Younger and Older Adults Demonstrate Similar Ability to Focus Attention When Listening to Signals in Noise

Dana R. Murphy, Filippo Speranza, Giampaolo Moraglia, and Bruce Schneider
Department of Psychology, University of Toronto at Mississauga, Mississauga, ON L5L 1C6

A pure-tone signal embedded in a background noise is easier to detect when its frequency is known, indicating that listeners can narrow their attentional focus to a specific frequency region. Low-intensity signals falling within the attentional "window" or band are detected whereas equally-intense signals falling outside the window are not as easily detected (Dai, Scharf, & Buus, 1991; Greenberg & Larkin, 1968; Scharf Quigley, Aoki, Peachey, & Reeves, 1987). To get listeners to establish an attentional focus, listeners are typically presented with a prime tone immediately before each detection trial. On most of the trials, the tone to be detected is identical to the prime; on the remainder of trials, a probe tone differing in frequency but not in intensity is presented. The detection accuracy for the primary and for each of the probes is then compared with the detection accuracy for each of these stimuli when they are being presented alone.

Scharf and his colleagues (Dai et al. 1991; Scharf et al., 1987) have used this "probe-signal" methodology to demonstrate that younger adults can effectively focus their attention on a narrow range of frequencies (typically corresponding to the critical bandwidth centred at the primary frequency). When attention is focused in such a way, probe-tone detection accuracy is maximal when the probe tone is identical to the priming tone, and declines to change levels as the frequency separation between the probe and prime tone approaches the limits of the critical band.

While extensive testing has been conducted on younger adults, there has been little or no use of the probe-signal methodology to test the ability of older adults to effectively focus their attention when detecting signals in noise. Cognitive psychology research has indicated that younger and older adults differ in terms of their ability to selectively focus their attention in the auditory modality (Barr & Giambra, 1990; Panek, Barrett, Sterns, & Alexander, 1978) with cognitive aging theorist proposing that this is related to an inability to inhibit the processing of unwanted information (Hasher, Soltsfus, Zacks, & Rympa 1991; Hasher & Zacks, 1988; McDowd & Oseas-Kreger, 1991; Tipper, 1991). If older adults do indeed have such difficulties focusing their attention and inhibiting the processing of unwanted information, then the possibility exists that the older adults will not detect tones in the same fashion as younger adults in a probe-signal situation. In particular, older adults would not demonstrate a tight focus of attention and would instead detect all tones at the same level of accuracy.

A possible basis for expecting a broader attentional focus in older adults comes from the work of Scharf and his colleagues (Scharf, Magnun, & Chays, 1997; Scharf, Magnun, Collett, Ulmer, & Chays, 1994), who have shown that individuals who have had their olivocochlear bundle severed do not demonstrate attentional selectivity in the probe-signal methodology. The olivocochlear bundle is known to be an important part of the efferent auditory pathway leading from the cortex to the cochlea. This system is believed to be important in allowing for the top-down control of the micro-mechanical properties of the cochlea and may serve an important role in detecting signals in noise. The olivocochlear bundle synapses mostly with outer hair cells of the cochlea which are known to suffer widespread damage as a person ages. In addition, infants and very younger children (also known to have inhibitory problems) do not show the attentional selectivity of young adults (Bargones & Werner, 1994). Thus, the possibility exists that older adults will also show a lack of attentional focus.

Method

Participants

Seven younger adults (mean age = 21.00 years) and 7 older adults (mean age = 69.71 years) participated in this research. All participants had what is considered to be "normal" hearing. That is, they all had pure tone thresholds 25 dB HL for all frequencies 3000 Hz (consideration was given such that one frequency could be 35 dB HL).

Apparatus and Material

In this experiment, we presented pure tones varying in frequency. We presented these tones over a Tucker Davis sound board and Tucker Davis equipment. These pure tones were then delivered to the right earphone of TDH 49 earphones.

We used 7 pure tones in this experiment. For the primary tone, we used a 350 ms 1-kHz tone. We used an additional 6 tones as probe frequencies. The specific frequencies of these probes were 800, 875, 950, 1050, 1125, and 1200 Hz. All tones were ramped on and off with a 10 ms ramp and were presented in a background of continuous noise presented at an overall level of approximately 60 dB SPL (approximately 25 dB/Hz).

Procedure

Individuals were tested in 3 phases in this experiment. In the first phase of the experiment, we used a method of constant stimuli to determine the level of the 1-kHz primary tone that would produce 85% accuracy when detected in noise in a standard 2IFC paradigm. To determine the level necessary for 85% accuracy, we found a level of presentation that produced accuracy above 85% over 100 trials and a level of presentation that produced accuracy below 85% (but above chance) over 100 trials and then calculated the 85% threshold by means of linear interpolation.

This 85% threshold was then used to set the level for all of the tones the individual listened to in the second phase of the experiment. Thus, all 6 of the probe frequencies as well as the primary frequency were presented at the same level which was the level producing 85% accuracy of detection for a 1-kHz tone as determined in phase 1.

In the second phase of the experiment, we used a variant of the probe-signal methodology similar to that used by Dai et al (1991). All individuals were required to detect the presence of a tone in a standard 2IFC paradigm with the tone presented in noise. To begin each trial, the participant pushed the middle button of a 3-button button-box. Five hundred milliseconds after the button press starting the trial, a "warning" tone (also a 1-kHz tone presented at 60 dB) was presented for 350 ms. This was followed by 400 ms of silence and then the noise began. This was followed 100 ms later by the first interval lasting for a total of 350 ms. This interval was signified by the presentation of a light above the left hand-button of the button box. Five-hundred ms after the end of the first interval, the second interval began which also lasted for 350 ms. This interval was marked by the presentation of a light above the right- hand button on the button box. The noise ceased 100 ms after the end of the second interval and there was silence until the participant indicated which interval contained the target stimulus by pressing the appropriate button. There was no feedback provided following the participant's response. Instead, the light above the central button came on indicating that the system was ready for the next trial and the participant pushed the center button when ready to begin the next trial.

In this probe-signal phase of the experiment, all 7 tones were presented. The primary tone (1-kHz) was presented on 75% of the trials while one of the 6 probe tones was presented on the remaining 25% of the trials. In addition, a warning tone (a 1-kHz) tone was presented prior to the two intervals in the 2IFC paradigm. Participants were instructed to listen for a tone in one of the two intervals and indicate which interval contained the tone by pressing the appropriate button.

In the third and final phase of this experiment (the single frequency phase), individuals were tested for their detection accuracy for each frequency used in the experiment when only one single frequency was tested. Testing was completed with the same methodology used in the probe-signal phase of the experiment, except that only one tone was presented in a block of 100 trials. This tone was used as both the primary and the warning tone in the 2IFC paradigm described previously. Completion of the testing of the different frequencies was counterbalanced so that no two individuals within an age-group completed testing in exactly the same order.

Results

Figure 1 presents the mean detection accuracy for both younger and older adults at each frequency when multiple frequencies were presented in the Probe-Signal condition, and when only single frequencies were presented as both prime and probe. The top two lines represent data from Single Frequency testing (circles represent older adults, squares represent younger adults) while the lower two lines represent the data from the probe- signal phase of the experiment (labeled Prb-Sig, circles represent older adults, squares represent younger adults). It is easy to see from this figure that younger and older adults are performing very similarly in this task, with both groups demonstrating a very narrow focus of attention. In particular, tones with frequencies more than one critical band away from the primary stimulus are processed at a level of accuracy near chance, while the two frequencies that are within 1 critical band are detected with a greater than chance level of accuracy. Meanwhile, the primary frequency is detected with a very similar level of accuracy as when it was tested alone.

Discussion

Clearly, younger and older adults demonstrate a similar ability to focus attention in order to improve their ability to detect pure tones presented in noise. Both age groups demonstrate a very narrow band of attentional focus. Only the two tones within 1 critical band away from the expected primary frequency were detected with a greater than chance level of accuracy. Thus, when detecting tones in noise, younger and older adults seem to demonstrate a very similar ability to narrow their focus in order to improve detection. This indicates that the differences between the two age groups in terms of inhibitory functioning are either smaller than expected or that the inhibitory functioning of the older adults remains intact for such simple auditory stimuli. We do not know if the ability to narrowly focus attention will be the same in all situations and with all stimuli. Perhaps more complicated stimuli (such as words or spoken sentences) do not lend themselves to the same sort of selective analysis in noisy situations. This would mean that older adults, despite their ability to narrowly focus attention when processing very simple stimuli may find it difficult to narrow their focus when more complex stimuli are employed and multiple frequency regions might have to be monitored. More research is needed in order to determine if older adults do indeed have difficulty narrowing their focus when trying to process more complex stimuli in noisy situations.

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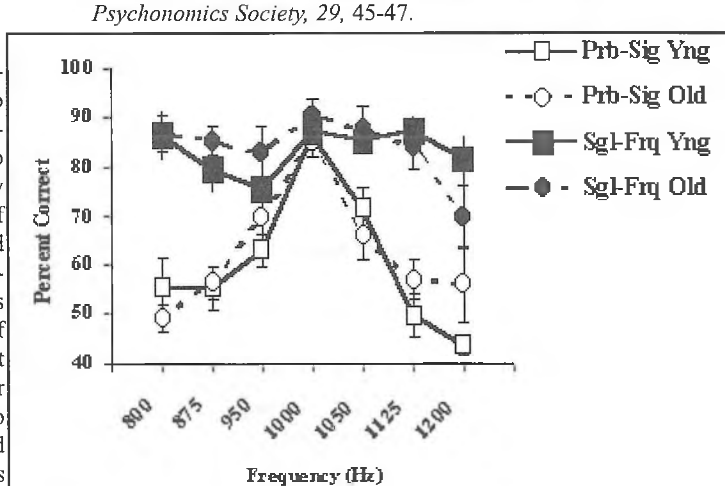

Figure 1. Mean detection accuracy of younger and older adults as a function of testing phase. Prb-Sig = Probe-Signal testing (Phase 2). Sgl-Frq = Single Frequency testing (Phase 3).