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# Lexical Access Without Attention? Explorations Using Dichotic Priming

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The authors used lexical decision in a dichotic listening situation and measured identity priming across channels to explore whether unattended stimuli can be processed lexically. In 6 experiments, temporal synchronization of prime and target words was manipulated, and acoustic saliency of the unattended prime was varied by embedding it in a carrier sentence or in babble speech. When the prime was acoustically salient, a cross-channel priming effect emerged, and participants were aware of the prime. When the prime was less salient, no identity priming was found, and participants failed to notice the prime. Saliency was manipulated in ways that did not degrade the prime. Results are inconsistent with models of late filtering, which predict equal priming irrespective of prime saliency.

The functional role of selective attention is to preserve the organism from information overload. There is so much stimulation from the outside world that without some kind of filtering process, the brain would be overwhelmed with information. However, filtering processes should not completely cut off the unattended channels, otherwise the organism might disregard important signals. Theories of selective attention address this conundrum by stipulating that only a very restricted set of stimuli are fully and efficiently processed, that is, the stimuli that are inside the focus of attention. In contrast, stimuli outside the focus of attention are processed "preattentively," that is, up to a relatively shallow level. This preattentive processing can nonetheless attract the focus of attention to some new or changing stimuli. Our interest is to find out whether preattentive processing includes lexical recognition.

The well-known cocktail party phenomenon (Cherry, 1953) suggests that even when one is focusing on a conversation (or to one channel), one's attention can be captured by a nearby conversation whenever an interesting lexical item comes about (i.e., one's own name). However, it is unclear whether it is the semantic properties of the word that draws one's attention or merely a low-level property, like a particular intonation or a slight pause in the signal. In the former case (late filtering), high-level linguistic properties are being extracted preattentively (Deutsch & Deutsch, 1963), whereas in the latter case (early filtering), only low-level features are processed preattentively (Broadbent, 1958). In this latter case, apparent instances of semantic "attraction" are just the result of attentional drifts from one channel to the next. This theoretical discrepancy has always been difficult to resolve experimentally, mainly because of the dynamic nature of attention. To control for rapid attentional switches, one must use a paradigm that can assess online processing with a very fine temporal resolution.

## Paradigms to Study Selective Attention

Auditory selective attention studies usually rely on dichotic listening. Participants are presented with a different message in each ear and are asked to perform a demanding task on the stimuli presented in one channel while ignoring the other channel. Before presenting our new paradigm, we review the different ways in which past studies have assessed processing of the unattended channel.

### *Explicit Recall*

In the seminal study conducted by Cherry (1953), participants were instructed to shadow a given channel and subsequently were asked to report what they recall from the unattended channel. Participants were only able to report that the unattended channel contained human speech, but none were able to report specific words or phrases. Participants failed to notice changes in the unattended channel from English to German or to backward speech. However, they were able to notice a change from speech to a 400-Hz tone and from a male voice to a female voice, suggesting that salient sensory changes can be processed preatten-

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tively. According to this study, apart from sensory information, no other information is extracted for stimuli that are outside the focus of attention. This was used by Broadbent (1958) as evidence for an early-filtering focus of attention.

Yet, studies subsequent to Cherry (1953) showed that the meaning of irrelevant stimuli can, at least sometimes, be noticed. One of the most cited is Moray's (1959) demonstration that about one third of participants are able to report having heard their own name in the unattended channel. These results suggest that, at least on some occasions, unattended messages are processed up to the semantic level. However, explicit recall may be a poor indicator of online processing of the unattended channel.

Holender (1986) pointed out that attention is a dynamic process that needs to be taken into consideration in studies of selective attention. Participants' attention can shift from one channel to the other throughout the experiment. A momentary attentional switch would allow participants to pick up some semantic information from the unattended channel and to identify their name on a certain proportion of trials. It is clear that the presence of attentional switches may lead participants to *overestimate* the amount of processing of the to-be-ignored channel. To investigate this, Wood and Cowan (1995a, 1995b) used an online measure of shadowing latencies to check for potential attentional switches. They replicated the classical finding of Moray (1959) showing that a third of the participants were able to recall their names presented in the unattended channel at the end of the experiment. They also reported that a third of the participants were able to recall a switch from backward to forward speech. However, the participants who noted these changes in the unattended channel also displayed a drastic increase in shadowing errors and latencies several items after the change. This demonstrates that when a change is noticed in the unattended channel, it correlates with a disruption in performance in the attended channel.[1] Conway, Cowan, and Bunting (2001) found important individual differences in the rate of intrusions from the unattended channels: Individuals with a low memory span noticed their names much more than individuals with a high memory span. Conway et al. noted that low working memory span correlates with distractibility (see Conway & Engle, 1994) and hence speculated that name intrusions are due to the reduced ability to ignore the unattended channel.

A second problem of these studies is that explicit recall requires participants not only to be aware of the information in the unattended channel but also to register it in (episodic) memory. However, semantic processing of the unattended channel may occur without awareness or episodic memory registration. In other words, this paradigm could *underestimate* the amount of processing of the unattended channel. It may be the case that all participants in Cherry's (1953) or Moray's (1959) studies unconsciously processed the meaning of words in the unattended channel but were later unable to report it. To resolve this issue, other studies addressed this second problem and used more sensitive measures of semantic processing than explicit memory.

### *Implicit Priming*

Eich (1984) had participants shadow a prose passage in one ear while a list of word pairs was presented in the other ear. The word pairs consisted of a homophone preceded by a disambiguating item associated to the less frequent meaning of the ambiguous word (e.g., taxi–FARE). After the shadowing task, participants showed no explicit recall of the word pairs; nonetheless, when asked to spell the ambiguous word, they were more likely to give the less frequent meaning of words than the more frequent one (i.e., FARE instead of FAIR). In a similar study, MacKay (1973) presented an ambiguous sentence in the attended channel while a disambiguating word was presented in the unattended channel. He found that the unattended word disambiguated the sentence, suggesting that it was processed all the way up to its meaning.

On the one hand, these studies are still subject to Holender's (1986) criticism. It could be that the results are due to attentional switches that occurred during the experiment rather than to lexical processing of materials in the unattended channel. Indeed, Wood, Stadler, and Cowan (1997) noted that Eich (1984) used a very slow presentation rate that could have allowed participants to switch periodically toward the irrelevant channel. They first replicated Eich's findings using the same shadowing rate, but they also showed that when the rate is doubled, forcing participants to pay more attention to the attended channel, implicit priming disappears. Similarly, Newstead and Dennis (1979) replicated MacKay's (1973) disambiguating effect of the word in the unattended channel, but only when this word was presented in isolation. The effect disappeared when the unattended word was embedded in a carrier sentence. Newstead and Dennis argued that isolated words in the unattended channel momentarily attract attention leading to conscious identification, which does not occur if the word is embedded in a sentence presented to the nonselected ear.

On the other hand, implicit priming could also underestimate lexical processing of the unattended channel. Indeed, there are many cases in which stimuli that are fully attended to and fully processed lexically nonetheless fail to produce implicit priming effects. For instance, frequent words may fail to produce implicit repetition priming effects (e.g., Bowers, 1999; K. I. Forster & Davis, 1984), and implicit priming disappears if not enough time is allotted to deeply process the stimuli (Subramaniam, Biederman, & Madigan, 2000; for a review of these implicit priming findings, see Bowers & Kouider, in press). Once again, it is possible that lexical processing of the word presented to the unattended channel occurred, leaving no long-lasting trace either in explicit or in implicit memory. Note, for instance, that visual words that do not reach consciousness because they are masked clearly show lexical effects but nevertheless are very short-lived (K. I. Forster & Davis, 1984). Maybe unconscious primes could be judged to be ineffective if their existence was assessed with long-term implicit or explicit measures.

### *Electrophysiological Measures*

A third technique uses electrophysiological measures to assess online semantic activation of an unattended channel. The early study by Moray (1970) measured galvanic skin responses (GSRs) to a stimulus word that has been previously associated with an electric shock. The issue is whether the shock-associated stimulus

[1] Note, however, that the causality is difficult to establish in this experiment. Is it the semantic change that caused the attentional switch, or is it because there was an attentional switch in the first place that the semantic change got noticed and became disruptive?

still produces a GSR when it is presented in the unattended channel. Several studies reported such effects (Corteen & Dunn, 1974; Corteen & Wood, 1972; P. M. Forster & Govier, 1978; Von Wright, Anderson, & Stennman, 1975; but see Wardlaw & Kroll, 1976).

These findings still are also subject to Holender's (1986) criticism. Indeed, the participant's attention may be attracted to the other channel by low-level cues (as in MacKay's, 1973, experiment), or it may drift from time to time toward the unattended channel, yielding an effect. Indeed, Holender claimed that in all of these studies there is no satisfactory control of attention deployment, and in the one study in which such a control is used (Dawson & Schell, 1982), GSRs are almost always restricted to cases in which test words have received some attention.

Other studies have more directly compared the early electrophysiological responses (ERPs) evoked by the attended versus the unattended stimulus. For instance, Hillyard, Hink, Schwent, and Picton (1973) presented a stream of short tones with occasional deviants of a slightly higher frequency that participants had to detect. A very similar stream, using tones of different frequencies, was presented on the unattended channel. ERPs to nontargets were recorded for both channels. Hillyard et al. found a significant decrement of the N1 response to the unattended compared with the attended stimuli. Earlier components (20–50 ms poststimulus) also showed a significant difference, suggesting that attention modulates processing down to primary auditory cortex (see also Woldorff et al., 1993). This strongly supports an early locus of attention and is incompatible with a late locus. Note that in these studies, attentional modulation was never found to be total. Even unattended stimuli produce significant evoked brain response. Hence, it is possible that the unattended stimuli are not completely filtered out but are merely *attenuated* (Triesman, 1964). If this were true, it is still possible that unattended stimuli are processed lexically, as a late-filtering hypothesis would state. Indeed, studies conducted using the N400 response to semantically related words or repeated words have yielded conflicting results (Bentin, Kutas, & Hillyard, 1995; Okita & Jibu, 1998). In brief, studies comparing attended and unattended ERPs are still inconclusive regarding the involvement of lexical processing in the unattended channel.

## Present Study

As is apparent in our review, the issue of the involvement of lexical processing in the unattended channel is still pretty much open. On the one hand, lack of control of the acoustic saliency of the prime and the time allocated to strategic switches makes it possible that some of the reported deep processing effects are due to momentary attentional switches onto the unattended channel. On the other hand, most studies have used insensitive methods to assess lexical processing, allowing the conjecture that the processing of unattended stimuli is more widespread than had been reported. As Wood et al. (1997) concluded, a more direct online measure of the semantic activation of the unattended channel is needed: "It remains to be seen whether there is a more rudimentary form of implicit memory for stimuli that are totally unattended at the time of their presentation, such as that indexed by simple semantic priming" (p. 778).

In the present study, we try to address these shortcomings by introducing two innovations in the dichotic listening paradigm. First, we follow the idea raised in Wood et al. (1997) and use a more direct measure of unattended lexical activations, in fact, even more direct than semantic priming: immediate repetition priming in an online lexical decision task. Second, we explicitly manipulate acoustic saliency of the unattended channel, using carrier materials as in Newstead and Dennis (1979).

As regards repetition priming, we asked participants to perform a lexical decision on the attended channel. Meyer, Schvaneveldt, and Ruddy (1975) found that in lexical decision, faster reaction times and less errors are found if a target is immediately preceded by the same item. K. I. Forster and Davis (1984) found repetition priming even when participants remain unaware of the prime because it is presented very briefly and is pattern masked. In our work, we use repetition priming as an index of lexical activation of the prime.

As regards the control of the likelihood of an attentional switch, we compared two situations. In one situation, the prime presented in the unattended channel is made salient (e.g., surrounded by silence). Saliency of the prime is likely to capture attention and to provoke a switch toward the unattended channel. In the second situation, the prime is surrounded by a carrier that has the same spectral and energy levels as the prime. In this situation, a stimulus-driven attentional switch just to the prime is implausible. Further, to minimize the possibility of a strategic attentional switch, we always presented the unattended materials attenuated and time-compressed so that they appeared to participants as uninteresting babble.

If early-filtering accounts are correct, we expect to find repetition priming from the unattended channel only when the prime is salient and captures the attention of the participants. If late-filtering accounts are correct, in contrast, repetition priming should obtain irrespective of attentional switches. Indeed, under this view, attention plays a role only after lexical access has been completed. Of course, we have to ensure that the manipulation performed to mask the saliency of the prime does not degrade the prime itself. To do this, we perform monaural control experiments with the same surrounding materials.

In the first three experiments, we present the prime and target simultaneously. In Experiment 1, the prime is presented alone in the unattended channel, and in Experiment 2, we surround it by a carrier sentence that is largely uninformative and kept constant throughout the experiment. Experiment 3 is a monaural control to check that the carrier sentence does not degrade perceptibility of the prime. In the final three experiments (Experiments 4–6), we apply the same logic to a situation in which the prime is presented before the target.

## Experiment 1

Participants had to perform a lexical decision to stimuli presented in one channel, the ear contralateral to the dominant hemisphere (right ear) while ignoring stimuli presented in the other channel (left ear). The task was quite demanding and required a speeded response. The unattended channel contained a prime that was either identical to the target or unrelated semantically and phonologically. We measured the response latencies to the target in the related and unrelated conditions and defined priming as the difference between these two latencies. The onset of the prime and target was simultaneous in this experiment. Under these conditions, it is possible that, despite the selective attention task, the unattended channel will capture the participant's attention at the moment the prime is presented, resulting in an attentional switch and lexical processing of the prime leading to a priming effect. This hypothesis also predicts that participants should consciously identify the prime and report having heard it.

## Method

*Materials.* Eighty French words and 80 nonwords were selected (see the Appendix). Half of them were monosyllabic (with a consonant–vowel–consonant [CVC] structure), and half were disyllabic (with a CV–CV structure). Half of the words were of high frequency, half were of low frequency.

These stimuli were split into two sets, the *target set* and the *control prime set*, of 80 items each. These two sets were matched in number of words and nonwords, word frequency, and number of syllables. Each set was further split into two subsets of 40 items each (the related subset and the unrelated subset). One list of 80 prime–target pairs, called List A, was then constructed by pairing each item from the target set either with itself, if it belonged to the related subset, or with a matched item of the same lexical status, number of syllables, and frequency range (for the words) from the control prime set, if it belonged to the unrelated subset. A second list, List B, was constructed in the same way, but the role of the related and unrelated subsets was switched. Hence, Lists A and B were counterbalanced, and a target appearing paired with itself in List A would appear paired with a control item in List B and vice versa. Two further counterbalanced lists (C and D) were constructed in the same way, by exchanging the role of the target set and the control prime set. This means that across the four lists, each of the 160 items appears both as a target and as a control prime. A training list of 8 prime–target pairs was further constructed along the same line.

The 160 experimental stimuli plus the additional 16 items for the training list were recorded by a native speaker of French. The stimuli were digitized in 16 bits 16-kHz format and stored into separate audio files. A copy of all the stimuli was made and was time-compressed down to 38% of their original duration using the PSOLA algorithm (Charpentier & Stella, 1986).[2] (Sample stimuli are available on the Internet at http://www.lscp.net/persons/dupoux/dichoprim/)

*Procedure.* For each prime–target pair, an experimental trial consisted of the following events. In the right channel, the target stimulus was played uncompressed at the original recording level. In the left channel, the compressed primed was played, attenuated by a factor of –12dB. The right channel was temporally synchronized with the left channel. The whole protocol was programmed using the mixing table function of the Expe6 experiment package (Pallier, Dupoux, & Jeannin, 1997).

Participants were randomly assigned to one of the four lists (A, B, C, or D) and given the same training list of eight trials. They were instructed to perform a lexical decision on the items appearing in the right channel and to ignore the other ear. They were not informed of the presence of the primes in the unattended channel. During the training trial, visual feedback was provided for correct versus incorrect responses. Incorrect trials were played again immediately, until a correct response was made by the participant. At the end of the experiment, participants were asked to verbally describe what they heard in the left channel.

*Participants.* Participants were university students recruited in Paris, France. They were native speakers of French and reported no language or auditory impairment. Participants making more than 30% total errors on the lexical decision task were replaced. The reason we used this strict criterion is that we wanted to discard participants who were paying too much attention to the unattended channel and hence would make a lot of errors in the lexical decision task. There was a total of 16 participants. One participant had more than 30% error for both words and nonwords and was replaced.

## Results

The mean reaction for correct responses was analyzed in two analyses of variance (ANOVAs), one with participant as the random variable ($F_1$), one with items as the random variable ($F_2$). In both analyses, reaction times above or below two standard deviations from the mean for a particular participant and condition were replaced by the relevant cutoff. To conduct the ANOVA by items, we discarded items that had no measure in one of the cells, owing to a high number of errors (in which case they were removed in both the related and unrelated conditions). In this experiment, four items were removed from the analysis (two words and two nonwords). We declared two experimental factors: a relatedness factor (within item and within participant) and a lexicality factor (between item and within participant). Additionally, we declared a counterbalancing group factor with four modalities. In the participants analysis, it corresponded to the list the participant was assigned to, and in the items analysis it corresponded to one of the four subsets that the item belonged to. Percentage error was also analyzed in two ANOVAs, one with participants as random variable, one with items as random variable.

The mean reaction times and error rates are presented in Table 1. For the words, we observed a significant priming effect (69 ms), $F_1(1, 12) = 8.6$, $p < .02$; $F_2(1, 74) = 5.8$, $p < .02$. For nonwords, there was also a trend numerically as large as for the words but that reached significance only in the items analysis (73 ms), $F_1(1, 12) = 3.3$, $.05 < p < .1$; $F_2(1, 74) = 4.3$, $p < .05$. As seen in Table 1, this is due to higher variability for the nonwords than for the words. The interaction between lexical status and priming was not significant ($F$s $< 1$).

Post hoc analyses revealed a significant frequency effect (72 ms, $p < .001$ in both analyses) and a numerically larger priming effect for the low-frequency items (100 ms, $p < .03$ in the participants analysis) than for the high-frequency items (44 ms, $p < .03$ in the participants analysis). However, the interaction of frequency and priming was not significant ($F$s $< 1$). Word length did not introduce any main effect and did not interact with the priming effect. As for the errors, no effect or interaction reached significance (all $p$s $> .1$). At the end of the experiment, all of the participants reported hearing a stimulus on the unattended channel and said that this stimulus was sometimes the same or similar to the target.

## Discussion

We found a significant priming effect in a situation in which the prime is simultaneous to the target. Moreover, participants were aware of the prime. This observation allows us to infer that despite the instructions to ignore the unattended channel, participants could not refrain from paying attention to it. This result is consis-

[2] The PSOLA algorithm reduces the duration of speech stimuli by averaging together some adjacent pitch periods. For unvoiced segments of speech, an arbitrary period is used by the algorithm. The result is high-quality stimuli that have the same pitch and spectral characteristics as the original but with a shorter duration. Time-compressed words remain highly intelligible up to a compression rate of about 40%–33% of the original duration (depending on original stimulus quality). The relative time course of various speech processes has been argued to remain basically unchanged with compressed stimuli (see Dupoux & Mehler, 1990).

Table 1
*Lexical Decision Reaction Time (RT), Standard Error, and Percentage Error Rate for Words and Nonwords in Experiment 1*

| Variable | RT | *SE* | % error |
|---|---|---|---|
| Words | | | |
| Unrelated | 893.1 | 64 | 13.1 |
| Related | 823.9 | 57 | 17.1 |
| Priming | 69.2** | 22 | |
| Nonwords | | | |
| Unrelated | 1,093.4 | 79 | 19.9 |
| Related | 1,020.2 | 53 | 15.5 |
| Priming | 73.2† | 39 | |

†Marginal by participant, $p < .05$ by item. ** $p < .02$ in both analyses.

tent with both the early-filtering and the late-filtering accounts. According to early filtering, the only possibility to account for priming effect is to postulate that participants made an attentional switch to the prime. This is plausible given that the prime was surrounded by silence, and hence the presence of a sudden change in energy in the unattended channel could have attracted the participant's attention. The fact that participants all reported hearing the prime adds support to this interpretation. According to late filtering, the prime is processed lexically, irrespective of attention allocation. Hence a priming effect is predicted regardless of attention. The fact that participants noticed the prime could be due to attention capture by the acoustic cue or by the semantic properties of the prime (i.e., the identity relationship between prime and target). The next experiment is designed to tease apart the two alternative interpretations.

## Experiment 2

The aim of Experiment 2 was to reduce the discontinuity in energy coincident with the prime to reduce the probability of an attentional capture of the prime owing to low-level cues. To achieve this, we surrounded the prime stimulus with a carrier of the same loudness, speaker, and rate. These conditions make it less likely that low-level cues in the unattended channel might capture the participant's attention when the prime is presented. The carrier sentence was always the same throughout the experiment. Subjectively, the stimuli in the unattended channel seem to be always the same, and the prime item does not stand out nor does it seem to attract one's attention.

Experiment 2 allowed us to test the existence of unattended lexical processing and to contrast the two diverging theories of selective attention. On the one hand, an early-filtering account predicts that there should be no priming under conditions in which attentional switches are discouraged. On the other hand, a late-filtering account predicts that a priming effect should still be present if participants successfully focus their attention on the channel of the target.

### Method

*Materials and procedure.* This experiment used the same materials and design as in Experiment 1. The only difference is that the prime was embedded in a carrier sentence. The carrier sentence "On parle souvent de '*prime*,' du moins je le crois" ("One often speaks about '*prime*,' so I have been told") was recorded by the same speaker who recorded the words. This sentence was attenuated by a factor of –12dB and time-compressed at the same rate as the words. Cross-spliced sentences were then created by inserting each prime in place of the word *prime.* These sentences were played in the unattended channels with the onsets of prime and targets temporally aligned.

The original carrier sentence was produced by giving prosodic emphasis to the token word *prime,* giving rise to a short pause before *prime* and a longer pause after it. In the compressed materials, these pauses were digitally adjusted to obtain a natural-sounding prosody. The primes were preceded by a pause between 13 ms and 36 ms as a function of the first phoneme of the prime (a slightly longer pause was necessary for unvoiced consonants than voiced consonants), followed by a pause of 200 ms. The overall duration of these sentences was on average 1,120 ms (369 ms for the first part, 170 ms for the prime itself, and 581 ms for the final part).

*Participants.* Nineteen new participants drawn from the same population as in Experiment 1 were run. None were excluded.

### Results and Discussion

The mean reaction times and error rates are presented in Table 2 and were analyzed as in Experiment 1. No items were removed from the analysis. We found a significant effect of lexicality, $F_1(1, 15) = 89.6$, $p < .001$; $F_2(1, 151) = 48.5$, $p < .001$, but no effect of relatedness and no interaction between these two factors (all $F$s $< 1$). Planned comparisons failed to find a significant priming effect for the words (6 ms), $F_1(1, 15) < 1$; $F_2(1, 75) < 1$, or for the nonwords (0 ms), $F_1(1, 15) < 1$; $F_2(1, 76) < 1$. A post hoc analysis of reaction time to the words as a function of frequency and syllable length revealed a large advantage for the items in the high-frequency range compared with the low-frequency range (128 ms, $p < .001$ in both analyses), but not even a trend of priming for the high-frequency or for the low-frequency items ($F$s $< 1$). Reaction times to monosyllabic and disyllabic items did not differ, and word length did not interact with priming.

The mean error rate by condition was subjected to the same analysis as the reaction time, but no main effect or interaction was found ($p > .1$). Participants reported hearing either unintelligible noise in the unattended channel or always the same sentence in the unattended channel. No participant reported hearing a word that changed from trial to trial, nor that there was an identity or similarity relationship between the prime and target.

The results of this experiment are clear-cut: No repetition priming effect was observed, and participants failed to notice the prime. It is as if the prime item was totally ignored by the processing

Table 2
*Lexical Decision Reaction Time (RT), Standard Error, and Percentage Error Rate for Words and Nonwords in Experiment 2*

| Variable | RT | *SE* | % error |
|---|---|---|---|
| Words | | | |
| Unrelated | 906.2 | 29 | 10.1 |
| Related | 900.4 | 33 | 7.2 |
| Priming | 5.9 | 16 | |
| Nonwords | | | |
| Unrelated | 1,052.3 | 44 | 11.3 |
| Related | 1,052.8 | 38 | 8.2 |
| Priming | −0.5 | 16 | |

system. The absence of a priming effect is compatible with an early-filtering account.[3] In the presence of a null effect, it is important to assess the power of the experiment. In Table 2, one can see that the standard error for the priming effect in the word is 16 ms, which means that the experiment could have detected a significant priming effect of 38 ms or more (with $p < .05$). Moreover, a global ANOVA taking into account Experiments 1 and 2 revealed a significant interaction between experiment and relatedness, $F_1(1, 33) = 5.6$, $p < .03$; $F_2(1, 153) = 5.3$, $p < .03$, corresponding to the fact that priming was indeed restricted to Experiment 1.

Of course, the introduction of a carrier sentence in Experiment 2 could have degraded the prime (e.g., by low-level masking). This is actually quite unlikely, because the carrier materials resulted in a sentence with a natural prosody, and as we indicated in this *Method* section, there was a small pause between the prime and the surrounding materials. Yet, to assess whether the compressed primes embedded in the carrier sentences were clear enough to potentially induce priming, we used a monaural presentation in Experiment 3.

## Experiment 3

### Method

*Materials and procedure.* In this experiment, the prime (still embedded in the carrier sentence) and the targets were both played monaurally. The prime sentence and carrier sentence were played first, followed by a 150-ms pause, followed by the target. The instruction given to the participants was to ignore the compressed materials and to perform a lexical decision on the target item following it.

*Participants.* Ten new participants drawn from the same population as in Experiment 1 were run. None were excluded.

### Results and Discussion

Four items, because of a high error rate, had zero observation in one of the analysis cells and were removed from the analysis (two words, two nonwords). The mean reaction times and error rates are presented in Table 3. For the words, we observed a very strong priming effect (197 ms), $F_1(1, 6) = 50.0$, $p < .001$; $F_2(1, 74) = 62.0$, $p < .001$. A smaller priming effect was also observed for the nonwords (119 ms), $F_1(1, 6) = 18.7$, $p < .005$; $F_2(1, 74) = 34.5$, $p < .001$, and there was an interaction between lexical status and priming, $F_1(1, 6) = 18.5$, $p < .005$; $F_2(1, 148) = 11.3$, $p < .001$. For the errors, we found a significant priming effect for the words, $F_1(1, 6) = 7.0$, $p < .04$; $F_2(1, 74) = 4.5$, $p < .04$, but no priming effect was found for the nonwords, $F_1(1, 6) = 1.1$; $F_2 < 1$. All of the participants reported hearing the prime embedded in the carrier sentence.

A post hoc analysis of reaction times to the words as a function of frequency and syllable length revealed a large advantage for the items in the high-frequency range compared with the low-frequency range (82 ms, $p < .001$ in both analyses), and there was an interaction between frequency and priming ($p < .05$ in the participants analysis and $p < .01$ in the items analysis). Indeed, priming was larger for the low-frequency items (234 ms) than for the high-frequency items (145 ms). Reaction times to monosyllabic and disyllabic items did not differ, and word length did not interact with priming.

Experiment 3 confirmed that the failure of a priming effect in Experiment 2 could not have been due to the degradation of the prime by the presence of a carrier sentence. Indeed, with the same carrier sentence, and a monaural presentation, we found a very strong priming effect in the present experiment.

Table 3
*Lexical Decision Reaction Time (RT), Standard Error, and Percentage Error Rate for Words and Nonwords in Experiment 3*

| Variable | RT | *SE* | % error |
|---|---|---|---|
| Words | | | |
| Unrelated | 863.0 | 24 | 10.2 |
| Related | 666.2 | 25 | 4.6 |
| Priming | 196.9**** | 30 | |
| Nonwords | | | |
| Unrelated | 974.7 | 35 | 7.0 |
| Related | 856.0 | 26 | 6.2 |
| Priming | 118.7* | 29 | |

* $p < .05$. **** $p < .001$.

## Discussion of Experiments 1–3

In the first three experiments, we found the following. (a) When the prime and target are presented simultaneously but the prime provokes a sudden acoustical change in the unattended channel, a priming effect is found along with conscious awareness of the presence of the prime in the "unattended" channel (Experiment 1). (b) When acoustic discontinuities around the prime are reduced by introducing a surrounding carrier sentence, no more priming effect is found (Experiment 2); correlatively, conscious recall of the presence of the prime is eliminated. (c) The absence of priming in Experiment 2 cannot be due to a degradation of the prime by the carrier sentence because this material gives rise to strong priming when it precedes the target in a monaural presentation (Experiment 3).

Prima facie, the results of the first three experiments support an early-filtering theory of selective attention and are problematic for a late-filtering account. Indeed, an early-filtering account predicts that priming can occur in the unattended channel only when an attentional switch to that channel occurs. Such an attentional switch is encouraged in Experiment 1 in which the prime is acoustically salient, and discouraged in Experiment 2 by the presence of a surrounding carrier sentence. In contrast, a late-filtering account predicts priming no matter what channel participants are paying attention to.

[3] Given that the target was always received at the privileged ear (the right ear, contralateral to the dominant hemisphere in most right-handers), the results could have been biased against intrusions originating from the nonprivileged ear. However, we have an indication that ear of presentation does not matter in this situation. In a control experiment, we replicated the conditions and design of Experiment 2, except that 9 participants had the target in the right ear and 11 participants had the target in the left ear. Moreover, the target and prime materials were spoken in different voices (prime: male voice, target: female voice). No significant priming was found on either side (target on the right: 5ms, *ns*; target on the left: –11 ms, *ns*).

Before accepting this conclusion, we have to consider an important caveat: It is possible that the presence of the carrier sentence had a small masking effect resulting in a *delay* in identification time of the prime. Hence, by the time the prime is identified, it would be too late to affect the lexical processing of the target. The next series of experiments assess this issue by giving the prime more processing time by presenting it just *before* the target.

## Experiment 4

In this experiment, the stimuli were exactly like those in Experiment 2, except that the prime and carrier sentence were shifted in time, such that the end of the prime coincided with the onset of the target. If the absence of priming in Experiment 2 was only due to the fact that prime identification was delayed by the presence of a carrier sentence, one should find a priming effect in this experiment. Of course, the time shift may also make the prime itself become more salient, because of the prosodically marked position of the prime within the carrier sentence. Such prosodic cues are now no longer masked by the simultaneous presence of the target in the other channel. So, the presence of priming in this experiment could probably also be accounted for in terms of an attentional switch. We control for the prosodic variables in Experiments 5. In the present experiment, we only test whether a simple shift in time is sufficient to induce a priming effect to reemerge.

### Method

*Materials and procedure.* The prime and carrier sentence were synchronized with the target so that the offset of the prime coincided with the onset of the target. Compared with Experiment 2, the prime and carrier sentences were shifted back in time by 170 ms on average, between 105 and 225 ms.

*Participants.* Sixteen new participants within the same pool as in previous experiments were run. None were excluded.

### Results and Discussion

Three items had zero observation in one of the analysis cells and were removed from further analysis (two words and one nonword). The mean reaction times and error rates are presented in Table 4. For the words, we observed a significant priming effect (107 ms), $F_1(1, 12) = 17.0$, $p < .002$; $F_2(1, 74) = 18.9$, $p < .001$. For nonwords, there was no significant priming effect (–28 ms), $F_1(1, 12) < 1$; $F_2(1, 75) = 1.6$, *ns*. The interaction between lexical status and priming was significant, $F_1(1, 12) = 8.8$, $p < .02$; $F_2(1, 149) = 14.7$, $p < .001$. Post hoc analyses revealed a significant frequency effect (140 ms, $p < .001$ in both analyses), and there was no significant interaction between frequency and priming. Word length did not introduce any effect and did not interact with the priming effect. For the errors, no effect or interaction reached significance ($p > .1$).

Table 4
*Lexical Decision Reaction Time (RT), Standard Error, and Percentage Error Rate for Words and Nonwords in Experiment 4*

| Variable | RT | *SE* | % error |
|---|---|---|---|
| Words | | | |
| Unrelated | 1,006.2 | 46 | 13.2 |
| Related | 899.7 | 48 | 10.4 |
| Priming | 106.6*** | 27 | |
| Nonwords | | | |
| Unrelated | 1,134.4 | 52 | 8.5 |
| Related | 1,162.6 | 66 | 8.8 |
| Priming | −28.3 | 35 | |

*** $p < .002$.

In this experiment, the prime and its carrier sentence were presented just before the target. This manipulation, 170 ms of time shift on average compared with the simultaneous presentation of Experiment 1, was sufficient to give rise to a significant priming effect (107 ms) to emerge. This can be interpreted in two ways. The first possibility is that the unattended prime produced lexical activation. The reason why there was no priming in Experiment 2 was that the prime was degraded or delayed. This would be compatible with an attenuated-filter or a late-filter theory. Yet, this interpretation does not hold, because all of the participants actually reported hearing the prime. It seems more plausible that participants began noticing some words in the other channel and initiated an attentional switch just before the target. Alternatively, the prosodic cues signaling the prime could have been strong enough to attract the participant's attention to the unattended channel. All these reasons make it difficult to dismiss involuntary or strategic switches in this condition. One way to clarify the situation is by removing the prosodic cues to assess whether the priming effect disappears. The next two experiments test this prediction.

## Experiment 5

In this experiment, we test whether selective attention can filter out an unattended channel, even when the prime is presented before the target and when the prosodic cues indicating the presence of the prime are removed from the carrier material. To carry out this experiment, we replaced the carrier sentence of Experiments 2, 3, and 4 with a randomly generated "babble noise" with similar spectral characteristics and amplitude as the prime. We also avoided the predictability of the carrier sentence by randomly selecting a different babble noise for each trial. The result is that the embedded prime is virtually not distinguishable from the babble noise by means of acoustic cues. Early filtering predicts that, as in Experiment 2, the participant's attention will not be captured in the unattended channel, and no priming should arise. Late filtering, in contrast, predicts that priming should be found just as in Experiment 4. Experiment 5 is hence identical to Experiment 4, with babble noise replacing the carrier sentence.

### Method

*Materials and procedure.* Babble noise was obtained by mixing together the stimuli used as primes. It was done in the following way. Sequences of primes were obtained by concatenating audio files of primes selected at random. Then babble noise was obtained by mixing together 10 extracts of 500-ms duration of such sequences. We created 20 such babble noise files, each with a duration of 500-ms duration. The energy level of these files was measured and adjusted to match the mean energy of the primes. For each experimental trial, the unattended channel consisted in a babble noise file, a prime, and another babble noise file. The babble noise files were randomly selected from trial to trial, and there was no silence between the babble noise and the prime.

*Participants.* Sixteen new participants of the same participant pool as the previous experiments were run. One participant made more than 32% errors on nonwords and was replaced.

### Results and Discussion

Two items (two words) had zero observation in one of the cells and were removed from the analysis. There was no effect of relatedness and no interaction between lexicality and relatedness (all $F$s $< 1$). Planned comparisons failed to find a significant priming effect for the words (8 ms; $F$s $< 1$) or for the nonwords (1 ms; $F$s $< 1$). No significant effect was found in the error analysis. Post hoc analyses revealed a significant frequency effect (104 ms, $p < .001$), which did not interact with priming, and no effect of number of syllables.

To assess the power of this experiment, we computed the standard error of the effects. One can see in Table 5 that the experiment was powerful enough to detect a priming effect of 28 ms or more (with $p < .05$). A global ANOVA ran over Experiments 4 and 5 revealed that the 8-ms tendency obtained here for the words was significantly different from the 107-ms effect we obtained in Experiment 4, $F_1(1, 30) = 10.0$, $p < .004$; $F_2(1, 76) = 11.8$, $p < .001$.

The results of this experiment are clear-cut. When prosodic cues are removed, no priming effect emerges, despite the fact that the prime is presented before the target. None of the participants reported hearing the prime. This is consistent with the hypothesis that embedding the primes in the babble noise was enough to prevent an attentional switch toward the primes. Hence, according to early filtering, the unattended primes were not processed lexically and could not produce priming. Of course, before endorsing such a view, we must check that the babble noise was not masking the prime or delaying its recognition. The next experiment addresses this point.

## Experiment 6

This experiment is similar to Experiment 5, except that the prime and targets are now both played in the two ears simultaneously. Because prime and targets are now presented in the same channel (subjectively, a central channel), one should find a significant priming effect, provided the prime is not degraded by the presence of the babble noise.

### Method

*Materials and procedure.* The same materials and procedure as in Experiment 5 were used, with one exception: The two channels that were presented dichotically in Experiment 5 were now mixed together and presented binaurally. To compensate for the fact that in the binaural presentation, we presented more acoustic energy to the two ears than in the previous experiments, an attenuation of the square root of 2 was applied to both channels. This resulted in a subjective loudness that is comparable with that in the dichotic experiments.

*Participants.* Sixteen new participants of the same pool as in the previous experiments were run. One participant made over 35% errors on nonwords and was replaced.

### Results and Discussion

Table 6 shows the means and standard deviations for each condition. Three items were removed from the analysis (two words, one nonword). Analysis of the latencies revealed a significant priming effect for the words (44 ms), $F_1(1, 12) = 8.6$, $p < .02$; $F_2(1, 74) = 6.2$, $p < .02$, but not for the nonwords (1 ms), $F_1(1, 12) < 1$; $F_2(1, 74) < 1$. The interaction between relation and lexicality was only marginal, $F_1(1, 12) = 3.73$, $p = .077$; $F_2(1, 148) = 3.75$, $p = .055$. No significant effect emerged in the analysis of the errors.

A post hoc analysis of reaction time to the words as a function of frequency and syllable length revealed a large advantage for the items in the high-frequency range compared with the low-frequency range (104 ms, $p < .001$ in both analyses), and there was no interaction between frequency and priming ($F$s $< 1$). Reaction times to monosyllabic and disyllabic items did not differ, and word length did not interact with priming.

It is clear that the babble noise in itself does not prevent the emergence of a priming effect. Indeed, the only difference between Experiment 5 and Experiment 6 is the fact that Experiment 5 requires focused attention on a single channel, whereas in Experiment 6 there is only one channel.

In brief, the final set of experiments (Experiments 4–6) replicate the findings we found in the first set (Experiments 1–3), even though the primes were presented before the target. In both sets, in a dichotic situation, we only found a significant priming effect when the primes are salient and attract the participant's attention in the unattended channel (i.e., in Experiments 1 and 4 and not in Experiments 2 and 5). In both sets, we found a significant priming effect in a controlled monaural situation (Experiments 3 and 6). There is, however, one difference between the two sets of results: In Experiment 1 and 3, we observed a priming effect for both word and nonword targets, whereas in Experiment 4 and 6, we found it only for word targets. This may be an indication that the primes were processed to different levels in the two sets. Nonword priming may be an indication that the priming effect is taking place, at least partially at the sublexical (phonological) level. Conversely, priming restricted to words may be an indication that priming is taking place at the lexical or semantic level. It is not clear why there should be a difference in locus between the two sets of experiments. Possibly, the presence of a sentential context, or of increased time between prime and target, can affect the level of

Table 5
*Lexical Decision Reaction Time (RT), Standard Error, and Percentage Error Rate for Words and Nonwords in Experiment 5*

| Variable | RT | *SE* | % error |
|---|---|---|---|
| Words | | | |
| Unrelated | 736.6 | 17 | 14.7 |
| Related | 728.4 | 21 | 12.2 |
| Priming | 8.3 | 10 | |
| Nonwords | | | |
| Unrelated | 865.1 | 21 | 12.8 |
| Related | 864.3 | 22 | 12.2 |
| Priming | 0.9 | 8 | |

Table 6
*Lexical Decision Reaction Time (RT), Standard Error, and Percentage Error Rate for Words and Nonwords in Experiment 6*

| Variable | RT | *SE* | % error |
|---|---|---|---|
| Words | | | |
| Unrelated | 809.4 | 21 | 14.2 |
| Related | 765.3 | 26 | 15.0 |
| Priming | 44.1** | 13 | |
| Nonwords | | | |
| Unrelated | 945.1 | 45 | 11.3 |
| Related | 946.1 | 47 | 9.1 |
| Priming | −1.0 | 14 | |

** $p < .02$.

priming across these experiments. Alternatively, differences in saliency of the prime may modulate strategic influences on the priming effect. Indeed, masked priming studies suggest that when strategic processing of the prime is made impossible, nonword priming is reduced to zero (e.g., K. I. Forster & Davis, 1984). More research is needed to explore these possibilities. The crucial point here is that in the two experiments in which successful filtering was obtained (Experiments 2 and 5), we did not find any repetition priming effect. The absence of any repetition priming effect in these experiments allows us to infer that, contrary to late-filtering theories, the unattended prime was not processed at any of the sublexical, lexical, or semantic levels.

## General Discussion

The aim of this study was to assess whether lexical activation can occur outside the focus of attention. We used both dichotic and monaural identity priming as an index of lexical activation. Figure 1 gives a general overview of the experimental conditions and results found in this study. In the first series of experiments (Experiments 1 to 3), we found that an acoustically salient linguistic stimulus in the unattended channel (the prime) can facilitate another simultaneous stimulus in the attended channel (the target), resulting in an identity priming effect (Experiment 1). Given the perceptual saliency of the isolated prime stimuli, we investigated whether this effect resulted from an attentional switch or was due to automatic lexical activation from the prime in the unattended channel. We used a carrier sentence surrounding the prime to minimize low-level acoustic attraction from the unattended channel. Under these conditions, no evidence of lexical activation from the unattended channel was found (Experiment 2), although identity priming was found when the prime and carrier sentence preceded the target and were presented in a monaural fashion (Experiment 3). In the second series of experiments (Experiments 4 to 6), we tested whether a dichotic presentation of the prime just before the target primes the latter. Using the same carrier sentence surrounding the prime as in the Experiment 2, we found a priming effect (Experiment 4). We interpreted this result as being due to an attentional switch, probably induced by the prosodically salient location of the prime (we return to this point later). When the carrier sentence was replaced by a homogeneous babble noise, no priming effect was found (Experiment 5). However, the primes in such a context were still able to produce priming when both prime and targets were presented in the same channel (Experiment 6).

Late-filtering accounts cannot accommodate these results easily. Indeed, late filtering stipulates that the prime should be processed lexically, even when no attention is directed to it. Hence, identity priming should be observed regardless of direction of attention. This is not what we found. We found significant identity priming only when the participants were paying attention to the channel of the prime and not when they ignored it. Attention allocation was experimentally controlled by manipulating the acoustic saliency of the prime in the unattended channel and was attested by the subjective reports of the participants. In the two dichotic experiments in which we found a priming effect (Experiments 1 and 4), participants noticed the presence of the prime in the unattended channel. They were even able to point out that the prime was identical to the target on some occasions. In contrast, in the two dichotic experiments in which we did not find a priming effect (Experiments 2 and 5), participants did not report hearing any meaningful word in the unattended channel.

This finding supports early-filtering models, that is, models in which words in unattended channels are not processed up to lexical or semantic levels. It is compatible with Holender's (1986) view on the cocktail party effect and the subsequent studies on unattended semantic processing. Holender's claim was that none of these studies that reported unattended semantic processing really controlled for attention allocation, leaving open the possibility that the observed effects might arise from uncontrolled attentional switches. Our study goes in the same direction and further suggests that the attentional switches might have been caused by salient acoustic cues signaling the presence of the prime in the unattended channel. We predict that if such cues were removed, none of the reported effects would remain. This prediction is quite in line with the work of Newstead and Dennis (1979) and Wood et al. (1997). Wood et al. showed that effects of the unattended channel in Eich's (1984) study are only found when the rate of presentation of stimuli in the main channel is slow. When it is speeded up, making the main task more demanding, no more effect of the unattended channel arises. This strongly suggests that participants in Eich's study were using the extra time to make attentional switches to the other channel. Even closer to our study, Newstead and Dennis (1979) showed that when the prime stimulus is embedded in a carrier sentence, the implicit priming effect reported by MacKay (1973) disappears. Similar to Newstead and Dennis, we found that when the prime stimulus is embedded in carrier materials with similar acoustic characteristics (sentence or babble noise), the cross-channel identity priming effect disappeared. The difference between our study and the two previous studies is that instead of using an offline implicit priming technique, which may not be very sensitive as a measure of lexical processing, we used an immediate identity priming, which gives both online and robust effects. As a consequence, our failure to measure a significant priming effect in Experiments 2 and 5, in which prime acoustic saliency is neutralized, can really be interpreted as a failure of lexical access of the prime under selective attention.

Our results are also congruent with ERP studies showing that attention modulates the processing of sounds down to very early stages. Hillyard et al. (1973), Woldorff et al. (1993), and others showed that down to 20-ms postonset, a significant decrease of

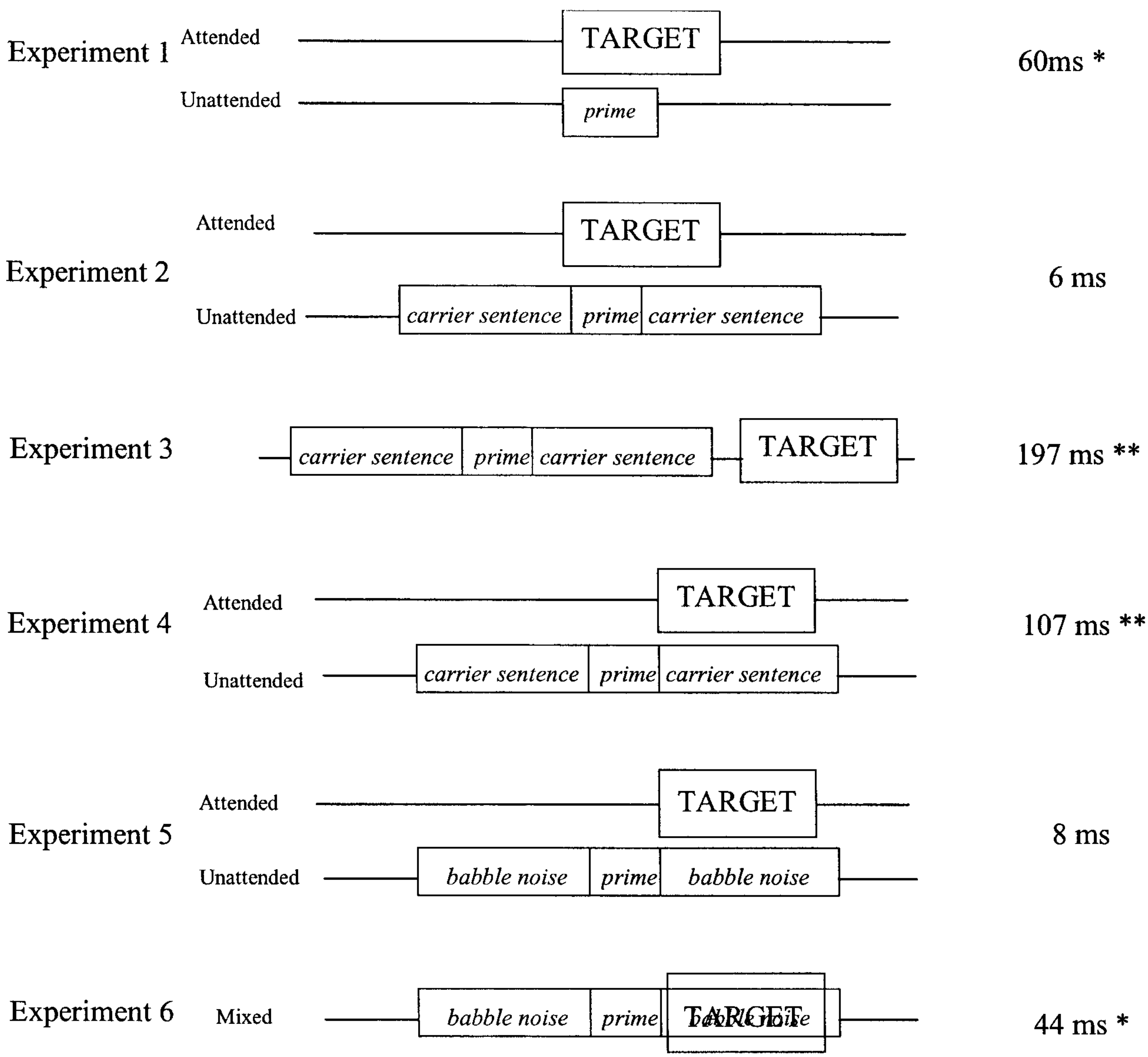


*Figure 1.* Summary results of the six experiments, with a description of the experimental trials and mean priming effect for the word targets. * $p < .02$ by items and participants. ** $p < .002$ by items and participants.

evoked response can be demonstrated for unattended stimuli. Similar demonstrations of very early effects of attention have been established in the visual modality using ERPs (Mangun & Hillyard, 1991), positron-emission tomography (Heinze et al., 1994), and single-unit recording (Luck, Chelazzi, Hillyard, & Desimone, 1997). What our study adds to this body of research is the important fact that the early effect of attention is strong enough as to prevent lexical access from occurring in the unattended channel.

Note, however, that our argument rests on the assumption that low-level (acoustic or prosodic) discontinuities can capture attention and trigger an attentional switch from one to another channel, even when participants were explicitly asked to ignore that channel. There is evidence that this is the case, at least within the visual domain. Indeed, many studies suggest that visual discontinuities in a spatial display can capture the attention of participants and do so more rapidly and automatically than cues that explicitly signal the locus to which participants should voluntarily move their attention (e.g., Jonides, 1981; Remington, Johnston, & Yantis, 1992; for a review, see Yantis, 1998). Much less is known about attention capture in the auditory modality, and similar work would have to be done to explore this issue. In this light, however, the results of Experiments 2 and 4 raise the issue of what counts as a salient stimulus. In Experiment 4, the prime was presented just before the target and was embedded in a carrier sentence. We found that participants reported paying some attention to the primes, and we found a significant priming effect. In contrast, when the same sentences were used in Experiment 2 with the prime and targets aligned, no priming or any evidence of an attentional switch was found. Why is there such a difference? We offer two tentative explanations.

The first one is based on attentional strategies that participants may develop during the experiment. In Experiment 4, participants had time to explore the unattended channel before the target arrives, and hence could notice the presence of the prime. Thereafter, they could program a strategic attentional switch just before the target. In contrast, in Experiment 2, the prime and target were simultaneous, and hence, the participants would never spontaneously discover the prime because their attention would be engaged in processing the target at that very time. This explanation proposes that participants' attention wanders across channels and, once a regularity is noticed, can be strategically programmed. This accounts well with the contrast between Experiments 2 and 4. To test this experimentally, one could try to teach participants to pay attention to the prime and then revert to focused attention instructions, in the hope that on some occasions, participants may wander in the unattended channel.

A second and maybe more plausible explanation rests on prosody. As already noticed, the prime in the carrier sentence occurs in a prosodically salient place. Such linguistic saliency could be sufficient to draw participants' attention to the unattended channel when the prime is presented before the target. However, when the prime is simultaneous with the target, these prosodic cues are now in competition with the powerful acoustic discontinuity in the main channel. The fact that participants never reported noticing the prime in the simultaneous presentation suggests that acoustic cues are stronger than prosodic ones when it comes to capturing attention.

It should be noted that our conditions of presentation are quite distant from naturalistic ones (e.g., time-compressed speech, energy equalized babble noise, isolated words). We used these controlled conditions to establish whether complete filtering of an unattended channel is possible and whether it can lead to the suppression of lexical processing of the unattended materials. In more ecological conditions, competing messages can be much more varied than our rather flat and nonsalient babble speech. It is therefore likely that the large changes in prosody (energy, pitch, or rhythm) associated with natural discourse can capture the attention of participants more frequently in a more natural setup. This would lead to relatively frequent identification of semantic information extracted from adjacent messages. Possibly, as is suggested by Conway et al. (2001), there are also individual differences in the ability to switch between channels in a dual-task situation.

More studies are needed to explore the precise conditions that lead to an attentional switch. In fact, if one endorses an early-filtering view, one can swap around the logic of our study and use dichotic priming to experimentally measure the "attention-grabbing" strength of various acoustic or prosodic cues. That is, use the amount of cross-channel repetition priming as an index of attention switches. A more extensive investigation of these parameters would allow us to better understand how attention can be captured in more ecological circumstances, such as in the classic cocktail party situation.

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(*Appendix follows*)

## Appendix

### Materials

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Monosyllabic nonwords | | | | |
| bose | /bɔz/ | doche | /dɔʃ/ | diche | /diʃ/ | doule | /dul/ |
| doure | /dur/ | ganrre | /gãr/ | guze | /gyz/ | quinde | /kɛ̃d/ |
| mague | /mag/ | mèpe | /mɛp/ | mude | /myd/ | poune | /pun/ |
| pase | /paz/ | peuze | /pœz/ | poite | /pwat/ | tamme | /tam/ |
| tèpe | /tɛp/ | tille | /til/ | bire | /bir/ | bauve | /bov/ |
| bousse | /bus/ | doune | /dun/ | gote | /gɔt/ | gaiche | /gɛʃ/ |
| goupe | /gup/ | coume | /kum/ | diffe | /dif/ | monne | /mɔn/ |
| monze | /mõz/ | moure | /mur/ | poge | /pɔj/ | posse | /pɔs/ |
| pinffe | /pɛ̃f/ | pite | /pit/ | puse | /pyz/ | taisse | /tɛs/ |
| toulle | /tul/ | toume | /tum/ | bansse | /bãs/ | paime | /pɛm/ |
| | | | Bisyllabic nonwords | | | | |
| baphin | /bafɛ̃/ | bafaut | /bafo/ | bakin | /bakɛ̃/ | beaupit | /bopi/ |
| bugin | /byjɛ̃/ | coubon | /kubõ/ | délin | /delɛ̃/ | déson | /dezõ/ |
| daurou | /doru/ | carain | /karɛ̃/ | cassu | /kasy/ | coubé | /kube/ |
| coupi | /kupi/ | mabé | /mabe/ | massou | /masu/ | mautin | /motɛ/ |
| moufu | /mufy/ | pécau | /peko/ | tasin | /tazɛ̃/ | techon | /teʃõ/ |
| télit | /teli/ | bassu | /basy/ | bochot | /boʃo/ | bouvin | /buvɛ̃/ |
| buvi | /byvi/ | deret | /dəre/ | dilon | /dilõ/ | tinon | /tinõ/ |
| dossé | /dose/ | camis | /kami/ | capi | /kapi/ | cossa | /kosa/ |
| matau | /mato/ | mavo | /mavo/ | paco | /pako/ | piba | /piba/ |
| tarant | /tarã/ | tavot | /tavo/ | tulin | /tylɛ̃/ | tourat | /tura/ |
| | | | Monosyllabic words: High frequency | | | | |
| bouche | /buʃ/ | doute | /dut/ | guerre | /gɛr/ | guide | /gid/ |
| quinze | /kɛ̃z/ | cause | /koz/ | mode | /mcd/ | messe | /mɛs/ |
| mur | /myr/ | passe | /pas/ | pente | /pãt/ | pomme | /pɔm/ |
| poche | /pɔʃ/ | tempe | /tãp/ | tache | /taʃ/ | thème | /tɛm/ |
| these | /tɛz/ | type | /tip/ | bord | /bɔr/ | dix | /dis/ |
| | | | Monosyllabic words: Low frequency | | | | |
| batte | /bat/ | manne | /man/ | dime | /dim/ | douve | /duv/ |
| gaffe | /gaf/ | gaine | /gɛn/ | gousse | /gus/ | quiche | /kiʃ/ |
| mangue | /mãg/ | mire | /mir/ | miche | /miʃ/ | mite | /mit/ |
| pagne | /paɲ/ | pince | /pɛ̃s/ | pull | /pyl/ | toge | /tɔj/ |
| toise | /twaz/ | tuile | /tɤil/ | benne | /bɛn/ | cosse | /kɔs/ |
| | | | Bisyllabic words: Low frequency | | | | |
| bateau | /bato/ | baton | /batõ/ | danger | /dãʒe/ | début | /deby/ |
| défaut | /defo/ | dégout | /degu/ | café | /kafe/ | canon | /kanõ/ |
| combat | /kõba/ | cousin | /kuzɛ̃/ | maison | /mezõ/ | maudit | /modi/ |
| moulin | /mulɛ̃/ | paquet | /pake/ | talon | /talõ/ | tapis | /tapi/ |
| témoin | /temwɛ̃/ | terrain | /terɛ̃/ | tissu | /tisy/ | taureau | /toro/ |
| | | | Bisyllabic words: High frequency | | | | |
| badeau | /bado/ | basset | /base/ | bossu | /bosy/ | boulon | /bulõ/ |
| burin | /byrɛ̃/ | devis | /dəvi/ | diva | /diva/ | dauphin | /dofɛ̃/ |
| capot | /kapo/ | carat | /kara/ | coulis | /kuli/ | manchot | /mãʃo/ |
| massue | /masy/ | peton | /pətõ/ | pavot | /pavo/ | tamis | /tami/ |
| tison | /tisõ/ | toupie | /tupi/ | tacot | /tako/ | devin | /dəvɛ̃/ |

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