Maturation of Auditory Scene Analysis in 10-16 year old Children

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Introduction

Auditory stream segregation describes the ability to filter a relevant stream of sound out from the other sounds in the environment. In the laboratory, the phenomenon of stream segregation can be examined using two sounds A and B. If these two sounds are alternated in time, the perception may seem to 'split' so that the listener hears two separate A-A-A and B-B-B streams rather than one A-B-A-B stream. Two prominent factors that can influence our ability to integrate or segregate two streams are stimulus onset asynchrony (SOA) and frequency separation (dF) (Bregman, 2000). Sequences with shorter SOA or larger dF between the tones will segregate into separate streams more easily, whilst those with longer SOA or smaller dF are more likely to be perceived as being integrated into one stream. Sussman et al. (2007) found that 9-11 year old children had significantly higher streaming thresholds than adults. The current study looks to determine how auditory stream segregation develops in adolescence and to provide a developmental trajectory.

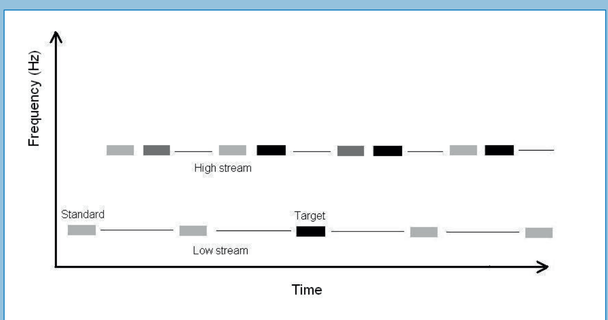
Subjects & Methods

63 Subjects participated in the study.

Adults n=19
Children (age10-12) n=17
Children (age 13-14) n=18
Children (age 15-16) n=9

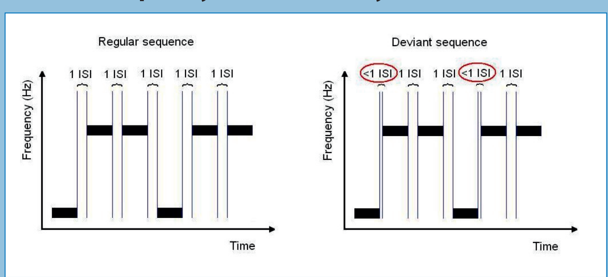
The experiment was set up to map out a developmental trajectory of auditory stream segregation by looking at the stream segregation and integration thresholds using a 3 up - 1 down staircase procedure (Kaernbach, 1991). Each condition was terminated after 14 reversals, and the average of the levels at the last eight reversals was taken as an estimate of the threshold.

Task 1: 1st Threshold determination (frequency condition – intensity task)



Subjects needed to hear two streams to complete task. Pure tones with 50ms duration were presented at differing intensities (darker shading indicates louder intensity). The low stream tones (200Hz) were played with an amplitude of 70dB for all tones or with a rare deviant (80dB target tone). Subjects were asked to identify whether or not the sequence contained a target tone. The high stream tones were presented with an amplitude of 65, 75 or 85 dB. Frequency difference between the two streams was varied, with the starting dF of 2 ST.

Task 2 : 2nd Threshold determination (frequency condition – rhythm task)



Subjects needed to hear one stream to complete the task. In each trial the subject was played a sequence, which would need to be identified as either a regular sequence (all interstimulus intervals (ISI) are equal in length) or a deviant sequence (the ISI between the low tone and the first high tone is 80% shorter than the other ISI). These were presented over 4 blocks, with an SOA of 100ms, 150ms, 200ms and 250 ms, with a starting dF of 2 ST.

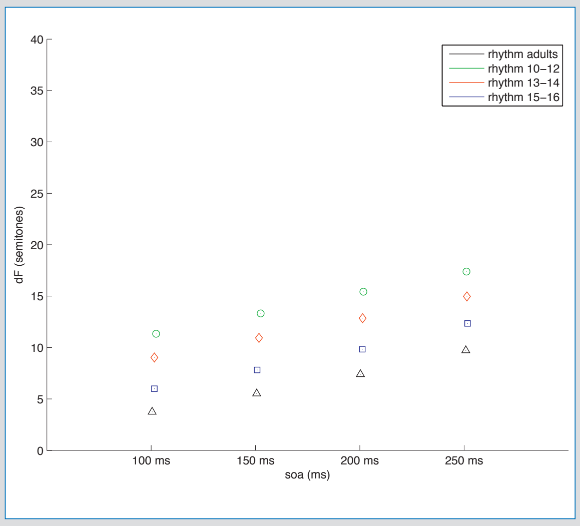
Task 3: Self determined threshold – only completed by the adult subjects

Subjects were able to adjust the frequency difference between the tones themselves until they felt they consistently heard the sounds as two streams. Subjects completed one self-adjustment task for each of the fixed conditions in Task 2.

Results

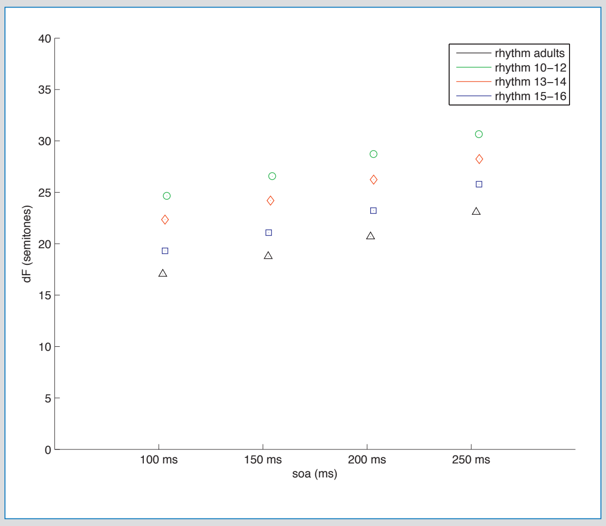
Hypotheses and expected results:

Task 1: Intensity task:



1) Across SOA levels, stream segregation thresholds (dF) decrease with an increase in age
2) Within each age group, stream segregation thresholds (dF) increase with an increase in SOA.

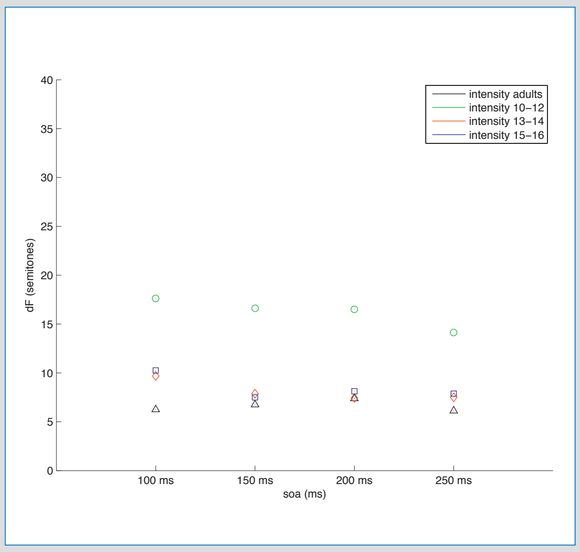
Task 2: Rhythm task:



1) Across SOA levels, stream integration thresholds (dF) decrease with an increase in age.
2) Within each age group, stream integration thresholds (dF) increase with an increase in SOA.

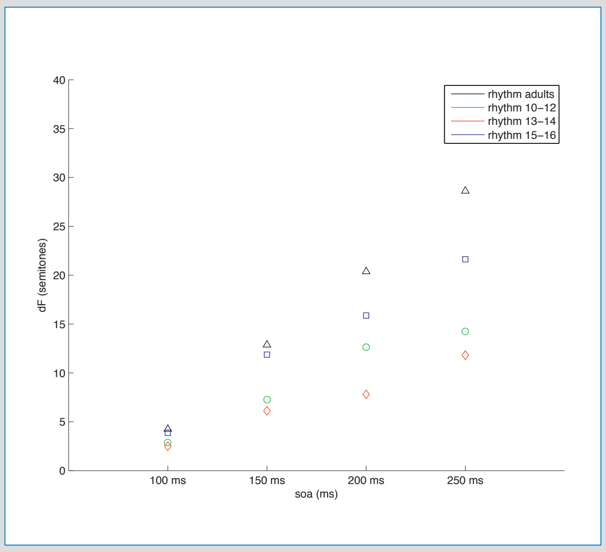
Results:

Task 1: Intensity task:



There was no effect of SOA length on the threshold achieved. Friedman's ANOVA confirms that within each age group, there was no significant difference between the thresholds in the 4 SOA conditions. Within each condition, a significant correlation between subjects' age and thresholds was found, with thresholds being higher in younger subjects than in older subjects.

Task 2: Rhythm task:



The threshold levels in the rhythm task appear to be dependent on both age and SOA, with thresholds diverging further the slower the SOA. Adult subjects were able to integrate at higher thresholds than children, with younger children being worse at integration than the older ones.

Task 3: Self-adjustment task (adults only)

Thresholds in the self-adjustment task correlated with those in the rhythm task (r=0.91, p=0.043).

References:

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Discussion

Whilst our results in the intensity task show an improvement in task performance with age, the lack of change to the thresholds at varying SOAs suggests that the higher thresholds found in children may be less related to streaming but rather to some other late developing mechanism, such as inhibition (Luna & Sweeney, 2004). As the biggest improvement we found was between the 10-12 and 13-14 age groups, one explanation might be that children whose inhibition is less mature are less able to suppress the irrelevant stream of sound, therefore performing worse in the task.

The results of the rhythm task again show an effect of age on thresholds, but in this task we also found an effect of SOA length. The positive correlation between adults' subjective judgments in the self-adjustment and the thresholds measured in the rhythm task support that the task is a true measure of integration. However, the results do not confirm our hypothesis that children would be better at tasks requiring integration. Instead, we found that the older subjects were able to integrate at higher thresholds than the younger ones. This implies that children have a narrower dF range where they are able to actively determine whether they hear sounds as integrated or segregated.

These results together might suggest that adults are better able to flexibly use their streaming/integration abilities, adjusting their percept depending on the task they are required to do, whilst the children are less skilled in the active regulation of streaming and integration.