# Effect of Background Noise on Temporal Processing in Children and Young-adults

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## Abstract

*Temporal processing refers to the ability of auditory system to resolve an acoustic signal in time domain. Temporal processing is critical to a wide variety of everyday listening tasks, including, speech perception and perception of music). Although the importance of signal-to-noise ratio (SNR) is well documented in speech perception experiments, it has been not been explored in temporal processing experiments. Both physiological and psychophysical experiments show degraded auditory performance in the presence of background noise. It is very much possible that background noise might alter the ability to process auditory signals in time domain, i.e., the ability to detect a gap in a continuous signal. From the result of study it was discovered that as the signal to noise ratio (SNR) was decreased from + 15 dB SNR to 0 dB SNR there was a significant deterioration in Gap detection thresholds. Children perform similarly in Gap detection test by the age of 9 to 10 years.*

***Key words:*** *Temporal processing, gap detection, speech perception.*

Time is a very important dimension in hearing, since almost all sounds fluctuate over time. Temporal processing refers to the ability of auditory system to resolve an acoustic signal in time domain. Temporal processing is critical to a wide variety of everyday listening tasks, including, speech perception (Phillips, 1999) and perception of music.

Temporal processing encompasses a wide range of auditory skills including temporal resolution or temporal discrimination, masking, temporal ordering, as well as localization and pitch perception (ASHA, 1996). The most common and reliable way of investing temporal processing is by means of gap detection which involves temporal resolution.

Although it is generally acknowledged that temporal processing improves substantially over the first several years of life, there is considerable disagreement about the specific developmental time table. For example, the age of achievement of adult-like temporal acuity is reported to be between 5 to 6 years of age by some investigator (Jense & Neff, 1993) and 9 to 11 years of age by others (Irwin, Ball, Kay, Stillman & Rosser, 1985; Grouse, Hall & Gibbs, 1992; Davis & Mc-Croskey, 1980). Shivaprakash (2003) developed normative data for Gap detection test in children & young adults with normal hearing. The findings suggest that normal hearing individuals start performing like adults on Gap detection test by the age of 6 to 7 years.

In everyday listening conditions, there is always some noise present. The adverse effects of noise on hearing are known for centuries. This background noise typically affects detection tasks, e.g., elevates auditory thresholds for tones and speech (Hawkins & Stevens, 1950) and speech perception tasks (Plomp & Mimpen, 1979; Duquesnoy, 1993; Wagener & Brand, 2005). Normal hearing individuals do not complain about understanding speech in quiet environment, but may have some difficulty with understanding speech in noisy environments (Wilson & Strouse, 1999).

Although the importance of signal to noise ratio (SNR) is well documented in speech perception experiments, it has not been explored in temporal processing experiments.

The primary aim of the present experiment was to systematically measure the effect of SNR on temporal processing abilities (via Gap Detection Test) in children and adults. The secondary aim was to evaluate whether children and adults differ in their temporal processing abilities in presence of background noise.

## Method

**Participants:** The study involved two grouos. Group 1 consisted of 25 normal hearing children (pure-tone thresholds ≤ 25 dB HL in frequency range of 250 – 4000Hz). This group was further divided into 5 sub-groups on the basis of their age: Sub-group A consisted of 5 children of age 7 – 7.11 years. Sub-group B consisted of 5 children of age 8 – 8.11 years. Sub-group C consisted of 5 children of age 9 – 9.11 years. Sub-group D consisted of 5 children of age 10 -10.11 years. Sub-group E consisted of 5 children of age 11 – 12 years. Group 2 consisted of 20 normal hearing young-adults (pure-tone thresholds ≤ 25 dB HL in frequency range of 250 – 4000Hz of age between 18 and 30 years.

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**Procedure**

In the study Gap detection thresholds were obtained at 50 dB SL (Ref: PTA). All the experiments were done on the right ear as no ear advantage is revealed in literature for any of the test for temporal processing including Gap detection test. For each participant Gap detection threshold was obtained in 5 conditions: Condition 1: Gap detection threshold in quiet condition. Condition 2: Gap detection threshold in presence of background noise at signal to noise ratio of +15 dB SNR. Condition 3: Gap detection threshold in presence of background noise at +10 dB SNR,. Condition 4: Gap detection threshold in presence of background noise at signal to noise ratio of +5 dB SNR. Condition 5: Gap detection threshold in presence of background noise at 0 dB SNR. In condition 2, 3, 4 and 5 white noise was presented ipsilaterally through the audiometer at the respective to (SNR).

Mean Gap detection threshold (GDT) of both the groups i.e. children and young-adults for all the five conditions i.e. quiet, +15 dB SNR, +10 dB SNR, +5 dB SNR and 0 dB SNR are represented in Figure 1. Mean Gap detection threshold (GDT) of both the groups i.e. children (GDT of sub-groups that constituted children of different ages represented separately) and young-adults for all the five condition i.e. quiet, +15 dB SNR, +10 dB SNR, +5 dB SNR and 0 dB SNR are represented in Figure 2.

## Results

Mean GDT of two groups i.e. children and young-adults across the different conditions is presented in Table 1.

*Table 1. Mean Gap detection thresholds with standard deviation for both the groups for all the five conditions*

| Group | Quiet | +15dB SNR | +10dB SNR | +5dB SNR | 0dB SNR |
|---|---|---|---|---|---|
| Children Mean | 3.8 | 4.3 | 6.0 | 8.1 | 10.7 |
| SD | 0.68 | 0.90 | 1.2 | 1.31 | 1.6 |
| Young-adults Mean | 3.3 | 3.5 | 4.5 | 6.6 | 8.8 |
| SD | 0.58 | 0.51 | 0.60 | 0.59 | 0.58 |

Results of mixed ANOVA revealed significant difference in Gap detection threshold between both the groups i.e. children and young-adults for all the five conditions at 5% level of significance: $F(1, 43) = 22.906$ ($p < 0.001$). It was also revealed that Gap detection threshold was significantly different in all the five conditions for children and young-adults at 5% level of significance: $F(4, 172) = 1152.792$ ($p < 0.001$).

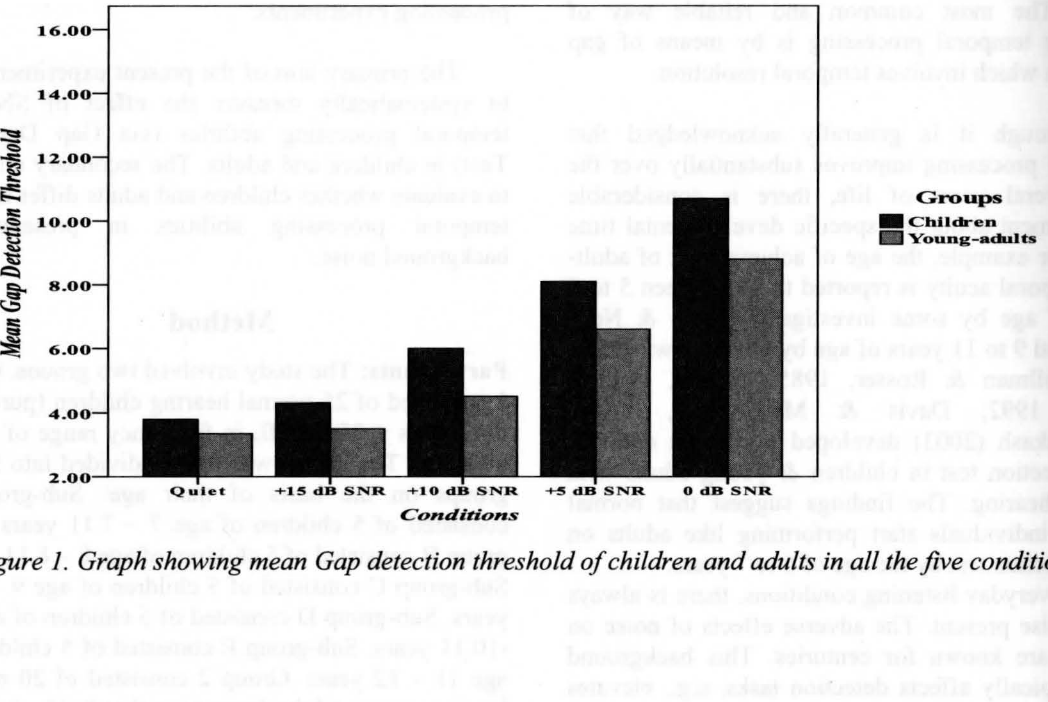


*Figure 1. Graph showing mean Gap detection threshold of children and adults in all the five conditions.*

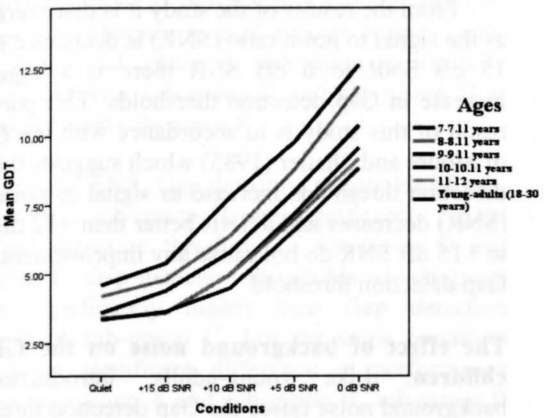


*Figure 2. Mean Gap detection threshold of both the groups for all the five conditions.*

Bonferroni's test revealed that Gap detection thresholds for all the five conditions are significantly different from one another at 5% level of significance. There is also a significant interaction between groups and conditions at 5% level of significance: $F (4, 172) = 13.964$, $p < 0.001$. Independent t- Test showed a significant difference between two groups i.e. children and young-adults across all the five conditions. Repeated measure ANOVA was done in children and young-adults separately to see the effect of five conditions on their respective Gap detection thresholds.

Results of Repeated measure ANOVA revealed significant difference in Gap detection threshold of children across the five conditions at 5% level of significance: $F (4, 96) = 614.632$ ($P < .001$). Similarly in young-adults, significant difference in Gap detection threshold across the five conditions was depicted at 5% level of significance: $F (4, 76) = 648.807$ ($P < .001$). Kruskal Wallis test was done on children to check the effect of different conditions on GDT across ages (i.e. sub-groups of children). Different sub-groups of children were compared to each other in terms of their respective performance on Gap Detection Test for the five conditions taken in the study using Mann-Whitney Test.

Results of Mann-Whitney Test are mentioned below: There was no significant difference between Gap detection thresholds of sub-group A (7 - 7.11 years) and sub-group B (8 - 8.11 years) in any of the five conditions. Between sub-group A (7 – 7.11 years) and sub-group C (9 – 9.11 years) a significant difference was depicted in Gap detection thresholds for four conditions i.e. +15 dB SNR, 10 dB SNR, +5 dB SNR and 0 dB SNR. There was no significant difference in the quiet condition. Gap detection thresholds of sub-group A (7 – 7.11years) were significantly different from sub-group D (10 – 10.11 years) and sub-group E (11 – 12 years) in all the five conditions. There was no significant difference between Gap detection thresholds of sub-group B (8 - 8.11 years) and C (9 – 9.11 years) in any of the five conditions. Gap detection thresholds of sub-group B (8 - 8.11 years) were significantly different from sub-group D (10 – 10.11 years) and sub-group E (11 – 12 years) for three conditions i.e. 10 dB SNR, +5 dB SNR and 0 dB SNR. There was no significant difference observed for quiet and +15 dB SNR conditions. There was no significant difference between Gap detection thresholds of sub-group C (9 – 9.11 years) and D (10 – 10.11 years) in any of the five conditions. Gap detection thresholds of sub-group C (9 – 9.11 years) were significantly different from sub-group E (11 – 12 years) for the 0 dB SNR condition. There was no significant difference for quiet, +15 dB SNR and +10 dB SNR and +5 dB SNR conditions. There was no significant difference between Gap detection thresholds of sub-group D (10 – 10.11 years) and E (11 – 12 years) in any of the five conditions.

Mann-Whitney Test was administered to check the performance on Gap Detection Test of each sub-group of children versus young-adults for different conditions (quiet, +15 dB SNR, +10 dB SNR, +5 dB SNR and 0 dB SNR). Gap detection thresholds of Sub-group A (7 – 7.11years) and sub-group B (8 - 8.11 years) of children was significantly different from young-adults for all the five conditions (quiet, +15 dB SNR, +10 dB SNR, +5 dB SNR and 0 dB SNR). Gap detection thresholds of sub-group C (9 – 9.11 years) of children was significantly different from young-adults for four conditions i.e. +15 dB SNR, +10 dB SNR, +5 dB SNR and 0 dB SNR. There was no significant difference for quiet condition. Gap detection thresholds of sub-group D (10 – 10.11 years) and sub-group E (11 – 12 years) of children were not significantly different from young-adults in any of the five conditions.

Wilcoxon's signed ranks test was done to compare Gap detection thresholds in five conditions with each other in each sub-group of children. Results of Wilcoxon's signed ranks test revealed the following facts: Gap detection thresholds of children's sub-group A (7 – 7.11years) was significantly different for each of the five conditions i.e. (quiet, +15 dB SNR, +10 dB SNR, +5 dB SNR and 0 dB SNR). There was no significant difference between quiet and +15 dB SNR condition on Gap detection thresholds in sub-group B (8 – 8.11 years), sub-group C (9 – 9.11 years), sub-group D (10 – 10.11 years) and sub-group E (11 – 12 years) of children, whereas Gap detection thresholds for the other three conditions i.e. +10 dB SNR, +5 dB SNR and 0 dB SNR were significantly different from each other and from quiet and +15 dB SNR condition also.

## Discussion

**Gap detection thresholds of children and young-adults in quiet condition:** Overall results of study show a significant difference in Gap detection thresholds of children and young- adults in quiet condition. Gap detection thresholds of sub-group A and sub-group B of children are significantly higher from young-adults in quiet conditions whereas the Gap detection thresholds of sub-group C, sub-group D and sub-group E of children are not significantly different from of the adults in quiet conditions. The results of the present study suggest that temporal processing in children develop till the age of 8 to 9 years and children perform equivalently to the young-adults on Gap Detection Test by the age of 9 to 10 years.

There is a large amount of contradiction in literature about time period when the children acquire similar performance to adults on temporal processing tasks.This finding on GDT is contrary to the findings of Morrongiello, Kulipg and Clifton (1984) & Jensen and Neff (1983), which suggested that the age of achievement of adult like temporal acuity is between 5 to 6 years. Also the results of the study contradict the finding of Shivaprakash (2003), in which children of age 6 to 7 years perform like adults on Gap Detection Test. This could be because of the different sample size employed in the present study.

The result of this study, however draws support from studies done by Irwin et al. (1985), Grouse, Hall and Gibbs (1993) & Davis and Mc-Croskey (1980), where it is suggested that children perform equivalently to adults by the age of 9 to 11 years.

### The effect of background noise on the Gap detection threshold in children and young-adults

**The effect of background noise on the GDT in young-adults:** It is clear from the results of the study that background noise impairs temporal processing in young-adults. Temporal processing performance deteriorates as the signal to noise ratio (SNR) is decreased. This deterioration in temporal processing task is evident by the results that show poorer (increased) Gap detection threshold (GDT) with the decreasing signal to noise ratio.

In general, it is found that GDT increased with the introduction of noise, this can be attributed to the poor temporal resolving power of the auditory system in the presence of noise. This finding is supported by the studies of Moore and Shailer (1983) & Snell (1997). Where it is revealed that Gap detection thresholds increase with the introduction of background noise.

From the results of the study it is discovered that as the signal to noise ratio (SNR) is decreased from + 15 dB SNR to 0 dB SNR there is a significant increase in Gap detection thresholds. This particular result of this study is in accordance with the finding of Moore and Shailer (1985) which suggests that Gap detection thresholds increase as signal to noise ratio (SNR) decreases and a SNR better than +12 dB SNR to +15 dB SNR do not cause any improvement in the Gap detection threshold.

**The effect of background noise on the GDT in children:** Like young-adults, introduction of background noise raises the Gap detection thresholds in children too. This can be due to fact that the presence of noise impairs temporal resolving abilities in children too. There is no quoted study in the literature about the effect of background noise on temporal processing (including Gap detection threshold) in children. However, it is evident from the studies on the auditory task performance (including detection tasks and speech perception impairments) in the presence of background noise in children, i.e., noise affects their performance in a variety of auditory tasks (Mills, 1975).

It is revealed from the results that Gap detection thresholds are higher for the conditions with the background noise than in quiet condition and Gap detection threshold increases as signal to noise ratio (SNR) is decreased from +15 dB SNR to 0 dB SNR. However, a significant increase in Gap detection threshold is not seen in +15 dB SNR condition than in quiet condition, except for children in sub-group A where a significant increase in Gap detection threshold with the introduction of noise at + 15 dB SNR is observed. From this result it can be suggested that a higher signal to noise ratio (SNR) like + 15 dB SNR do not have much effect on the temporal processing task (Gap detection threshold in this study), on the contrary a poorer signal to noise ratio (SNR) i.e. from +10 dB SNR to 0 dB SNR deteriorates temporal processing in a significant manner. The result of the children in sub-group A can be attributed to their higher sensitivity to noise or poorly developed temporal processing abilities in presence of noise when compared to the other sub-groups of children.

Also the results of the study suggest that with the increasing age children's sensitivity to noise is decreasing i.e. as the age increases there is a improvement in performance on temporal processing tasks (Gap detection thresholds in this study). This is evident from their relative performance at different signal to noise ratio (SNR) as follows: At 0 dB SNR, Gap detection thresholds of sub-group A, sub-group B and sub-group C are significantly higher than sub-group E. Gap detection thresholds of sub-group A and sub-group B, are significantly higher from Gap detection threshold of sub-group D and sub-group E. There is no difference in performance between sub-group A and sub-group B, sub-group B and sub-group C, between sub-group C and sub-group D & sub-group D and sub-group E.

At +5 dB SNR, Gap detection thresholds of sub-group A and sub-group B, are significantly higher than Gap detection threshold of sub-group D and sub-group E. Gap detection thresholds of sub-group A are significantly higher than Gap detection threshold of sub-group C. For the same condition there is no significant difference in performance between sub-group A and sub-group B, sub-group B and sub-group C, sub-group C and sub-group D & sub-group D and sub-group E. At +10 dB SNR, Gap detection thresholds of sub-group A are significantly higher than Gap detection threshold of sub-group C, sub-group D and sub-group E. Gap detection thresholds of sub-group B are significantly higher than Gap detection threshold of sub-group D and sub-group E. For the same condition there is no significant difference in performance between sub-group A and sub-group B, sub-group B and sub-group C, sub-group C and sub-group D & sub-group D and sub-group E.

At +15 dB SNR, Gap detection threshold of sub-group A is significantly higher than other sub-groups of children except sub-group B. Other sub-groups of children i.e. sub-group B, sub-group C, sub-group D and sub-group E showed similar performance at +15 dB SNR.

Although a significant difference is not obtained for any of the adjacent sub-groups of children i.e. A-B, B-C, C-D and D-E (which could be because of the small sample size in each sub-group) but the mean Gap detection thresholds shown in Table 1, suggest poor performance on temporal processing tasks in presence of background noise of (1) sub-group A when compared to sub-group B. (2) sub-group B when compared to sub-group C (3) sub-group C when compared to sub-group D (4) sub-group D shows poorer performance when compared to sub-group E only for +5 dB SNR and 0 dB SNR.

This suggest that at poorer signal to noise ratio i.e. +5 dB SNR and 0 dB SNR performance on temporal processing task in presence of background noise is improving up to the age of 11 to 12 years, whereas for better signal to noise ratio i.e. +10 dB SNR and +15 dB SNR performance on temporal processing task in presence of background noise was improving up to the age of 10 to 11 years. These both results can be attributed to the fact that poorer SNR results in better performance in auditory tasks as the age increases (Mills, 1975). Goldman et al. (1970, as cited in Mills, 1975) suggested that the performance of 10 years and younger is affected more by the presence of competing noise (cafeteria noise, monosyllabic words, SNR=9) than the performance of older children and adults on Goldman-Fristoe-Woodcock test of auditory discrimination. Stuart (2005) evaluated performance of 80 normal hearing school age children (6 to 15 years) and 16 normal hearing young-adults with Northwestern University-Children's perception of speech (NU-CHIPs) stimuli in quiet and in backgrounds of competing continuous steady-state and interrupted SNR's 10, 0, -10 and -20 dB. The results suggest that by 8 years of age children's performance in quiet equated to that of the adult levels, but did not do so in noise until after 11 years of age.

**Comparison between children and young-adults in their performance on GDT in presence of background noise:** Sub-group A, sub-group B and sub-group C show significantly higher Gap detection thresholds in all four conditions of noise than young-adults, whereas sub-group D and sub-group E show no significant difference for any of the four conditions of noise.

There is no study quoted in the literature about children and young-adult's differences in temporal processing task in the presence of noise, however it is evident from the studies on the effect of noise on various auditory abilities ( e.g. speech intelligibility, speech discrimination, etc) that children require higher signal to noise (SNR) to perform equivalent to young-adults (Mills, 1975). So, it can be concluded from these results that the temporal processing abilities in children in presence of noise is developing upto the age of 9 to 10 years and performance on temporal processing task in the presence of background noise reaches young-adult's like performance by the age of 10 to 11 years.

## Conclusions

Background noise affects temporal processing in both children and young-adults. Background noise impairs temporal processing in children more than the adults, which could be because of the fact that children are more sensitive to noise, poor temporal resolving abilities in children in presence of noise or poorly developed temporal processing abilities in children as compared to young-adults.

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