What is “same” and “different” in pattern recognition by young children?

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Abstract

Before children start to produce musical sounds by singing, chanting, and creating noises of any kind, they have already acquired a listening vocabulary. Very soon they learn to differentiate between familiar and unfamiliar sounds or sound combinations which are most frequently used in the language heard and spoken to them as well as in the songs heard and sung to them. An experiment was designed to investigate infants' ability to differentiate between "same" and "different" using tonal and rhythm patterns which, then, were modified gradually with respect to tempo, meter, pitch and structure. Twenty children between the ages of 10 and 23 months were tested twice before and after a habituation phase using the head-turn method measuring children's attention span. Here, the assumption is that novel patterns call for a longer attention time than familiar patterns. The children learnt two standard melodies and two standard rhythms. After four weeks of habituation these standard items were combined with the modified versions. The head-turn reaction during the pre- and post-test was recorded and the data of both tests were compared. Although not all results are statistically significant, a clear tendency is apparent. Children of that early age respond very sensitively to changes and are able to differentiate between "same" and "different" in tonal and rhythm patterns.

Introduction

Before children start to produce musical sounds by singing, chanting, and creating all kinds of noises, they have already acquired a listening vocabulary by exposure to many kinds of vocal and instrumental sounds. They listen to songs and parental speech directed to them, and they unconsciously participate in the different types of music appearing in their environment. These environmental sounds prime their aural perception. Very quickly they learn to differentiate between familiar and unfamiliar sounds or sound combinations which are most frequently used in the language heard and spoken to them as well as in the songs heard and sung to them. Children are extremely fast and strong statistical learners. Even very young infants learn the substantial differences between similar sounds and sound combinations of the language and sound system of their environment. "Correlational data on distributional properties of Western music indicates that statistical induction is a plausible mechanism for this kind of learning" (McMullen & Saffran, 2004).

This basic type of discrimination learning is concerned with the distinction of “same” and “different” with regard to the perceived sound patterns. Former studies on infants' pattern recognition have demonstrated a highly developed ability to differentiate between sounds. Even 7 to 8 month old infants are already able to classify tonal stimuli on the basis of timbre (Trehub, Endman, & Thorpe, 1990). Furthermore, it has been demonstrated that infants by 7 months of age show a clear preferences for correctly segmented musical phrases as opposed to incorrectly segmented phrases (as they do with speech): they listen longer to musical sections where pauses are placed at the end of phrases instead of the middle of phrases (Jusczyk & Krumhansl, 1993). By this, they clearly follow the inherent musical syntax which has already been developed by acculturation. This is also reflected by the very early segregation and grouping processes in infancy (Fassbender, 1993).

Chang and Trehub have shown that 4 to 6 month old infants can already recognize familiar melodies even if they are presented in transpositions (Chang & Trehub, 1977). However, here the infants focus on the melodic contour which is one of the first musical aspects differentiated by infants (McMullen & Saffran, 2004). This is also true in infants' visual recognition of static subjective contours (Kavsek, 2002) and even of contour-deleted figures (Rose, Jankowski, & Senior, 1997). In music a standard melody will be recognized if the contour is preserved (Trehub, Thorpe, & Morrongiello, 1987). Since young children focus on contour rather than on pitches and intervals, they are able to recognize the same contour even in transposition. It is a matter of developmental growth that children become aware of the distinct differences in pitch structure and interval relations. However, infants who do not differentiate between a target tune and its transposition or structural change as long as the contour is not violated, show a more global distinction between what appears "same" or "different" to them.

Aural discrimination becomes a very crucial aspect in auditory and vocal learning. Children can only imitate a perceived sound pattern vocally if they have already established an aural image of "same". For this it is important that they repeatedly listen to the same songs and the same rhythms so that they can develop mental representations of the perceived patterns. These mental representations can then be referred to when confronted with a presented new pattern (pattern matching).

Background

From the perspective of music learning one has to distinguish between *recognition* and *preference*. A considerable amount of research has addressed the issue of recognition of changes in pitch contour, rhythm structure, timbre etc. (for a survey see Borth 2005; McMullen & Saffran, 2004) which always employs *memory* whereas preference refers to *familiarity* and *arousal*. The present study, however, was to investigate the cognitive structure which is involved in the development of the cognitive concept of "sameness" and "difference". It is cognitive because it is based on a conscious or pre-conscious cognition of a relation between two elements (patterns). This underscores a crucial step in the developing of the individual learning potential.

Infants are able to imitate facial expressions and the vocal spectra of maternal speech at a very early age. Imitation is an initiating prerequisite for learning which is first and primarily based on the distinction between "same" and "not same". Later on, this rough distinction becomes more differentiated when similarities and structural deductions can be recognized by referring a pattern to an already established representation of that pattern. This cognitive function becomes extremely important with regard to discrimination learning. A basic understanding of "same" and "different" can be seen as a cue issue for further cognitive development.

For this, it is essential to understand infants' and young children's recognition of sameness and difference. The question is what musical aspects are dominant in infants' perception. This study was to investigate the degree to which children aged one to two years are sensitive to alterations in tempo, meter, form, and pitch level. But in contrast to studies which concentrate on the short-term memory, this experiment was concerned with long-term learning to avoid the possibility that it is predominantly the memory which is engaged in the recognition of "same" or "different". The differentiation between "same" and "different" calls for a cognitive achievement depending on the cognitive development and maturation of children.

Methods

Twenty children between the ages of 10 and 23 months participated in the study. They were recruited from an early childhood music class so that they were all familiar with the type of songs (melodies without words) and chanted rhythms (without pitches) used in the study. During a four weeks' training phase (habituation period) the subjects learned two target melodies and two rhythms by listening to them twice a day so that they became familiar with these standard items. In the following test the two rhythms and two melodies were gradually altered with respect to tempo, meter, form, and pitch level (see appendix). The intention was to find out at what level of transformation a familiarized pattern can be recognized as "same" or "different".

For this, the head-turn paradigm was applied as a standardized computer supported procedure to measure attention. Here, the attention span to a sound source was measured as an indication of attraction. It has been shown that young children prefer novel – or what they perceive as novel – over familiar patterns (Saffran, 2003), that is they pay more attention to tunes and rhythms which they perceive as novel or not quite the same as the already familiar patterns. To recognition that a pattern presents some new aspects – maybe in tempo, meter, pitch, or tonality – calls for a robust representation of the familiar pattern to which it can be referred and compared with. In this study the duration of the head-turn toward the direction where the sound appeared, was measured.

For this, the infant was seated on its parent's lap. Parents listened to soft music from headphones so that they did not hear the music examples and could not influence the children's behaviour by their own body reaction. Two loudspeakers were set up on the right and left side of the child. To draw the infants' attention towards the centre, pictures were presented for five seconds on a laptop in front of the child before a music example was played from one of the loudspeakers either from the right or left hand side in random order (fig. 1). The attentive behaviour was recorded by a video camera positioned behind the laptop and then coded by the *Observer Pro* 5.0 behavioural observation programme from Noldus. The behavioural classes applied to this experiment were 1. attention span (i.e. the duration of head turn toward one of the active loudspeakers), 2. voice production, and 3. rhythmic movements accompanying the music they listened to. The infants' attentive reaction was measured twice: before (pre-test) and after the training phase (post-test). The first measurement (pre-test) functioned as a reference for the attention to tunes and chants when they all were equally novel and could not yet be referred to standard and modified versions. After training (post-test) differences of reaction time were expected according to the degree of the transformation of the learned target version.

The research design was built on the assumption that the fixation towards the sound source indicates the level of attention. If an infant looks at the loudspeaker for a longer time, this indicates that he/she is more attentive because the item is perceived as somehow novel (dis-habituation). Conversely, if a child fixates on the loudspeaker only for a shorter span, it is supposed that the example is familiar (habituation) so that the child looses interest in it. Therefore, the hypotheses were:

1. Children recognize familiar patterns (tunes and rhythms) as same.
2. They respond to changes of form and meter in familiar patterns.
3. However, they recognize the alteration of tempo and the melodic transposition of a familiar pattern as same.

The data analysis was performed by SPSS 11.0. For comparing the results of the pre-test and post-test the data had to be normalized so that the average fixation durations were always related to the grand average of the unfamiliar patterns (Borth 2005).

Results

The mostly shorter attention times at the post-test reflect a general habituation effect (fig. 2). Therefore, it becomes crucial to determine the differences in the attention span regarding the unchanged and modified items. In general, shorter attention times for the unchanged examples clearly demonstrate that infants at that early age are already able to recognize learned melodies and rhythms as “same”. However, only for three items the difference is statistically significant. Neither age nor sex of the infants and toddlers had an influence on the results.

The fixation durations for modified items regarding form and meter were heterogeneous. In half of all cases the fixation duration was longer in comparison to the standard stimuli. Here, a clear age effect was observed: In general, toddlers from 18-23 months showed longer fixation duration to these modifications in the post-test. This differentiation might be due to maturation and development. Younger infants who listen more holistically focus on the same melodic gesture and general mood so that they perceive it as more or lass the same. However, the older infants grow, the more they are able to focus on particular musical aspects and recognize the modification of the form (permutation of two melodic sections) as something more novel to them (fig. 3).

However, the results regarding form and meter were not consistent for all children. This could be due to the fact that these children are still in a developmental transition. However, children from the age of 18 months and older were found to detect the difference between the standard stimulus and the alterations of form and meter more easily. Female infants recognized these changes as “different” more readily than male infants.

As to influence of the transposition on children's recognition, it was found that infants and toddlers recognized the transposition as "same" if it was presented within the range of two half steps. However, the transposition of melody 2 (M2) which exceeds six half steps, was treated as “different” from the standard melody by all children. With respect to transposition, neither an age effect nor an effect of sex was exhibited.

The most interesting results were demonstrated by the alteration of tempo. There is some evidence that the children of this study could discriminate between the learnt standard stimuli and their acceleration of 20% and the deceleration of 20 % and 50 % respectively. But these findings are not always statistically significant. However, significant differences exist in melody 1 when the tempo was increased by 20 %. Similarly, significant differences were observed in rhythm 2 (R2) at half tempo (fig. 4). Again, there was no age effect in recognition of tempo alterations. Contrary to our expectations, the acceleration of 100 % (double speed) in melody 2 did not call for a longer attention which normally happens when a pattern seems novel to the subjects. But this double speed pattern was obviously unattractive at all.

Although not all results are statistically significant because of the widespread distribution depending on the developmental age of the children, there are nevertheless general tendencies that appear to be consistent. Familiar tunes tend to cause shorter attention span, whereas non-familiar alterations attract longer attention (fig. 5).

Regarding vocal and motor responses, only very few children showed spontaneous reactions along with the listening. Mainly in the post-test the original items (especially the melodies) encouraged to spontaneous vocal reactions like babbling or singing, but not to rhythmic movement. In general, there is a slight tendency in young children to respond to melodies more frequently with vocal activities and to rhythms with rhythmic movement.

Conclusions

Although the study is based on just a small sample, the result sheds some light on a better understanding of young children's ability to recognize familiar musical patterns even if they are modified gradually. The fact that not all findings are statistically significant might be caused by the extended number of 28 items presented to them in the same session so that the young infants had difficulty in performing the entire test with full concentration. Nevertheless, there is a clear indication that children between the ages of one and two years are able to differentiate between "same" and "different". Regarding the gradual modifications of meter, tempo, and form they realize that examples played at a faster tempo or in a more distant key are related to the learnt standard items but are not recognized as the same familiar examples. The inconsistency of the results caused by these modifications may reflect that children undergo a transition phase in which some are able to relate a transposition to the standard melody whereas others do not. The general tendency that most of the reactions in the post-test are shorter than in the pre-test regardless of modifications or repetitions may be caused by an over-learning effect since the children listened to the target stimuli for four weeks. Therefore it is likely to assume that they lost all interest in the tunes and chants. However, the results of the observational data support the general conclusion:

- Shorter attention is paid to melodies and rhythms when they remain unchanged (* / **), to tunes with narrow transpositions (* / **) and often even to large scale transpositions (n.s.).
- Same attention is paid to structural changes of melodies (n.s.).
- Longer attention is paid to rhythms with modified meter (2 → 3) (n.s.), to unfamiliar tunes (**), and in some cases to melodies with strong tempo modifications (double speed, n.s.).
- However, the results are ambivalent for tempo modifications in a smaller range (+/- 20%).

These findings could have an impact on the teaching method in early childhood music classes. If teachers want to establish a listening vocabulary, they should carefully deal with tempo, meter, and pitch. In view of the children's ability to clearly differentiate in pattern recognition, it should be recommended that teachers always present tonal and rhythm patterns in precisely the same tonality and meter so that children can establish distinct mental representations of musical elements. Further research is needed in order to identify the threshold at which the recognition of each of the musical parameters changes from "same" to "different".

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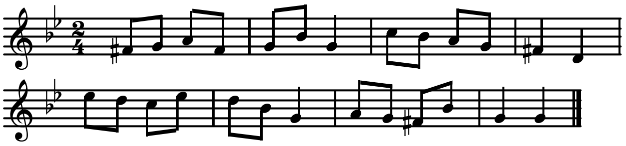
Appendix

M 1

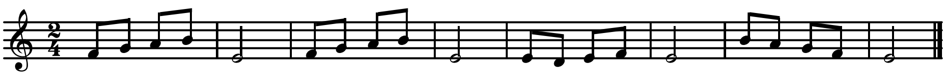
(D; Cis; G - MM = 132; 160; 92)

M 2

(e; d; g - MM = 60; 88; 120)



M 3



M 4

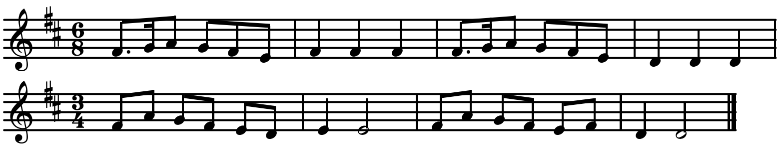


Fig. 6: Melodies and their modifications. M 1 and M 2 functioned as standard melodies; M 3 and M 4 represent novel melodies for control condition.

Fig. 7: Rhythms and their metric modifications. R 1 and R 2 functioned as standard rhythms; R 3 and R 4 represent novel rhythms for control condition.

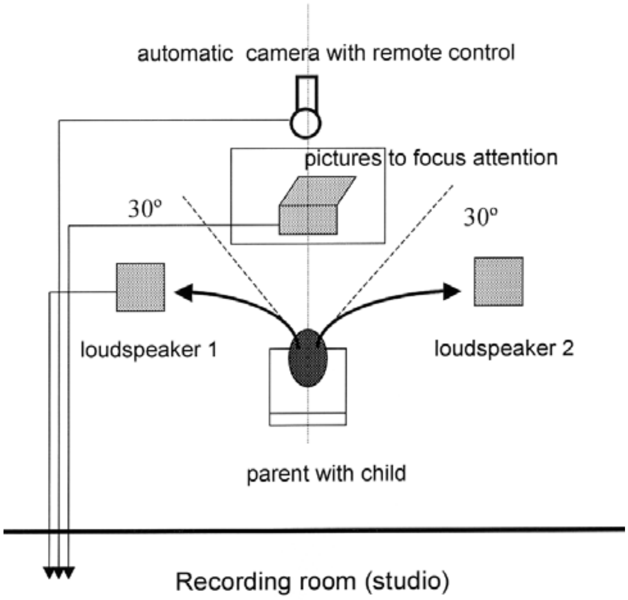


Fig. 1: Arrangement for the head turn paradigm

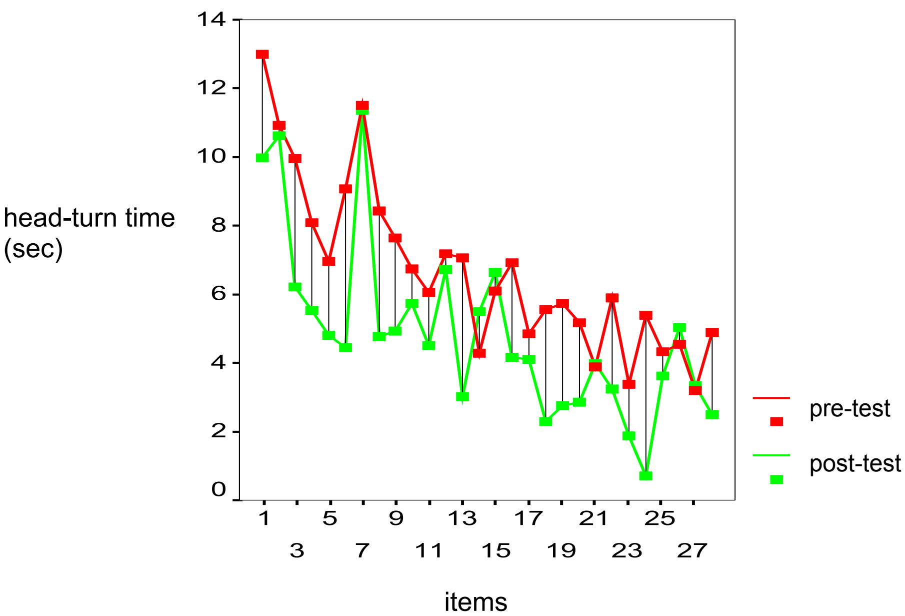


Fig. 2: Mean head-turn times of all items in pre-test (dark) and post-test (light)

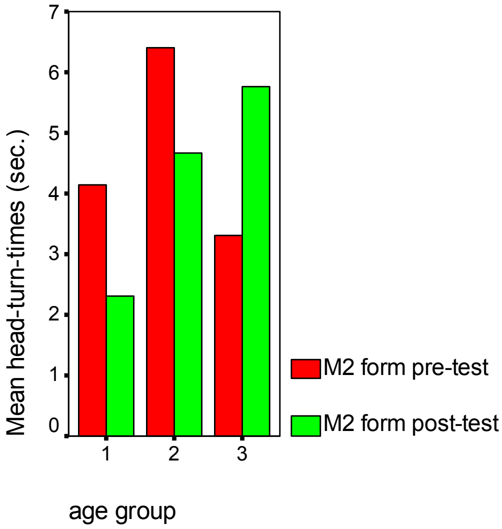


Fig. 3: Melody 2 pre- and post-test

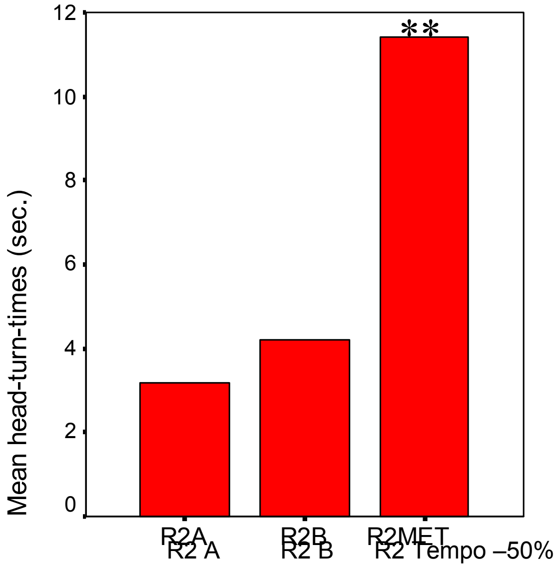


Fig. 4: Head turn times for Rhythm 2 (A, B) compared with tempo change (-50%)

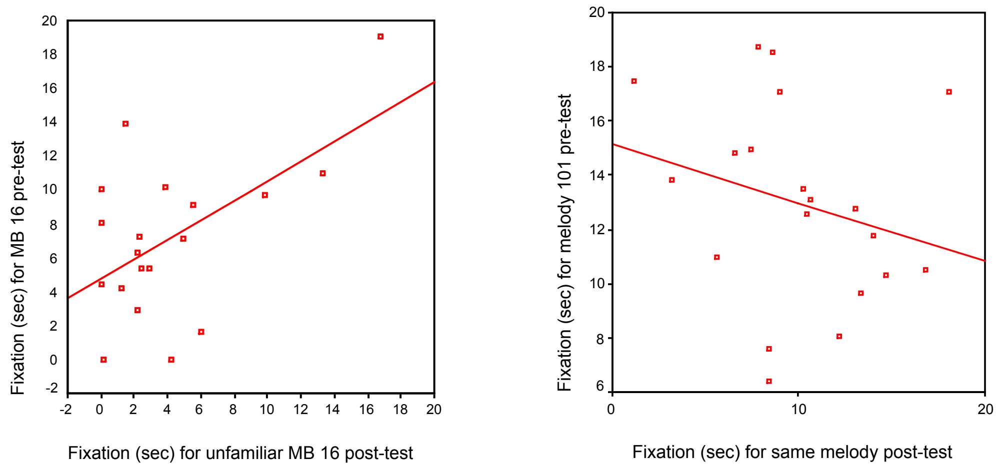


Fig. 5: Change of the attention span to an unfamiliar (left) and a familiar (right) tune between pre- and post-test.