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Sexual distractors boost younger and older adults' visual search RSVP performance

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Do sexual words have high attentional priority? How does the ability to ignore sexual distractors evolve with age? To answer these questions, two experiments using Rapid Serial Visual Presentation (RSVP) were conducted. Experiment 1 showed that both younger and older participants were better at identifying a target (the name of a colour) when it was preceded by 336 ms by a sexual word rather than by a musical word. Strikingly, the sexual-word advantage was more pronounced for older adults than for younger adults. Experiment 2 showed that introducing a variable delay between the distractor and the target eliminated the sexual-word advantage. This finding suggests that the sexual-word advantage found in Experiment 1 was due to learning to utilize the sexual word as a temporal cue with a fixed duration between the distractor and the target. Contrary to previous research [Arnell *et al.*, 2007, Emotion, ***7,*** 465), neither experiment showed that sexual words produce an attentional blink.

In everyday life, few of the many stimuli present in the environment are selected by our cognitive system for further processing. During the selection process, categories of stimuli that exhibit certain natural features may be given priority. For example, a person with a threatening face represents a potential danger, so she or he might attract the observer's attention (e.g., Bannerman, Milders & Sahraie, 2010). In France, among the numerous stimuli likely to attract attention, those related to sexuality are quite common in the environment. Billboards and advertisements very often make use of a strategy that consists of presenting photographs or slogans related to sexuality (e.g., bare bodies, slogans with a double meaning, etc.). The present article uses the Rapid Serial Visual Presentation (RSVP) paradigm to address the questions of whether and to what extent

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individuals are able to ignore irrelevant sexual stimuli when searching for a target, and how this ability evolves with age.

In the RSVP paradigm, a series of items are displayed in rapid succession (typically about 100 ms per item) in the middle of a screen. The participant's task is to detect predefined targets (e.g., a name, a coloured letter or an image) inserted in the stream. Studies using this paradigm have shown that when the duration separating two targets is less than about 500 ms, participants frequently fail to report the second target. This drop in detection rate, called the *attentional blink* (AB), has been repeatedly replicated (e.g., Broadbent & Broadbent, 1987; Chun & Potter, 1995; Raymond, Shapiro & Arnell, 1992). This AB phenomenon is thought to occur because participants' attentional resources are directed towards processing the first target (T1), preventing the second target (T2) from being processed until attentional awareness (Chun & Potter, 1995).

This AB phenomenon is also observed in RSVP tasks in which only a single target is to be identified shortly after the display of an irrelevant item of a particular type (e.g., Most, Chun, Widders & Zald, 2005; Most, Smith, Cooter, Levy & Zald, 2007). For example, Most *et al.* (2007) found that the ability to detect a photograph of a building in a sequence of photographs was impaired when it was preceded by a photograph of a woman who was partially or fully naked. This AB is a robust phenomenon: it stands up under monetary incentives encouraging participants to ignore an erotic photograph to better detect a target (Most *et al.*, 2007; Experiment 2). While emotional stimuli are generally effective at capturing our attention (e.g., Most *et al.*, 2005), there is some evidence that sexuality-related ones are particularly effective. In this vein, Arnell, Killman, and Fijavz (2007) found that, among various kinds of emotional distractors (e.g., positive, sad, threatening, anxiety-provoking), sexual terms produced the greatest AB effect. These authors noted that the negative effect of sexual words on visual search performance persisted even when the very same sexual distractors were repeated in each of the 10 blocks of trials. Furthermore, this negative effect was comparable for participants warned in advance that there would be sexual words to ignore and for those who were not warned. These findings suggest that the AB effect triggered by sexual words is involuntary (because the emotional stimulus was not a specified target) and not due merely to surprise (Harris & Pashler, 2004) since it persisted over 10 blocks. In sum, sexual distractors produce a robust AB effect that runs counter to the participants' goal of detecting a target.

An unresolved issue is whether this involuntary AB phenomenon evolves with age. Although most AB studies have been conducted with young participants, a large body of research has shown that emotion processing often changes with age (e.g., Leclerc & Kensinger, 2008). The age effect in RSVP studies using emotional words is still unclear. Some RSVP studies using emotional material have demonstrated greater AB effects with age (e.g., Langley *et al.*, 2008), whereas others have found no age effect at all (e.g., Mickley Steinmetz, Muscatell & Kensinger, 2010). In the last sentence of the abstract of their AB study with sexual words as distractors, Arnell *et al.* (2007) wrote:

> The results provide evidence that arousing sexual words involuntarily capture attention and enter awareness at the expense of goal-driven targets, at least in the context of laboratory experiments performed by young university participants for whom sexual material might have high impact and relevance. (p. 465)

This statement goes against many studies showing that sexuality is not exclusively the prerogative of young people, although it is widely regarded as such (e.g., Weeks, 2002). High numbers of older people, of equivalent proportions in each gender, maintain a considerable

degree of interest and capacity for sexual activity (Deacon, Minichiello & Plummer, 1995; Johnson, 1996). Hence, the question that remains unanswered is whether the robust AB phenomenon produced by sexual words is limited to young participants or whether the same type of phenomenon can be demonstrated with older participants too. This question is important because if the valence of most emotional words is clear (positive or negative), the valence of sexual words is often much less clear. It is known that the effect of aging on attention–emotion interactions depends on the valence of the material (e.g., Langley *et al.*, 2008). Consequently, the lack of clarity concerning the valence of sexual words, combined with their high frequency of occurrence in our daily visual environment, render rather intriguing the question of the evolution with aging of the capacity to ignore them.

The present study was aimed at first replicating the findings of Arnell *et al.* (2007), Experiment 4 with younger adults and then testing the effect of age on performance using an RSVP task containing sexual distractors. To this end, we closely replicated the task that Arnell *et al.* used on young participants, but adapted it for use with the French population and added an older sample as well.[1] Specifically, younger and older participants had to report the name of a colour in a stream of non-words that also contained a sexual word or a musical word. Following Arnell *et al.*'s procedure, the sexual or musical word was always presented three items before the to-be-identified target.

If the attention-capturing effect of sexual material decreases with age, then we can expect a less pronounced AB effect for the older adults than for the younger adults. If the declining interest of older persons in sex is an unfounded stereotype, then we can expect an equivalent AB effect for the younger and older participants.

EXPERIMENT 1

Method

Participants

Twenty-five younger adults (M = 21.7 years, SD = 2.53 years; range = 18–29 years, 15 women) and 25 older adults (M = 64.95 years, SD = 3.64 years; range = 60–72 years, 16 women) were recruited as volunteers from the University of Franche-Comté (Besançon, France) and the surrounding local community.[2] They gave their written informed consent before participation. The level of education was higher for young adults (M = 14.4 years, SD = 2.0 years) than for older adults (M = 11.4 years, SD = 3.0 years), $t(48) = 4.13$, $p < .01$. The Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975) indicated normal global mental status among the 25 older adults (the lowest score of 27 was observed for 1 older adult).

Materials

The experimental procedures were controlled by programs written in E-Prime (Version 2.0) and run on Intel Pentium computers. Eighteen items were presented in each stream of visual stimuli: one item was a critical distractor word (a sexual word or a musical word),

[1] *We limited this experiment to Arnell* et al.*'s condition in which participants were told in advance about the material to be used (i.e., the 'informed' condition). The first reason is that these authors found no difference between the 'informed' and 'uninformed' conditions. The second reason is that it was deemed to be indelicate in French culture to present elderly persons with sexual words (some of which are relatively vulgar) without informing them beforehand.*

[2] *No gender effects were found in this experiment.*

one item was a target word (the name of a colour) and 16 items were distractor pseudo words (e.g., CLON).

The length of the critical distractor words ranged between four and six letters. Two semantic categories were used: musical words and sexual words. The words were matched for frequency of occurrence in French books (New, Pallier, Ferrand & Matos, 2001; mean frequency of sexual words: 21.33; mean frequency of musical words: 18.21). The musical distractors consisted of 12 words related to music: *banjo, chant, danse, jazz, opera, orgue, piano, rock, rythme, tango, valse, violon* (the French words for banjo, singing, dance, jazz, opera, organ, piano, rock, rhythm, tango, waltz, violin). The sexual distractors consisted of 12 words related to sexuality: *nichon, anus, gouine, vagin, penis, sperme, porno, bite, pédé, baise, sexe, pute* (French for boobs, anus, dyke, vagina, penis, sperm, porn, dick, gay, fuck, sex, whore). Ten colour words served as the target words for the RSVP task: *noir, bleu, brun, vert, orange, rose, pourpre, argent, blanc, jaune* (French for black, blue, brown, green, orange, pink, purple, silver, white, yellow). The non-critical distractors were 60 pseudo words with lengths comparable to the lengths of the critical distractors. The non-words obeyed all orthographic rules of French and included no pseudohomophones. All words were capitalized and presented in 18-point bold Courier New font. The visual angle subtended by the letters was 1.4° in height and approximately 3.6°–7.2° in width at a binocular viewing distance of approximately 40 cm. All words were presented using rapid serial visual presentation (RSVP), in which the stimuli were presented one at a time in the same spatial location in the screen centre.

Procedure

The participants were instructed to identify the target-colour word on each trial, guessing if necessary, and to ignore all other items in the stream. They were shown the set of 10 target-colour words and informed that one target in each RSVP trial would always be from this set. Next they were informed that the goal of the experiment was to study people's ability to ignore messages related to sexuality often seen in advertising of all sorts. Then they were shown all of the musical and sexual distractor words. The participants were told that one of these words would be presented in each RSVP stream, but that they should ignore it every time and focus solely on identifying the target colour. Five practice RSVP trials preceded the 240 experimental trials. Each trial began with the mid-screen presentation of a black fixation cross for 500 ms, followed by a 500-ms blank screen before the start of the RSVP stream. In the stream, each word was presented in black against a grey background for 112 ms with no interstimulus interval between words. Immediately after each stream, participants were prompted by a sentence on the screen telling them to press the key that matched the colour of the target (a row of 10 keys on the keyboard were labelled with the names of colours). The instructions stressed response accuracy rather than speed. The intertrial interval was 2,000 ms. Each of the 24 critical distractors was randomly presented once per block of 24 trials. There were 10 blocks, separated by 2-min breaks. The critical distractor was presented in stream position 5 or 8 (each position was used equally often for each combination of critical distractor types). The critical distractor always occurred three items (i.e., 336 ms) before the target-colour word.

Results

Figure 1 shows the percentage of correct target-colour identifications for both age groups as a function of block and critical distractor category (sexual or musical). We conducted an

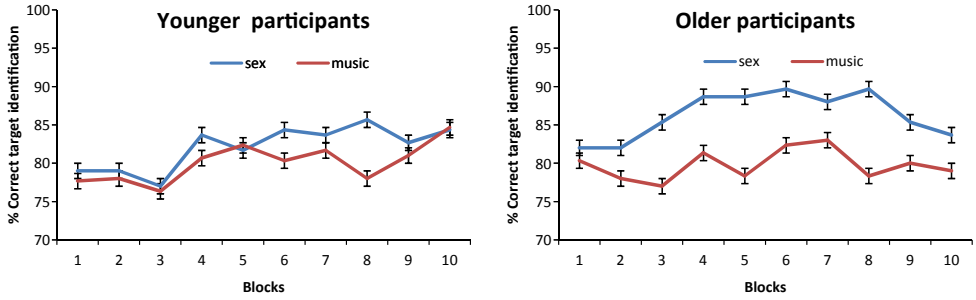

Figure 1. Mean percentage of correct colour target identification responses demonstrated by younger and older participants as a function of block and critical distractor category (sexual vs. music). Bars show the standard error of the mean.

ANOVA with age (young, old) as a between-subjects factor and type of distractor (sexual words, musical words) and block (1–10) as within-subject factors. The normality of the distributions was assessed and confirmed using both visual inspection of the distributions and quantile–quantile analyses. There was a main effect of block, $F(9, 432) = 2.91$, $p < .01$ (partial $\eta^2 = .057$), with accuracy increasing slightly across blocks. The main effect of distractor type was also significant, $F(1, 48) = 37.05$, $p < .001$ (partial $\eta^2 = .436$), with higher accuracy in the sexual-word condition ($M = 84\%$) than in the music-word condition ($M = 80\%$). The main effect of age was not significant, $F(1, 48) < 1$ (partial $\eta^2 = .011$).

A significant interaction was found between age and distractor type, $F(1, 48) = 10.22$, $p < .01$ (partial $\eta^2 = .176$). The sexual-musical difference was more pronounced for older participants (6%) than for young participants (2%). No interaction was observed between age and block, $F(9, 432) < 1$ (partial $\eta^2 = .016$), block and distractor type, $F(9, 432) = 1.27$, $p = .25$ (partial $\eta^2 = .026$), or between age, block and distractor type, $F(9, 432) < 1$ (partial $\eta^2 = .011$).

Pairwise comparisons yielded a significant effect of distractor type for young participants (82% for sexual words vs. 80% for musical words), $F(1, 24) = 5.17$, $p < .05$ (partial $\eta^2 = .176$), and for older participants (86% for sexual words vs. 80% for musical words), $F(1, 24) = 36.39$, $p < .001$ (partial $\eta^2 = .603$).

Discussion

The purpose of this experiment was to examine age effects on the AB generated by sexual words in a RSVP task. There are several noteworthy results. First, younger and older participants exhibited roughly equivalently good performance on the complex attentional task used here, in particular when the distractor word was a music word (mean accuracy of 80%). This finding is in sharp contrast to the majority of aging studies, which show performance decrements in older adults. Second, performance was even better when a sexual word, rather than a musical word, preceded the target, suggesting that the presence of a sexual distractor actually boosted visual search performance. Third, this advantage was significantly greater for the older than for the younger adults.

The results of the younger adult sample in this experiment did not replicate those of Arnell *et al.* (2007): the presence of a sexual distractor on RSVP performance conferred an advantage in the present experiment but a disadvantage (an AB effect) in Arnell *et al.*,

even though the experiments were essentially identical. Our results also contrast with a few other studies using sexual stimuli (e.g., Mathewson, Arnell & Mansfield, 2008; Most *et al.*, 2007). However, not all studies, including the present one, find an emotional AB. Mickley Steinmetz *et al.* (2010) who used non-sexual emotional words and a different task (detect two targets as opposed to only one, as in our study), also found no such AB effect.

How can we account for these empirical discrepancies? One hypothesis is that a peculiarity of our task made it notably significantly different from the tasks used in many other studies. In Experiment 1 (which was a replication of Arnell *et al.*, 2007, Experiment 4), we used just one lag: the distractor and the target were always three words apart (i.e., the lag was 336 ms). Perhaps our participants made use of this fixed lag to anticipate the display of the target. A perfectly valid temporal cue, the critical distractor systematically announced the arrival of the target three words later. If sexual words have greater perceptual salience than do musical words, they would provide a stronger cue indicating the arrival of the target. Following this speculation, we hypothesized that the observed difference between musical words and sexual words was a matter of learning. To test this assumption, we carried out two additional analyses.

If the effect was a learning effect, it should have taken several blocks to be observed and should increase over the blocks. On the contrary, if the results were a kind of attentional blink effect, the effect should classically be observed from the first blocks (as in Arnell *et al.*, 2007, Experiment 4) and not increase over the blocks. The figures do show at least a trend in the direction prediction by the learning hypothesis. To test for significance, we performed *post-hoc* comparisons using Tukey's procedure. Results demonstrated that, pooling across the two age groups, there was no effect of the type of the critical distractor in block 1 ($p = .46$) and block 2 ($p = .21$), but there was a significant effect in blocks 3 ($p = .03$), 4 ($p = .01$), 5 ($p = .04$) and 6 ($p = .001$). These *post-hoc* analyses are consistent with a learning effect that takes time to be established. A linear-trend analysis carried out over the first half of the experiment demonstrated that the distractor effect increased in a linear manner from blocks 1–5 for older adults ($F[1, 24] = 14.51$, $p < .001$) but not for younger adults ($F[1, 24] < 1$).

These follow-up analyses described above support the hypothesis that the participants, and notably the older ones, learned the fixed duration between the distractor and the target and how to take advantage of it (e.g., by constraining their target search to a more specific time window). Experiment 2 was aimed at testing this hypothesis more definitively by using two lags (instead of just one, as in Experiment 1). If the better detection of targets preceded by a sexual word was due to the fixed lag, making target onset perfectly predictable, then the effect should disappear or at least be greatly reduced with variable lags in Experiment 2. We again tested both younger and older adults, using essentially the same RSVP design as in Experiment 1 but using two lags instead of one.

EXPERIMENT 2

Method

The method was the same as in Experiment 1 unless otherwise specified.

Participants

Twenty-five young adults ($M = 21.5$ years, $SD = 3.57$ years, range = 18–29; 15 women) and 25 older adults ($M = 66.2$ years, $SD = 3.15$ years, range = 62–72 years; 17 women)

were recruited as volunteers. The level of education was higher for young adults (M = 14.2 years, SD = 2.6 years) than for older adults (M = 10.12 years, SD = 1.7 years), $t(48) = 6.67$, $p < .001$. The lowest score on the mini-mental state examination was 28 and was observed for one older participant.

Materials and procedure

Twenty-four critical musical distractors (mean frequency = 19.54) and 24 critical sexual distractors were used (mean frequency = 16.62). The 48 critical distractors were presented once per block in random order, resulting in 48 trials per block. There were six blocks separated by 2-min breaks. Overall, there were 288 trials. The lag between the irrelevant critical distractor and the target-colour word was either 3 or 8 (i.e., 336 ms or 896 ms) and was selected randomly with the restriction that all lags be used equally often within a block.

Results and Discussion

Figure 2 presents the percentage of correct target-colour identifications as a function of block (1–6) and critical distractor category (sexual or musical) for the two lags. To facilitate comparison with Experiment 1, Figure 2 also summarizes the results of Experiment 1 for the first 6 blocks.

We conducted an ANOVA with age (young, old) as a between-subjects factor and type of distractor (sexual words, musical words), block (1–6), and lag (three items, eight items) as within-subject factors. The normality of the distributions was assessed and confirmed using both visual inspection of the distributions and quantile–quantile analyses. The results indicated no main effect of block, $F(5, 240) = 1.76$, $p = .12$ (partial $\eta^2 = .04$), age, $F(1, 48) < 1$ (partial $\eta^2 = .00$), or distractor type, $F(1, 48) < 1$ (partial $\eta^2 = .00$). The lag effect was marginally significant, $F(1, 48) = 3.84$, $p = .056$ (partial $\eta^2 = .07$). The only significant interaction was between lag and age, $F(1, 48) = 4.85$, $p < .05$ (partial $\eta^2 = .09$). Among younger participants, the percentage of correctly identified targets was lower at lag 3 (M = 80.0%) than lag 8 (M = 82.9%), $F(1, 24) = 7.56$, $p < .05$ (partial $\eta^2 = .239$), whereas among older participants, the percentage of correctly identified targets was the same for lag 3 (M = 81.6%) and lag 8 (M = 81.5%), $F(1, 24) < 1$ (partial $\eta^2 = .0014$). The effect of lag on accuracy, observed among the younger participants only, is probably indicative of an overall AB effect linked to the presence of a word (rather than a pseudo word) three items before the target. Given that this result was independent of the type of distractor (sexual or musical)—the main factor tested in this article—we will not discuss it further.

The main finding of this experiment is that, as soon as the experimental setup included more than one lag, the superiority of sexual words observed in Experiment 1 disappeared. Whereas in Experiment 1 we observed a significant effect for lags 3, 4, 5 and 6, in Experiment 2 a *post-hoc* analysis using Tukey's procedure demonstrated no significant effect in any of the six blocks. This suggests that the advantage in RSVP performance seen with sexual distractors in Experiment 1 was due to the use of a fixed distance between the sexual distractor and the target, producing a kind of warning signal effect that optimized preparation, probably unconscious.

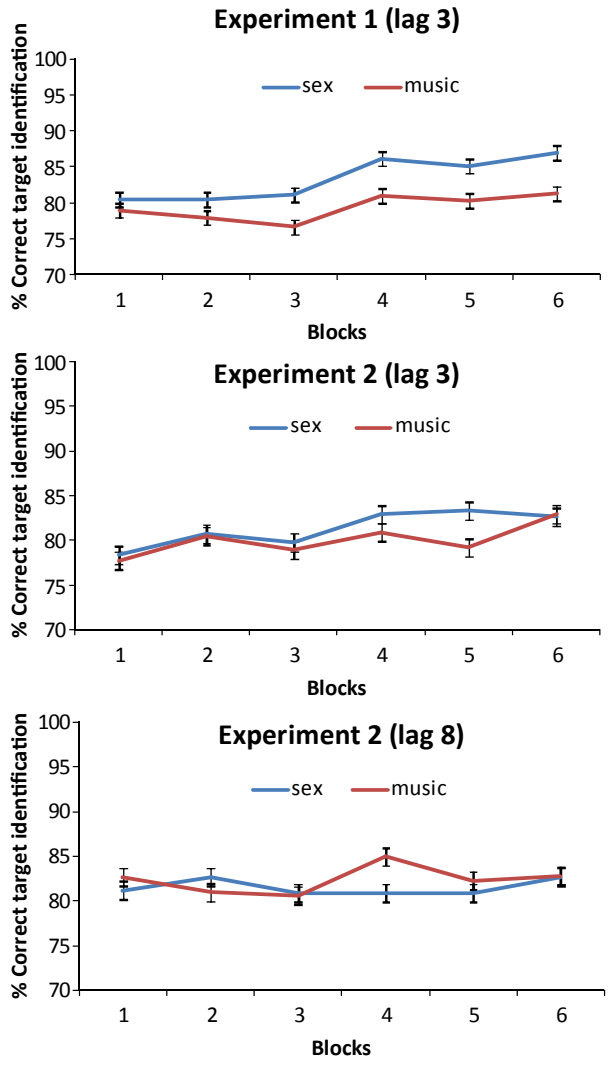

Figure 2. Mean percentage of correct colour target identification responses as a function of block and critical distractor category (sexual vs. music) for Experiment 1 (first six blocks only), lag 3 of Experiment 2 and lag 8 of Experiment 2. Bars show the standard error of the mean.

GENERAL DISCUSSION

The aim of this study was to determine how the presumed influence of irrelevant sexual distractors on visual search changes with age. The results offer a number of interesting and unexpected findings. First, both the younger and older participants performed better in Experiment 1 when the target was preceded by a sexual word rather than a musical word. This advantage is at odds with Arnell *et al.* who found the opposite effect for younger adults, despite our efforts to replicate their procedure as closely as possible (for discussion of the high importance of replication, see, e.g., Pashler & Harris, 2012). Second, in our study the sexual distractor advantage was more pronounced for the older participants than for the younger ones.

In Experiment 2, two target-distractor lags were used to reduce the likelihood that participants could use the distractor to predict the moment of target onset. There, no difference was observed between the two types of distractors. This finding suggests that the effect of distractor type (sexual word vs. music word) in Experiment 1 was a kind of warning signal effect; that is, participants were able to use the appearance of the sexual distractor to better prepare (either explicitly or implicitly) for the target.

In any case, none of our results replicated those of Arnell *et al.* (2007). Experiment 1 produced an effect in the opposite direction and Experiment 2 then eliminated the effect by using a variable lag. In the literature, the results of the studies using emotional stimuli in an RSVP task are highly discrepant. While some authors have found an AB effect with emotional stimuli (e.g., Mathewson *et al.*, 2008; Most *et al.*, 2005, 2007), others have not, or have even found opposite effects, as we did here (e.g., Huang, Baddeley & Young, 2008; Mickley Steinmetz *et al.*, 2010; Stein, Zwickel, Ritter, Kitzmantel & Schneider, 2009). Mickley Steinmetz *et al.* (2010), for example, showed that when participants had to detect two targets, the use of an emotional word as the first target, whether positive or negative in valence, *increased* detection of the second target. Our results point in this same direction. Perhaps the difference between Arnell *et al.*'s (2007) results and our own (i.e., negative vs. positive effect of the presence of a sexual distractor on visual search performance) could be due to cultural differences between English-speaking Canadian people and French people in terms of their attitudes towards sexual stimuli.

Also, and quite interestingly, both of our experiments (using completely separate samples of participants) showed no decline in performance with age. Note that, unlike some aging studies (e.g., Mickley Steinmetz *et al.*, 2010), we presented each item for the same duration for older and younger adults. The absence of a decline in performance with age is consistent with a number of studies showing that automatic detection processes are not affected much by aging, especially when emotional material is used (e.g., Leclerc & Kensinger, 2008; Mather & Knight, 2006). The difference between the results of Experiments 1 and 2 suggests that the facilitation observed in Experiment 1 in the presence of a sexual word may have been a learning effect: the participants probably learned the fixed distance between the distractor and the target. Our results indicate that older participants were better able to take advantage of this relationship, either because they were better at detecting it, better at using it or (perhaps more likely) benefitted more when they did use it. Although some studies have shown that implicit learning resists the effects of aging when the rules to be learned are not too complex (e.g., Howard & Howard, 1992), very few studies have found superior performance among older participants on a difficult cognitive task (detecting a target displayed for 112 ms and masked). One hypothesis to explain this unusual result is based on the common finding that normal aging is accompanied by a decline in inhibitory capacities (e.g., Hasher & Zacks, 1988; McDowd, 1997). With aging, inhibitory processes often fail to prevent irrelevant information from entering or being maintained in working memory. In our study, the instruction given to the participants was to ignore the sexual words presented within the stream. It is plausible therefore that younger participants, because they have better inhibitory capacity, were better able to ignore the distractors, especially the sexual ones which have greater perceptual salience. In Experiment 1, however, the critical distractors offered a useful cue, announcing the arrival of the target three words later. Therefore, one hypothesis to explain our results is that older learn to use the distractors better because they have less inhibitory control.

In summary, neither of the experiments showed any significant AB effect from sexual words, contrary to Arnell *et al.* (2007). In some circumstances, an effect opposite to the

AB can be observed. In our study, this opposite effect is probably provoked by the use of a fixed lag, so that the distractor reliably predicted the moment of target onset. Moreover, our research is one of the rare studies demonstrating better learning capacities for older participants than for younger ones. Paradoxically, this advantage for the older participants could be provoked by a decline in their inhibitory capacity.

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