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# The Cocktail Party Phenomenon Revisited: Attention and Memory in the Classic Selective Listening Procedure of Cherry (1953)

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Though E. C. Cherry (1953) examined the recall of information from an irrelevant spoken channel in selective listening, the relationship between attention and subsequent recall still has not been examined adequately. It was examined here in 4 experiments, 3 of which were designed to identify conditions under which some participants, but not others, would notice a change from forward to backward speech. Only participants who shifted attention toward the irrelevant channel during the backward speech later recalled hearing it. In those whose attention shifted, shadowing errors peaked dramatically about 15 s after the change. There was no evidence of direct or indirect memory for phrases presented in the irrelevant channel. The results contradict models of attention stating that listeners process task-irrelevant information extensively without diverting resources used in shadowing.

A basic, yet unanswered, question in selective attention research is the extent to which task-irrelevant information is processed and recalled. Cherry (1953) used what has proven to be a seminal technique to examine this question. His participants "shadowed," or immediately repeated, prose heard through one ear while ignoring another channel of speech presented to the other ear. The irrelevant channel always began and ended with English spoken in a male voice, but the center portions of the channel changed in ways that differed between conditions. After the shadowing task, participants were questioned on their detection of these changes and other features of the irrelevant channel.

All participants were able to identify the irrelevant input as human speech, but none were able to report words or phrases from the irrelevant channel. They noticed some changes, but not others, in the irrelevant channel. In particular, a change from speech to a 400-Hz tone always was detected, and a change from a male to a female voice nearly always was detected. On the other hand, a change from English to German generally was not detected. Thus, the changes that were noticed were those involving basic acoustic features.

Cherry's (1953) original findings play a prominent role in cognitive psychology even today and, partly for historical reasons, are illustrated in many textbooks in the field. Subsequent investigations have determined that although semantic characteristics of the irrelevant channel generally are not encoded or recalled (Moray, 1959; Norman, 1969; Treisman, 1964a, 1964c) and changes to a foreign language are noticed only occasionally (Treisman, 1964d), changes in tone (Ingham, 1957; Lawson, 1966) and voice (Treisman & Riley, 1969) usually are detected.

However, one of Cherry's (1953) findings, an "in-between" case, never has been reexamined. In that condition, the irrelevant channel changed from ordinary English to English played backward. Cherry stated that this change generally was not noticed but that "a few subjects" indicated that the irrelevant channel had "something queer about it." However, Cherry did not report essential details of his experiment, including the length of the shadowed message, the duration of the irrelevant channel segments, the time between a change and participants' retrospective report, the sample size, and quantitative and statistical results.

The backward speech condition may be of special interest because it may be near a threshold for detection of a change in the task-irrelevant channel. The change was noticed by some participants but not others, whereas more dramatic physical changes were noticed uniformly and purely semantic changes generally were not noticed. Backward speech includes subtle physical departures from forward speech, including anomalies in intonation contour, consonant attack and decay rates, and phonetic quality and sequence. It also lacks perceptible semantic content, in contrast to the preceding forward speech. Perhaps because the change to backward speech involves both subtle physical changes and a dramatic semantic change, it is a borderline case. Consequently, the rate of detection in this condition plausibly might be modulated through manipulations in task conditions. Most important, a change that is sometimes detected and sometimes not should be useful for comparing on-line measures of attention shifts in participants who do versus do not later recall hearing the backward speech. That was the main emphasis of the present research.

One other study has suggested that a change to backward speech may be barely detectable. Treisman (1964d) presented backward speech in an irrelevant channel throughout

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a 1-min selective listening session, but it was binaurally mixed with a same-voice relevant channel; the messages were not presented dichotically as in Cherry (1953). (This method of presentation may not be not ideal if one aims to keep participants focused on the relevant message throughout most of the selective listening session.) The backward speech was found to cause slightly more difficulty in shadowing (46% correct) than an unfamiliar foreign language presented in the same voice (56% correct). Of 17 participants who received the backward speech, 8 noticed that it was not ordinary English, but only 2 could identify what it was. However, Treisman's measure of attentional disruption was not a temporally precise measure and was not reported separately for those participants who did and did not notice the backward speech.

Selective listening experiments stemming from Cherry's (1953) article have played an important role in theories of information processing. Broadbent (1958) proposed that selective attention acts as a filter that prevents irrelevant information from being processed beyond its basic physical characteristics (e.g., pitch, location, and intensity). However, other researchers subsequently found that some semantic aspects of irrelevant sounds sometimes were processed, including the participant's own name (Moray, 1959) and words relevant to the attended message (Gray & Wedderburn, 1960; Treisman, 1960). In addition, Treisman (1964b) found that participants were aware that an irrelevant message was identical to an attended one when the attended message was played at a 5-s lead ahead of the irrelevant message. On the basis of such examples of "breakthrough of the filter," Treisman (1960, 1964a, 1964c, 1964d) proposed an alternative hypothesis of attention in which it was assumed that the semantic analysis of nonselected channels is merely attenuated, not filtered out totally. Still others proposed a *late-filter* view (in contrast to Broadbent's view, which was described as an *early-filter* view) in which all channels are processed, although only one response at a time can be planned and executed (e.g., Corteen & Wood, 1972; Deutsch & Deutsch, 1963; Duncan, 1980; Lewis, 1970; Marcel, 1983).

The question of how much information can be extracted from unattended channels of information in selective listening continues to be controversial. For example, whereas many investigators have suggested that semantic elements of memory can be activated without the involvement of attention, Holender (1986) extensively reviewed the relevant studies and concluded that one cannot rule out the possibility that, in those studies, attention actually shifted subtly to the allegedly unattended channel without that attention shift having been detected by the experimenters. Holender (1986) allowed the possibility that an attention shift would follow, rather than precede, the activation of memory. This would be consistent with the attenuation theory of attention (Treisman, 1964c), which viewed semantic activation as a possible attention trigger, but it still differs from the hypothesis of semantic activation without any involvement of attention held by the late-filter theorists (see earlier discussion). To distinguish among competing attentional hypotheses, one needs to know not only whether there was a shift of attention but also when *it* occurred relative to significant, irrelevant-channel stimuli.

One way to examine the processing of unattended information in selective listening is to compare the results of on-line measures of attention shifting with subsequent memory measures. We assume that explicit recall requires that the participant was aware of the event during, or at least shortly after, the time that it was presented (for supporting evidence, see Cowan, 1988, 1995). There are competing views as to how attention may shift in individuals who later recall hearing an event in a task-irrelevant channel. First, a staunch early-filter theorist might expect that a change in the irrelevant channel subtle enough to be recalled by only some participants (in particular, a change to backward speech) is recalled in those participants only because their attention happened to wander off of the task-relevant channel, and onto the irrelevant channel, when the change occurred. If so, then participants who go on to recall the backward speech should display attention shifts at various, widely distributed points just before and during the backward speech. These participants might also be expected to shift attention throughout the selective listening session more frequently than other participants.

Second, a late-filter theorist believes that all channels of information are processed at the same time, to a semantic level. Assuming that the information is processed automatically and the semantic change accompanying backward speech (a cessation of semantic meaning) is severe, it may be detected very rapidly. Therefore, a late-filter view might suggest that on-line shifts of attention may occur very soon after the onset of backward speech in participants who later recall the backward speech. An alternative possible prediction from this basic view is that the regular processing of the irrelevant channel may permit the participant to detect the backward speech even without any shifts of attention.

An intermediate theory such as Treisman's (1964b) attenuation theory (see also Cowan, 1988, 1995) would lead one to suspect that detection of the backward speech could occur in some participants only after a considerable delay. The partial processing of the irrelevant channel could mean that it would take some time for sufficient information about that channel to build up to a threshold level at which attention is recruited to that channel. Thus, a delayed attention shift to the backward speech can be predicted. The more-than-coincidental resemblance of such an attention shift to the attentional orienting response mechanism (e.g., Sokolov, 1963) is explored in more detail in the General Discussion section.

Studies that have used methods designed to detect subtle shifts of attention from a primary task to a channel that is to be ignored (e.g., Barr & Kapadnis, 1986; Corteen & Wood, 1972; Cowan, Lichty, & Grove, 1990; Dawson & Schell, 1982; Treisman & Geffen, 1967; Yates & Thul, 1979) served as an inspiration for the present study, in which disruptions in shadowing provided a measure of attention shifts. Although the aim of most of those studies was to detect automatic semantic processing in the absence of attention shifts, we applied the methods to a slightly different aim: to distinguish between the attentional processes in participants who did versus did not recall a backward speech segment in the channel to be ignored.

Through the use of computer-digitized speech, researchers are now able to control characteristics of auditory stimuli to a greater degree than previously possible. They can better specify the timing distribution of words, maintain intensity level throughout the session, and make smoother acoustic transitions to eliminate artifactual differences between conditions. In our first experiment, we used these advantages to determine the experimental conditions under which Cherry's (1953) findings with backward speech may apply. In a second experiment, we altered the primary task in three different ways in an attempt to optimize the measurement of shadowing performance and the control of attention. In Experiment 3, we examined the relation between the detection of backward speech in an irrelevant channel and concomitant shifts in attention. We also examined, in Experiments 3 and 4, whether participants remember phrases from the irrelevant auditory channel.

Because Cherry's (1953) description of his methods was ambiguous, one cannot be certain what an exact replication would entail. However, in Experiment 1, we replicated his backward speech condition as precisely as possible, with several minor exceptions. First, whereas Cherry recorded both stimulus channels in a male voice, we recorded both in a female voice (for practical rather than theoretical reasons). Second, from his report, it is impossible to discern the exact timing parameters of his stimulus channels. In a conservative attempt at replication, we kept the duration of backward speech to a half minute (which seems brief given Cherry's statement that the "center, major" portion of the tapes contained backward speech) and had participants shadow for an additional half minute after the backward speech before they were asked about the irrelevant channel.

Third, we provided 1, 3, or 5 min of shadowing before the backward speech to determine whether the duration of shadowing practice would affect the detection of the backward speech. Treisman, Squire, and Green (1974) showed that the degree of relatedness between simultaneously presented attended and unattended words increased response latencies for the first few words of a 12-word list but stopped having an effect by the 7th word. They concluded that it takes a relatively short time for one channel to fully occupy one's attentional capacity and block the semantic analysis of another, unattended channel. However, Underwood (1974) and Ostry, Moray, and Marks (1976) found longer term practice effects on the detection of expected targets in an irrelevant channel, and such practice effects may or may not generalize to the present situation.

Finally, Cherry (1953) reported that his prose passages were presented at a "normal" rate of speech. We were concerned that such a rate may have been too slow and may have allowed attention shifts to the irrelevant channel concurrent with performance of the shadowing task. Instead, we presented our passages at the quick rate of 175 words per minute (wpm) to better constrain attention.

## Experiment 1

### Method

*Participants.* Seventy-two undergraduate students (27 men and 45 women) were recruited from introductory psychology courses and received course credit for participation. Participants were native English speakers with no known hearing or speech impairments.

*Apparatus.* Both stimulus channels were initially individually recorded on a four-channel, reel-to-reel audiotape deck in a sound-attenuated chamber and then digitized on an Apple Macintosh II computer with Sound Designer II software (Digidesign Corporation, Menlo Park, CA) at a sampling rate of 22.05 kilohertz with a resolution of 16 bits. Once the speech was digitized, selected speech segments were reversed in the irrelevant channel, and the left- and right-ear channels were appropriately synchronized.

Participants completed the task individually in the sound-attenuated chamber. The left- and right-ear stimulus channels were presented to participants from the Apple Macintosh II computer over stereo audiological headphones. The level of intensity of both channels was set to a range of 65–70 dB (A) with a Model 1551-C sound level meter equipped with a 9A Type Earphone Coupler (GenRad Corporation, Concord, MA). Participants spoke into a microphone and were recorded on one channel of the four-channel, reel-to-reel tape player while the attended and irrelevant passages were transferred to two other channels of the reel-to-reel deck.

*Stimuli.* The attended channel consisted of a 6-min passage from *The Grapes of Wrath* spoken in a female voice at a rate of 175 wpm, with pauses and changes in intonation minimized (i.e., in a natural, although somewhat droning, intonation pattern). This is a slightly quicker rate than the often-used 120–150 wpm rate that, for example, had been used by Moray (1959) and Treisman (1964a, 1964d).

The irrelevant channel consisted of a 6-min passage from the first chapter of *2001: A Space Odyssey.* The prose was recorded by the same female speaker in the same manner as was the attended channel, at a rate of 190 wpm. Both channels began together, with the irrelevant channel faded in over a 5-s period, and ended simultaneously.

*Design and procedure.* Relevant and irrelevant channels always were presented concurrently in this experiment. To vary the duration of shadowing before a change to backward speech, we randomly assigned participants to one of three shadowing-duration conditions. All participants received the same attended and irrelevant channels except for alterations in the duration of the tape presented before the onset of backward speech in the irrelevant channel (1, 3, or 5 min), as shown in Figure 1. Participants

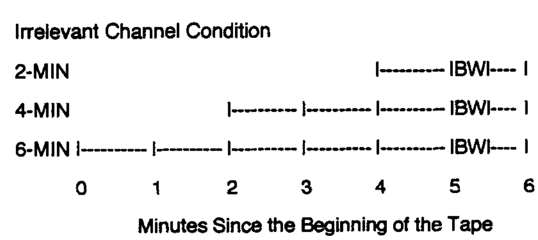


*Figure 1.* Illustration of irrelevant channel conditions in Experiment 1. Periods of backward speech in the irrelevant channel are labeled BW; dashed lines indicate forward speech. The attended channel always was presented concurrently with the irrelevant channel in this experiment.

shadowed for a total of 2 min, 4 min, or 6 min in these three conditions, respectively.

There is a well-established shadowing efficiency advantage for right-ear messages in verbal selective attention tasks (Murray & Richards, 1978; Treisman & Geffen, 1968). Both in order to capitalize on this advantage and to duplicate Cherry's (1953) method, the to-be-attended passage always was played to the right ear, and the irrelevant passage to the left ear.

Participants were informed that the primary task was to listen through the right ear and repeat each word as soon as it was heard, without errors if possible. They were told that the left-ear sounds were simple distractors that should be ignored. Participants were asked to continue shadowing until all sounds on the attended channel stopped and then to turn over the paper and answer the questions. In the questionnaire, participants were to report anything they could from the irrelevant channel. Next they were to note whether anything "unusual" was heard in the irrelevant channel and, if so, what it was. Participants were considered to have detected the backward speech only if they agreed that something unusual had occurred and went on to specify something appropriate, such as "garbled speech" or "a foreign language" (as opposed to a simple physical characteristic, such as an increase in loudness, or a semantic characteristic, such as the unexpected occurrence of a rare word or unusual topic).

Finally, participants were to report whether they had ever heard speech played backward before. Treisman (1964d) found that participants who were familiar with a foreign language that was presented in an irrelevant channel were more likely to report the nature of the irrelevant passage (27 of 28 participants) than were those unfamiliar with the language (11 of 16 participants). We therefore reasoned that participants familiar with backward speech might be more likely to identify it.

### *Results and Discussion*

Whereas Cherry (1953) reported that none of his participants were able to recall any word from the irrelevant channel, 13% of our participants in the 2-min group, 17% in the 4-min group, and 13% in the 6-min group were able to recall words, phrases, or gists from the to-be-ignored passage (e.g., 1 participant recalled hearing the word *muscular,* and another stated that there was a topic like what is found in *Clan of the Cave Bear,* a movie about prehistoric humans). Almost all of the reports consisted of a small number of isolated words or short phrases. On average, participants who recalled any content recalled 2.20 words ($SD = 0.92$). The number of participants in each shadowing-duration condition who reported some content is shown in Table 1. Whether participants reported some content of the irrelevant channel was not related to the overall duration of shadowing, $\chi^2(2, N = 72) = 0.22, p > .9$.

Cherry (1953) somewhat vaguely reported that a few of his participants thought that there was something "queer" about the irrelevant channel in the backward speech condition. In the present experiment, 67% of the 2-min participants, 46% of the 4-min participants, and 29% of the 6-min participants said they detected something unusual that could reflect the backward speech, such as a portion of garbled speech or a foreign language (see Table 1). This detection was significantly related to the duration of shadowing practice before the onset of the change, $\chi^2(2, N = 72) = 6.80, p < .04$.

Table 1
*Number of Participants in Each Condition in Experiment 1 Who Reported Content of, or Detected Backward Speech in, the Irrelevant Channel*

| Presentation condition | *n* | Type of information: Content | Type of information: Backward speech |
|---|---|---|---|
| 2 min | 24 | 3 | 16 |
| 4 min | 24 | 4 | 11 |
| 6 min | 24 | 3 | 7 |

*Note.* The presentation condition refers to how long the participants shadowed. Backward speech was presented in the irrelevant channel during the first half of the last minute of shadowing (see Figure 1).

Across shadowing-duration conditions, 75% of the students reported that they had heard a segment of backward speech before the experimental session. However, this previous experience was not related to detection or identification of the backward speech (Fisher's exact test, $p > .2$). This finding appears to differ from Treisman's (1964d) finding with unfamiliar versus familiar foreign languages in the irrelevant channel, which may simply indicate that few if any participants in the present experiment were comparably familiar with backward speech.

In summary, we found a strong effect of the duration of shadowing practice on detection of backward speech in an irrelevant auditory channel. It appears that more than 4 min of shadowing practice are needed to minimize awareness of irrelevant channel events. This may be because it takes that long for the participant to establish a comfortable shadowing rhythm in which the participant can switch between speaking and listening efficiently. It also could take this long for participants to habituate fully to the sounds in the irrelevant channel.

Our results resemble Cherry's (1953) results in two ways. First, 14% of the participants in the present experiment reported some content of the irrelevant message, which is not very discrepant from Cherry's statement that none of his participants did so given that his sample size (which he did not state) probably was considerably smaller than ours. Second, the incidence of noticing backward speech may be consistent across studies. Cherry simply stated that a few participants thought that there was something odd about the irrelevant channel, whereas others did not. If one were to assume that Cherry had 10 participants in his backward speech condition, his description of the results suggests that about 3 participants ("a few") may have detected the backward speech; this also would approximate our most conservative estimate of the frequency with which participants detect backward speech (29% in the 6-min condition). Thus, Cherry's (1953) results may parallel ours, although he is sometimes represented as having found that people do not detect the backward speech.

## Experiment 2

In our second experiment, we examined the detection of a change to backward speech in a to-be-ignored channel while systematically deviating from the primary task used in our first experiment. The main purpose was not to compare these conditions with one another or with Experiment 1 but, rather, to obtain a task that would result in detection of the change by approximately half of the participants. This was necessary if we were to be in a good position to study the consequences of on-line shifts of attention subsequently, in Experiment 3. Of course, the degree of sensitivity of the results to differences in task demands may be of interest in its own right.

The change in procedure from Experiment 1 was in the match of voice in the attended and irrelevant channels, in the content of the attended channel, or both. Specifically, in one condition, participants shadowed prose as before, but with the attended and irrelevant channels presented in two different voices. In another condition, the voices of the channels matched, as in Experiment 1, but the to-be-shadowed channel contained unrelated, monosyllabic words. In a third condition, a prose passage was read aloud by participants, and the irrelevant passage was presented binaurally.

Error rates can be interpreted only if the primary task is of a reasonable level of difficulty (see Treisman, 1969). If the task is too difficult, errors caused by the task itself will obscure those that would be indicative of an attention shift to a change in the irrelevant channel. If the task is too easy, on the other hand, a shift in attention may occur without any observable errors. The task used ideally should challenge the processing capacity of participants to such an extent that they can attend to one and only one channel.

Most studies of attention shifts have examined shadowing of prose. However, several researchers have suggested that such shadowing is inadequate in consuming attention. Dawson and Schell (1982) observed that participants shadow prose in spurts rather than continuously and argued that participants can then divide their attention between the two channels without any noticeable decrement in shadowing. Prose also has been criticized because it provides contextual cues that may permit participants to shift attention intermittently without losing their place in shadowing. However, we hypothesized that the quicker, more demanding rate of 175 wpm would require participants to shadow with minimal delays, which would offset any decrease in difficulty afforded by contextual cues.

Several investigators have chosen instead to use monosyllabic, nonrelated words as the stimuli to be shadowed. Lewis (1970), for example, argued that having participants shadow a word list not only eliminates the contextual cues in prose material but provides distinct, measurable units of response. However, the durations of the shadowing of words in previous studies have been relatively short; participants have only had to shadow 30 or fewer words in a row per trial block (Dawson & Schell, 1982; Lewis, 1970; Mackay, 1973; Murray & Richards, 1978; Treisman & Riley, 1969). Given that, in Experiment 1, it appeared to take some time for attention to lock fully onto the correct channel (see also Treisman et al., 1974), it seems more appropriate to require shadowing for a longer uninterrupted time period (e.g., several minutes) so that a change in the irrelevant channel will not occur until after participants are well practiced and steadily shadowing.

Finally, reading prose aloud (in a whisper) as a primary task has been used successfully by Cowan et al. (1990, Experiment 4) to demonstrate that memory for irrelevant spoken syllables is superior on trials in which pauses or errors in reading occur at approximately the same time as the target syllable. Thus, shadowing prose, shadowing unrelated words, and reading prose all may be promising tasks for absorbing attention, providing useful performance measures, or both.

In addition, although it was not the main purpose of the experiment, we again manipulated factors of practice and memory. First, concerning practice, we used two different periods of shadowing practice before the backward speech began: 5 min (similar to the 6-min condition of Experiment 1, in which the fewest number of participants detected the backward speech) and 7 min. Second, concerning memory, we also varied the duration between the offset of backward speech and the end of shadowing. The backward speech segment lasted 1 min in this experiment, and the duration of shadowing after it was either 1 or 3 min.

### *Method*

*Participants.* Seventy-one undergraduate students (34 men and 37 women) who had not participated in Experiment 1 were tested, and the restrictions were the same as in that experiment. An additional participant was excluded as a result of an experimenter error.

*Apparatus.* The equipment used to create the stimulus tape and to record shadowing responses was the same as that used in the previous experiment. However, unlike in Experiment 1 (in which the auditory stimuli were presented directly from the computer), the channels were output to cassette tape after they had been synchronized. During the experimental session, the left- and right-ear stimulus channels were presented to participants through an audiocassette tape player over stereo audiological headphones. Shadowing responses were recorded on one channel of the four-channel, reel-to-reel tape player while the attended and irrelevant passages were transferred from the cassette (stimulus) tape deck to two other channels of the reel-to-reel deck.

*Stimuli.* Participants were randomly assigned to one of three different primary task groups (shadowing prose, shadowing words, or reading prose). For participants who shadowed prose, the attended channel consisted of a 9-min passage from *The Grapes of Wrath* spoken in a male voice at a rate of 175 wpm, with pauses and changes in intonation minimized.

For participants who shadowed words, the attended channel consisted of a 9-min segment of 720 unrelated, monosyllabic words spoken in a monotone. All of the words had approximately equal average frequency of occurrence in English, according to Thorndike and Lorge (1944). The list was recorded in a female voice at a rate of 80 wpm, as used by Dawson and Schell (1982). For participants who read prose, the attended material consisted of the same passage from *The Grapes of Wrath* that was presented to prose shadowing participants; however, the passage was typed double spaced and bound in a booklet.

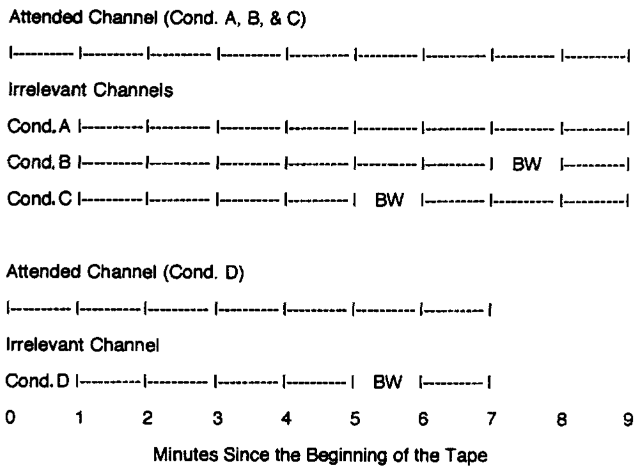


*Figure 2.* Illustration of attended and irrelevant channels for each condition in Experiment 2. Periods of backward speech in the irrelevant channel are labeled BW; dashed lines indicate forward speech.

In all three primary task conditions, the irrelevant channel was identical, consisting of an 8-min passage from the first chapter of *2001: A Space Odyssey.* It was recorded in the same manner with intonation minimized as was the attended prose passage, by the same female speaker as was the attended monosyllabic word list, at a rate of 190 wpm. Unlike in Experiment 1, the attended channel (and reading task) always began 1 min before the irrelevant channel to allow a short practice period without distraction, and both channels ended together.

For the shadowing participants, the to-be-attended channel was presented to the right ear and the irrelevant channel was presented to the left ear. For the reading participants, the irrelevant passage was presented binaurally.

*Design and procedure.* To vary the duration of shadowing before and after a change to backward speech, within each primary task condition, we randomly assigned participants to one of four conditions (A, B, C, or D). All participants within each primary task condition received the same attended and irrelevant channels except for alterations in different segments of the irrelevant channel (see Figure 2). Condition A involved no change, Condition B involved backward speech during the 8th minute, Condition C involved backward speech during the 6th minute, and Condition D was the same as Condition C except that both channels ended after 7 min instead of 9 min.

Shadowing participants were given the same instructions as those in the previous experiment, and they filled out the same postshadowing questionnaire, with the exception that the final question about familiarity with backward speech was omitted. Reading participants were asked to read the passage in the booklet aloud. It was explained that their rate of reading should be quick enough that it made the task difficult to perform but not so quick as to result in frequent errors. They were told that there would be sounds over the headphones that were simple distractors to test their ability to concentrate on a single task and that, at the end, they would be tested on the reading material. These participants read one page as practice and were given feedback as to their reading rate and accuracy. They then began the experiment proper by reading for the 1st minute without distractions, after which the *irrelevant* passage was played over headphones to both ears. When all sounds over the headphones ceased, these participants were required to fill out the same short questionnaire as participants in the shadowing groups.

## *Results and Discussion*

There were no noticeable effects of the timing of presentation of backward speech (Conditions B, C, and D in Figure 2), so the results are presented collapsed across these three conditions. In response to the questionnaire items, 29% of our prose shadowing participants, 54% of our word shadowing participants, and 61% of our reading participants were able to recall some semantic or lexical content of the to-be-ignored channel. Almost all of these recollections consisted of a small number of isolated words or short phrases. On average, participants who recalled any content recalled 2.53 words ($SD$ = 1.21). The number of participants who reported some content is shown in Table 2. The relationship between the number of participants reporting content from the irrelevant channel and primary task assignment did not reach significance, $\chi^2(2, N = 71) = 5.30, p > .07$.

Regarding recall of the backward speech, 50% of the prose shadowing participants, 83% of the word shadowing participants, and 94% of the reading participants who received backward speech reported that there was a portion of gibberish or distorted speech (see Table 2). A chi-square test on the overall number of participants who did and did not report the backward speech segment in this way indicated that task assignment was related to whether or not such a change was recalled, $\chi^2(2, N = 53) = 10.10, p < .007$. Across primary tasks, no participant in the control condition reported noticing anything unusual in the irrelevant channel. (Recall, however, that the purpose of the experiment was not mainly to compare the tasks with one another but to identify which ones would permit detection of backward speech by about half of the participants. Only the prose shadowing task succeeded in this regard.)

Although the readings constituting the irrelevant and relevant prose passages were taken from novels with very

Table 2
*Number of Participants in Each Condition in Experiment 2 Who Reported Content of, or Detected Backward Speech in, the Irrelevant Channel*

| Presentation condition | $n$ | Type of information: Content | Backward speech |
|---|---|---|---|
| Shadowing prose | | | |
| Control | 6 | 2 | 0 |
| Backward speech | 18 | 5 | 9 |
| Shadowing words | | | |
| Control | 6 | 4 | 0 |
| Backward speech | 18 | 9 | 15 |
| Reading prose | | | |
| Control | 6 | 5 | 0 |
| Backward speech | 17 | 9 | 16 |

*Note. Backward speech* refers to Conditions B, C, and D shown in Figure 2, and *Control* refers to Condition A, in which backward speech was not presented.

different stories, we noticed that both of them touched on certain topics in common (specifically, farming or food gathering, vegetation, and survival). We considered the possibility that coincidental similarities in topic could have caused some of the shifting of attention presumably underlying the reports of content in the irrelevant channel. This would have led to reports being skewed toward the topics that were common between the two prose channels. However, arguing against this possibility, there were no observable differences in the nature of the content reported by participants who received the prose passage versus unconnected words in the relevant channel.

To examine the difficulty of the task and the extent of interference of the irrelevant channel, we obtained error rates in shadowing, an error being an omitted or mispronounced word. In an average minute of prose shadowing, participants had to repeat 175 words and erred on an estimated 20.1 of them, for a mean error rate of 12% (ranging little across the four presentation conditions from 8% to 15%). In an average minute of word shadowing, participants had to repeat 80 words and erred on an estimated 16.4 of them, for a mean error rate of 21% (ranging across the four presentation conditions from 15% to 27%). In contrast, in an average minute in the reading condition, 210 words were read and 2.2 errors were made, for a much lower error rate of 1% (ranging across conditions from 1% to 2%).

Thus, reading prose appears to have been easier than we intended. This task led to very few errors and yet produced the greatest amount of reported awareness of backward speech in the irrelevant channel (94%). This pattern may have occurred because participants were able to control their own reading pattern. For example, they could have intermittently paused to monitor the irrelevant channel.

On the other hand, shadowing unrelated words for an extended period of time appears to have been more difficult than we intended. Because participants could not continuously shadow unrelated words with a high degree of accuracy, their forced errors created breaks in shadowing, during which they might have shifted attention to the other ear and consciously processed, as well as later recalled, aspects of the irrelevant channel. This could explain the high (83%) rate of recall of the backward speech segment. Indeed, Moray and Taylor (1958) noted that it is difficult to maintain shadowing of unrelated words, relative to shadowing of prose, because the unrelated words contradict learned probabilities of transition. Another explanation for the high recall of content and backward speech in this condition was suggested by several participants' comment that the irrelevant channel was "more compelling" than the attended channel. They claimed that their attention was sometimes "drawn" to the irrelevant channel because it contained a continuous stream of prose rather than the seemingly choppy, unrelated words on the attended channel.

The intermediate error rate for shadowing prose (12%) suggests that the presentation rate of 175 wpm generally was demanding but not too quick for participants to shadow. This resulted in a rate of reported awareness of the backward speech segment (50%) that was much lower than the rates in the other conditions. It should be noted that different voices were used for the attended and irrelevant channels in the prose shadowing condition in this experiment, unlike the word shadowing condition. However, the proportion of participants reporting the change was even lower in the 4- and 6-min conditions of Experiment 1, in which attended and irrelevant prose channels occurred in the same voice (although this might be partly because the backward speech segment was only 0.5 min rather than 1 min long in that experiment). Given the evidence from the first two experiments, we decided that a version of the prose shadowing task was preferable to the other two primary tasks for our investigation, in Experiment 3, of attention shifting in participants who do versus do not recall the backward speech.

The fact that about half of the participants in the prose shadowing condition still noticed the backward speech could indicate either that the focusing of attention still was not complete or that attention was completely focused but the backward speech automatically recruited attention away from the primary task. More generally, the nature of the relationship between the direction of attention and retrospective reports of noticing the backward speech is unclear. This issue was addressed in Experiment 3.

## Experiment 3

It theoretically would be possible to find a dissociation between on-line measures of attention shifts and retrospective recall of memory of the change to backward speech. One would expect attention shifting to the backward speech even without recall of the change if backward speech is noticed but then forgotten or if it is noticed for too fleeting a period to be registered fully in memory. Conversely, one would expect recall of the backward speech without on-line evidence of attention shifting if it is possible to notice the backward speech without diverting a limited attentional capacity. However, a convergence of on-line and retrospective measures would suggest that later recall of the change to backward speech requires attention shifting to the irrelevant channel at the time of the presentation of backward speech. A subsequent question then would be whether the attention shifting had to occur coincidentally before the backward speech could be noticed or whether the backward speech recruited attention.

To address the preceding issues, we adopted the prose shadowing task of Experiment 2 with a few minor modifications. We expected, on the basis of the previous study, that a reasonable number of participants who did and who did not notice the backward speech would be obtained with this task. Inasmuch as the manipulation of the duration of shadowing practice before the change to backward speech (5 vs. 7 min) had no observable effect in the previous experiments, the period of shadowing before the change was kept at 5 min. For practical reasons, the backward speech segment lasted 30 s, as in Experiment 1, rather than 1 min, as in Experiment 2, to cut down the period to be coded for time-intensive speech analyses. Two different delays (0.5 and 2.5 min) between the end of the backward speech and the end of shadowing were examined to determine whether memory of the backward speech is lost over time during shadowing. In an attempt to evaluate more adequately recall or recognition of the content of the irrelevant channel, the postshadowing questionnaire was extended to include multiple-choice questions.

For participants who did not receive a backward speech segment, the questionnaire also was followed by direct and indirect tests of memory for phrases within the irrelevant channel. Research has suggested that stimuli not consciously attended, and therefore not available for explicit recall, still may affect performance on indirect (i.e., implicit) tests (Eich, 1984; Graf & Schacter, 1985; Jacoby, Woloshyn, & Kelly, 1989; Parkin & Russo, 1990; Schacter, 1987). However, it remains an open question whether substantial portions of a spoken passage may be encoded when the passage is presented in a to-be-ignored auditory channel. To examine this, we used not only a direct test in which participants were to indicate which of two phrases were present in the left-ear, irrelevant channel but also an indirect test in which participants were to decide which of two phrases was more likely to have come from a novel. The results were assessed in relation to one control group in which participants attended to the left-ear channel ignored by the experimental participants and a second control group in which participants did not listen to any stimulus tape at all.

## *Method*

*Participants.* One hundred sixty-eight participants took part in the experiment. Of these, 72 (25 men and 47 women) were tested in the main experiment assessing detection of backward speech in an irrelevant auditory channel. These participants were further subdivided into three groups (A, B, and C) of 24 on the basis of the occurrence of backward speech (B and C only) and the duration of the following period of selective listening. To assist in the evaluation of direct and indirect memory tests, we compared Group A results on these tests with the results of two additional groups: a group of 24 (4 men and 20 women) participants who listened to the channel of the stimulus tape that was irrelevant to participants in the main experiment, providing a measure of memory for attended information, and another group of 72 (33 men and 39 women) participants who did not hear any stimulus tape and simply filled out the indirect memory test. The same participant criteria were used as in Experiments 1 and 2, but the present participants had not been tested previously.

*Apparatus, stimuli, and procedure.* The equipment was identical to that used in Experiment 2. The attended and irrelevant channels were those used for shadowing prose in Experiment 2, with several minor modifications. First, to examine whether two different periods of shadowing following the backward segment in the irrelevant channel affected later recall, we randomly assigned participants in the main experiment to one of three groups (A, B, or C) as shown in Figure 3, with 24 participants per group. All participants received the same attended channel, but the irrelevant channel included the following: no change to backward speech in 8.5 min of shadowing (Group A), backward speech during the first half of the 6th minute of 8.5 min of shadowing (Group B), or backward speech during the first half of the 6th and last minute of shadowing (Group C). Participants were given shadowing instructions identical to those in the previous experiments.

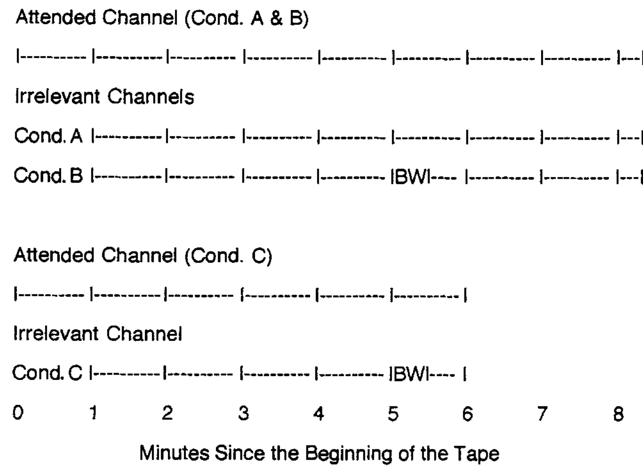


*Figure 3.* Illustration of attended and irrelevant channels for each condition in Experiment 3. Periods of backward speech in the irrelevant channel are labeled BW; dashed lines indicate forward speech.

In the postshadowing questionnaire, the strategy was to elicit spontaneous memories and to then obtain additional information by providing increasingly more specific recall cues. Page 1 was identical to that used in the previous experiments. On the bottom of this page, participants also were asked how frequently, and for what reasons, their attention shifted during the shadowing task. Pages 2–4 each contained a single multiple-choice question. The first was whether the irrelevant left-ear channel contained female speech, male speech, simple sounds, or music. The second question identified the irrelevant channel as consisting of female speech and asked participants to indicate whether it was a story, a scientific lecture, a nonfiction biography, or a list of unrelated words. The final multiple-choice question informed participants that a change in the content of the irrelevant channel had occurred and asked them to choose which change they thought most probable: from forward to backward speech, from a female to a male speaker, from speech to animal sounds, or from speech to music. The order of the questions remained constant, whereas the order of the four possible answers to each question was counterbalanced across participants.

For Group A participants only, a final two pages of the questionnaire contained direct and indirect tests of memory for phrases presented in the irrelevant channel (see Appendix). Two different sets of 14 phrase pairs were constructed for these tests. Within each set, one phrase of each pair was taken from the irrelevant channel, which, as in the previous experiment, consisted of a prose passage from *2001: A Space Odyssey.* The test sets contained one phrase from each half minute of the irrelevant channel, except for the half minute that was backward for participants in Groups B and C. The other phrase of each pair was taken from random paragraphs of an unheard final chapter of the same book. The order of phrases within the pair, as well as the order of the pairs, was counterbalanced across participants, as was the assignment of the two test sets to the direct versus indirect memory test conditions and the order of the test conditions themselves. The direct test instructions asked participants to select the phrase in each pair that they thought had come from the left-ear, irrelevant channel. Instructions for the story identification task (indirect test) informed participants that half of the phrases came from a published story by a well-known author and asked them to indicate which phrase in each pair they believed this to be.

An additional 24 participants who were not involved in the main experiment attended to the channel that participants in Group A had received and ignored. These control participants were told that the purpose of the experiment was to assess how well people are able to follow a speaker while simultaneously being distracted by other speech. They were asked to listen carefully to the speech presented to their left ear (the irrelevant channel of the main experiment) and to ignore that presented to their right ear. They performed no shadowing task. These participants then filled out the direct and indirect memory tests, counterbalanced in the same manner as previously mentioned, on the content of the channel to which they had attended.

Finally, another 72 control participants in a memory test only condition heard no stimulus tape but received both of the memory test phrase sets with indirect test instructions. Their data were used to assess guessing biases on the indirect memory test.

### *Results and Discussion*

*Questionnaire data.* Open-ended recall question results were in accordance with findings for prose shadowing participants in Experiment 2. Across conditions, 25% of participants reported a specific word, phrase, or semantic content from the irrelevant channel. As can be seen in Table 3, there was no significant difference between presentation conditions in this regard. Among participants who reported content, the average report included 1.89 words from the irrelevant channel ($SD$ = 0.96).

No participant in Group A (no backward speech segment) thought that there was anything unusual in the irrelevant channel, whereas 42% of participants in Groups B and C reported the occurrence of something unusual (see Table 3). According to Fisher's exact tests, the differences between Groups A and B and Groups A and C were both significant at the $p < .0008$ level. There was no significant difference between Groups B (11 of 24) and C (9 of 24) in the proportion who detected something unusual ($p > .3$).

The percentage of participants recalling the backward speech was more similar to the percentage for the prose shadowing group in Experiment 2 (50%) than to that found in Experiment 1 (e.g., 29% for the 6-min prose shadowing group). This pattern of results across experiments helps to establish which task parameters were critical. The fact that different voices were used for the relevant and irrelevant channels in Experiments 2 and 3, but not Experiment 1, can explain the similarity of findings across Experiments 2 and 3. In contrast, the fact that the duration of backward speech was longer in Experiment 2 (1 min) than in the other experiments (0.5 min) seems to have had little effect.

Table 3
*Number of Participants in Each Condition in Experiment 3 Who Reported Content of, or Detected Backward Speech in, the Irrelevant Channel*

| Presentation condition | $n$ | Type of information: Content | Type of information: Backward speech |
|---|---|---|---|
| A (control) | 24 | 5 | 0 |
| B | 24 | 5 | 11 |
| C | 24 | 8 | 9 |

*Note.* A = control condition in which backward speech was not presented; B = backward speech during the first half of the 6th minute; C = same as B but ending after 6 min rather than 8.5 min (see Figure 3).

In response to the question regarding attention shifts, 10 participants claimed that their attention never wandered (4 control participants, 1 participant who noticed the change to backward speech, and 5 participants who did not notice). The average estimated number of attention shifts during the shadowing session for Group A participants was 3.3 ($SD$ = 1.58); the corresponding numbers for Groups B and C participants were 2.9 ($SD$ = 1.41) and 3.6 ($SD$ = 3.81), respectively. One control participant and 4 participants who did not detect the change to backward speech said that it occurred only when the irrelevant channel first began. Three control participants said that it occurred then and also a few times later in the session when they were curious. Among the 20 participants who detected the change to backward speech, 4 said that they shifted attention to the backward speech only, and 2 others said that they shifted attention then and when the irrelevant channel began. Another 15 participants (6 controls, 6 who noticed the change to backward speech, and 3 who did not notice) said that they shifted attention only when they were curious about the irrelevant channel. Finally, 33 participants thought that they shifted attention but offered either no reason or a reason that was not theoretically interpretable, such as a slight intensity change in the stimuli or a coincidental match between stimuli in the two channels. There was no difference in mean estimate between participants who did ($M$ = 2.95, $SD$ = 1.57) and did not ($M$ = 2.80, $SD$ = 3.58) notice the backward speech. Given that these groups did differ in the on-line measure of attention shifting (see later discussion), this result simply suggests that, understandably enough, participants were unable to recall their attentional allocation during the prior several minutes of shadowing, having had no forewarning that they would be asked to do so.

Within the multiple-choice questions, 97% of participants correctly indicated that the irrelevant channel speaker was female, with only 2 participants incorrect (both from Group B). However, across conditions, only 44% of participants correctly indicated that the content of the irrelevant channel was a story. These findings are consistent with previous reports that participants were aware of the gender of a speaker of an ignored channel but were, for the most part, unaware of the channel's verbal content (Cherry, 1953; Moray, 1959; Treisman, 1964a; Treisman & Riley, 1969).

The final multiple-choice question, which asked participants to decide what type of change had occurred in the irrelevant channel, was relatively uninformative given participants' response bias on this question. Nineteen of 24 participants in each group (A, B, and C) selected backward speech over the other three possibilities (described earlier), even though no backward speech had been presented to control participants (Group A). This result simply suggests that the other choices offered in the multiple-choice test seemed less plausible to the participants. It should not be confused with the more informative finding that some of the experimental participants recalled something unusual in the speech stream and went on to offer descriptions seeming to reflect the detection of backward speech. No control participants responded in this way.

*Shadowing performance.* Error rates and response times were obtained to assess participants' shadowing performance. The overall percentage of errors was plotted across the half-minute periods before, during, and after the backward segment. To examine the relation between shadowing errors (which might reflect an attention shift to the backward speech) and subsequent recall of this backward speech, we separated participants who received a backward speech segment (Groups B and C) into subgroups that reported versus did not report this change to backward speech in response to the open-ended questions. The results of this analysis are shown in Figure 4.

The average percentages of errors per half-minute interval were subjected to a two-way analysis of variance (ANOVA) with time period as a within-subject variable and subgroup (Group A [no backward speech] participants, Group B participants who noticed the backward speech, Group B participants who did not notice, Group C participants who noticed, and Group C participants who did not notice) as a between-subjects variable. The main effects of subgroup, $F(4, 67) = 4.34, p < .004, MSE = 119.01$, and time period, $F(2, 134) = 12.68, p < .001, MSE = 24.14$, were highly significant, as was the Subgroup × Period interaction, $F(8, 134) = 4.63, p < .001, MSE = 24.14$.

Separate one-way ANOVAs with subgroup as a between-subjects variable were performed at each half-minute time period to determine when group differences emerged. These ANOVAs showed no difference between subgroups at the prechange, $F(4, 67) = 1.71, p > .15, MSE = 61.33$, or postchange, $F(4, 67) = 1.96, p > .11, MSE = 62.25$, half-minute periods. There was, however, a significant difference between subgroups in the percentage of shadowing errors during the half minute of backward speech, $F(4, 67) = 11.73, p < .001, MSE = 43.72$. Figure 4 illustrates that the most important basis of this effect of backward speech on the error rate was an elevation in errors for only those participants who received and later reported the change in the irrelevant channel. Newman–Keuls pairwise comparisons between means accordingly indicated that the difference between subgroups was significant ($p < .05$) for Group A (no backward speech) participants versus all other subgroups except Group B participants who did not report the backward speech. The difference also was significant for either of the subgroups who reported the backward speech versus either of the subgroups who did not report it.

To determine more precisely when this shift or increase in shadowing errors occurred, we plotted the percentage of errors for each 5-s interval for the half-minute periods surrounding and including the backward speech segment (see Figure 5). Groups B and C again were separated into participants who did and did not report the backward speech. We then computed difference scores for each 5-s interval during the backward speech by subtracting participants' baseline percentage from their percentage of errors in each interval. The baseline measurement was each participant's percentage of errors averaged across the six 5-s intervals in the half minute before backward speech. These difference scores then were subjected to a two-way ANOVA with subgroup as a between-subjects variable and time interval as a within-subject variable.

In the prechange–postchange difference scores, there were significant main effects of subgroup, $F(4, 67) = 8.66, p < .0002, MSE = 366.81$, and time interval within the half minute of backward speech, $F(5, 335) = 7.40, p < .0002, MSE = 262.39$. Also, there was a reliable interaction between the two variables, $F(20, 335) = 2.74, p < .0008, MSE = 262.39$ (with Greenhouse–Geisser corrections for potential violations of homogeneity assumptions). To clar-

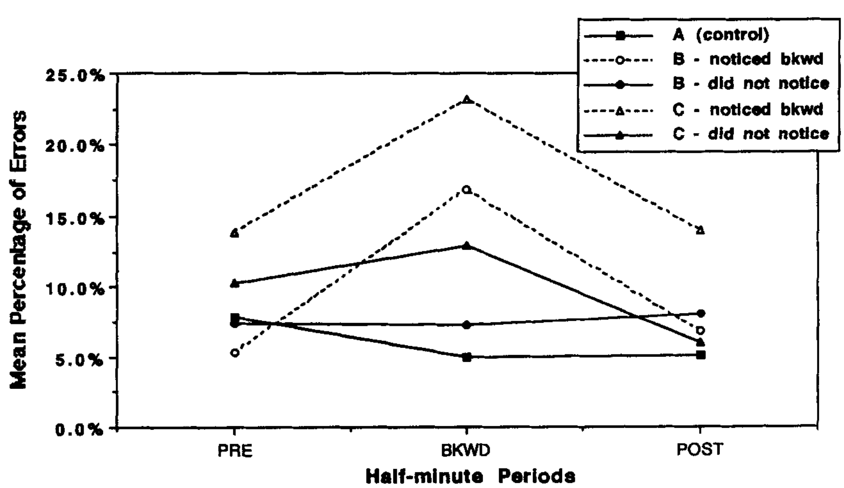


*Figure 4.* Mean percentage of errors in shadowing by half-minute period before, during, and after backward speech in the irrelevant channel, separately for participants who did and did not notice the backward speech in Experiment 3. A = control condition; B = backward speech during the first half of the 6th minute; C = same as B but ending after 6 min rather than 8.5 min. BKWD = backward.

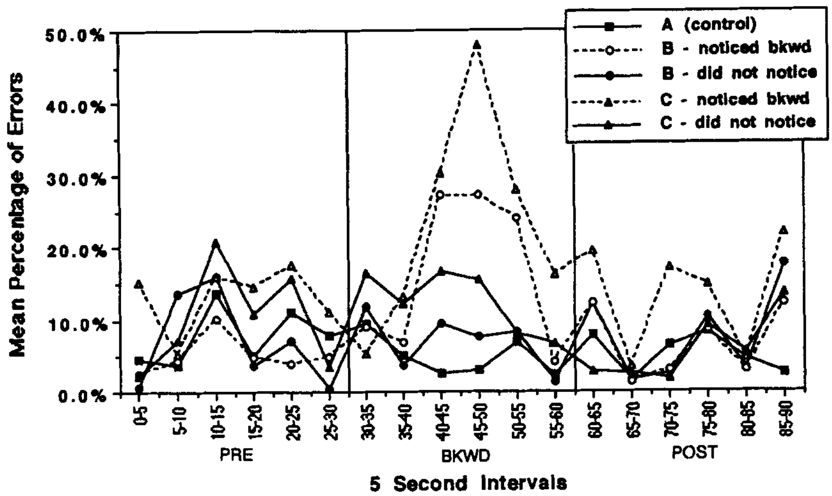


*Figure 5.* Mean percentage of errors in shadowing for each 5-s interval within the half-minute periods immediately before, during, and after backward speech, separately for participants who did and did not notice the backward speech in Experiment 3. A = control condition; B = backward speech during the first half of the 6th minute; C = same as B but ending after 6 min rather than 8.5 min. BKWD = backward.

ify the nature of subgroup differences across intervals, we compared difference scores for Group A (no backward speech) with those for each of the other four subgroups separately at each 5-s interval. For participants in Group B who later reported the backward segment, the percentages of errors in the third, fourth, and fifth 5-s intervals were significantly greater than those of Group A (all *p*s $< .007$). Similarly, for participants in Group C who later reported the backward speech, the percentages of errors in the third, fourth, and fifth intervals were significantly greater than those of Group A (all *p*s $< .05$). No other interval yielded significantly more change in an experimental subgroup than in the control group. Corresponding to the time periods with significant results (as described earlier), attention appears to have shifted in participants who later reported the change to backward speech during a window that peaked 10–20 s after the onset of backward speech (see Figure 5). There was, in striking contrast, no evidence of an attention shift in participants who later did not report the change.

It remained possible that a shift in attention may have occurred earlier in some participants but more subtly than could be detected with the error measure. To examine this possibility, we looked for 1-s pauses in shadowing immediately after the change to backward speech. A 1-s pause is a substantial hesitation considering that participants were shadowing at a rate of about 175 wpm. Previously, Cowan et al. (1990) found pauses or hesitations in reading to be useful indicators of attention shifts. We obtained an oscillographic representation of each participant's voice by using Macintosh Sound Designer II software. This enabled the measurement of time lags between participant responses to an accuracy of $\pm 8$ ms.

Across Groups B and C, 20% of the participants who later recalled the backward speech displayed a pause of at least 1 s in shadowing after the onset of the change in the irrelevant channel. None of the participants who did not later recall the backward speech displayed such a pause. This difference was significant at the $p < .025$ level (Fisher's exact test). Thus, recollection of backward speech in the irrelevant channel was also related to an immediate pause in shadowing, but only in a minority of the participants.

Furthermore, we considered whether shadowing response latencies for participants who detected the backward speech may have been longer than those of the other participants either shortly before or shortly after the onset of the change. Of course, a shadowing latency difference before the change could indicate a different a priori deployment of attention in participants who went on to notice the change, whereas a latency difference afterward could be just another consequence of attention shifting to the change. Response latencies were measured for each word as the interval from the shadowed stimulus onset to the response onset.

It was not possible to measure shadowing response latencies for an extended period of time, or for all participants, given that there were shadowing errors of omission that affected the subsequent lags. For example, participants sometimes were able to repeat a word very quickly when the previous word had been skipped. Therefore, we established a window of analysis surrounding the change to backward speech in the irrelevant channel that was as large as possible while still affording a respectable sample size of participants with errorless data in the window. The window so chosen included 8 words (1.8 s) before the change to backward speech and 8 words (2.6 s) after the change to backward speech. (The difference in duration reflects more multisyllabic words in the immediate postchange period.) The number of errorless participants for the analysis and their mean response latencies are shown in Table 4. To compen-

Table 4
*Mean Response Lags (in Milliseconds) for Error-Free Participants for Eight Words Before and After the Change to Backward Speech in the Irrelevant Channel in Experiment 3*

| Presentation condition | *n* | Prechange period *M* | Prechange period *SD* | Postchange period *M* | Postchange period *SD* |
|---|---|---|---|---|---|
| Control (A) | 16 | 902.8 | 284.9 | 923.7 | 364.3 |
| Did not notice (B and C) | 16 | 926.2 | 259.0 | 867.7 | 227.5 |
| Did notice (B and C) | 14 | 1,041.7 | 427.5 | 941.8 | 411.5 |

*Note.* Participants in Groups B and C were divided into those who did versus did not report noticing the backward speech. A = control condition in which backward speech was not presented; B = backward speech during the first half of the 6th minute; C = same as B but ending after 6 min rather than 8.5 min (see Figure 3).

sate for the limited number of participants in each condition, we divided Groups B and C into participants who did versus did not notice the backward speech. The window of analysis resulted in about the same percentage of participants being retained for each of the three subgroups: Group A (no backward speech) participants, 66%; Group B and Group C participants who did not notice the backward speech, 57%; and Group B and Group C participants who did notice, 70%.

Latencies for each word in the window of analysis were subjected to a two-way ANOVA with subgroup (Group A [no backward speech] participants, Group B and Group C participants who noticed, and Group B and Group C participants who did not notice) as a between-subjects variable, and period (prechange vs. postchange) and word within the period (1–8) as within-subject variables. In the full analysis, no effects involving subgroup approached significance. Two main concerns were addressed with additional ANOVAs. The first was whether there were subgroup differences in latencies before or after the backward speech onset, which would indicate differential attention shifting. The second was whether response latencies increased at the onset of backward speech. We found that subgroups differed in neither the prechange period nor the postchange period (both $Fs < 1$). Moreover, in ANOVAs for each subgroup separately across periods, no subgroup showed an effect of period ($F < 1$ in each case). Thus, in contrast to the shadowing error measures, shadowing latencies did not discriminate between participants who did versus did not detect the backward speech, nor did it distinguish either of these subgroups from Group A participants. Furthermore, the onset of backward speech did not significantly affect the response latencies for the subsequent eight words shadowed.

Finally, in an attempt to analyze a longer prechange time period, we were able to extend the period to 14 words (3.8 s) by omitting only 3 participants with errors in shadowing. For this extended prechange period, we again found no effect of subgroup, $F(2, 40) = 1.52, p > .2$. We could not extend the postchange period any further without losing a considerable number of participants as a result of shadowing errors.

The results tentatively address the difficult question of the direction of causation between attention shifts and detection of backward speech. They suggest that automatic processing of the change to backward speech caused an attention shift to that change, rather than the attention shift occurring for some other reason (e.g., sampling of the irrelevant channel). Five of our findings support this interpretation. First, the significant increase in shadowing errors occurred only after the change to backward speech. Second, no significant elevation in errors occurred for participants who did not receive a change to backward speech. These first two points establish a sequential chain that starts with the presentation of backward speech, continues with observable attention shifts after the backward speech in some participants, and culminates in conscious recollection of the backward speech by those participants.

Even given this sequential chain, there theoretically could be an a priori difference between participants who go on to recollect backward speech and those who do not. In particular, the participants who notice the backward speech might spontaneously sample the irrelevant channel more frequently than the other participants. However, the remaining three points argue against this interpretation. The third point is that the timing of attention shifts was quite regular across participants who noticed the backward speech, peaking strongly 10–20 s after the onset of backward speech. This suggests that the backward speech served as a trigger for a gradual attentional shift process, whereas an internal control of attention should not have produced this degree of synchrony across participants. Fourth, the baseline error rates were rather comparable for participants who reported the change to backward speech (5% and 13% in the B and C groups, respectively) and those who did not report it (7% and 10% in the B and C groups). Fifth, participants who detected the backward speech did not differ significantly in their response latencies from participants who did not detect the backward speech or from Group A (no backward speech) participants. Thus, it seems unlikely that participants who noticed the change to backward speech did so only because they sampled the irrelevant channel more frequently than other participants.

In summary, the main impact of these findings is that they reveal the previously undocumented, gradual time course of attention shifts, as measured by shadowing errors, after a subtle change in an irrelevant channel. Such attention shifts appear to be a necessary prerequisite for subsequent explicit recall of the change.

*Direct and indirect memory test performance.* The first analyses of the tests of direct and indirect memory included only participants who actually received the stimulus tapes. The number of selected phrases that matched what had been presented in an auditory channel, out of 14 possible in each test, was subjected to a two-way ANOVA with the direction of attention toward or away from the material to be tested (i.e., attended vs. ignored) manipulated between participants and test instructions (direct or indirect) manipulated within participants. The means corresponding to this analysis are shown in Figure 6. The main effect of the direction of attention was significant, $F(1, 46) = 68.13, p < .0001, MSE = 3.82$, whereas the main effect of test instruction was only marginally significant, $F(1, 46) = 3.83, p < .06, MSE = 3.93$. There was a significant Direction of Attention × Test Instruction interaction, $F(1, 46) = 7.74, p < .008, MSE = 3.93$. Figure 6 suggests that the basis of these effects is that phrases from the stimulus tape were selected more frequently with direct memory instructions than with indirect memory instructions, but only for participants who had attended to the materials that were to be tested.

Follow-up one-way ANOVAs showed an advantage for participants who attended to the materials tested on both the direct test, $F(1, 46) = 80.46, p < .001, MSE = 2.91$, and the indirect test, $F(1, 46) = 11.66, p < .002, MSE = 4.83$. There was a large effect of the test instructions for the attended stimulus group, $F(1, 46) = 11.23, p < .003, MSE = 3.93$. However, there was no effect of test instructions for participants who ignored the tested channel, $F(1, 46) < 1, p > .54, MSE = 3.93$.

These analyses alone cannot determine which conditions produced better-than-chance memory performance. To do that in the case of the indirect test, we compared participants in each of the preceding groups with those who had not heard the stimulus tapes at all. The latter group's data were used to control for biases in responding. The mean for this memory test only group is represented by the dashed line in Figure 6. In one-tailed $t$ tests, test scores of participants in the attended stimulus group were significantly higher than those of participants in the memory test only group, $t(94) = 5.19, p < .0002$. In contrast, there was no hint of a difference between the ignored stimulus group and the memory test only group, $t(94) = -0.13, p > .44$. The result was the same when the attended and ignored stimulus groups were compared, instead, with a simple, chance-level guessing rate of 7 out of 14.

For the direct test, the mean number of correct phrase choices in the attended and ignored stimulus groups was compared against chance levels of recognition (7 phrases out of 14) with one-tailed $t$ tests. We found that, for the attended stimulus group, the memory test score was significantly greater than chance, $t(23) = 18.45, p < .0002$; for the ignored stimulus group, however, it was not, $t(23) = 0.59, p > .27$. The results were the same when these groups were compared instead with the indirect memory test only group. Thus, there was no evidence of direct or indirect memory for materials that were presented in an auditory channel that was to be ignored.

It should be kept in mind that examining the possibility of implicit or explicit memory for the irrelevant speech materials was not the primary purpose of the present experiment. One reason for the absence of implicit memory may be that there was a change in modality between the auditory presentation and the written test. Previous research has suggested that although explicit recall of ignored materials is likely to be at chance regardless of modality (e.g., Eich, 1984; Fisk & Schneider, 1984), performance on indirect memory tests is reduced or eliminated by switches in modality (Graf, Shimamura, & Squire, 1985; Jacoby & Dallas, 1981; Roediger & Blaxton, 1987).

To evaluate this possibility in a final experiment, we administered the same direct and indirect tests of memory for attended and ignored spoken information auditorially rather than visually. We also examined the extent to which

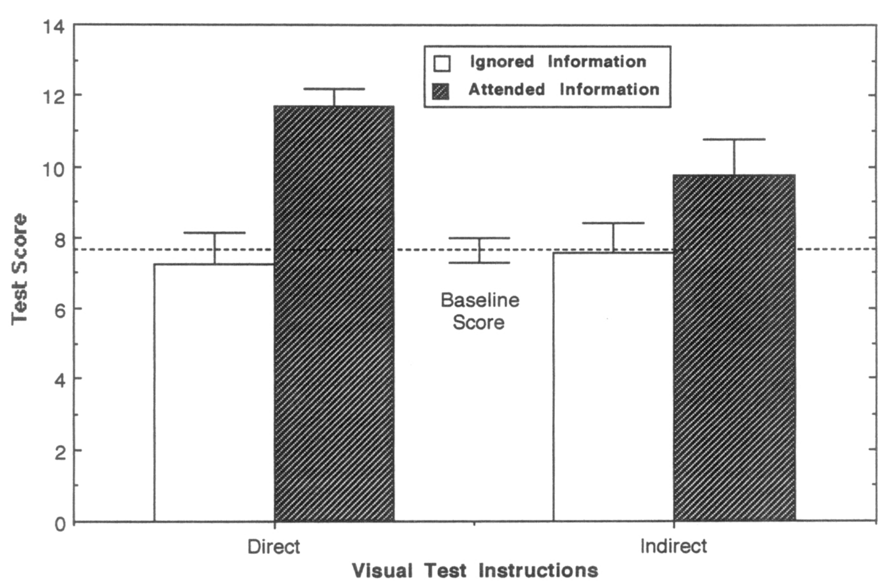


*Figure 6.* Mean scores on the visual direct and indirect tests of memory for groups of participants for whom the material to be tested was ignored versus attended during selective listening in Experiment 3. Error bars represent 95% confidence intervals. The horizontal dashed line represents the baseline performance on the visual indirect test for participants who did not listen to a stimulus tape.

participants were aware of the connection between the stimulus tape presentation and the story identification task (indirect test) to determine whether our indirect test truly was able to index memory without awareness.

## Experiment 4

### Method

*Participants.* Seventy-two participants (20 men and 52 women) were tested; the criteria were the same as in the previous experiments. These participants had not participated in the earlier experiments. They were divided randomly into three groups of 24 who participated in different conditions.

*Apparatus, stimuli, and procedure.* The equipment was identical to that used in Experiment 3. The attended and irrelevant channels were those used for Group A in that experiment. In the present experiment, 24 participants ignored and 24 attended to a to-be-tested passage played to their left ear. Participants in the ignored stimulus group were given shadowing instructions identical to those given in the previous experiments; they were asked to carefully shadow the right-ear passage and to ignore the voice in their left ear. Participants in the attended stimulus group were asked to listen carefully to the speech presented to their left ear and to ignore the voice in their right ear.

After tape presentation, participants were given direct and indirect tests of memory (set and order were counterbalanced as in the previous experiment). However, whereas the tests were visually presented in Experiment 3, in the present experiment the instructions and test items were read aloud by the same female speaker who had recorded the left-ear channel of the stimulus tape.

After the memory tests, participants were asked a series of questions: (a) Were any of the phrases I read to you in the story identification task (indirect test) familiar to you for any reason, and, if yes, why were they familiar? (b) Do you recall having heard any of those phrases earlier over the headphones, and, if yes, in which ear were they played? (c) On what basis did you choose one phrase over the other in the story identification task? and (d) There were two different famous stories played to you over the headphones, one in each ear; did you recognize either of those stories?

The first two questions were used to ascertain the extent of participants' awareness that some of the phrases heard during the indirect test had been played to them earlier over the headphones. Participants were judged to be unaware if they responded no to the first two questions or if they responded yes to the first question, but with an inappropriate explanation (e.g., "I think some of the phrases came from a story I have read previously"), and no to the second question. Otherwise, participants were considered to be aware.

On the basis of responses made to the final two questions, 4 participants were replaced. One participant in the ignored stimulus group recognized that the content of the left-ear channel had been taken from *2001: A Space Odyssey,* his favorite book, and stated that, as a result, he had a difficult time ignoring the left-ear channel. Three other participants, all from the attended stimulus group, reported that, in the story identification task (indirect test), they intentionally avoided picking any phrase that they thought may have come from the left-ear passage.

Finally, another 24 control participants in a memory test only condition heard no stimulus tape and auditorially received both of the memory test phrase sets with indirect test instructions. These participants provided a baseline for guessing on the indirect memory test.

### Results and Discussion

For the direct and indirect memory tests, participants' scores (out of 14 possible) were subjected to a two-way ANOVA with direction of attention to the to-be-tested materials (attended vs. ignored) manipulated between participants and test instructions (direct vs. indirect) manipulated within participants. The data for this analysis are shown in Figure 7. The main effects of direction of attention, $F(1, 46) = 88.12, p < .0001, MSE = 3.14$, and test instruction, $F(1, 46) = 5.13, p < .03, MSE = 2.49$, were significant as was the Direction of Attention × Instruction interaction, $F(1, 46) = 16.63, p < .0003, MSE = 2.49$.

Follow-up one-way ANOVAs revealed an effect of the direction of attention on both the direct and indirect tests of memory, $F(1, 46) = 98.72, p < .001, MSE = 2.70$, and $F(1, 46) = 17.76, p < .001, MSE = 2.93$, respectively. Participants who ignored the to-be-tested material during selective listening showed less memory for its content than those who attended to it. Also, there was a significant effect of test instructions for participants who attended to the to-be-tested auditory channel, $F(1, 46) = 20.11, p < .001, MSE = 2.49$, but not for participants who ignored the to-be-tested channel, $F(1, 46) = 1.64, p > .22, MSE = 2.49$. Thus, for the attended stimulus group, direct memory test scores were higher than the indirect memory test scores; for the ignored stimulus group, however, the test scores did not differ.

In addition, we examined evidence for memory for phrases from the left-ear channel beyond that which could be due to chance or a bias in the materials. For the indirect test, the mean number of correct phrase choices for the attended and ignored stimulus groups was compared with the baseline score of memory test only participants (represented by the dashed line in Figure 7) with one-tailed *t* tests. The attended stimulus group scored higher than the memory test only group, $t(46) = 5.10, p < .0002$, whereas the ignored stimulus group did not, $t(46) = 1.13, p > .13$.

For the direct test, we compared the mean number of correct phrase choices with chance performance (7 phrases out of 14) for both the ignored and attended stimulus groups with one-tailed *t* tests. For the attended stimulus group, explicit memory was significantly greater than chance, $t(23) = 17.66, p < .0002$; for the ignored stimulus group, it was not, $t(23) = 0.32, p > .37$. (The outcome was the same when the results were compared with the memory test only group data.) All of the preceding results replicate the pattern found for the visual test conditions of Experiment 3. Whereas participants who attended to the to-be-tested auditory channel displayed both explicit and implicit memory for phrases taken from it, those who ignored the to-be-tested channel showed neither type of memory for its content. Thus, our failure to find implicit memory for phrases from an ignored auditory channel in Experiment 3 cannot be attributed to a change in modality between study and test presentations.

Finally, in response to our probes about awareness of the relationship between the phrases in the story identification task and the stimulus tape presentation, 17 of 24 participants in the attended stimulus group were aware of the connec-

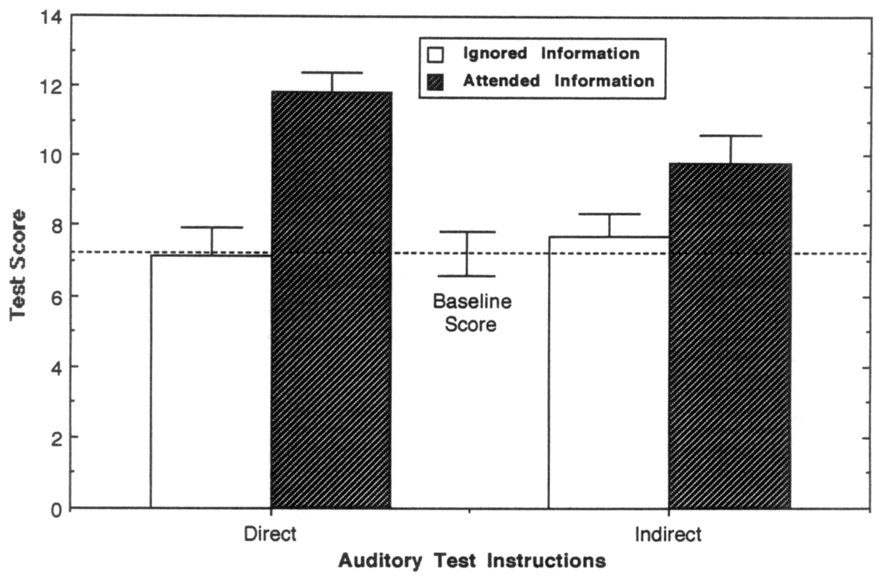


*Figure 7.* Mean scores on the auditory direct and indirect tests of memory for groups of participants for whom the material to be tested was ignored versus attended during selective listening in Experiment 4. Error bars represent 95% confidence intervals. The horizontal dashed line represents the baseline performance on the auditory indirect test for participants who did not listen to a stimulus tape.

tion. However, two-tailed *t* tests between participants who were aware and unaware revealed that their indirect test scores ($M$ = 9.82, $SD$ = 1.85, and $M$ = 9.71, $SD$ = 2.22, respectively) did not significantly differ, $t(22) = -0.13$, $p > .90$. Thus, although not all participants remained naive to the relationship between the phrases presented in the indirect memory test and the stimuli previously heard over the headphones, those who did remain naive still displayed implicit memory for those phrases. No participants in the ignored stimulus group were aware that some of the phrases presented during the indirect test had been presented previously over the headphones.

In summary, although awareness that some phrases on the indirect test previously had been presented during selective listening was not necessary for implicit memory to be displayed, attention to the phrases during selective listening was required. The apparent absence of implicit memory, without attention, must be viewed cautiously. We may have found no implicit memory for the content of the irrelevant channel because the indirect task that we used was not sufficiently sensitive. Although we did establish that participants displayed implicit memory with these materials when the phrases were attended during selective listening, it remains possible that a test requiring less semantic processing may result in implicit memory for materials ignored during selective listening.

However, the only prior evidence suggesting that participants show implicit memory for information from an irrelevant auditory channel in selective listening was offered by Eich (1984). While participants in that study were busy shadowing prose, pairs of words were presented in an irrelevant channel that included a word with homophonic properties and an adjective that connoted the lower frequency of two possible meanings (as in the word pair *taxi–FARE*). Participants later displayed no explicit recognition of the homophonic words. However, when those words were presented auditorially for participants to spell, participants more often gave the spelling consistent with the context word (e.g., *FARE* instead of *FAIR*), suggesting that they had implicit memory of the target words. However, the control of attention in Eich's study may not have been optimal. Words in the irrelevant channel were presented at a 1-s rate with 2 s between word pairs, and the attended prose passage was presented at a very slow rate of 85 wpm. The observed dissociation between explicit and implicit measures of memory in that study does not imply that items necessarily were encoded for implicit recall without any attention at all, so the question of how much semantic encoding occurs automatically in selective listening remains unresolved in the literature.

## General Discussion

The basic aim of this study was to determine the relation between the deployment of attention in selective listening and memory for the information. We pursued this aim in a replication of a classic condition devised by Cherry (1953) suggesting that most listeners do not notice a change from ordinary speech to backward speech in an ignored auditory channel. This condition was selected because the change is not noticed consistently, as is a simple physical change

(Ingham, 1957; Lawson, 1966; Treisman & Riley, 1969), but is not overlooked consistently, as is a complex semantic change (Cherry, 1953; see also Cherry & Taylor, 1954; Treisman, 1964a, 1964c). The basic aim was pursued through four, more specific questions: (a) How well are Cherry's findings regarding the detection of backward speech replicated when a better controlled (or at least better documented) methodology is used? (b) How does performance compare among several tasks commonly used in selective listening? (c) What is the relation between on-line measures of attention shifts and retrospective reports of having heard the backward speech? and (d) Is there evidence of explicit or implicit memory for phrases in a to-be-ignored channel in selective listening? The answers and their theoretical implications are considered in turn.

In Experiment 1, we found that, in our most conservative estimation (after the longest period of shadowing before the backward speech), about one third of participants detected an unexpected change to backward speech in an irrelevant channel. We propose that this may, in fact, correspond quite closely to Cherry's (1953) results and suggest that such a subtle physical change is more readily detected than some subsequent portrayals of Cherry's findings would have one believe. In addition, we determined that the amount of shadowing practice was related to detection of the backward speech and that 5 min of continuous shadowing practice before the change to backward speech was enough that a significant portion of participants failed to detect the change.

Past researchers often have failed to take into account the absolute effectiveness of their primary task at maintaining attention to a single channel of input (Holender, 1986). The primary task must sufficiently focus participants' attentional capabilities but not be so laborious as to cause frequent errors, which can disrupt attention. Accordingly, in Experiment 2, we departed from the method of our first experiment in several ways, in search of the best primary task. We tried out three different primary tasks that differed from Experiment 1 in the match of voice in the attended and irrelevant channels, in the primary task materials, or both. We found that when the primary task was shadowing prose at a relatively fast rate while the attended and irrelevant channels were presented in different voices (unlike what Cherry, 1953, did), still only about half of the participants indicated that they had heard something unusual in the irrelevant auditory channel. Many more participants noticed the change to backward speech when the primary task was shadowing unrelated words or reading prose. Finally, these findings did not appear to depend critically on whether participants shadowed for 5 or 7 min before the change to backward speech or on the exact amount of time between the backward speech and the recall test.

One might ask why even the prose shadowing condition did not block participants' awareness of the change to backward speech more consistently. One hypothesis would be that some of our participants sampled the irrelevant channel periodically, with attention shifts throughout the session. In contrast to that hypothesis, however, in Experiment 3 we found that participants who noticed the change declined temporarily in shadowing accuracy only after the change to backward speech. Moreover, response latencies of participants who detected the change did not differ from those of the other participants in the few seconds before the change to backward speech or the few seconds immediately after its onset. It thus seems fairly clear that the direction of causation was as follows: Automatically detected discrepancies in the irrelevant stimulus provoked attention shifts, rather than habitual sampling of the irrelevant channel leading some participants to notice the backward speech. Similarly, Wood and Cowan (1995) found that shadowing performance differentiated participants who did versus did not detect their own name presented in an irrelevant auditory channel and that the difference in shadowing occurred only after the name presentation.

In the present case, it still might be argued that many participants monitored the irrelevant channel intermittently and that the ones who happened to do so during the backward speech were the ones who later recalled the backward speech. One additional aspect of the data that argues against this view is that the errors in shadowing peaked rather precisely about 10–20 s after the onset of backward speech (see Figure 5). If participants had only sampled the irrelevant channel intermittently, the errors should have been distributed more broadly across the backward speech period. Even if it takes some time after the initial detection of backward speech for the errors to emerge, a sampling strategy should not have resulted in errors that decline in the latter half of the backward speech period. Therefore, we believe that it is likely that automatic processing triggered a shift of attention to the backward speech in participants who went on to recall hearing the backward speech.

Underwood and Moray (1971) worried that "the low rejected message detections traditionally obtained may not be so much a reflection of diverted attention but of the high information processing load of the shadowing task" (p. 294). However, the use of on-line attention shifts to relate shadowing performance to later recall of events in the irrelevant channel, both in Wood and Cowan (1995) and in the present study, can allay these fears. These studies indicate that rates of detection of irrelevant channel events are low precisely when attention does seem to be locked onto the relevant channel, whereas detection rates are high when attention is observed to shift.

Another hypothesis that must be considered is that all participants actually noticed the change to backward speech, but some participants forgot the change before they had a chance to report it. However, in Experiment 3, an increase in shadowing errors during backward speech in comparison with the previous forward speech period was obtained only for participants who later said that they noticed something unusual in the irrelevant channel. These increases in shadowing errors presumably serve as a measure of attention shifts to the irrelevant channel (e.g., Cowan et al., 1990; Dawson & Schell, 1982). If the other participants had also noticed the backward speech but had forgotten it before the recall period, then they too should have shown the same increase in shadowing errors.

This observed relation between on-line measures of attention shifts and retrospective reports provides evidence against extreme views of selective attention. The backward speech was recalled only by some participants, and then only at the expense of primary task performance. On one hand, according to an early-filter view of attention (Broadbent, 1958; Cherry, 1953), it might have been expected that such a subtle physical change would not be noticed by any of the participants unless their attention happened to shift at some random point during the backward speech. The attention shifts (shown in Figure 5) seem too well aligned temporally for this interpretation to hold. On the other hand, in a late-filter view of attention (e.g., Corteen & Wood, 1972; Deutsch & Deutsch, 1963; Duncan, 1980; Marcel, 1983), all stimuli are processed to a semantic level, and the attentional limit is a limit in response selection (e.g., see Moray, Fitter, Ostry, Favreau, & Nagy, 1976). According to that view, it should be possible to process the subtle physical and striking semantic changes that occur when the irrelevant channel changes to backward speech without an attentional cost. Therefore, the change to backward speech should have been noticed almost immediately by most or all participants. This might be expected to have caused an attention shift immediately after the change, which appeared to be the case in only a small percentage of the participants. Alternatively, given that the processing was automatic, it might have been possible for participants to notice the backward speech without any disruption in shadowing. Instead, the results provide support for Holender's (1986) proposal that, in cases of apparent processing of stimuli in an irrelevant channel, attention shifts actually have occurred (see also Johnston & Heinz, 1979; Treisman & Riley, 1969; Treisman et al., 1974; Yates & Thul, 1979).

The data are most consistent with an intermediate-level theory, such as Treisman's (1964c) attenuation theory. The attenuation theory holds that material in an unattended channel makes contact with representations in long-term memory and activates them to some extent, but typically not to the level of conscious awareness. Changes in an irrelevant stimulus channel are noticed if they trigger a shift of attention to that channel. Whether or not an attention shift will occur presumably depends on both the severity of the change in the physical characteristics of the irrelevant stimuli and the preexisting level of activation of the units in memory that are excited by the postchange stimuli (for more recent, basically compatible accounts, see Cowan, 1988, 1995; Hackley, 1993; Naatanen, 1992).

The automatic processing leading to such a shift of attention can be accounted for by Sokolov's (1963) theory of the orienting response (see also Cowan, 1988, 1995; Hulstijn, 1979; Ohman, 1979). According to that theory, participants form a memory representation or "neural model" of each stimulus in the environment. To the extent that features of a new stimulus can be analyzed, the featural representation of that stimulus is compared with the preexisting representation in memory, and a substantial mismatch between the two produces an orienting response. The orienting response is a complex of transient changes including motor quieting, temporary lowering of sensory thresholds, and a shift in attention to the eliciting stimulus.

Although analysis of an irrelevant stimulus probably cannot produce a complete set of features for comparison with the neural model, it seems clear, at least, that some analysis of physical features occurs automatically (Cherry, 1953; Cowan, 1988; Naatanen, 1992). Thus, a change from forward to backward speech could result automatically in a discrepancy between prechange and postchange mental representations of the irrelevant channel's stimuli, eliciting a shift of attention to that channel.

The timing of the observed attention shift in participants who noticed the change to backward speech in Experiment 3 was theoretically informative (see earlier discussion). One account of the delayed attention shift 10–20 s after the onset of backward speech is that it took a long time for the perceptual analysis of the backward speech to become refined enough to register as different from the neural model of the prior, forward speech and thus trigger an orienting response. A second possible account is that small, fleeting orienting responses occurred starting at approximately the beginning of the backward speech, with each subtle shift of attention adding to the mental representation of the backward speech until some critical threshold level of completeness of the neural model was reached, finally triggering the full-fledged orienting response and producing measurable errors in shadowing.

The latter account predicts that there could be some subtle measure of attention shifting soon after the beginning of backward speech. One-second pauses in shadowing occurred at the onset of backward speech for 4 of the participants who noticed the change, but that number is too small to provide strong support. In addition, participants who detected the backward speech did not differ from other participants in their pattern of response latencies for the first eight words shadowed during the backward speech. Thus, it remains for future research to determine the reason for the intriguing delay in attention shifting in most of the participants who later reported the change to backward speech.

The questionnaire data of Experiment 3 also provide some support for theories of memory that postulate a central role for attention (e.g., Cowan, 1988, 1995; Jacoby, 1991; Schacter, 1989). Direct measures of memory should not indicate recall unless the stimuli were attended at the time of presentation, and the close relation between attention shifting and recall of backward speech is consistent with that expectation.

It might have been expected, on the basis of previous research (Eich, 1984), that an indirect measure of memory would have revealed implicit memory of phrases within the irrelevant channel. However, this expectation was not confirmed, no matter whether the test modality was auditory, like the original presentation modality (Experiment 4), or visual (Experiment 3). Moreover, the presence of considerable memory in participants who attended to the channel to be tested, as measured in both direct and indirect tests, provides assurance that it was the absence of attention that caused a failure of memory in the other participants.

There are several reasons why one, in fact, might not expect implicit memory in the absence of attention. First, there is no previous finding of implicit memory for ignored speech in which one can be confident that attention was blocked. Most studies (e.g., Parkin & Russo, 1990) have used split attention rather than directing attention totally away from one channel. Eich (1984) included an irrelevant channel, but reservations about the control of attention in that study were noted earlier. Kidd and Greenwald (1988) found no memory for nine-digit auditory sequences that had been presented 10 times in a to-be-ignored voice. It thus may well be that the perceptual analysis of the irrelevant channel does not include enough detail to be of use in the indirect test that we included, which involved multiword phrases.

The present study generally supports the utility of the methodological and theoretical approach to selective attention first adopted by Cherry (1953) and elaborated on by Broadbent (1958). It may serve as an impetus for further research, long overdue, on the mechanisms of auditory attention shifting. Now that it has been shown that participants may take a number of seconds to shift attention fully to a salient change in an irrelevant channel, it is a priority to determine more precisely what mechanisms are involved in this gradual attention shifting. Such information should help to resolve still-unanswered, fundamental questions about the nature of selective attention.

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# Appendix

## Memory Test Instructions and Materials

This appendix contains verbatim instructions given to participants (first for the direct test of memory and then for the indirect test) for whom the tasks were visual and the information was ignored at study. The instructions were modified slightly for the other presentation conditions.

Also, Table A1 contains two sets of pairs of phrases (A and B). The first phrase of each pair came from the designated minute of the left-ear passage. The second phrase of each pair, which had never before been presented to participants, came from a final chapter of the same book as the passage presented to the left ear. The pairing of sets and task instructions was counterbalanced so that every participant received each set (A and B) and each type of memory test instructions only once, except for the memory test only participants, who received both Sets A and B with the indirect memory test instructions. In addition, the order of memory tests, as well as the order of phrases within each presented pair and the order of pairs of phrases within each task, was counterbalanced.

### Recognition Task

Your task in this section is to *try and remember* what was being said in the ear that you were not repeating. The following are pairs of sentences or phrases. One of each pair was played to the ear that you were *not* repeating. The other of the pair was *never* presented to you in this session. Do your best to check the blank in front of the one in each pair that *was* presented to your left ear.

*(Appendix continues on next page)*

## Story Identification Task

Your task in this section is to make judgments about the wording of *stories in general.* The following are sentences or phrases. Half of them came from a story written by a famous author. The other half are simply made up and do not appear in any known story. Please put a check in the blank before the one in each pair that seems *more likely* to you *to have come from a published story.*

Table A1
*Phrase Pairs*

| Designated minute | Phrase Set A | Phrase Set B |
|---|---|---|
| 1–2 | ______The victor was not yet in sight | ______They were not flourishing |
| | ______More vividly of his remoteness | ______That no man would have recognized |
| | ______When the first faint glow of dawn | ______Fed from snows in the mountains |
| | ______There was one slight change | ______It gave no heat at all |
| 2–3 | ______He looked at the emaciated body | ______Gave him an angry growl |
| | ______Four or five years hence | ______Perhaps for the last time |
| | ______Ridges over the eye sockets | ______Weighed over a hundred pounds |
| | ______But whatever secret they might hold | ______It was a delicate bow |
| 3–4 | ______There was no sign of danger | ______Began to hasten toward the muddy water |
| | ______The sharp-edged boundary | ______That there was some way of telling |
| | ______There had been many deaths | ______Since they were nowhere to be seen |
| | ______A block of ebony | ______With the dark mystery at its center |
| 4–5 | ______Occasional windfalls like small lizards | ______At the last quarter of the moon |
| | ______The faces seem absolutely smooth | ______That it made much difference |
| | ______They were already waiting | ______The hyenas would soon be in luck |
| | ______His carefully measured photographs | ______Very few single buildings |
| 5.5–6.5 | ______As they saw him coming | ______There were about thirty of them |
| | ______For one dizzy moment | ______By an effort of will |
| | ______They had little surplus energy | ______Honor had been satisfied |
| | ______He was not alarmed | ______Which defied the laws of perspective |
| 6.5–7.5 | ______They could not be driven away | ______The nearest worthwhile grazing |
| | ______It goes on forever | ______Turned and twisted upon itself |
| | ______Yet the thousands of tons | ______It was beyond their imagination |
| | ______For just one broken sentence | ______Too short to be measured |
| 7.5–8.5 | ______A full moon was rising | ______Merely part of the background of life |
| | ______They were theories no longer | ______That had opened to let him through |
| | ______Not a voice was raised in protest | ______Down there in the darkness |
| | ______Shining there in the dark | ______Now that it was far too late |

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