Random Gap Detection Test: A Useful Measure of Auditory Ageing?

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Introduction
Older listeners often perform poorly on tasks of speech understanding in noisy and reverberant listening conditions. It has been suggested that deficits in temporal resolution and in the precedence effect may be responsible for this difficulty [1], with gaps between sounds becoming less distinct with age. Temporal resolution is defined as "the ability of the auditory system to respond to rapid changes in the envelope of a sound over time" [2], and gap-detection paradigms measure a key aspect of this ability. They assess the smallest time interval between two stimuli that can be detected either cortically or at the level of the brainstem. In the normal hearing population, psychoacoustic gap detection thresholds are typically between 2 and 20 milliseconds (ms) [3]. One commercially available test for the assessment of gap detection ability is the Random Gap Detection Test (RGDT) [4].

Evaluation of temporal processing ability is required for the diagnosis of Auditory Processing Disorders (APD). Recent consensus studies including the American Speech and Hearing Association position statement (ASHA, 2005) [5], and the Bruton (2000) consensus on the diagnosis of APD in school age children [6], stipulate the evaluation of temporal aspects of audition as part of a diagnostic test battery. In addition, childhood speech-processing dysfunction may result from temporal processing disorders [7].

The effects of ageing on temporal resolution ability remain unclear. Musiek et al (2005) argue that "older subjects may present with increased GDTs in comparison to younger control subjects" [8], however only limited normative data are available for this age group. As far as we are aware, no age-related normative data exist for gap detection using click (broadband) stimuli. The following results are discussed in this light and with a view to identifying age-related effects on temporal resolution ability, as measured by the RGDT.

Participants and Methods
Participants
Subjects were recruited from a larger study investigating effects of ageing on the ability to hear and reproduce synthetic speech [9], and were divided into two groups: a younger group (aged 18-30 years; 2 males, n=11) and an older group (aged 50-67 years; 10 males, n=22). Informed consent was obtained in all cases.

Methods
Pure Tone Audiometry (PTA) thresholds were assessed across the 500 Hz to 4 kHz range. Only participants with pure-tone average of 20 dB HL or less for the frequencies 500 Hz, 1 kHz, 2 kHz and 4kHz were included in the study. All subjects had normal middle ear function as assessed by tympanometry. For the *Random Gap Detection test,* stimuli were presented at 60dB HL to subjects in a soundproof booth using a Sony Personal CD player connected to a Grason-Stadler GSI 61 Audiometer, with subjects listening through Telephonics TDH-50P Headphones. The

RGDT is available on CD (AudiTec Ltd, St Louis), and comprises 7 sections summarised in Table 1 below.

Subtest	Stimuli Type	Stimuli Duration	Gap presentation order
Practice/ Screening	500 Hz pure tone pairs	15 ms	Ascending
Tonal Stimuli 1	500 Hz pure tone pairs	15 ms	Random
Tonal Stimuli 2	1 kHz pure tone pairs	15 ms	Random
Tonal Stimuli 3	2 kHz pure tone pairs	15 ms	Random
Tonal Stimuli 4	4 kHz pure tone pairs	15 ms	Random
Practice/ Screening	Click pairs	230 μs	Ascending
Click Stimuli 1	Click pairs	230 μs	Random

Table 1: RGDT Stimuli

Tone and click pairs were presented with inter-stimuli intervals of 0, 2, 5, 10, 15, 20, 25, 30 and 40 milliseconds – in ascending order for the practice/ screening subtests, and in random order for the tonal and click tests. Stimulus pairs were separated by a 4.5 second interval to give subjects time to respond.

Results

Mean gap detection thresholds are shown in Table 2. Group means for all stimuli were lower for younger subjects, although the groups did not differ significantly for tonal stimuli at 1000 Hz, 2000 Hz or 4000 Hz, or for paired click stimuli. This lack of statistical evidence of a difference is reflected in the confidence intervals, in that they span zero for these stimuli. There was however a significant difference between the two groups for tonal stimuli presented at 500 Hz. Keith (2000) [3] established mean thresholds values of: 8 ms for 8-50 year olds, 9 ms for 60 year olds, and 22 ms for 70 year olds. For the younger subjects in our sample, thresholds compare favourably with these values although our data would suggest higher thresholds for 50 to 60 year olds.

	500 Hz	1000 Hz	2000 Hz	4000 Hz	Clicks
Younger Group (18-30 years)	8.23	8.62	8.15	6.85	9.23
Older Group (50-67 years)	18.95	14.45	13.45	10.95	12.15
Difference	10.72	5.83	5.3	4.1	2.92
Mann-Whitney U	189.5	151.5	141	168	120
Probability	0.008**	0.24	0.45	0.06	0.98
95% Confidence Interval	2.99 to 13.00	-0.00005 to 10.00	-3.00 to 7.99	-0.000069 to 7.99	-4.99 to 5.00

Table 2: Mean Gap Detection Thresholds (ms) for Older and Younger Subjects

Figure 1 summarises group variance measures. There was generally less variance within the younger group, particularly for the 500 Hz tone pairs. For the other stimulus categories, median values and first quartile values were similar between groups. The groups appeared to be most alike when comparing thresholds for the higher frequency pure tones and click stimuli. The increased range for the older group is due in part to the fact that several older subjects had thresholds of 40ms or higher for all stimuli.
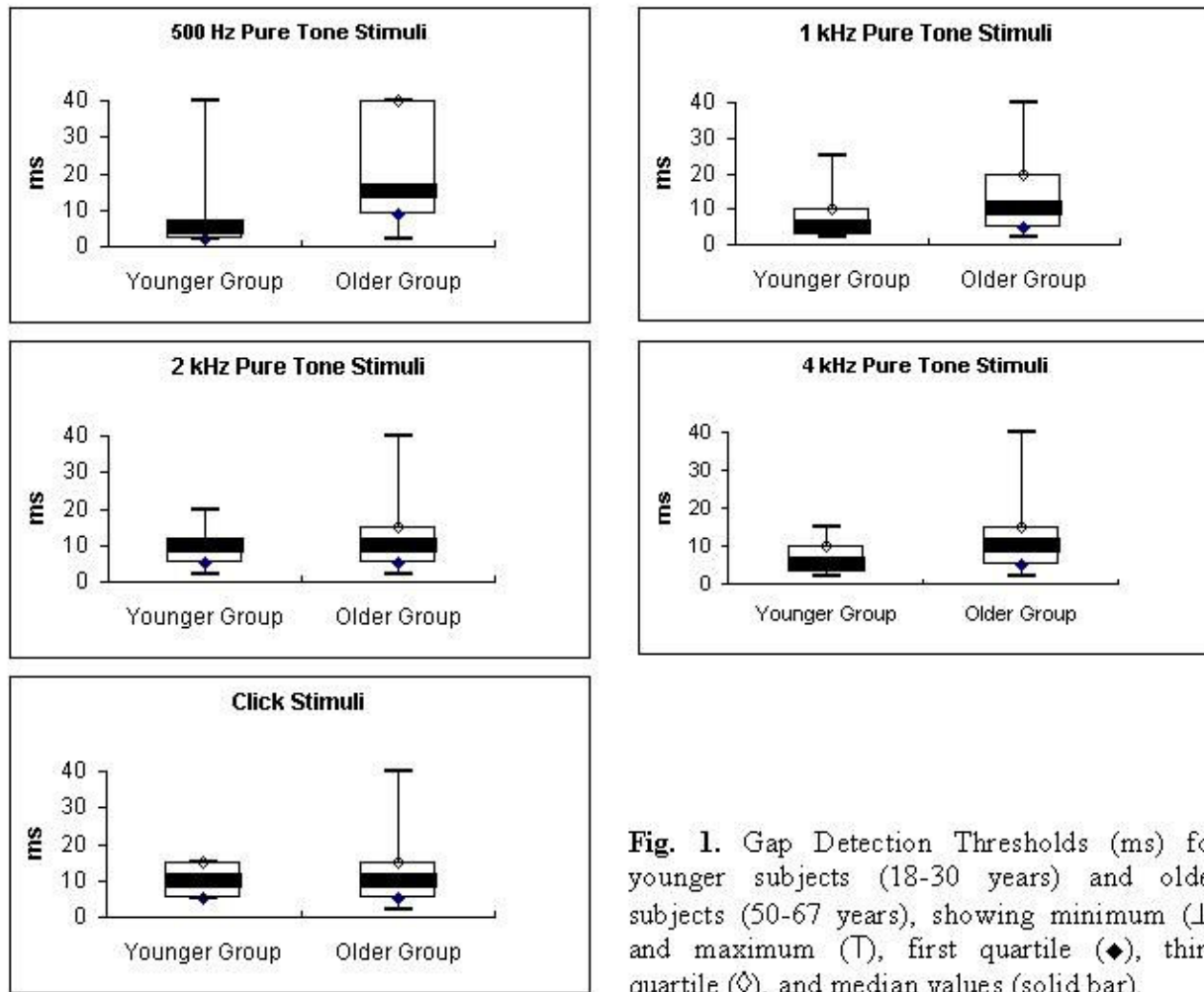
Fig. 1. Gap Detection Thresholds (ms) for younger subjects (18-30 years) and older subjects (50-67 years), showing minimum (⊥) and maximum (⊤), first quartile (◆), third quartile (◊), and median values (solid bar).

Discussion

Results suggest that younger adults are better able to detect short gaps between low frequency stimulus pairs than older adults. However, the design of the RGDT is such that 500 Hz is always the first frequency tested (after the practice/ screening subtest) and so the possibility that younger subjects are simply quicker at understanding the test cannot be discounted. Further research is needed to establish the strength of this association. Future studies should incorporate a randomised presentation order for tonal frequencies to control for presentation order effects. It may also be necessary to increase the range of gap durations tested to make the test more fine-grained and, at the upper end, to allow for normal hearing subjects who are not able to detect gaps of 40 ms. Additional practice sessions would help those subjects who found the test concept difficult.

The development and validation of the Gaps-in-Noise (GIN) test by Musiek et al (2005) [8] reflects the need to develop temporal resolution measures that take account of processing in the presence of background noise, since this is the situation that most affects speech comprehension for older adults. Gap detection thresholds for gaps of between 2 and 20 ms inserted into segments of white noise were shown to be significant predictors of the presence of brainstem and cortical lesions in a clinical sample, with 67% sensitivity and 94% specificity. This test could be applied to a non-clinical sample and therefore broadens the scope for future studies.

Previous research has shown that the ability to detect gaps between two broadband noise stimuli predicts performance on speech recognition in noise tests [10], while the ability to detect a gap between tones is not correlated with speech recognition in noise [11]. We did not find an effect of ageing on the detection of gaps between click (broadband noise) stimuli, and it may be worthwhile in future studies to increase the sample size and to include subjects who report speech-comprehension difficulties in background noise.

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