other half started on the right side) and order of presentation (ie., half heard the fast tempo version first and the other half heard the intermediate tempo version first). The duration of this procedure took approximately 15-20 minutes.

Results

A 2 x 2 x 2 mixed Analysis of Variance (ANOVA) was conducted, with tempo (fast vs. intermediate) as the within-subjects factor, and first stimulus presentation (fast first vs. intermediate first) and first side of presentation (left vs. right) as the between-subjects factors. The dependent variable was the duration of looking time (in seconds) infants spent listening to the melodies. The ANOVA indicated a significant 3-way interaction, $F\ (1,10) = 5.50$, $p < .05$.

To breakdown the 3-way interaction, a 2 x 2 between-subjects ANOVA was computed between tempo (fast vs. intermediate) and first stimulus presentation (fast first vs.

intermediate first), holding side of presentation constant. No significant main effect or interaction was found. A second 2 x 2 between-subjects ANOVA was calculated between tempo (fast vs. intermediate) and first side of presentation (left vs. right), holding the first stimulus presentation constant. No significant main effects or interaction were found.

Discussion

An unexpected side of presentation x first stimulus x tempo interaction was found in the experiment. When this interaction is broken down, it seems that the effect is driven by increased looking to the intermediate tempo only when the intermediate tempo was presented first on the left side (although the 2 x 2 main effect is not statistically significant). When the fast tempo is presented first or when either tempi are presented on the right side first there is no difference in looking time to intermediate and fast tempi. While it is unclear whether this result is reliable and valid due to the relatively small sample size in the experiment, there are a number of possible explanations for the interaction that should be noted beyond the sample size.

One explanation for this observed result of the intermediate tempo preference might be a familiarity effect that is impacted by the side of presentation. It is possible that being exposed to their ideal referent level (fast tempo) first eliminated the effectiveness of the arousal induction, thus optimizing infants' natural preference for the fast tempo version. Additionally, it is interesting to note that Steffler (2012) found the order of the first stimulus presentation had a small effect on infant listening preferences. Results from Steffler (2012) revealed that infants exhibited a strong preference for the fast tempo version when it was presented first (M = 43.82) compared to when the fast tempo version was presented second (M = 25.39). However, when the intermediate tempo version was presented first (M = 36.47),

infants looked less long to the fast tempo version than when the fast version was presented first. To explain this order of the first stimulus presentation effect, Steffler (2012) suggested that having the preferred temporal speed presented first served to enhance the infants' listening preference. Thus, both the side of presentation effect found in the current study and the first stimulus presentation effect found in Steffler's study suggest that the context in which the temporal stimulus is presented has an impact on infant listening preferences.

Very little data has been reported on side of presentation effects in the infant auditory literature. However, what little research exists suggests a right hemisphere dominance for musical or tonal stimuli and a left hemisphere dominance for speech and language processing (Best, Hoffman, and Glanville, 1982). This right hemisphere dominance suggests a natural proclivity for music like-stimuli. Because the auditory pathway is crossed, auditory information coming from the left ear connects to the right hemisphere's auditory cortex. A study by Glanville, Levenson, and Best (1977) found that when musical stimuli were presented to the left ear, infants exhibited a stronger preference for the stimuli than when presented to the right ear. These findings suggest that infants should show a preference for musical stimuli presented on their left side over musical stimuli presented on their right side. However, if side of presentation was the only factor accounting for infant listening preferences then an effect would have been found for the fast tempo version when it was presented on the left side. Clearly there must be other mitigating factors that need to be taken into consideration.

One explanation for this observed result might be the effect of a shift in the referent level. Referent level refers to the stimulus level within a sequence to which one initially attaches attention to (Drake, Jones, & Baruch, 1998). It is the stimulus level that initially

enables a listener to form expectations and develop preferences for specific temporal pattern. If the arousal induction in the experiment was effective, it is possible that the infants' referent level shifted from fast to intermediate tempo levels. Thus, having both the optimal referent level (intermediate) and the side of presentation bias (left) paired together to start the test session only served to strengthen infants' preference.

Sieratzki, Roy, and Woll (2002) suggest that there is a relationship between cradling an infant on the left side of your body and the infants left ear advantage for speech prosody. Following a reanalysis of Turnbull and Bryson's (2001) data, Sieratzki et al., (2002) found a significant left ear advantage among left cradlers, in comparison to right cradlers. Although side of cradling was not examined in the present study, it has been well established in the literature that a strong bias for holding infants on the left side of our body exists (Bourne & Todd, 2004; Manning & Chamberlain,1991; Sieratzki & Woll, 1996). One explanation for why there is a left holding bias is handedness (Huheey, 1977). Right handed caregivers are more likely to hold their infants on the left side of their body so that their right hand could be kept free to perform other tasks (Sieratzki & Woll, 1996), which is the dominant hand for 90% of humans (Annett, 2004). When a caregiver holds an infant, unless the infant is sleeping, it is uncommon to have the infant's head positioned toward the caregiver's neck. Moreover, when holding an infant on the left side of their body the infants right ear is usually pressed against the body, which may be obstructing sound to that ear. Conversely, the left ear is facing outward and is likely exposed to more sounds and therefore experiences more stimulation than the right ear. Thus, it is plausible that the left ear advantage is a result of the left ear being exposed to more auditory stimulation than the right ear during infancy. Therefore, it is possible that the infants showed a preference for the intermediate tempo

version, when it was presented on their left side first, because of their left ear advantage, which could be a result of environmental factors (the side in which their parents cradle them) or biological factors (right hemisphere dominance for musical stimuli). Future research should control for environmental factors by recording the parents' dominant hand.

The zone of optimal processing theory provides two possible explanations for infants' sensitivity to tempo. The first hypothesis postulates that infants have the same intermediate temporal processing as adults. However, there has been little empirical support for this theory. The second hypothesis, which predicts that the zone of optimal processing slows with age, has been supported by more recent findings (Baruch et al., 2004; Steffler, 2012), specifically suggesting that infants prefer to listen to faster tempi. Although the current results are not consistent with past findings, the present research does not contradict the notion of a generalized preference for a specific tempi. Rather, our results merely suggest that tempo preferences in infancy can be variable in specific situations. These findings provide important implications for parents and caregivers. Knowing what infants prefer to listen to, in specific situations, can help caregivers provide the appropriate care and support for their infants. For example, knowing that your infant prefers to listen to fast tempo music over slower tempo music during a temper tantrum (high arousal), but that they would prefer to listen to slower tempo music when waking up from a nap (low arousal), could be extremely beneficial for both the infant and the caregiver.

To our knowledge, the present research is the first of its kind to investigate whether tempo preference in infants are affected by situational context. Specifically, this study focuses on the influence of arousal levels on tempo preference, rather than the effects of

tempo on arousal levels. An abundance of research has found a correlation between preferred tempi and emotions (Cupchik et al., 1982; Juslin & Sloboda, 2010). Furthermore, it has been well documented in the literature that emotions can influence arousal levels. For instance, when an individual is excited, they generally tend to be more aroused, and when an individual is down or depressed, they tend be less aroused. If there is a correlation between tempo and emotions, and a relationship between emotions and arousal levels, it is plausible that there may be a relationship between arousal levels and tempo in infants as well.

A number of limitations must be addressed when interpreting the present findings. As mentioned above, the results may be an artifact of the sample tested. It is possible that if more participants were included, different results may have been obtained, although it should be noted that there were no obvious outliers in the present sample. In any case, a larger sample could strengthen the effect size, producing more reliable results.

In addition, the present research lacks a direct measure of physiological arousal. Based on the significant 3-way interaction found in the current study, it is evident that the arousal induction phase had an impact on the infants' tempo preferences. However, results revealed a difference for one tempo (intermediate), but not the other (fast). Furthermore, since the infants did not exhibit a statistically significant preference for the fast tempo version, which is what has been found in past research (Steffler, 2012) it is reasonable to presume that the arousal induction phase had an effect on the infants tempo preferences. However, without a direct measure of physiological arousal, these findings are only correlational. Therefore, an important follow up measure would be to use actual measures of physiological arousal in order to get a better understanding of the impact arousal levels have on infant tempo preferences. Having a direct measure of physiological arousal will also allow

us to validate whether or not the arousal induction phase used in the present experiment was effective.

Today, Western society has placed an increased emphasis on academic achievement. Parents fear that if they do not provide their infants with the proper stimulation to best foster their development, their children will fall behind. A significant amount of research surrounding the impact of exposing children to music at an early age has suggested that exposure to certain types of music during infancy can impact the development of the young brain (Bales, 1998). Nowadays, children are diagnosed with cognitive, emotional, psychological and behavioural problems at a younger age than ever before. Thus, understanding how the brain works and what types of music positively enhance infant development has become an important field in developmental research. Furthermore, understanding why infants show a preference for certain tempi in different contexts and determining the specific mechanisms which underlie these tempo preferences will allow parents and educators to optimize and enhance infant auditory experiences.

In conclusion, the results of the present study are encouraging, as they shed light on the importance of context in infants' tempo preferences. Specifically suggesting a correlation between preferred tempi and levels of physiological arousal. Future studies should explore this further to extend the existing literature on infant auditory preferences.

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