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Older Adults Don't Notice their Names: A New Twist to a Classic Attention Task

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Abstract

Although older adults have lower working memory spans on average than young adults, we demonstrate in five experiments one way in which older adults paradoxically resemble higher-capacity young adults. Specifically, in a selective-listening task, older adults almost always failed to notice their names presented in an unattended channel. This is an exaggeration of what high-span young adults show, and the opposite of what low spans show. This striking finding in older adults remained significant after controlling for working memory span and for noticing their names in an attended channel. The findings were replicated when presentation rate was made slower and when the ear in which the unattended name was presented was controlled. These results point to an account of older adults' performance involving not only an inhibition factor, which allows high-span young adults to suppress the channel to be ignored, but also an attentional capacity factor, with more unallocated capacity allowing low-span young adults to notice their names much more often than older adults with comparably low spans.

Keywords

Selective attention; Working Memory; Young and old; Divided attention; Cocktail party effect

Older Adults Don't Notice their Names: A New Twist to a Classic Attention Task

A hallmark of multiple psychological processes is the occurrence of a constellation of behavioral effects that cannot be explained by a single process, and the present work focuses on one such case for cognitive aging; quite a dramatic one in fact.

Many accounts of cognitive aging highlight age differences in working memory task performance. In such tasks, participants must process information while storing a small number of items, and the capacity for these items is measured. A variable that has been important in explaining individual differences in working memory in young adults is the ability to tune out or suppress irrelevant information in order to do a better job of storing and processing relevant information (e.g., Bunting, 2006; Kane, Bleckley, Conway, & Engle, 2001). Similarly, deficits in this process of inhibition in aging adults has been noted as an important source of cognitive decline (e.g., Hasher, Stolzhus, Zacks, & Rypma, 1991; Hasher, Tonev, Lustig, & Zacks, 2001; Lustig, May, & Hasher, 2001).

Several recent studies present a less certain, more ambiguous picture regarding the role of inhibition in age-related decline (e.g., in visual selective attention, Schooler, Neumann, Caplan, & Roberts, 1997; in the ability to ignore a color word and name its color, McDowd & Shaw, 2000; in this Stroop performance and also negative priming, Verhaeghen & Cerella, 2002). Verhaeghen (2011) suggested broadly, on the basis of a large meta-analysis of literature, that the central executive control of cognition (including inhibitory processing) does not account for variance in aging beyond the effects of processing speed and working memory. Taken together, all of this work suggests that inhibition is not the only basis of adult cognitive aging and that we do not yet have a clear idea of when other factors predominate.

There is recent research suggesting that older adults retain fewer items in a capacity-limited working memory store than younger adults (Cowan, Naveh-Benjamin, Kilb, & Sauls, 2006; Gilchrist, Cowan, & Naveh-Benjamin, 2008; Naveh-Benjamin, Cowan, Kilb, & Chen, 2007). An important question is which factor is primary. Do working memory differences cause differences in performance on inhibition tasks, or vice versa?

Although this may seem like an intractable question, one classic procedure pits inhibition and capacity against one another. Specifically, Moray (1959) used a dichotic listening task in which participants shadowed (repeated) the relevant message presented to one ear, and had to ignore the irrelevant message in the other ear, into which their name was inserted. About one-third of the participants reported hearing their name in the unattended channel, a finding replicated by Wood & Cowan (1995). Conway, Cowan and Bunting (2001) used the improved method of Wood and Cowan to ask which participants notice their names. According to one hypothesis, a large working memory capacity would allow one both to pay

attention to the relevant message and to monitor the irrelevant message, enabling noticing of one's own name should it appear in the unattended channel. The alternative hypothesis is that having a large working memory capacity would be related to having relatively good cognitive control over the allocation of attention to the relevant message, resulting in the ability to inhibit information presented in the unattended message so as to avoid distraction. Conway et al. found that only 20% of participants in the top quartile of working memory capacity noticed their name in the unattended channel, whereas 65% of those in the bottom quartile noticed their names. This finding is heavily in support of the inhibition hypothesis; low spans did not inhibit the irrelevant channel well and therefore were more likely than high spans to notice their names. A further finding of Wood and Cowan and also Conway et al. was that those who noticed their names were much more likely than others to exhibit errors and pauses in the shadowing task just following the name, confirming that their attention was captured by the name after it was presented.

In our Experiment 1, we asked whether older adults' attention-control capabilities were comparable to those of young adults; especially those with equivalent working memory spans. If older adults (known to have smaller working memory spans than younger adults, e.g., Light and Anderson, 1985) process information in a manner comparable to younger adults with similar working memory spans, then participants in both of these groups should notice their names about equally often. If, on the other hand, older adults suffer from a working memory capacity deficit that is separable from the attention-control process, the result could be very different. In theories of working memory, attention control is represented by central executive processes that are separate from storage capabilities (e.g., Baddeley, 1986, 2007; Cowan, 1988, 2005) and it has been found that even attention-related storage and processing are partly overlapping and partly separate in terms of individual differences in young adults (Cowan, Fristoe, Elliott, Brunner, & Sauls, 2006). Unlike low-capacity young adults who may have poor control of attention, older adults on average may exert better control but could fail to have enough unoccupied capacity to notice their names, provided that they use their control to do a reasonably good job of favoring the relevant channel at the expense of the irrelevant channel.

EXPERIMENT 1

In this experiment, we used both younger and older adults in a dichotic listening paradigm to assess whether older adults notice their names, and to compare their performance to younger adults with high and low WM capacity. As in Conway et al. (2001), both acoustic messages included a list of single words presented sequentially for 5.5 minutes, with the participant's name and another control name inserted in the unattended message. Then participants were asked about information presented in the unattended channel. After completion of the dichotic listening task, each participant completed the Operation Span and the Reading Span tasks, to assess their WM capacity.

Method

Participants—The participants were 50 young adults and 29 older adults, all native English speakers. We screened the older participants for their auditory acuity using several measures. After testing several males who did quite poorly on the auditory acuity tasks, in

line with reports that older males show a more severe decline in hearing relative to older females (e.g., Kausler, 1992), we resorted to testing females only. Inasmuch as auditory presentation is used in all the current experiments, this resulted in the vast majority of the participants tested being female (with 4 younger males and 1 older male included in the current experiment).

One auditory acuity measure employed in 15 older participants included the use of a pure tone audiometer (Model MA-20, Maico Hearing Instruments) with headphones (see Lindenberger & Baltes, 1994). We measured thresholds separately for each ear at eight different frequencies from 500 to 8000 Hz. Since there are technical difficulties in using the audiometer with a hearing aid, none of our older participants used one during the test (see similar procedure by Lindenberger & Baltes, 1994). We tested the left and the right ear separately, beginning at the lowest intensity (i.e., loudness) of 25dB and increasing it gradually to 30, 40, 50, 60, and 80dB. Since the average sound level of the words presented in the experiment was 65dB and most speech frequencies lie between 100 and 4,000 Hz, we included the 12 older adults that were able to detect a sound of 60dB with a frequency of 6,000 Hz. The other measure used was the W-22 speech identification instrument (see Runge and Hosford-Dunn, 1985), in which 100 common monosyllabic words are presented via headphones one at a time (using intensity level 65 dB), with the participant required to say each word aloud. Presentation is response-paced with the next word being presented once the participant says a word, or indicates that he/she does not know or couldn't hear. We included participants who had a score higher than 65%. Overall, 12 of the 15 participants who were tested with the pure tone audiometer and the W-22 passed the above mentioned criteria and were included in the results. For the other 20 participants who were not tested by the above instruments we used their shadowing performance of the attended ear as the criterion for inclusion. We excluded 3 of them that were not able to shadow at least one of the 5 target words (see description in the following Stimuli and Procedure section). This resulted in an overall sample of 29 older adults.

Young participants were undergraduate students at the University of Missouri, who participated in the experiment for research credit in their introductory psychology course. The mean age for this group was 18.7 ($SD = 0.9$, range = 18–21). All older adults were high functioning residents in the community and reported being in good health. All were tested in other experiments in our laboratory and their performance level was as good as that of younger adults on several memory measures of item recognition. They were compensated \$15 for their participation in the current experiment. The mean age for this group was 72.5 ($SD = 6.1$, range = 64–86). Older adults had a somewhat higher level of formal education than the young adults ($M = 13.1$ and 14.5 and $SD = 0.8$ and 1.7 , for younger and older adults, respectively, $t(71) = 4.70$, $p < .01$). This difference seems inevitable if one is to use participants with similar life courses in both groups while the undergraduates' education is still ongoing.

Based on their performance on the WM span tasks (see below), approximately the top 30% of the young adults were categorized as having a high WM span and the bottom 30%, as having a low WM span. The numbers of participants differ slightly because of ties that shifted the boundary point. The young lower span group ($n=16$, $M=37.41$, $SEM=1.94$) had

memory span scores similar to the older adults group ($n=28$, $M=38.91$, $SEM=3.18$; one participant did not complete the span task), whereas the high-span young adults had scores quite a bit higher ($n=18$, $M=61$, $SEM=0.97$).

Half of each young span group and half of the older adult group were randomly assigned to a condition in which the participant's first name occurred in one of two slots: after 4 minutes of shadowing or after 5 minutes of shadowing. The other slot was filled with the name of a yoked control individual. The order of presentation of the participant's name and the yoked control name did not matter and therefore will not be discussed further.

Stimuli and Procedure

Selective attention task: Participants were tested individually in a sound-attenuated room. The audio stimuli were those used in the Conway et al. (2001) study, digitized and presented by computer through stereo headphones at a constant volume with an average intensity of 65dB and a range of 57–75dB. The relevant message, which lasted 5.5 minutes, contained 330 mono- and bi-syllabic words recorded in a monotone female voice at a rate of 60 words per minute. The irrelevant message also contained 330 mono- and bi-syllabic words, recorded in a monotone male voice. The onset of the words in both messages was synchronized, and samelength words (mono- or bi-syllabic) were matched to be presented simultaneously in both messages. The order of the words in both messages was kept constant across participants, except for the names, which were digitally inserted into the irrelevant messages in place of a word after 4 and 5 minutes of shadowing. We used the names that the participants preferred to call themselves, including nicknames. This information was obtained during a standard phone screening conversation with participants several days before the experiment. Participants were matched in pairs and, for each, we used the other's name as the yoked control name.

Participants were asked to listen to the message presented in the female voice to their right ear, and repeat aloud (shadow) each word as it was presented. They were told to make as few errors as possible, and also to ignore the distraction coming from the left ear. The experimenter sat with the participant throughout the experiment. Participants shadowed the attended message for 5.5 minutes until all words were presented. All these shadowing responses were recorded. After completing the shadowing, participants answered a questionnaire that included several probes. The first was whether they recalled any words from the unattended list, the second was whether the words they remembered from the unattended list have any special significance for them, and finally, the third was whether they recognized any names in the unattended list. Those who mentioned their name in response to any of these questions were counted as have noticed their name.

WM span tasks: We used two standard procedures to measure WM capacity. First, the Operation span task procedure was adapted from Turner and Engle (1989). It involved a presentation of a series of displays on the computer screen, each display containing a simple mathematical operation and a letter (for example, $5+9)/2 = 7 ? G$). The participant's task was to say each equation aloud, answer "yes" or "no" to whether the equation was correct, and then repeat aloud each letter. At the end of the series, participants had to report the

letters that appeared in the series in the order in which they appeared, by pressing buttons corresponding to one of the 12 letters presented on the computer screen. The number of letters to be remembered in each series was between 2 and 6. For each length, 3 series were presented, for a total of 15 series. Series length order was randomized for each participant. Second, the Reading span task (Daneman & Carpenter, 1980) was very similar to the Operation span task, except that instead of the mathematical operation, a sentence was presented along with the final letter, and participants responded “yes” or “no” to indicate whether the sentence was grammatically correct. For each task, the participant’s span score was the cumulative number of words he or she was able to recall from each series that was perfectly recalled with the items in the correct serial order. No credit was given for imperfect recall of a series. The use of visually-based working memory span tasks ensures that the qualities that apply to our auditory attention tasks are general across modalities, rather than auditory-specific resources (for documentation of such general working memory resources see Kane et al., 2004). Similarly, Conway et al. (2001) used a visually-based working memory task to gauge span to be compared with selective listening.

Results and Discussion

Performance on the Irrelevant Message (Name-Noticing)—Out of 50 young adults, 29 (58%) noticed their names, whereas out of 29 older adults, only 1 (i.e., 3%) noticed the name (see Table 1). These probabilities were highly significantly different, $p < .001$ by Fisher’s Exact Test. Moreover, as shown in Figure 1, this difference between younger and older adults was not the result of the difference in working memory span; the overlap between young and old in working memory span was considerable, whereas the difference in name-noticing was extreme. Among the young adults in the lower and higher quartiles, 69% and 33% noticed their names, respectively, a statistically significant difference by Fisher’s Exact Test, $p < .05$, closely replicating Conway et al. (2001). Most importantly, a comparison of the percentages of name-noticers among low-span young adults and older adults was highly significant by Fisher’s Exact Test, $p < .001$, even though these two groups had very similar working memory capacity scores.

On-line Attention Measure—The on-line measure of errors following the presentation of the name conform to the pattern observed by Conway et al. (2001) in that the number of errors in shadowing following the name was much higher in participants who went on to say they remembered their name. Among 22 young adults who had complete shadowing data and did not notice their names, the proportions of correct shadowing were similar across the five words spanning the period from two words before the presentation of the name in the unattended channel, through two words after the name (.91, .77, .95, .91, and .91), $F(4,84)=1.29$, $\eta_p^2=.06$, n.s. (see Figure 2). In contrast, among 28 young adults who had complete shadowing data and did notice their names, the proportions correct were not all the same, with accuracies of .93, .86, .89, .54, and .71, $F(4,108)=5.11$, $\eta_p^2=.16$, $p < .001$ (see Figure 2); the next-to-last measurement was significantly below the others according to Newman-Keuls post-hoc tests, providing evidence of shifting attention following the name presentation.

One possibility to consider is that older adults might notice their names at the time of the name presentation and then forget the name by the time of the post-shadowing questionnaire (which was administered 30 to 90 s after the name presentation). However, the shadowing data did not support that possibility. An ANOVA in the 28 older adults who did not notice their names showed no significant change in accuracy across the five-word period from two words before the name to two words after it, $F(4,108)=0.58$, $\eta_p^2=.02$ (see Figure 2). Shadowing accuracy in these participants at the five intervals was .83, .83, .80, .87, and .78.

No participant noticed the yoked control name, in keeping with the finding of Conway et al. (2001). Finally, the older adults' failure to notice their names could not be attributed to fatigue over the testing period (as their name appeared after 4 or 5 minutes of shadowing). Their mean proportion of words shadowed correctly for each 30-s period of shadowing was .83, .83, .85, .86, .86, .86, .89, .87, .87, .89, and .87, respectively, and these words had to be shadowed quickly given the 1 word per second presentation rate.

This experiment shows that there is a striking inability of older adults to notice their own names in an unattended channel of selective listening. We next felt that we needed to know more about the specificity of this finding. Is attention in older adults strongly focused on the attended channel that represents the assigned task, or would older adults fail to notice their names just as often when these were presented in the attended channel in selective listening? The second experiment addressed that question.

EXPERIMENT 2

Method

There were 20 older adults with a mean age of 70.65 years ($SD = 4.88$, range = 64–79). They were screened for their hearing in the same way as done in Experiment 1 in order to minimize the role of hearing problems in performance, and the final older participant group was composed only of females due to older males' poorer hearing. There were 20 younger adults with a mean age of 18.9 years ($SD = 0.55$, range = 18–20). None of the younger or older participants has taken part in Experiment 1. As in Experiment 1, older adults had a somewhat higher level of formal education than the young adults ($M = 12.1$ and 13.7 and $SD = 0.5$ and 2.1 , for younger and older adults, respectively, $t(38) = 3.14$, $p < .01$). The method was the same as in Experiment 1 except that the participant's name was inserted into the channel to be shadowed instead of the unattended channel, and the working memory tasks were not administered. The name replaced a word on the attended channel, which was moved to the original name position in the unattended channel. The name and the replaced word appeared in the same voice (male or female) as the rest of each of the respective messages.

Results and Discussion

In shadowing, the name in the attended channel was pronounced by 14 of 20 young adults (70%) and by 9 of 20 older adults (45%). For comparability with Experiment 1, however, a more important measure might be indication in the post-shadowing questionnaire that the name was heard. This was the case for 17 of 20 young adults (85%) and 7 of 20 older adults (35%).

Discrepancies between the measures were possible in part because the name could be noted without having been pronounced adequately during shadowing. Both some young and some older adults made this error. Another type of error was correctly pronouncing the name, yet failing to report it in the post-shadowing questionnaire, which happened in three of the older adults and not at all in younger adults. It happened in two older adults who may have forgotten that their name had occurred, and a third whose name was identical to a common noun (Dot) and during shadowing interpreted the list item as the common noun, according to a subsequent questionnaire answer.

Thus, older adults recalled hearing their name much more often in Experiment 2, in which the name was in the attended channel, than in Experiment 1, in which the name was in the unattended channel (but still not as often as younger adults). Note that potential auditory interference among events in the two channels (attended and unattended) was identical in both Experiments 1 and 2. (In an unpublished report from our lab, when the name appeared in an attended singly-presented channel, older adults have performed similarly to younger adults in shadowing their name, 61% and 71%, for older and younger adults, respectively).

One interesting question is why the names in the shadowed channel were repeated less frequently than other words in the shadowed channel, especially in older adults (45% for the names in Experiment 2 versus 57% for other words,). We gather that this difference may occur because the older adults are not expecting to hear their names and therefore are biased against perceiving the sounds that way, perhaps assuming that they must have mis-heard some other word. This type of attribution may be more likely for older adults, given the extra attention they may need for perceiving speech.

Comparison with Experiment 1 Results—For detailed comparison with Experiment 1, we use the more conservative outcome, the post-shadowing questionnaire. The statistical comparison between two groups of participants at different levels of name detection is an important psychometric problem. We address it based on a simple model of performance. It is assumed in this model that the probability of noticing one's name in an attended channel for a Group x is A_x . Then it is assumed that the probability of noticing the name in an unattended channel for that same group, P_x is as follows:

$$P_x = A_x U_x.$$

Within this product, U_x represents the reduction in name-noticing due to making the name presentation unattended. It is multiplied by A_x under the assumption that the presence of noticing the name in an attended presentation is, on average, more likely than noticing the name in an unattended presentation. The results of Experiment 2 show that the two groups differ in A_x and the question we ask is whether they differ also in U_x (that is, whether $U_y > U_o$) or whether the group difference can be attributed entirely to A_x .

For young adults, $A_y = .85$ (from Experiment 2) and $A_y U_y = P_y = .58$ (from Experiment 1). Therefore, for young adults, $U_y = .58 / .85 = .68$. In the older adults, $A_o = .35$. The next step in our calculation is to see whether we get a reasonable value of P_o if we assume that $U_y = U_o$. If not, then that will serve as a demonstration that $U_y > U_o$.

What we find if we do assume that $U_y = U_o$ is that $P_o = A_o U_y = (.35)(.68) = .24$. What we learn is that the assumption leads to an unreasonable result. In particular, it leads to the expectation that in Experiment 1, 6.96 older participants ($= 29 \times .24$) noticed their name, and the other 22.04 did not notice. These expected frequencies are significantly less extreme than the observed frequencies of 1 and 30 of older adults who noticed, and did not notice their names, respectively, $\chi^2(1) = 6.71$, $p < .01$, indicating that it is untenable to assume $U_o = U_y$. That is, even taking into account the group differences in noticing and remembering the name in the attended channel in Experiment 2, older adults still appear to be less likely than young adults to notice their name in an unattended channel. Estimates were $U_y = .68$ as shown above, versus $U_o = .10$ calculated similarly for older adults.

In Experiment 3 we investigated the control of attention issue in another way, asking whether younger and older adults would differ in the ability to notice their names when attention is divided between channels, rather than focused on the attended channel, as in Experiments 1 and 2; participants were asked to shadow one channel and also listen for their name in the other channel. Given that no inhibition is required but the processing load is heavy, age group differences should be indicative of differences in basic capacity, not inhibition. Colflesh and Conway (2007) carried out this kind of divided-attention task with young adults and found that high spans noticed their names more often than low spans. We replicated this finding and extended the procedure to older adults. In the second part of the session we used a visual shadowing task with an acoustic second channel to observe whether dividing attention could be made easier by making the channels less confusable, thus requiring still less attentional control (Johnston & Heinz, 1978).

EXPERIMENT 3

Method

Participants—The participants were 90 young adults and 24 older adults, all native English speakers taken from the same respective populations mentioned in Experiment 1. None of them had participated in either Experiment 1 or Experiment 2. They were screened for their hearing in the same way as done in Experiment 1 in order to minimize the role of hearing problems in performance, and the final older participant group was composed only of females due to older males' poorer hearing. The mean age for the younger group was 19.2 ($SD = 1.33$, range = 18–23), whereas the mean age for the older group was 70.4 ($SD = 6.01$, range = 64–84). As in Experiments 1 and 2, older adults had a somewhat higher level of formal education than did the young adults ($M = 12.9$ and 14.5 and $SD = 1.19$ and 1.46 , for younger and older adults, respectively, [$t(114) = 5.03$, $p < .01$]).

Stimuli and Procedure—The procedure was similar to the one used in Experiment 1 with the use of two simultaneously presented lists. Two trials were used (with one name presentation per trial). In the first, the list to be shadowed was presented auditorily (as in Experiments 1 and 2), and in the second trial it was presented visually. The second list for both trials was presented auditorily, as in previous experiments, and included the participant's and another person's name. As in previous experiments, participants were asked to shadow one message. However, in this experiment they were told that their name

would appear in the other message, and their task was to press a response key as soon as they heard it. WM capacity was measured by an operation span task.

Given that the participants were told to listen for their names, a post-experimental questionnaire would be meaningless and name-noticing was taken from the response at the time of the name presentation. Thus, there was no issue of remembering the name during the rest of shadowing.

Results and Discussion

We used performance on the operation span task to rank order the young participants, choosing the bottom 25% for the low WM group and the top 25% for the high working memory group ($n=24$ in each such group). The average score was 67.3 (range of 63 to 75) for high span younger adults, and 35.9 (range of 17 to 45) for low span younger adults. Older adults' average span was 35.4 (range of 3 to 67), similar to that of the low-span younger adults.

Name-detection During Auditory Shadowing—For the first list, where the shadowed list was presented auditorily, overall, 73% of the younger adults noticed their name in the non-shadowed channel. Breaking down that amount, 83% of high-span younger adults reported hearing their name, compared to 63% of the low-span younger adults (see Table 1). These results are opposite to those reported for young adults in Experiment 1 (when there was no task involving the channel in which the name appeared) and this provides a replication of the pattern of the results obtained by Colflesh & Conway (2007) under divided attention conditions, although the group difference was not significant by Fisher's exact test.

Interestingly, older adults still behaved in a manner very different from the younger adults, with only 43% noticing their name. Fisher's exact test showed that the probability of obtaining these proportions by chance (under the assumption that both young participants and older participants are equally able to detect their name in the non-shadowed message), is $p<.001$. The difference between older adults and low-span young adults, however, now did not reach significance. However, for further insight we examined a subset of participants who were matched as closely as possible to the older adults in span (and otherwise randomly selected). It was possible to match 17 younger-older participant pairs, and the result was a significant difference between them in name detection (younger, 14 of 17; older, 7 of 17, $p<.05$, Fisher Exact Test).

Comparison to Experiment 1—Notice that the proportions of younger and older adults noticing their names in a divided-attended condition in this experiment (.73 and .43, respectively) were quite similar to the proportions of younger and older adults noticing their names in fully-attended speech with a distracting channel in Experiment 2 (.70 and .45, respectively). Therefore, the same logic applies in that these results are much different than when the names are presented in channels to be ignored (.5 and .03, respectively). Thus, for older adults, the presentation of names in a truly unattended channel in Experiment 1 resulted in a much greater cost compared to attended or divided conditions, compared to the much smaller cost in younger adults.

Name-Detection during Visual Shadowing—For the second, spoken list presented along with a visual list to be shadowed, 79% of the younger adults noticed their name in the non-shadowed channel (see Table 1). There was no difference between high and low span younger adults in this regard; the percentage was the same for high- and low-span participants. The fact that low-span younger adults caught up in this trial with the high-span ones could be due to the nature of the shadowing task, which is less confusable with the second channel when the words in the shadowed channel are presented visually.

Interestingly, only 48% of older adults noticed their names. Fisher's exact test showed that the probability of obtaining these proportions by chance (under the assumption that both young participants and older participants are equally prone to the detecting of their name in the non-shadowed message), is $p < .05$. Furthermore, a comparison of older adults with low-span young participants using Fisher's exact test showed significant poorer performance in the former group, $p < .05$; the pattern was similar but non-significant in the first auditory list. Finally, the yoked control name was not noticed by any of the younger or older participants.

Across-Trial Correspondence—Out of 24 low-span young adults, 14 detected their name in the first, auditory trial and also the second, visual trial; 1, in the first trial only; 5, in the second trial only; and 4, in neither trial. Similarly, in high-span adults, the numbers were 16, 4, 3, and 1. These numbers were very different for older adults: 8, 2, 3, and 10. Thus, a considerably higher proportion of older adults failed to detect the name on either trial.

Note that the alignment of groups has shifted in this experiment compared to the previous ones. When the task involved ignoring one channel (in Experiment 1), the low-span young adults noticed their names the most often; the high-span young adults, less often; and older adults, least often. In the present, divided-attention experiment, the *high* spans noticed their names most often; the low-span young adults, less often; and the older adults, again least often.

It is possible that the older-adult failure to notice their names is in part not a failure of perception, but a failure of prospective memory, which is known to be deficient in older adults compared to young adults (Einstein & McDaniel, 2005). Specifically, they might have sometimes heard their names but have forgotten to press the response key. We do not think that this is very likely to be an important factor, though. Prospective memory failures are intermittent, and one might have expected a distribution in which more older individuals failed on Trial 1 or Trial 2, but not both. Instead, 18 of 23 older adults succeeded either both times or neither time. Moreover, older adults were noticeably worse than low-span younger adults, even though low spans also would be expected to be deficient in prospective memory. Ultimately, there is not a great difference in interpretation between the perceptual and prospective memory possibilities because the failure to keep active the secondary task goal (monitoring for one's own name) theoretically should result in *both* perceptual and response failures.

Although name-noticing always occurred least often in the elderly, it cannot be attributed to a perceptual deficit. Making the name unattended (in Experiment 1) without changing the acoustic arrangement significantly compounded the difficulty that older adults had in

noticing the name. This was clear in that the parameter U_o estimated across experiments was below the analogous parameter for young adults overall and, moreover, below the analogous parameter for either high- or low-span young adults. Also, easing the perceptual task in divided attention by making the channel to be shadowed visual was of only moderate help to young adults (bringing their name-noticing from 73% to 79%) and, similarly, was of only moderate help to older adults (bringing their name-noticing from 43% to 48%). If perceptual difficulty plagued older adults despite our hearing screening procedure, then we would expect that making the shadowing task easier should have helped older adults more than younger adults.

One issue related to the results of Experiment 1, is that of speed of processing of stimuli. Older adults are known to be slower than young adults in processing sensory stimuli (e.g., Salthouse, 1996). For example, Salthouse shows that for sequential tasks older adults' speed of processing is about 25% slower than that of younger ones. In our experiments, in which the shadowed words were presented every 1 second, this might have left older adults with less time to shadow the words, hence making the shadowing task more difficult for them, resulting in less opportunity to encode information (and particularly their name in the unattended channel). To make the shadowing task easier, in Experiment 4 we presented to a new group of younger and older adults an identical task to the one presented in Experiment 1, except that the words were presented at a pace of 1 every 1.25 seconds, a slowdown that should be adequate according to Salthouse. We looked at whether this will change the pattern of the results, and in particular, affect older adults' ability to detect their name in the unattended channel.

EXPERIMENT 4

Method

Participants—The participants were 31 young adults and 27 older adults, all native English speakers taken from the same respective populations mentioned in Experiment 1. None of them had participated in Experiments 1–3. They were screened for their hearing in the same way as done in Experiment 1 in order to minimize the role of hearing problems in performance, and the final older participant group was composed only of females due to older males' poorer hearing. To provide an appropriate comparison, the younger participant group also included only females. The mean age for the younger group was 19.1 ($SD = 1.61$, range = 18–23), whereas the mean age for the older group was 70.7 ($SD = 5.46$, range = 64–82). As in Experiments 1–3, older adults had a somewhat higher level of formal education than did the young adults ($M = 13.22$ and 14.53 and $SD = 1.56$ and 2.30 , for younger and older adults, respectively, $t(56) = 2.56$, $p < .05$).

Stimuli and Procedure—The procedure employed was identical to the one used in Experiment 1 with two simultaneously presented auditory lists. The non-attended list included the participant's and another person's name. As in previous experiments, participants were asked to shadow one list. Both messages were presented at a rate of 1.25 per word.

Results and Discussion

Performance on the Irrelevant Message (Name-Noticing)—Overall, 48% of the younger adults (15 of 31) noticed their name in the non-shadowed channel. In contrast, only 7% of the older adults (only 2 of 27) noticed their name (see Table 2). Fisher's exact test showed that the probability of obtaining these proportions by chance (under the assumption that both young participants and older participants are equally able to detect their name in the non-shadowed message), is $p < .001$, indicating that this assumption fails. Notice that the slowdown was of no apparent benefit for the younger adults, with the proportion who noticed their names somewhat smaller than what was obtained in Experiment 1 with the faster presentation rate.

These results indicate that the inability of older adults to notice their name in the unattended channel is probably not related to a slower speed of processing: when we increased the time they have had to shadow each word by 25%, almost all of them still failed to notice their name when it appeared in the unattended channel.

An additional issue related to the results of Experiments 1–4, and in particular to those of Experiment 1, is the assignment of the attended and unattended messages to a given ear. In these experiments the to-be-attended information was always presented to the right ear and the unattended information (including the name) was always presented to the left ear. It could be the case that the inability of older adults to notice their name in the unattended message was partially due to the differential deterioration of hearing in the left ear (increased left-ear disadvantage with linguistic materials, especially in noisy situations, e.g., Jerger & Jordan, 1992, although there are some other views, e.g., Clark & Knowles, 1973; also see Broadbent & Gregory, 1964 for some right-ear advantage in dichotic listening task). To rule out this possibility, in Experiment 5 we ran a procedure identical to the one used in Experiment 4, but with the messages to the ears switched; that is, the attended to-be-shadowed message was presented to the left ear, and the unattended message (including the participant's name) was presented to the right ear. If older adults' inability to notice their name in the unattended channel in Experiments 1–4 was due to the name appearing in the left ear, they should be able to notice it when it appears in the right ear.

EXPERIMENT 5

Method

Participants—The participants were 20 older adults, all native English speakers taken from the same respective populations mentioned in Experiments 1–4. None of them had participated in Experiments 1–4. They were screened for their hearing in the same way as done in Experiment 1 in order to minimize the role of hearing problems in performance, and the final older participant group was composed only of females due to older males' poorer hearing. The older group had a mean age of 69.8 ($SD = 5.64$, range = 65–83) and mean level of education of 14.0 ($SD = 1.65$), similar to the levels reported in the previous experiments.

Stimuli and Procedure—The procedure was identical to the one used in Experiment 4 with the use of two simultaneously presented auditory lists. The attended list was presented to the left ear and the unattended one to the right ear. The non-attended list included the

participant's and another person's name. As in previous experiments, participants were asked to shadow one list. Both messages were presented at a rate of 1.25 per word.

Results and Discussion

Performance on the Irrelevant Message (Name-Noticing)—Only 15% of the older adults (3 out of 20) noticed their name in the unattended ear. It should be noted that the 3 older adults who noticed their name did so only after a significant amount of probing; that is, they responded negatively when asked whether they recalled any words from the unattended list, and likewise when asked whether they recognized any names in the unattended list. Only when probed directly about whether they remember hearing their name in the unattended list did they respond positively. These results are in line with those reported in Experiments 1–4 showing that the vast majority of older adults (in contrast to younger ones) do not notice their name in the unattended channel. The fact that in this experiment, 3 of them were able to notice their name when presented to their preferred right ear (in contrast to 1 and 2, in Experiments 1 and 4, respectively), may indicate that a declining hearing may have some role in older adults inability to notice their name in the unattended information, although it seems that a much larger role is played by cognitive-attentional factors.

General Discussion

The reported series of 5 experiments sheds light on older adults' selective attention, particularly for their ability to notice prominent information (i.e., their name) when presented within a stream of unattended information. Although previous research shows that many younger adults can notice their name when presented in the unattended channel in a dichotic listening paradigm (Conway et al., 2001; Moray, 1959; Wood & Cowan, 1995), Experiment 1 of the current series showed clearly that older adults almost always fail to notice their name when it appears in the unattended channel. This is based on the fact that a minute after the name was presented, they were not able to report it, even when probed specifically about whether or not they heard their name in the unattended channel. In addition, an indirect measure of whether they noticed their name in the unattended information, derived from their shadowing of the attended information, did not indicate any such noticing of their name, as there was no change in shadowing performance before, during, or after the time the name appeared in the unattended information. This was in contrast to those younger adults who noticed their name in the unattended channel, which demonstrated a decrease in shadowing performance just after the appearance of the name in the unattended information. Such results provide empirical evidence that older adults do not readily notice their names in an unattended channel (as when spoken in a cocktail party conversation).

The older adults' failure to notice their names is paradoxical, given the finding of Conway et al. (2001) that individuals with low working memory spans noticed their name much more often than high spans. Older adults did not notice their name, despite having working memory spans comparable to low-span young adults (as shown in Figure 1), who most often did notice their name. Older adults also did not show a decrease in shadowing performance just after the appearance of the name in the unattended information, unlike young adults who noticed their name, even though most of these were low spans.

These results cannot be dismissed on the basis that older adults simply do not notice any subtle event as often as young adults. The results of Experiment 1 were usefully compared to Experiment 2 (in which the name occurred unexpectedly in the attended channel in dichotic listening) and Experiment 3 (in which participants monitored both channels and shadowed one of them, while the name occurred in the other channel). Although older adults did notice their names less frequently than young adults in both of these circumstances, a model was used to partition performance into two terms for each group, reflecting (1) the probability of noticing one's name in an attended or monitored channel, and (2) the added difficulty of noticing a name on the unattended channel. It was shown that this second probability, as well as the first, was lower in older adults.

Experiments 4 and 5 rule out some potential mediating factors of older adults' poor ability to notice prominent information in the unattended channel. Both these experiments rule out a major role of age-related processing speed (Salthouse, 2006) as a factor since despite information being presented at a slower pace (25% slower relative to Experiments 1–3), older adults were still very poor in noticing their names. Furthermore, Experiment 5 rules out ear preference as a factor (as the participants' name in the other experiments was presented to the left ear), replicating the basic results when the unattended message that included the name, was presented to the right ear.

The data suggest that older adults are lower in some attentional resource that is used to monitor channels for information and that some of this resource is spread to supposedly unattended channels in young adults, or at least in those with low spans (who tend to notice their names most often). Given that older adults have spans equivalent to low-span young adults, it stands to reason that older adults either must have more inhibitory ability than the low-span young (which, as mentioned below, does not fit the results in the literature), or else must have fewer resources to spread to the unattended channel.

Which of these differences is correct must await further research. If, however, older adults had more inhibitory ability than low-span young adults, we would still need a capacity or resource limitation factor to explain why older adults perform poorly on working memory tasks, and the proposal that older adults have more inhibitory ability runs counter to findings that limiting proactive interference reduces the age difference in span (e.g., Lustig et al., 2001). Thus, we argue that the results support a deficit in processing resources in older adults that caused them to miss their name in an unattended channel (despite their most likely not exerting more inhibition on the irrelevant channel than high-span young adults exert). One potential source for such an age-related deficit in processing resources in the current context is the fact that perceptual processes become more cognitively loaded and resource demanding, with older adults possibly using more effortful processes to compensate for sensory decline (see the cognitive permeation hypothesis, Lindenberger, Marsiske & Baltes, 2000, and the resource reorganization explanation, Li & Lindenberger, 2002, and Murphy, Craik, Li, and Schneider, 2000). In the current experiments, the demand for resources in order to decipher the auditory attended message may leave fewer such resources for noticing the name in the unattended channel. As one kind of evidence against that possibility, however, the need to shadow an auditory versus visual channel in

Experiment 3 yielded rather comparable performance in noticing the participant's own name in an un-shadowed auditory channel.

Another possibility is that what is attention-demanding for older adults, compared to younger adults, is the need to decipher the channel to be shadowed while at the same time inhibiting the other channel (in the selective-attention experiments). Perhaps this situation acts as a dual task even though only one channel is to be attended, and perhaps executing a dual task takes more resources in older adults. Against this possibility, though, specific dual-task performance deficits have been observed in adults with Alzheimer's dementia but, in the same study, have been found to be absent in normal older adults compared to younger adults (Logie, Cocchini, Della Sala, & Baddeley, 2004). These findings suggest that the critical factor instead may be a smaller amount of attentional resources available in older adults, leaving less capacity free to monitor one channel while shadowing another.

As mentioned earlier, the results can also partially be due age-related changes in hearing, as there is research showing an age related decline in speech processing in noise and demonstrating that distracting information affects listening comprehension (e.g., Schneider, Daneman, Murphy, & Kwong-See, 2000; Murphy, Daneman, & Schneider, 2006; Wingfield A, Tun, O' Kane, & Peelle, 2004). However, as Experiments 1, 2, and 3 show, changing attentional instructions, with no change in perceptual factors, lead to large differences in older adults' performance, whereas changing perceptual factors (for example visual vs. auditory presentation in Experiment 3), has a relatively small effect on older adults' performance. The suggestion that there are multiple factors involved in selective attention tasks is supported by the results of Seegmiller, Watson, and Strayer (2011), who used the inattention blindness task in which a gorilla saunters through a basketball court unexpectedly while participants are engaged in counting ball passes. In that situation it was the high-span individuals who were more likely to notice the unexpected event, in opposition to the results of Conway et al. (2001) with selective listening. It is up to future research to discern the critical differences between these procedures, but one possibly relevant difference is that the participants in Seegmiller et al. were not told explicitly to ignore a particular channel.

Our aging results provide evidence that multiple processes can be important not only between procedures, but also within the same procedure administered to different individuals. One process is needed to account for the correlation between name-noticing and working memory span in young adults (with high spans better able to inhibit the irrelevant channel and less likely to notice their name in that channel). A different factor is needed to account for the effect of age on name-noticing that persists even with working memory spans controlled (with low-span young adults noticing their names in the unattended channel often; older adults with comparable spans, almost never). For reasons described above, our working hypothesis is that older adults have fewer attentional resources than young adults, and therefore fewer such resources free to monitor one stimulus channel either deliberately or incidentally, while shadowing another channel. Identifying seemingly paradoxical differences between effects of working memory span, on one hand, and correlates of cognitive aging, on the other hand, can serve to uncover multiple processes when they operate together.

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Figure 1.

Histogram of working memory scores in older adults (top panels) and younger adults (bottom panels) who did not (left) or did (right) notice their name in the unattended channel within the selective listening task of Experiment 1. Two additional older adults who did not complete the working memory tasks did not notice their names.

Figure 2.

Percentage of spoken words presented in the attended channel correctly shadowed in Experiment 1, out of those words that occurred before and after the participant's name (2 before and 2 after) in the unattended message. Shown separately for younger adults who noticed and who did not notice their name, and for older adults. Error bars are standard errors.

Table 1

Summary of Name-Detection Percentages in All 5 Experiments

Condition	Young Adults	Older Adults	Age Diff.
<u>Experiment 1</u>			
Ignored (Dichotic)	58%	3%	55%
High Span	33%	---	(30%)
Low Span	69%	---	(66%)
<u>Experiment 2</u>			
Attend - name appearing in attended message	70%	45%	25%
<u>Experiment 3</u>			
Dual Task, Dichotic	73%	43%	30%
With auditory Channel			
High Span	83%	---	(40%)
Low Span	63%	---	(20%)
Dual Task, Dichotic	79%	48%	31%
With Visual Channel			
High Span	79%	---	(31%)
Low Span	79%	---	(31%)
<u>Experiment 4</u>			
Ignored (Dichotic)	48%	7%	41%
With slower presentation rate			
<u>Experiment 5</u>			
Ignored (Dichotic)	---	15%	---
Name in right ear			

Note. The numbers in parentheses were obtained by subtracting the older adult overall percentage from the low- and high-span young adult percentage. Note that low-span young adults and older adults had similar working memory spans.