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The Frequency Attenuation Effect in Identity and Associative Priming

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Three lexical decision experiments were carried out, where the masked priming paradigm is used to study the role of the frequency attenuation effect (more priming in low-frequency target words than in high-frequency target words) in repetition and associative priming, manipulating Prime Duration (PD) and Stimulus Onset Asynchrony (SOA). A new concept was introduced, Minimum Time Threshold (MTT), this is, the minimum time interval of exposure to the masked word in order to become aware of it. Results support the notion that MTT is a key to the appearance of the frequency attenuation effect when enough word processing time is allowed. Results do not support the unified explanation of masked priming and long-term priming as proposed by Bodner and Masson (2001). Moreover, information feedback from the semantic level was not the reason for the frequency attenuation effect in repetition priming.
Keywords: lexical decision task, masked priming, repetition priming, associative priming, frequency attenuation effect, SOA, MTT.

Se han realizado tres experimentos de decisión léxica, en donde se utiliza el paradigma de facilitación enmascarada, para estudiar el efecto de atenuación de la frecuencia (más facilitación para las palabras objetivo de baja frecuencia que para las de alta frecuencia) para la facilitación por repetición y asociativa, manipulando la duración de la palabra preparatoria (PD) y la asincronía entre los comienzos de los estímulos preparatorio y objetivo (SOA). Un nuevo concepto se ha introducido, el umbral de tiempo mínimo (MTT), que es el intervalo mínimo de exposición necesario para que la palabra enmascarada sea percibida conscientemente. Los resultados apoyan la noción de que el MTT es la clave para que aparezca el efecto de atenuación de la frecuencia cuando se da suficiente tiempo de procesamiento de la palabra. Los resultados refutan la explicación unificada de la facilitación enmascarada y facilitación a largo plazo como ha sido propuesta por Bodner y Masson (2001). Además, la retroalimentación de la información desde el nivel semántico no es la razón de la aparición del efecto de atenuación de la frecuencia en la facilitación por repetición.
Palabras clave: tarea de decisión léxica, facilitación enmascarada, facilitación por repetición, facilitación asociativa, efecto de atenuación de la frecuencia, SOA, MTT.

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If the processing of one stimulus (the target) is influenced by the presentation of a prior stimulus (the prime), there is said to be a priming effect. The importance of the priming effect within current cognitive psychology can be seen in the large quantity of related research. Though successive reviews have shown that the priming effect is reliable, (e.g. Richardson-Klavehn & Bjork, 1988; Schacter, 1987; Schacter, Chiu, & Ochsner, 1993; Tenpenny, 1995), presently there is no well-established explanation for it and it is a matter of controversy. The main goal of this study is to explore the origin of the priming effect and shed light on the relationship between the priming effect and awareness.

There are various types of priming—repetition, semantic, form, etc.—depending on how the prime and the target are related. This study utilizes repetition and associative priming. In the repetition priming situation, the prime and the target are the same word, whereas in the associative priming condition, the prime and the target are associatively related. How have authors explained the source of priming effects to date? Within the group who conceptualize the priming effect as one mechanism, some authors give priming effects a purely episodic explanation. In this approach, repetition priming stems from the retrieval, during target processing, of memory traces constructed during prime processing (Becker, Moscovitch, Behrmann, & Joordens, 1997; Bodner & Masson, 2003; Jacoby, 1983; Jacoby, Baker, & Brooks, 1989; Joordens & Becker, 1997; Kolers & Roediger, 1984; Logan, 1990; Masson & Bodner, 2003; Neill, Valdes, Terry, & Gorfein, 1992; Ratcliff & McKoon, 1988; Roediger & Blaxton, 1987; Salasoo, Shiffrin, & Feustel, 1985). For other authors, according to spreading activation theories (e.g. Anderson, 1976, 1983; Collins & Loftus, 1975; Collins & Quillian, 1969; MacKay[1],1987, 1990; Neely, 1977; Posner & Snyder, 1975), the mechanism is a transient variation in the activation level of pre-existing memory representations (e.g. Graf & Mandler, 1984; Squire, 1987; Tulving, 1984), or a permanent change in the threshold level of activation of representations (Morton, 1969); or the activation resting level (McClelland & Rumelhart, 1981); or the strength of connections between representations or units (Monsell, 1991).

According to Tenpenny (1995), none of these points of view can explain all the results observed in studies using the priming paradigm. Many authors have developed an alternative position by assuming that word repetition priming effects result from more than one mechanism. One mechanism is a short-term effect mediated by lexical activation and another mechanism is a long-term effect based on episodic memory trace retrieval (e.g. Durgunoglu & Neely, 1987; Forster, Booker, Schacter, & Davis, 1990; Forster & Davis, 1984; Humphreys, Besner, & Quinlan, 1988; Schacter & Graf, 1986; Versace & Nevers, 2003; Whitlow, 1990; Whitlow & Cebollero, 1989; Woltz, 1990).

The masked priming paradigm, or prospective view

In a typical priming experiment, two stimuli are presented successively. The task requires the participant to respond in some way to the target. Priming is said to occur when the prime facilitates response to the target, relative to some neutral baseline. Unlike the standard long-term priming paradigm, where the time interval between the prime and target might be on the order of many minutes, with many intervening items, masked priming usually involves a very short interval, with no intervening items. Furthermore, the prime is presented for such a brief period of time that participants are generally unaware of the nature of the prime. Of crucial importance in this regard is the presence of a forward mask presented immediately prior to the prime. For example, Forster and Davis (1984) used a three-field paradigm (mask-prime-target), sometimes referred to as a “sandwich” technique, with a very brief prime (50 to 60 ms) surrounded by a forward mask and a backward mask (the target), both being presented for 500 ms. The forward mask is a row of hash signs (#####), the prime is a string of lower case letters, and the target is a string of upper case letters (in order to ensure that the two stimuli are physically distinct). Each stimulus is located in the center of the display screen, and the width of the forward mask is designed to cover the prime completely. The most important feature of this method is that at a prime duration of 60 to 67 ms, most participants are aware that something occurred just prior to the target, but they are unable to identify it. At prime durations below 50 ms, most participants are surprised to learn that anything intervened between the forward mask and the target (Forster & Davis, 1984; Forster, Davis, Schoknecht, & Carter, 1987; Forster, Mohan, & Hector, 2003).

Forster, Mohan and Hector (2003) proposed five basic types of priming that had been studied. The first and strongest is identity, or repetition priming (e.g. Bodner & Dypvik, 2005; Bowers & Turner, 2005; Butler & Berry, 2004; Fleischman & Gabriele, 1998; Frings & Neubauer, 2005; Hino, Lupker, Ogawa, & Sears, 2003; Holcomb, Reder, Misra, & Grainger, 2005; Koivisto & Revonsuo, 2004; Kunde, Kiesel & Holfmann, 2005; Lingnau & Vorberg, 2005; Lleras & Enns, 2005; Sears, Campbell & Lupker, 2006; Van Opstal, Reynvoet, & Verguts, 2005

[1] In this theory, activation does not spread but there is an analogous process that behaves in the same way. This process is called *priming.*

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and 2005b; Zeelenberg, Wagenmakers, & Shiffrin, 2004), where the prime is the same word as the target (*attitude-ATTITUDE*). The magnitude of this identity priming effect is typically from 50 to 60 ms, depending on prime duration. Next comes form-priming (e.g. Castles, Davis, & Letcher, 1999; Davis & Lupker, 2006; Dehaene et al. 2004), where the prime and target have similar form. Often this involves a one-letter-different prime that can be either a word (e.g., *aptitude-ATTITUDE*), or a pseudoword (e.g., *antitude-ATTITUDE*). Typical effects obtained here are around 20 to 30 ms, although the amount of priming depends to a large extent on properties of the target word (Forster et al., 1987). Another type of form priming involves letter transposition (e.g., *attiutde-ATTITUDE*), which is generally stronger (e.g. Finkbeiner, Forster, Nicol, & Nakamura, 2004; Perea & Lupker, 2003b; Van Assche & Grainger, 2006). Finally, there is a group of priming effects that all depend on some type of semantic relationship. There is a morphological priming effect (e.g., *kept-KEEP*) (e.g. Carreiras, Ferrand, Graninger, & Perea, 2005), where the prime and target are both morphological variants of the same stem; an associative priming effect (e.g., *black-WHITE*) (e.g. Anaki & Henik, 2003; Angwin et al. 2004; Brown & Besner, 2002; Dennis & Schmidt, 2003; Forster, 2003; Locker, Simpson, & Yates, 2003; Perea & Rosa, 2002b; Plaut & Booth, 2000; Reynvoet, Gevers, & Caessens, 2005), where prime and target are related associatively; and a translation priming effect (e.g., *cheval-HORSE*) (e.g. Duyck, 2005), where prime and target are equivalent words in different languages. All of these effects are assessed relative to a baseline condition, in which the prime differs from the target at all letter positions (e.g., *harmless-ATTITUDE*).

A crucial assumption underlying interpretations of priming is that the prime creates a temporary state of activation that influences target processing, usually in a beneficial way. The classic explanation for such effects is that the prime creates some form of temporary change in the cognitive system that provides an advantage or head start in processing the target, as compared to the case where the prime consists of an unrelated or neutral stimulus. For instance, in the case of semantically related prime-target pairs, the theory of automatic spreading activation assumes that the prime stimulus activates not only its own lexical entry, but also the entries of other semantically related words (e.g. Anderson, 1976, 1983; Collins & Loftus, 1975; Collins & Quillian, 1969; MacKay, 1987, 1990; Neely, 1977; Posner & Snyder, 1975).

This masked priming technique has been widely used to examine contributions of phonological, orthographic, and other processes to early stages of word identification. The fundamental assumption in masked priming methodology is that by masking the prime, one can avoid the possibility of episodic influences or strategic effects (Forster & Davis, 1984; Forster, Mohan, & Hector, 2003).

Forster and Davis (1984) established three main dissociations between masked and long-term repetition priming. First, positive priming in masked priming methodology was found for words but not for nonwords (e.g. Forster, 1987; Forster, Davis, Schoknecht, & Carter, 1987; Rajaram & Neely, 1992). If masked priming is based on access to a lexical entry, only words have the possibility of producing priming, because only those items have lexical entries. However, if masked priming were episodically based, one might expect that nonwords would also show a priming effect as they do in long-term priming paradigms.

Second, Forster and Davis (1984) showed that, with masked primes, high- and low-frequency word targets produced similar amounts of priming (e.g. Ferrand, Grainger, & Segui, 1994; Segui & Grainger, 1990; Sereno, 1991), whereas low-frequency words generated substantially more priming than high-frequency words in long-term priming (e.g. Duchek & Neely, 1989; Norris, 1984; Scarborough, Cortese & Scarborough, 1977).

Third, the influence of a masked prime is short-lived (seconds), whereas long-term priming effects are often long-lasting (minutes, hours, even days) (e.g. Forster, Booker, Schacter & Davis, 1990; Forster & Davis, 1984).

These dissociations serve as an important foundation for the assumption that masked priming is free of episodic or even strategic influences (Forster, 1998; 1999).

The episodic explanation, or retrospective view

In long-term priming tasks involving word identification, participants typically are presented with a list of words that appear later, along with a set of new words. Tasks such as word naming, lexical decision, word-stem completion, word-fragment completion, and masked word identification show improvement in either speed or accuracy in identification of words that appeared on the study list, relative to nonstudied items (e.g. Feustel, Shiffrin, & Salasoo, 1983; Jacoby & Dallas, 1981; MacLeod & Masson, 2000; Scarborough, Cortese, & Scarborough, 1977; Toth, Reingold & Jacoby, 1994; Tulving, Schacter, & Stark, 1982). These enhanced identification effects are thought to be generated by a form of memory of the specific study episode, particularly memory of the perceptual aspects of that episode, rather than activation of a stable, lexical representation.

Some authors (Jacoby, 1983; Jacoby & Dallas, 1981) assume that both memory and perception depend on access to a large population of memories of prior episodes. Thus, what is taken as temporary activation of a stable memory representation in a prospective view of priming, can be seen from a retrospective view as a summary statistic reflecting the number and similarity of memories for episodes called up by the current stimulus configuration.

Ratcliff and McKoon (1988; 1994) and Dosher and Rosedale (1989) propose a compound-cue retrieval theory of priming. In their account, a prime and a target presented in close temporal proximity form a compound cue that is used to probe long-term memory. The existence in long-term memory of direct associations between the elements of a compound cue leads to large familiarity values, which in turn speeds response times on a target identification task.

Masson and Bodner (2003) dismantle the dissociations made by the prospective view. They propose that masked priming can be explained within a retrospective account of how priming events influence word identification. First, they address the finding that masked priming of lexical decisions is restricted to word targets (e.g. Ferrand et al., 1994; Forster & Davis, 1984). They suggest that the lack of masked repetition priming of nonword targets may be an unintended consequence of how nonwords are classified during lexical decision tasks (Bodner & Masson, 1997; Masson & Bodner, 2003; Masson & Isaak, 1999).

The second dissociation between masked priming and long-term priming established by Forster and Davis (1984) and Forster et al. (1990) is that the influence of a masked repetition prime is relatively short-lived, whereas long-term priming effects endure over substantial delays (minutes or even days) between the prime event and presentation of a target. Masson and Bodner (2003) explain that the presentation of other linguistic material in the delay interval that separates the prime and the target displays may serve as a source of retroactive interference that weakens the memory representation of the prime event or reduces accessibility of that representation.

The third dissociation proposed by Forster and Davis (1984) provides evidence that, unlike long-term priming, masked priming is equally strong for low- and high-frequency target words. However, in recent masked priming studies (Bodner & Masson, 2001; Bodner & Masson, 2003; Masson & Bodner, 2003), a clear, statistically reliable interaction was obtained between word frequency and repetition priming, with a larger priming effect for low-frequency words. It must be taken into account that this frequency attenuation effect was found using alternating-case target words (with degraded targets) and with high-frequency words that fell within the median of 200 occurrences per million.

Masson and Bodner (2003) and Bodner and Masson (2004) explain the advantages and usefulness of developing a unified, retrospective explanation for both masked priming and long-term priming in word identification. They have been able to extend this proposal to three different domains (repetition, semantic, and parity priming). I will focus on the first two domains.

Current issues

Forster and Davis (1984) provide evidence that, unlike long-term priming (e.g. Duchek & Neely, 1989; Jacoby & Dallas, 1981; Norris, 1984; Scarborough et al., 1977), masked priming is equally strong for low- and high-frequency target words (e.g. Ferrand, Grainger, & Segui, 1994; Segui & Grainger, 1990; Sereno, 1991). An initial effort to obtain an interaction between target word frequency and masked priming was not successful (Bodner & Masson, 1997). In both studies word frequency manipulation was comparable; high-frequency words were in the range of 40 to 60 occurrences per million. A stronger manipulation of word frequency was used by Forster and Davis (1991). High frequency words were defined as 100 or more occurrences per million. There was a stronger priming effect for low-frequency words relative to high-frequency words in the lexical decision task (54 versus 72 ms), but they did not report any tests of this interaction.

In their experiments, Bodner and Masson (2001) use high-frequency words that fall within the range of 100 to 1000 occurrences per million (median frequency was about 200 across the experiments). In four experiments they obtain a clear, statistically reliable interaction between word frequency and repetition priming, with a larger priming effect for low-frequency words. This result was obtained using target words in upper case or alternating upper- and lower-case (degraded).

This study represents the first clear demonstration of a frequency-modulated masked repetition priming effect. The pattern of this interaction conforms to the pattern observed in long-term priming experiments. This effect has traditionally been observed with non-masked primes (e.g. Forster & Davis, 1984; Jacoby, 1983; Jacoby & Dallas, 1981; Jacoby & Hayman, 1987; Nevers & Versace, 1998; Norris, 1984; Scarborough, Cortese, & Scarborough, 1977; Versace, 1998), but not with masked primes (e.g. Ferrand, 1996; Forster & Davis, 1984; Humphreys et al., 1988; Humphreys, Evett, & Quinlan, 1990; Segui & Grainger, 1990; Sereno, 1991; Versace, 1998). Therefore, if the frequency attenuation effect is a marker of episodic contribution and this effect is reported with masked primes, then the current masked experiments involve an episodic component. This argument will form the central core of my study.

A second issue is the role of prime awareness in masked experiments (e.g. Holender & Duscherer, 2004; Logan & Balota, 2003; Marcel, 1983; Merikle, Smilek, & Eastwood, 2001; Stolz, & Merikle, 2000; Visser, Merikle, & Di Lollo, 2005). The first investigations of subliminal semantic priming using backward masking appeared in the early 1980s (e.g. Balota, 1983; Carr, McCauley, Sperber, & Parmelee, 1982; Fischler & Goodman, 1978; Fowler, Wolford, Slade, & Tassinary, 1981; Marcel, 1983; McCauley, Parmelee, Sperber, & Carr, 1980), but Holender (1986) concluded that the effects were unreliable and that the stimuli had probably been consciously identified. A second generation of research on unconscious priming used improved methods for defining and assessing awareness of the prime (Dagenbach, Carr & Wilhelmsen, 1989; Hines, Czerwinski, Sawyer & Dwyer, 1986). The results showed that statistically reliable semantic priming was obtained in the condition where primes were presented at the detection threshold. (Semantic priming was at about 32 ms and 27 ms.)

The crucial idea is that some forms of priming occur only when participants are aware of the prime, as in cross-modal priming (Kouider & Dupoux, 2001) or semantic priming (de Groot, 1990; Perea & Gotor, 1997; Rastle, Davis, Marslen-Wilson, & Tyler, 2000; Sereno, 1991). For example, Rastle et al. (2000) report strong semantic effects at 230 ms, a marginal effect at 72 ms, and not even a trend at 43 ms. Finally, Brown and Hagoort (1993) and Frenck-Mestre and Bueno (1999) used brief primes, but inserted a mask between the prime and target, which increases the SOA; this has the effect of increasing visibility of the prime. However, Forster and Davis (1984) explain the absence of long-term priming effects by assuming that episodic traces are generated only for events that one is aware of.

The most surprising result is that words that overlapped orthographically (e.g. *mother-bother*) fail to show reliable priming when the prime was visible (e.g., Colombo, 1986; Martin & Jensen, 1988), but when the prime was masked, reliable facilitation effects were obtained (Forster, Davis, Schoknecht, & Carter, 1987). Dehaene, Naccache, Cohen, Le Bihan, Mangin, Poline and Rivière (2001) were able to demonstrate that masked words produce activation patterns that differ from those produced by visible words. In particular, activation of a masked word was drastically reduced in intensity, and was far more localized. While visible words induced increased activity at multiple distant sites, this correlated activity was completely absent with masked words.

A third issue concerns the proportion of related trials in the experiments. Automatic processes are traditionally defined as those having a quick onset, proceeding without intention or awareness, and producing benefits but not costs. Strategic processes are slow acting, require intention, are conscious, and produce both benefits and costs (e.g., Posner & Snyder, 1975; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). It is well documented that inhibition is small or nonexistent for SOAs shorter than 300 ms (e.g., de Groot, 1984; den Heyer, Briand, & Smith, 1985; Neely, 1977). A second factor that seems to influence strategic processing is the relatedness proportion, that is, the proportion of related trials out of all word prime-word target trials. Relatedness proportion effects are reduced or eliminated at short SOAs (de Groot, 1984; den Heyer, Briand, & Dannenbring, 1983; Tweedy, Lapinski, & Schvaneveldt, 1977).

Now there is even evidence that the relatedness proportion affects subliminal semantic priming (Bodner & Masson, 2003). These authors found that semantic priming from briefly presented primes (45 ms, masked by the target) was 24 ms when the relatedness proportion was .8, and 13 ms when the relatedness proportion was .2. Post-experimental interviews and direct assessment of prime perceptibility indicated that the results could not easily be attributed to conscious awareness of primes. However, Cheesman and Merikle (1986) found that relatedness proportion did not affect the magnitude of priming when primes were presented at the subjective threshold. Perea and Rosa (2002) found no evidence of an effect of relatedness proportion (.82 and .18) on semantic priming at an SOA of 66 ms. It may be that the conscious perception of briefly presented primes can interfere with semantic priming.

Threshold study

One could say that the most important feature of the masked priming procedure is a very short SOA between prime and target. According to Forster, Mohan and Hector (2003), it seems that prime durations on the order of 30 to 50 ms rule out accurate identification of the prime, at least for the vast majority of individuals (only one person in 50 can identify 60-ms masked primes). However, less demanding awareness tests, which do not require the participant to recall the prime, indicate that some limited information about the prime appears to be available. For example, a two-alternative forced-choice recognition test administered immediately after the target presentation yields slightly better than chance performance, although under the same conditions, participants might be completely unable to decide whether the prime was a word or a nonword (e.g., see Forster et al., 1987). This is important because priming effects appear whether or not the participant is aware of the prime, as mentioned above.

Cheesman and Merikle (1984) consider two definitions of awareness and distinguish between two associated awareness thresholds. According to one definition, participants were unaware of the prime if they said they could not perceive it. The subjective threshold was defined as the maximum level of stimulus presentation at which participants reported no phenomenal awareness of the prime. According to the other definition, participants were said to be unaware of the prime if they could not reliably make a forced-choice decision (e.g. present-absent, word-pseudoword) on the prime. The objective threshold was the maximum level of stimulus presentation to produce chance performance in a task requiring a forced-choice decision on the prime.

The problem is that different procedures for measuring awareness yield different estimates of the degree of awareness, and what is unawareness by one procedure may well prove to be awareness by another. Methods used in the past have required participants to make same-different judgments between the prime and target, or to decide whether the prime was a word or not, or to decide which of two subsequently presented alternatives matches the prime. Thus participants classified as aware by one criterion might well be classified as unaware by other methods.

I have chosen the subjective threshold (Cheesman & Merikle, 1984) as a means to diagnose the "relative" awareness of the prime stimulus because I believe that the problem is not to find the zero absolute threshold, but to establish some average threshold for each participant and each group of words, in order to find dissociations in priming effects. This method was derived from Marcel's study (1983), where different individuals were found to have different thresholds in perceiving the same words. In the masked priming studies, the authors used the same threshold for all participants. Thus, some persons might have been aware of the prime while others were not.

One potential problem is that thresholds may decrease during the course of the experiment because of learning, adaptation, and so forth (Holender, 1986). Therefore, the subjective threshold must be established for each participant individually and with different words than those used in the experiment. Words that have analogous printed usage frequency can give us an average threshold needed for future experiments.

The following tasks were designed to obtain an average subjective threshold, defined as the minimum level of masked stimulus presentation at which participants reported phenomenal awareness of the stimulus. The tasks began with 1000 ms of forward mask consisting of a row of seven hash signs (#######). Following this, a word stimulus appeared during some time, and finally a backward mask, identical to the forward mask, was likewise presented for 1000 ms. Because the computer screen utilized in the experiments has a frequency of 60 Hz, the minimum presentation time between masks was 16.7 ms. This time was incremented by the duration of the refresh cycle (16.7 ms) until the individual guessed the word, say, 17, 33, 50, 67, 83, 100, 117, etc.

Method

Participants. A total of 30 volunteers participated in the three tasks. The group consisted of university students drawn from first year classes in an Educational Psychology program. All had normal or corrected-to-normal vision and had not learned Spanish as their second language. They received course credit for their participation.

Stimuli. A set of 60 words (see Appendix B) were selected from Juilland & Chang-Rodríguez (1964), where frequency was measured by occurrences per 1 million. For the H-THRESHOLD task, 20 words had two syllables (mean = 2.05, *SD* = .22), five or six letters (mean = 5.1, *SD* = .31), and a high printed usage frequency (mean = 147.6, *SD* = 29.4). For the M-THRESHOLD task, another 20 words had two syllables (mean = 2.0, *SD* = .0), five or six letters (mean = 5.1, *SD* = .31) and a medium printed usage frequency (mean = 76.8, *SD* = 6.0). Finally, for the L-THRESHOLD task, a different 20 words had two syllables (mean = 2.2, *SD* = .37), five or six letters (mean = 5.1, *SD* = .31), and a low printed usage frequency (mean = 16.2, *SD* = .8). In addition, the words selected were always presented in lower case letters, with a white font against a black background.

Design. A within-participants design was used with Word Frequency (High, Medium, and Low) as the only factor. Half of the participants followed the task sequence of first, H-THRESHOLD; second, M-THRESHOLD; and third, L-THRESHOLD. For the other half the sequence was first, L-THRESHOLD; second, M-THRESHOLD; and finally, H-THRESHOLD.

Equipment. A Pentium-4 compatible IBM PC computer was used. For stimulus presentation and data recording, a MS-DOS 6.22 operative system with a text mode of 25 x 80 rows and columns was used. Stimuli were displayed on the screen with Dlhopolsky's (1989) routines and responses were made on the keyboard. A hardware modification was performed to eliminate the timing error associated with the CRT scanning rate and the clock precision was less than 1 ms. Monitor frequency was 60 Hz with VGA high-resolution, thus, the scanning rate was 16.7 ms. Stimulus presentation and time recording were programmed in "C" language.

Procedure. Participants were tested individually. They were seated approximately 40 cm from the computer screen. Stimuli were presented in text mode 80 columns x 25 rows in white lower case on a 13.7" screen, approximately 1.7 º. Words were presented in row 12. All stimuli were centered on the screen.

Each trial began with an asterisk "*" at the centre of the screen as a fixation point. This was followed by a two-second pause and the appearance of a forward masking stimulus (#######) consisting of a row of seven hash signs. The hash signs were presented for 1000 ms and were immediately replaced by a brief exposure of a word stimulus in lower case letters. The stimulus was then immediately replaced with a 1000 ms presentation of backward masking stimulus (#######).

Exposure to the word began with one refresh cycle (17 ms) for the first trial. In the coarse approximation, if the word is guessed wrongly, the next word exposure trial is incremented by another refresh cycle (33 ms) and so on, until a word is guessed correctly. In the fine approximation, two refresh cycles (33 ms) are deducted from the most recent correct elapsed time in the coarse approximation. If the elapsed time were 17 ms in the coarse approximation, no time was deducted for the fine approximation. If the time was 33 ms in the coarse approximation, only one refresh cycle (17 ms) was deducted for the fine one. Using this resulting time (the fine approximation), word trials are presented until five trials are done correctly, then the task is finished. If five trials are guessed wrongly, then word exposure time is incremented one refresh cycle (17 ms), this procedure being repeated until five correct trials are performed successively.

Participants were instructed to focus their attention at the fixation point where the "*" sign appeared, and later the hash signs would appear. The task consists of guessing and verbalizing the word between the two masks, since reading the word would be very difficult. Participants were encouraged to guess the word even though it might be wrong. Once a word was guessed and verbalized, the space bar was pressed, and the word then appeared for several seconds, enabling the experimenter to check whether the two words were the same. Upon recognizing the word stimulus as either correct or incorrect, the experimenter pressed the "M" key for a right response or the "C" key for a wrong answer. Trials were randomly chosen from the twenty words for each list and presented to each participant (see appendix B).

Data analysis. The minimum level of stimulus presentation at which participants reported five correct responses was computed for each participant in each list These minimum time thresholds (MTT) were then analyzed with an analysis of variance.

Results

As can be seen in the table 1, the mean of the Minimum Time Threshold (MTT) for awareness by guessing was 35.8 for the H-Threshold task, 39.2 for the M-Threshold task and 38.7 for the L-Threshold task. The effect of Word Frequency (High, Medium, and Low threshold) was not significant $F(2, 58) = 1.88$, $MS_e = 53.04$, $p = .162$ although the effect showed a trend. This trend was confirmed by the comparison of H-Threshold with M-Threshold, which was marginally significant $F(1, 29) = 3.22$, $MS_e = 53.81$, $p = .083$.

Table 1
Minimum Time Threshold (MTT) at which participants can become aware of words. Number of participants at this threshold (N) and percentage (%) of participants for the three lists: H-THRESHOLD, M-THRESHOLD and L-THRESHOLD

	H-THRESHOLD		
	MTT	***N***	***%***
	33	26	87
	50	3	10
	67	1	3
MTT Mean	35.8		
SD	7.8		
	M-THRESHOLD		
	MTT	***N***	***%***
	33	20	67
	50	9	30
	67	1	3
MTT Mean	39.2		
SD	9.5		
	L-THRESHOLD		
	MTT	***N***	***%***
	33	20	67
	50	10	33
	67	0	0
MTT Mean	38.7		
SD	8.2		

Discussion

The three tasks show that MTT for correctly guessing a word was 38 ms on average. It is interesting to note that in standard masked experiments, prime exposure is about 50 or 60 ms and participants are not aware of the stimulus. One possible explanation is that, for the lists presented here, the participant had only one task, to name the stimulus, whereas in standard masked experiments the participant has to do several tasks at the same time (e.g. recognize the prime, recognize the target, make a lexical decision about the target and make a response to the target). Thus, as Kahneman (1973) asserts, resources are divided between concurrent tasks. Another possibility is that the backward masking stimulus (#######) used in this experiment is different from the backward masking stimulus (the target) that is usually used in standard masked experiments, and this may influence the visibility of the prime stimulus. The hypothesis to be tested in the following experiments is that, in MTT tasks, the participant has the time required for guessing the masked word, whereas in standard masked experiments, this process interacts with target recognition, so that time needed for recognizing the prime word becomes limited by target recognition.

The most important result is that MTT can be different for each participant and for each word group with the same frequency. According to spreading activation theories (e.g. Anderson, 1976, 1983; Collins & Loftus, 1975; Collins & Quillian, 1969; MacKay,1987, 1990; Neely, 1977; Posner & Snyder, 1975), for some participants that have practiced these words more in the past, their MTT will be lower than for those individuals that have read or named the words fewer times. This fact is observed in some preliminary experiments with children. MTT will be lower for high-frequency words than for low-frequency words. This result was supported by the previous threshold study. This threshold experiment gives us an average MTT for each participant and for each word frequency level, that is, high-, medium-, or low-frequency words. For future experiments, the M-threshold task will be selected as an average MTT for word frequency and for participant threshold.

In standard masked priming experiments, 50 ms is the critical value to explain short-term effects: 1) rapid onset; 2) short-lived; and 3) automatic. Might this critical value be better than the MTT value that we find above for describing the dissociations seen in this field? Below I explore the effects of these values on the frequency attenuation effect in repetition and associative priming experiments.

Experiment 1

In this experiment, I seek to reproduce or replicate effects found (e.g. the frequency attenuation effect) in previous studies (e.g. Bodner & Masson, 2001; Foster & Davis, 1984) with items selected for the joint study of associative and identity priming.

This experiment was designed as a standard masked priming experiment (Forster & Davis, 1984) with a three-field paradigm (mask-prime-target), but with long prime duration (PD = SOA = 100 ms for 1a experiment condition), allowing prime awareness under their criteria, or with short prime duration (PD = SOA = 50 ms for 1b experiment condition) allowing no prime awareness. The interval between prime onset and target onset is commonly referred to as SOA (Stimulus Onset Asynchrony).

Some authors (Ferrand, 1996; Ferrand, Grainger, & Segui, 1994; Forster & Davis, 1984; Humphreys et al., 1988; Humphreys, Evett, & Quinlan, 1990; Segui & Grainger, 1990; Sereno, 1991; Versace, 1988) show that with masked primes (PD = SOA = 50), high- and low-frequency target words produce similar amounts of priming. That is, the frequency attenuation effect must be absent as in the experiment condition 1b. Forster and Davis (1984) explained the absence of long-term priming effects in the masked priming paradigm by assuming that episodic traces are generated only for events that one is aware of. When the participant is aware of the prime, the frequency attenuation effect should be present, that is, greater priming effects occur for low-frequency targets than for high-frequency targets. However, if the participant is not aware of the prime, the frequency attenuation effect should be missing, that is, equal priming for low- and high-frequency words.

Bodner and Masson (2003) and Masson and Bodner (2003) have proposed the retrospective account for explaining both short- and long-term effects. Their proposal of a unified account of masked and long-term priming is based on the assumption that prime events create a memory resource that can be recruited to assist with subsequent target processing. And it is independent of prime durations. Therefore, the frequency attenuation effect should be present in the following experiment in both 1a and 1b conditions.

Since prime duration (PD), the time that the prime is exposed, will be very important in future experiments, for this experiment both PD and SOA were set as the same length of time (100 ms for 1a condition and 50 ms for 1b condition). An SOA= 100 ms allowed for participant awareness, but not an SOA = 50 ms (Forster & Davis, 1984; Forster, Davis, Schoknecht & Carter, 1987; Forster, Mohan, & Hector, 2003). The prime was surrounded by a forward mask presented for 500 ms and the target (backward mask), exposed for 1000 ms. The forward mask was a row of hash signs (#######), the prime was a string (word) of lower case letters, and the target was a string of upper case letters. Basically, two types of priming were studied. The first was identity, or repetition priming, where the prime was the same word as the target (cat-CAT). The

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second was associative priming, where prime and target were related associatively (dog-CAT). Both effects were assessed relative to a baseline condition, in which the prime differs from the target at all letter positions (e.g. sun-CAT).

According the NST (Nodal Structure Theory) (MacKay, 1990), when you are aware of a stimulus, two processes are engaged. The first is the *activation* process that is related to the properties of lexical activation: short lived, rapid onset and automatic. The second is the *prolonged activation* process that necessarily occurs when the condition of awareness is present ("pertinent novelty"). This last process is related to episodic memory trace retrieval: long-lived, slow onset and non automatic. This theory concurs with many authors who have developed their theoretical position under the assumption that word repetition priming effects result from more than one mechanism: a short-term effect mediated by lexical activation and a long-term effect based on episodic memory trace retrieval (e.g. Durgunoglu & Neely, 1987; Forster, Booker, Schacter, & Davis, 1990; Forster & Davis, 1984; Humphreys, Besner, & Quinlan, 1988; Schacter & Graf, 1986; Versace & Nevers, 2003; Whitlow, 1990; Whitlow & Cebollero, 1989; Woltz, 1990). I think that the critical interval is the MTT in both processes: short-term and long-term effects. When Participants could not name the word (without awareness), with PD < MTT, only *activation* processes should be engaged. However, with PD ≥ MTT, the participant can name the word (with awareness) and both *activation* and *prolonged activation* processes must be involved.

Therefore, my initial hypothesis is that if PD is equal to or greater than MTT, and the prime is sufficiently processed, strategic effects will appear, in particular, the frequency attenuation effect. If PD is less than MTT, this effect should not be found. Therefore, my hypothesis states that MTT is the time needed to form an episodic trace. In order for the frequency attenuation effect to appear, this episodic trace should have been constructed, and the prime should have been processed long enough to develop the episodic trace with the target. Thus, one assumption is that the frequency attenuation effect is a marker of the episodic contribution.

One possible reason for frequency attenuation effects in short- and long-term priming is that lexical memory may receive feedback from semantic memory (e.g. see Stolz & Neely, 1995). According to this account, when the frequency attenuation effect appears in identity priming, significant priming must appear in associative priming. There should not be a situation where the frequency attenuation effect appears in identity priming while there is no significant priming in the associative component.

A general method will be reported because all the experimental conditions were similar, except for PD and SOA variables. This method is reported for experiment 1; the same method was applied in all experiments.

General Method

Participants. A total of 180 volunteers participated in the following three experiments, 30 volunteers per experimental condition (60 per experiment); all were university students recruited from first-year classes of an Educational Psychology degree program. All had normal or corrected-to-normal vision and had not acquired Spanish as their second language. They received course credits for their participation.

Stimuli. A set of 60 words (see Appendix A) was selected using the association norms of Algarabel, Sanmartin, García and Espert (1985); these formed the word/word trials. Prime words were two syllables (mean = 2, *SD* = 0) and had four, five, or six letters (mean = 5.1, *SD* = .7) with a medium printed usage frequency (Juilland & Chang-Rodríguez, 1964), that is, occurrences per 1 million (mean = 35.9, *SD* = 35.6). For each prime word, an associate target was selected per the former association norms, with associative strength higher than 30% (mean = 42.5, *SD* = 9.7); with one, two, or three syllables (mean = 2.1, *SD* = .5); with three, four, five, six or seven letters (mean = 4.7, *SD* = 1.1); and a medium printed usage frequency (mean = 83.4, *SD* = 77.8). This set of 60 prime-target words were divided into two sets of 30 prime-target pairs. One for low printed usage frequency targets (mean = 15.5, *SD* = 9.5) and another for high printed usage frequency targets (mean = 151.2, *SD* = 146.0) (see Appendix A for details of number of syllables, number of letters and printed usage frequency for primes and targets). All primes and targets belonged to an open class (nouns, adjectives and verbs).

Each target was preceded by an identical prime (cat-CAT), an associated prime (dog-CAT) and an unrelated prime (sun-CAT). Prime-target pairs were counterbalanced for the factor "relatedness" (identical, associated, unrelated), with three resulting lists for the participants.

Another set of 60 words (see Appendix A) was selected from Juilland and Chang-Rodríguez (1964) and they formed the word/ pseudoword trials. These prime words had two syllables (mean = 2, *SD* = 0) and four, five, or six letters (mean = 4.7, *SD* = .6), with a medium printed usage frequency (mean = 36.1, *SD* = 8.2). The pseudowords were formed by changing two vowels, or changing two syllables, or changing two consonants or by adding a new vowel from the following prime in the list. In addition, these changes were made for the prime in order to form a pseudoword with legal syllables but without meaning (see Appendix A). Moreover, primes were always presented in lowercase letters, whereas targets were presented in uppercase.

Each participant was presented with 120 prime/target pairs: 60 experimental pairs (word/word) composed of two words, a prime word and a target word (see Appendix A). And 60 filler pairs composed of a word as prime and a pseudoword as target were common to all participants. For half of the experimental pairs, targets were high-frequency words, and for the other half, targets were low-frequency words. We must take into account that stimulus repetition may interact with relatedness (den Heyer, Goring, & Dannembring, 1985; Durgunoglu, 1988; McNamara, 2005; Wilding, 1986), so stimuli must be counterbalanced for experimental conditions across participants.

Practice trials were constructed from a different set of words: 9 were word-word pairs and another 9 were word-pseudoword pairs. For the practice word-word trials: 33% had identical prime and target, 33% were associated pairs, and 33% were unrelated.

Design. A factorial design was used with Relatedness (Identical, Associated, Unrelated) and Target Frequency (High, Low) as within-participant factors and Group (condition a, condition b) as between-participant factor for each experiment. In the word/word trials, three stimulus lists were formed so that, across lists, each target was preceded once by each of the three types of primes: identical, associated and unrelated. Although no participant saw any target word more than once, all the target words occurred equally often, across participants, under all the possible Relatedness x Target Frequency combinations. The related pairs in one list were unrelated in another list. This ensured that comparisons between identical, associated and unrelated conditions were based on the same type of stimulus items, thus allowing each target to serve as its own control (remember that unrelated pairs were created by randomly re-pairing primes and targets).

Equipment. A Pentium-4 compatible IBM PC computer was used. For stimulus presentation and data recording, an MS-DOS 6.22 operative system with a text mode of 25 x 80 rows and columns was used for the experiment. Stimuli were displayed on the screen with Dlhopolsky's (1989) routines and responses were made on the keyboard. A hardware modification was performed to eliminate the timing error associated with the CRT scanning rate and the clock precision was lower than 1 ms. Monitor frequency was 60 Hz with VGA high-resolution, thus, the scanning rate was 16.7 ms. Stimulus presentation and time recording were programmed in "C" language.

Procedure. Participants were tested individually. They were seated approximately 40 cm from a 13.7'' computer screen. Stimuli were presented in a text mode of 80 columns x 25 rows (approximately 1.7º) in lower case for the prime and in upper case for the target. Prime and target were presented in row 12. The error signal was presented in row 14 and a signal (beep) sounded when a wrong response was made. All stimuli were centred on the screen.

Trials were presented in blocks of 30 at an inter-trial interval equal to 2 s plus the participant's previous response time. The presentation sequence and exposure durations are generally consistent with those of previous studies (e.g. Forster & Davis, 1984). Each trial began with the asterisk "*" presented at the fixation point at the centre of the screen for two seconds. This was followed by a two-second pause and the appearance of a forward masking stimulus (#######) consisting of a row of seven hash signs. The hash signs were presented for 500 ms and were immediately replaced by a brief exposure of a priming stimulus (PD) in lower case letters. When PD and SOA were different, a mask of seven hash signs (#######) was presented in the interval between the end of PD and the beginning of the target. The stimulus was then immediately replaced with a 1000 ms presentation of a target stimulus in upper case letters. The timing of the response began with the onset of the target until the participant responded, or for a maximum of 2000 ms. Participants were instructed to focus their attention at the fixation point where the "*" sign appeared, and where the hash signs would appear afterward. Upon recognizing the target stimulus as either a word or pseudoword, participants were to make a quick manual response with either their left or right index finger. To indicate that the target was a word, the participant had to press the "M" key; for pseudowords, the "C" key. Participants were coached to respond as quickly as possible to the target stimuli, but not so fast that it compromised their accuracy. The experimental and filler trials were randomly presented to each participant.

Practice trials were selected randomly from a pool of 18 trials; participants had to meet a criterion of 12 successive trials without error before starting the experimental trials.

The M-THRESHOLD task was run before the experiment, in order to determine for each participant the MTT (Minimum Time Threshold) for becoming aware of the prime.

Non-degraded stimuli were utilized for the experiments, that is, primes, masks and targets were presented in white and the error signal in yellow characters on a black background.

In experiment 1, PD = SOA = 100 ms for experiment 1a, while PD = SOA = 50 ms was the experimental condition in the Group factor for experiment 1b.

Data analysis. Mean reaction times and response accuracy were computed for each participant in each condition (see Table 2) for the next three experiments. Reaction times were considered an error if higher than 2000 ms, and were excluded from the reaction time analysis as incorrect responses (less than .16 %, on average).

Reaction times were analyzed through two ANOVAs, one with participants as the random variable (F_1), and another with items as the random variable (F_2). Some authors feel that only the analysis with participants is necessary (McNamara, 2005; Pollatsek & Well, 1995; Raaijmakers, 2003; Raaijmakers, Schrijnemakers, & Gremmen, 1999). In the participant analysis, the mean was calculated and treated as a single observation for each participant and condition. In the item analysis, the mean

Table 2
Mean Response Times (RTs; in ms), Standard Errors (SEs; in ms) and Percentage of Errors (%E) for word targets in the Experiments as a function of Relatedness and Target Frequency (Low Frequency (LF) and High Frequency (HF))

			Type of prime					
			Identical		Associated		Unrelated	
Exp.		Pseudowords	*LF*	*HF*	*LF*	*HF*	*LF*	*HF*
1a	***RT***	716	579	564	621	602	672	630
1a	***SE***	14	12	11	11	11	15	12
1a	***%E***	4.4	3.0	.7	3.7	1.0	7.7	2.7
1b	***RT***	712	587	567	640	607	652	611
1b	***SE***	15	13	15	12	12	12	12
1b	***%E***	4.2	3.7	.7	6.0	2.3	6.3	1.3
2a	***RT***	699	577	568	632	612	635	619
2a	***SE***	15	11	11	11	14	11	10
2a	***%E***	4.6	6.0	1.7	3.0	3.7	7.7	2.0
2b	***RT***	731	601	601	645	616	662	625
2b	***SE***	14	13	12	14	9	12	12
2b	***%E***	3.4	2.7	1.7	4.0	2.0	7.7	2.3
3a	***RT***	709	634	591	653	628	640	610
3a	***SE***	11	11	10	12	12	11	12
3a	***%E***	4.6	5.0	2.7	5.0	2.7	5.7	2.0
3b	***RT***	679	605	586	626	582	611	597
3b	***SE***	10	10	9	10	7	9	9
3b	***%E***	2.8	4.0	1.7	4.0	2.7	5.0	1.3

was calculated for each target and condition. The resulting means were treated as single scores. Table 2 presents the mean RT for each condition.

Data for participant analysis were submitted to an ANOVA with a factorial design of 3 (Relatedness: Identical, Associated and Unrelated) x 2 (Target Frequency: Low versus High) within-participants x 2 (Group: condition a versus condition b) between-participants. Data for item analysis were submitted to an ANOVA with a 3 (Relatedness: Identical, Associated and Unrelated) x 2 (Group: condition a versus condition b) within-items x 2 (Target Frequency: Low versus High) between-items factorial design. Effects were considered to be significant when both participant and item analyses were significant at the .05 level.

Results

The M-THRESHOLD task showed that 17 participants had an MTT of 33 ms and 13 participants had an MTT of 50 ms for experiment condition 1a. Average MTT was (mean = 40.4, *SD* = 8.6). The M-THRESHOLD task showed that 23 participants had an MTT of 33 ms; 6 participants had an MTT of 50 ms; and one participant had an MTT of 83 ms for experiment condition 1b. The average MTT was (mean = 38.1, *SD* = 10.9).

The comparison between Target Frequency (Low and High) x Relatedness (Identical versus Unrelated) (see Table 4) showed that the interaction was significant as can be seen in table 3; repetition priming for Low Frequency word targets was higher than priming for High Frequency word targets. That is, the frequency attenuation effect was significant in repetition priming.

The comparison between Target Frequency (Low and High) x Relatedness (Identical versus Unrelated) x Group (1a versus 1b) showed that the interaction was not reliable (see Table 4). The frequency attenuation effect did not differ between condition 1a and 1b. That is, the frequency attenuation effect was present in condition 1a and 1b for repetition priming.

Table 3
Facilitation or priming (difference between the unrelated word condition and the related word condition) for Reaction Times (RT) and Percentage of Errors (%E) as a function of Relatedness (repetition and associative priming) and Target Frequency (Low Frequency (LF) and High Frequency (HF)). Each Experiment was characterized by Prime Duration (PD), Stimulus Onset Asynchrony (SOA)

			Priming					
			Repetition			Associative		
Exp.	Intervals		*LF*		*HF*	*LF*		*HF*
1a	PD=100	RT	93*	≠	66*	51*	≠	28*
1a	SOA=100	%E	4.7		2.0	4.0		1.7
1b	PD=50	RT	65*		44*	12		4
1b	SOA=50	%E	2.6		.6	.3		-1
2a	PD=MTT	RT	58*		51*	3		7
2a	SOA=MTT	%E	1.7		.3	4.7*	≠	-1.7
2b	PD=MTT	RT	61*	≠	24*	17		9
2b	SOA=MTT+50	%E	5.0*	≠	.6	3.7		.3
3a	PD=MTT-17	RT	6		19*	-13		-18
3a	SOA=MTT	%E	.7		-.7	.7		-.7
3b	PD=MTT-17	RT	6		11	-15	≠	15*
3b	SOA=MTT+17	%E	1.0		-.4	1.0		-1.4

* Significant magnitudes, $p \leq .05$
≠ Significant differences, $p \leq .05$

Target Frequency (Low and High) x Relatedness (Associated versus Unrelated) showed that the interaction was also significant; associative priming for Low Frequency word targets was higher than priming for High Frequency word targets. The frequency attenuation effect was reliable in associative priming.

The comparison between Target Frequency (Low and High) x Relatedness (Associated versus Unrelated) x Group (1a versus 1b) showed that the interaction was not significant (see Table 4). The frequency attenuation effect did not differ between condition 1a and 1b. That is, the frequency attenuation effect was present in condition 1a and 1b for associative priming.

Discussion

The prospective view (e.g. Forster & Davis, 1984) and the retrospective view (e.g. Bodner & Masson, 2001) tell us that the frequency attenuation effect is a marker of the episodic contribution. Only with conscious primes (1a: PD = SOA = 100) will this effect appear, but with unconscious primes (1b: PD = SOA = 50 ms), the frequency attenuation effect must be absent according to prospective view. Reaction time data showed that the frequency attenuation effect was significant in experiment 1a and 1b. Therefore, these data correspond to the unified retrospective view. The retrospective account predicts that the frequency attenuation effect must appear in all experiment conditions (With 1a: PD = SOA = 100 and with 1b: PD = SOA = 50), since the participant always uses the prime event to construct a trace with the target in order to process the information of the trace. This view predicts analogous results with even shorter SOA. This prediction will be tested below.

One proposed reason (Bodner & Masson, 2003; Stolz & Neely, 1995) is that the frequency attenuation effect in repetition priming was prompted by feedback from the semantic memory system to the lexical memory system. This hypothesis is not discarded in experiment 1 because the frequency attenuation effect is triggered in the lexical and semantic memory system.

Experiment 1 supports recent masked priming studies (PD = SOA = 50 ms) (Bodner & Masson, 2001; Bodner

Table 4
ANOVA results for mean response latency (ms) and percentage error in Experiment 1

	Latency							
	Participants				Ítems			
Effect	MS_e	*Df*	F_1	*p* <	MS_e	*df*	F_2	*p* <
G(1a,1b)	21698	(1.58)	.01	.967	1137	(1.58)	.1	.833
TF(L,H)	1214	(1.58)	60.0	.001	7446	(1.58)	10.9	.002
R(I,A,U)	1406	(2.116)	98.5	.001	1446	(2.116)	99.9	.001
TF(L,H)xG(1a,1b)	1214	(1.58)	.6	.432	1137	(1.58)	1.1	.310
R(I,A,U)xG(1a,1b)	1406	(2.116)	6.0	.003	1223	(2.116)	8.4	.001
TF(L,H)xR(I,A,U)	918	(2.116)	4.9	.009	1446	(2.116)	3.4	.041
TF(L,H)xR(I,A,U)xG(1a,1b)	918	(2.116)	.5	.609	1223	(2.116)	.45	.641
G(1a,1b)	15533	(1.58)	.2	.670	1203	(1.58)	1.9	.169
TF(L,H)	1277	(1.58)	41.4	.001	5749	(1.58)	10.5	.002
R(I,U)	1605	(1.58)	167.9	.001	1731	(1.58)	162.3	.001
TF(L,H)xG(1a,1b)	1277	(1.58)	.1	.846	1203	(1.58)	.2	.702
R(I,U)xG(1a,1b)	1605	(1.58)	6.1	.016	1556	(1.58)	7.5	.008
TF(L,H)xR(I,U)	1011	(1.58)	8.6	.005	1731	(1.58)	5.3	.025
TF(L,H)xR(I,U)xG(1a,1b)	1011	(1.58)	.2	.665	1556	(1.58)	.3	.600
G(1a,1b)	14653	(1.58)	.1	.803	1221	(1.58)	.4	.548
TF(L,H)	953	(1.58)	72.1	.001	5931	(1.58)	12.6	.001
R(A,U)	1259	(1.58)	27.1	.001	1357	(1.48)	25.9	.001
TF(L,H)xG(1a,1b)	953	(1.58)	.6	.452	1221	(1.58)	.5	.473
R(A,U)xG(1a,1b)	1259	(1.58)	11.9	.001	1358	(1.58)	13.5	.001
TF(L,H)xR(A,U)	868	(1.58)	4.3	.043	1357	(1.58)	3.4	.070
TF(L,H)xR(A,U)xG(1a,1b)	868	(1.58)	1.1	.309	1358	(1.58)	.8	.379

	Error							
	Participants				Ítems			
Effect	MS_e	***Df***	F_1	*p* <	MS_e	***df***	F_2	*p* <
G(1a,1b)	.006	(1.58)	.1	.739	.002	(1.58)	.3	.590
TF(L,H)	.005	(1.58)	21.9	.001	.016	(1.58)	7.6	.008
R(I,A,U)	.003	(2.116)	6.4	.002	.004	(2.116)	4.9	.009
TF(L,H)xG(1[a],1b)	.005	(1.58)	.1	.720	.002	(1.58)	.3	.590
R(I,A,U)xG(1a,1b)	.003	(2.116)	2.6	.081	.003	(2.116)	2.2	.112
TF(L,H)xR(I,A,U)	.003	(2.116)	1.7	.195	.004	(2.116)	1.2	.307
TF(L,H)xR(I,A,U)xG(1a,1b)	.003	(2.116)	.1	.931	.003	(2.116)	.1	.916
G(1a,1b)	.006	(1.58)	.3	.604	.003	(1.58)	.5	.488
TF(L,H)	.004	(1.58)	22.6	.001	.012	(1.58)	7.2	.009
R(I,U)	.003	(1.58)	13.3	.001	.004	(1.58)	8.6	.005
TF(L,H)xG(1a,1b)	.004	(1.58)	.1	.837	.003	(1.58)	.1	.817
R(I,U)xG(1a,1b)	.003	(1.58)	1.5	.229	.004	(1.58)	1.2	.283
TF(L,H)xR(I,U)	.003	(1.58)	2.7	.107	.004	(1.58)	1.9	.178
TF(L,H)xR(I,U)xG(1a,1b)	.003	(1.58)	.1	.816	.004	(1.58)	.1	.829
G(1a,1b)	.005	(1.58)	.1	.794	.002	(1.58)	.2	.674
TF(L,H)	.006	(1.58)	15.8	.001	.016	(1.58)	6.1	.017
R(A,U)	.004	(1.58)	2.3	.132	.004	(1.48)	2.3	.136
TF(L,H)xG(1a,1b)	.006	(1.58)	.1	.809	.002	(1.58)	.2	.674
R(A,U)xG(1a,1b)	.004	(1.58)	3.7	.058	.005	(1.58)	3.3	.076
TF(L,H)xR(A,U)	.003	(1.58)	1.8	.184	.004	(1.58)	1.2	.272
TF(L,H)xR(A,U)xG(1a,1b)	.003	(1.58)	.1	.715	.005	(1.58)	.1	.776

G = Group; **TF** = Target Frequency; **R** = Relatedness; **I** = Identical; **A**= Associated; **U** = Unrelated; **L** = Low; **H** = High.

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Table 5

ANOVA results for mean response latency (ms) and percentage error in Experiment 1a

	Latency							
	Participants				Ítems			
Effect	MS_e	*Df*	F_1	*p* <	MS_e	*df*	F_2	*p* <
Latency								
TF(L,H)	1237	(1.29)	23.7	.001	3196	(1.58)	9.8	.003
R(I,A,U)	1430	(2.58)	66.8	.001	1303	(2.116)	78.1	.001
TF(L,H)xR(I,A,U)	905	(2.58)	3.7	.031	1303	(2.116)	3.1	.051
TF(L,H)	1267	(1.29)	19.6	.001	2999	(1.58)	9.0	.004
R(I,U)	1460	(1.29)	130.8	.001	1553	(1.58)	131.1	.001
TF(L,H)xR(I,U)	987	(1.29)	5.8	.023	1553	(1.58)	4.4	.041
TF(L)xR(U-I)	1518	(1.29)	86.6	.001	1887	(1.29)	75.4	.001
TF(H)xR(U-I)	929	(1.29)	70.2	.001	1219	(1.29)	55.8	.001
TF(L,H)	1143	(1.29)	24.9	.001	2538	(1.58)	12.2	.001
R(A,U)	1463	(1.29)	32.2	.001	1334	(1.58)	39.0	.001
TF(L,H)xR(A,U)	1060	(1.29)	3.9	.057	1334	(1.58)	3.8	.056
TF(L)xR(U-A)	1481	(1.29)	26.7	.001	1426	(1.29)	31.4	.001
TF(H)xR(U-A)	1042	(1.29)	11.2	.002	1243	(1.29)	9.9	.004
Error								
TF(L,H)	.007	(1.29)	7.5	.010	.008	(1.58)	6.5	.014
R(I,A,U)	.002	(2.58)	7.8	.001	.004	(2.116)	5.1	.008
TF(L,H)xR(I,A,U)	.003	(2.58)	1.1	.347	.004	(2.116)	.8	.438
TF(L,H)	.005	(1.29)	7.8	.009	.008	(1.58)	5.3	.025
R(I,U)	.002	(1.29)	14.5	.001	.005	(1.58)	6.2	.016
TF(L,H)xR(I,U)	.004	(1.29)	1.5	.234	.005	(1.58)	1.0	.323
TF(L)xR(U-I)	.003	(1.29)	10.9	.003	.009	(1.29)	3.5	.070
TF(H)xR(U-I)	.003	(1.29)	2.7	.161	.002	(1.29)	4.0	.056
TF(L,H)	.008	(1.29)	5.5	.028	.009	(1.58)	5.0	.029
R(A,U)	.003	(1.29)	7.9	.009	.005	(1.58)	5.1	.029
TF(L,H)xR(A,U)	.003	(1.29)	1.3	.257	.005	(1.58)	.9	.359
TF(L)xR(U-A)	.003	(1.29)	8.1	.008	.008	(1.29)	3.0	.097
TF(H)xR(U-A)	.003	(1.29)	1.3	.258	.001	(1.29)	3.0	.096

TF = Target Frequency; **R** = Relatedness; **I** = Identical; **A**= Associated; **U** = Unrelated; **L** = Low; **H** = High; **R(U-I)** = Identity priming; **R(U-A)** = Associative priming.

& Masson, 2003; and Masson & Bodner, 2003); a clear, statistically reliable interaction between word frequency and repetition priming was obtained, with greater priming effect for low-frequency words. We must take into account that the frequency attenuation effect was found using alternating-case target words (with degraded targets) and with high-frequency words that fell within the median of 200 occurrences per million. Additionally, Kinoshita (2006) showed that a reliable frequency attenuation effect is found with masked primes when the low-frequency words are familiar to the participants.

Experiment 2

Our initial hypothesis is that MTT is the minimum time interval for constructing an episodic trace. And that estimating this time is better than using 50 ms for all persons. When primes are presented for a shorter duration than the MTT, the episodic trace is not constructed, whereas with presentations equal to the MTT or longer, the frequency attenuation effect appears if the target is processed long enough.

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Table 6
ANOVA results for mean response latency (ms) and percentage error in Experiment 1b

	Latency							
	Participants				Ítems			
Effect	MS_e	*Df*	F_1	$p <$	MS_e	*df*	F_2	$p <$
Latency								
TF(L,H)	1190	(1.29)	37.1	.001	5386	(1.58)	9.5	.003
R(I,A,U)	1382	(2.58)	37.2	.001	1366	(2.116)	38.8	.001
TF(L,H)xR(I,A,U)	930	(2.58)	1.7	.188	1366	(2.116)	1.0	.362
TF(L,H)	1287	(1.29)	21.8	.001	3954	(1.58)	8.5	.005
R(I,U)	1749	(1.29)	50.4	.001	1734	(1.58)	51.4	.001
TF(L,H)xR(I,U)	1035	(1.29)	3.1	.091	1734	(1.58)	1.6	.209
TF(L)xR(U-I)	1389	(1.29)	44.9	.001	2261	(1.29)	27.3	.001
TF(H)xR(U-I)	1394	(1.29)	20.8	.001	1207	(1.29)	25.0	.001
TF(L,H)	762	(1.29)	53.4	.001	4614	(1.58)	9.7	.003
R(A,U)	1054	(1.29)	1.9	.184	1381	(1.58)	1.0	.325
TF(L,H)xR(A,U)	677	(1.29)	.7	.409	1381	(1.58)	.5	.504
TF(L)xR(U-A)	1060	(1.29)	2.1	.162	2162	(1.29)	.9	.354
TF(H)xR(U-A)	671	(1.29)	.4	.546	601	(1.29)	.1	.733
Error								
TF(L,H)	.004	(1.29)	16.9	.001	.01	(1.58)	6.7	.012
R(I,A,U)	.003	(2.58)	2.0	.140	.003	(2.116)	2.1	.133
TF(L,H)xR(I,A,U)	.003	(2.58)	.6	.545	.003	(2.116)	.5	.631
TF(L,H)	.003	(1.29)	18.1	.001	.008	(1.58)	6.3	.015
R(I,U)	.003	(1.29)	2.5	.125	.003	(1.58)	3.3	.077
TF(L,H)xR(I,U)	.002	(1.29)	1.2	.281	.003	(1.58)	1.2	.284
TF(L)xR(U-I)	.004	(1.29)	2.4	.133	.004	(1.29)	2.4	.133
TF(H)xR(U-I)	.001	(1.29)	.5	.489	.001	(1.29)	1.0	.326
TF(L,H)	.004	(1.29)	12.7	.001	.010	(1.58)	5.8	.019
R(A,U)	.005	(1.29)	.1	.798	.004	(1.58)	.1	.772
TF(L,H)xR(A,U)	.003	(1.29)	.5	.475	.004	(1.58)	.3	.563
TF(L)xR(U-A)	.006	(1.29)	.1	.865	.005	(1.29)	.1	.861
TF(H)xR(U-A)	.002	(1.29)	.8	.375	.003	(1.29)	.6	.448

TF = Target Frequency; **R** = Relatedness; **I** = Identical; **A**= Associated; **U** = Unrelated; **L** = Low; **H** = High; **R(U-I)** = Identity priming; **R(U-A)** = Associative priming.

Experiment 2 is similar to experiment 1 but instead of using a PD = SOA = 50 ms, now PD = SOA = MTT for each participant in the 2a condition. In the 2b condition, PD = MTT and SOA = MTT + 50. According to our initial hypothesis, with PD = SOA = MTT the episodic trace is constructed, but it needs time in order to show itself; therefore, for the 2a condition we propose that the frequency attenuation effect would not appear. But in the 2b condition, the frequency attenuation effect could appear. If we prolong prime processing through longer exposures (increased SOA) while maintaining a constant prime duration (PD = MTT), the frequency attenuation effect should be found in priming.

Results

The M-THRESHOLD task showed that 20 participants had an MTT of 33 ms and 10 participants had an MTT of 50 ms for experiment 2a. Average MTT was (mean = 38.7, *SD* = 8.2). The M-THRESHOLD task showed that 20 participants had an MTT of 33 ms; 9 participants had an MTT of 50 ms and one participant had an MTT of 67 ms for experiment 2b. Average MTT was (mean = 39.2, *SD* = 9.5).

The comparison between Target Frequency (Low and High) x Relatedness (Identical versus Unrelated) (see Table 7) showed that the interaction was significant, as can be seen in table 3; repetition priming for Low Frequency

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Table 7

ANOVA results for mean response latency (ms) and percentage error in Experiment 2

	Latency							
	Participants				Ítems			
Effect	MS_e	*df*	F_1	*p* <	MS_e	*df*	F_2	*P* <
G(2a,2b)	19040	(1.58)	1.5	.225	1389	(1.58)	21.0	.001
TF(L,H)	1148	(1.58)	26.7	.001	8935	(1.58)	4.3	.043
R(I,A,U)	1305	(2.116)	61.4	.001	1670	(2.116)	52.7	.001
TF(L,H)xG(2a,2b)	1148	(1.58)	1.0	.335	1389	(1.58)	.7	.405
R(I,A,U)xG(2a,2b)	1305	(2.116)	2.2	.111	953	(2.116)	3.1	.049
TF(L,H)xR(I,A,U)	955	(2.116)	4.4	.014	1670	(2.116)	3.2	.046
TF(L,H)xR(I,A,U)xG(2a,2b)	955	(2.116)	1.7	.181	953	(2.116)	2.2	.118
G(2a,2b)	12110	(1.58)	2.5	.119	1134	(1.58)	27.7	.001
TF(L,H)	1205	(1.58)	11.7	.001	5914	(1.58)	3.4	.069
R(I,U)	1635	(1.58)	87.0	.001	1550	(1.58)	100.6	.001
TF(L,H)xG(2a,2b)	1205	(1.58)	.4	.515	1134	(1.58)	.2	.629
R(I,U)xG(2a,2b)	1635	(1.58)	1.3	.269	899	(1.58)	1.7	.194
TF(L,H)xR(I,U)	747	(1.58)	9.0	.004	1550	(1.58)	6.2	.015
F(L,H)xR(I,U)xG(2a,2b)	747	(1.58)	4.4	.041	899	(1.58)	4.3	.042
G(2a,2b)	13523	(1.58)	.7	.403	1279	(1.58)	7.9	.007
TF(L,H)	955	(1.58)	40.2	.001	7186	(1.58)	6.6	.013
R(A,U)	1082	(1.58)	4.7	.034	1764	(1.58)	3.2	.080
TF(L,H)xG(2a,2b)	955	(1.58)	3.5	.068	1279	(1.58)	3.0	.091
R(A,U)xG(2a,2b)	1082	(1.58)	.9	.351	939	(1.58)	1.5	.227
TF(L,H)xR(A,U)	1009	(1.58)	.1	.880	1764	(1.58)	.3	.583
TF(L,H)xR(A,U)xG(2a,2b)	1009	(1.58)	.5	.486	939	(1.58)	.3	.571

	Error							
	Participants				Ítems			
Effect	**MS_e**	***df***	**F_1**	***p* <**	**MS_e**	***df***	**F_2**	***p* <**
G(2a,2b)	.007	(1.58)	.5	.492	.006	(1.58)	.6	.442
TF(L,H)	.003	(1.58)	23.8	.001	.020	(1.58)	3.8	.055
R(I,A,U)	.004	(2.116)	3.5	.034	.004	(2.116)	3.7	.028
TF(L,H)xG(2a,2b)	.003	(1.58)	.1	.783	.006	(1.58)	.1	.833
R(I,A,U)xG(2a,2b)	.004	(2.116)	.7	.502	.003	(2.116)	.9	.430
TF(L,H)xR(I,A,U)	.004	(2.116)	4.4	.015	.004	(2.116)	4.8	.010
TF(L,H)xR(I,A,U)xG(2a,2b)	.004	(2.116)	1.7	.192	.003	(2.116)	2.1	.124
G(2a,2b)	.005	(1.58)	.7	.421	.004	(1.58)	.8	.388
TF(L,H)	.005	(1.58)	19.8	.001	.018	(1.58)	5.5	.022
R(I,U)	.004	(1.58)	5.3	.025	.003	(1.58)	7.4	.009
TF(L,H)xG(2a,2b)	.005	(1.58)	1.0	.321	.004	(1.58)	1.1	.292
R(I,U)xG(2a,2b)	.004	(1.58)	1.2	.275	.004	(1.58)	1.3	.253
TF(L,H)xR(I,U)	.004	(1.58)	3.3	.075	.003	(1.58)	4.0	.049
TF(L,H)xR(I,U)xG(2a,2b)	.004	(1.58)	.9	.341	.004	(1.58)	.9	.348
G(2a,2b)	.006	(1.58)	.1	.935	.006	(1.58)	.1	.936
TF(L,H)	.003	(1.58)	19.6	.001	.016	(1.58)	3.6	.064
R(A,U)	.005	(1.58)	3.7	.060	.005	(1.48)	3.6	.062
TF(L,H)xG(2a,2b)	.003	(1.58)	.7	.405	.006	(1.58)	.3	.577
R(A,U)xG(2a,2b)	.005	(1.58)	.1	.785	.003	(1.58)	.1	.717
TF(L,H)xR(A,U)	.005	(1.58)	7.6	.008	.005	(1.58)	6.9	.011
TF(L,H)xR(A,U)xG(2a,2b)	.005	(1.58)	.7	.397	.003	(1.58)	1.2	.279

G = Group; **TF** = Target Frequency; **R** = Relatedness; **I** = Identical; **A**= Associated; **U** = Unrelated; **L** = Low; **H** = High.

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Table 8
ANOVA results for mean response latency (ms) and percentage error in Experiment 2a

	Latency							
	Participants				Ítems			
Effect	MS_e	*Df*	F_1	*p* <	MS_e	*df*	F_2	*p* <
Latency								
TF(L,H)	1408	(1.29)	7.2	.012	4503	(1.58)	3.0	.088
R(I,A,U)	1054	(2.58)	51.4	.001	1037	(2.116)	55.8	.001
TF(L,H)xR(I,A,U)	787	(2.58)	.6	.566	1037	(2.116)	.4	.701
TF(L,H)	1137	(1.29)	4.1	.053	2600	(1.58)	3.1	.085
R(I,U)	963	(1.29)	92.6	.001	992	(1.58)	95.0	.001
TF(L,H)xR(I,U)	829	(1.29)	.4	.545	992	(1.58)	.7	.425
TF(L)xR(U-I)	959	(1.29)	52.1	.001	967	(1.29)	57.1	.001
TF(H)xR(U-I)	832	(1.29)	47.4	.001	1018	(1.29)	40.0	.001
TF(L,H)	948	(1.29)	10.1	.003	3909	(1.58)	3.1	.082
R(A,U)	1047	(1.29)	.8	.382	1049	(1.58)	.7	.417
TF(L,H)xR(A,U)	695	(1.29)	.2	.644	1049	(1.58)	.1	.901
TF(L)xR(U-A)	560	(1.29)	.2	.628	877	(1.29)	.5	.472
TF(H)xR(U-A)	1181	(1.29)	.7	.405	1221	(1.29)	.2	.653
Error								
TF(L,H)	.003	(1.29)	13.1	.001	.019	(1.58)	2.4	.131
R(I,A,U)	.004	(2.58)	1.0	.373	.003	(2.116)	1.1	.340
TF(L,H)xR(I,A,U)	.005	(2.58)	3.1	.054	.003	(2.116)	5.2	.007
TF(L,H)	.006	(1.29)	12.4	.001	.016	(1.58)	4.7	.034
R(I,U)	.003	(1.29)	.9	.351	.003	(1.58)	.9	.350
TF(L,H)xR(I,U)	.004	(1.29)	.3	.588	.003	(1.58)	.4	.532
TF(L)xR(U-I)	.007	(1.29)	.6	.433	.005	(1.29)	.8	.378
TF(H)xR(U-I)	.001	(1.29)	.1	.712	.002	(1.29)	.1	.745
TF(L,H)	.003	(1.29)	6.9	.014	.014	(1.58)	1.3	.259
R(A,U)	.004	(1.29)	1.6	.213	.004	(1.58)	1.6	.205
TF(L,H)xR(A,U)	.007	(1.29)	4.4	.044	.004	(1.58)	7.3	.009
TF(L)xR(U-A)	.006	(1.29)	5.3	.028	.005	(1.29)	6.9	.014
TF(H)xR(U-A)	.005	(1.29)	.9	.362	.003	(1.29)	1.2	.283

TF = Target Frequency; **R** = Relatedness; **I** = Identical; **A**= Associated; **U** = Unrelated; **L** = Low; **H** = High; **R(U-I)** = Identity priming; **R(U-A)** = Associative priming.

word targets was higher than priming for High Frequency word targets. That is, the frequency attenuation effect was significant in repetition priming.

The comparison between Target Frequency (Low and High) x Relatedness (Identical versus Unrelated) x Group (2a versus 2b) showed that the interaction was also reliable (see Table 7). The frequency attenuation effect differed between condition 2a and 2b. That is, the frequency attenuation effect was present in condition 2b but was not present in condition 2a for repetition priming.

Target Frequency (Low and High) x Relatedness (Associated versus Unrelated) showed that the interaction was not significant; associative priming for Low Frequency word targets was not higher than priming for High Frequency word targets. The frequency attenuation effect was not reliable in associative priming.

The comparison between Target Frequency (Low and High) x Relatedness (Associated versus Unrelated) x Group (2a versus 2b) showed that the interaction was not significant (see Table 7). The frequency attenuation effect did not differ between condition 2a and 2b. That is, the frequency attenuation effect was not present in condition 2a or 2b for associative priming.

Discussion

Results from experiment 2 show that the frequency attenuation effect does not appear when PD = SOA = MTT,

Table 9

ANOVA results for mean response latency (ms) and percentage error in Experiment 2b

	Latency							
	Participants				Ítems			
Effect	MS_e	*Df*	F_1	*p* <	MS_e	*df*	F_2	*p* <
Latency								
TF(L,H)	887	(1.29)	24.4	.001	5821	(1.58)	4.4	.040
R(I,A,U)	1556	(2.58)	18.6	.001	1586	(2.116)	20.8	.001
TF(L,H)xR(I,A,U)	1123	(2.58)	4.8	.011	1586	(2.116)	4.4	.014
TF(L,H)	1273	(1.29)	7.9	.009	4449	(1.58)	2.8	.097
R(I,U)	2308	(1.29)	23.9	.001	1457	(1.58)	43.4	.001
TF(L,H)xR(I,U)	664	(1.29)	14.6	.001	1457	(1.58)	8.9	.004
TF(L)xR(U-I)	1767	(1.29)	31.4	.001	1344	(1.29)	49.6	.001
TF(H)xR(U-I)	1205	(1.29)	7.7	.009	1570	(1.29)	6.0	.020
TF(L,H)	962	(1.29)	33.4	.001	4557	(1.58)	8.5	.005
R(A,U)	1118	(1.29)	4.7	.038	1654	(1.58)	3.8	.056
TF(L,H)xR(A,U)	1322	(1.29)	.3	.602	1654	(1.58)	.5	.482
TF(L)xR(U-A)	1230	(1.29)	3.4	.075	1783	(1.29)	3.3	.080
TF(H)xR(U-A)	1210	(1.29)	1.2	.287	1524	(1.29)	.8	.366
Error								
TF(L,H)	.003	(1.29)	10.8	.003	.007	(1.58)	4.7	.034
R(I,A,U)	.004	(2.58)	3.0	.059	.004	(2.116)	3.5	.033
TF(L,H)xR(I,A,U)	.003	(2.58)	3.0	.060	.004	(2.116)	2.1	.123
TF(L,H)	.004	(1.29)	7.4	.011	.007	(1.58)	4.5	.039
R(I,U)	.005	(1.29)	4.9	.035	.003	(1.58)	7.1	.010
TF(L,H)xR(I,U)	.003	(1.29)	4.9	.035	.003	(1.58)	4.2	.046
TF(L)xR(U-I)	.005	(1.29)	6.9	.014	.005	(1.29)	7.4	.011
TF(H)xR(U-I)	.002	(1.29)	.3	.601	.002	(1.29)	.4	.536
TF(L,H)	.003	(1.29)	13.1	.001	.008	(1.58)	5.0	.029
R(A,U)	.006	(1.29)	2.1	.161	.004	(1.58)	3.2	.080
TF(L,H)xR(A,U)	.002	(1.29)	3.4	.077	.004	(1.58)	2.2	.143
TF(L)xR(U-A)	.006	(1.29)	3.6	.070	.006	(1.29)	3.4	.078
TF(H)xR(U-A)	.003	(1.29)	.1	.801	.002	(1.29)	.1	.745

TF = Target Frequency; **R** = Relatedness; **I** = Identical; **A**= Associated; **U** = Unrelated; **L** = Low; **H** = High; **R(U-I)** = Identity priming; **R(U-A)** = Associative priming.

in experiment condition 2a. According to our hypothesis, with intervals equal to or greater than MTT, the frequency attenuation effect should appear, if the target is processed long enough for the prime to have its effect.

With prime durations equal to or greater than MTT, the episodic trace has been formed. It needs only a certain amount of time to develop and for the frequency attenuation effect to appear. In experiment 2b with PD = MTT, that is, where the episodic trace has formed, and with SOA = MTT + 50 ms, there is enough time for this formed episodic trace to develop; therefore, the frequency attenuation effect was present in experiment condition 2b.

It is important to underscore that, if the frequency attenuation effect has not appeared in associative priming, then there is no feedback from associative to identity priming; thus, the frequency attenuation effect should not appear in identity priming. This data point indicates that the frequency attenuation effect is not a direct cause of feedback from the semantic to the lexical system. Therefore, the hypothesis that the frequency attenuation effect in identity priming is due to feedback from the semantic to the lexical system is not correct. This experiment shows that the effect appears in identity priming but that it is absent in associative priming. Therefore, the frequency attenuation effect in the lexical system is proven not to be the result of feedback from the semantic system, simply because it does not appear in this experiment.

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Experiment 3

Our initial hypothesis is that with PD < MTT, the person does not have long enough to construct the episodic trace. In this experiment, prime duration will be less than the limit for the trace to be constructed (PD = MTT - 17) and target processing time will be increased to SOA = MTT ms for experiment condition 3a and SOA = MTT + 17 ms for experiment condition 3b. In these circumstances, the frequency attenuation effect should not appear, according to our initial hypothesis.

Results

The M-THRESHOLD task showed that 20 participants had an MTT of 33 ms; 9 participants had an MTT of 50 ms; and one participant had an MTT of 67 ms for experiment 3a. Average MTT was (mean = 39.2, *SD* = 9.5). The M-THRESHOLD task showed that 25 participants had an MTT of 33 ms; 5 participants had an MTT of 50 ms for experiment 3b. Average MTT was (mean = 35.8, *SD* = 6.4).

The comparison between Target Frequency (Low and High) x Relatedness (Identical versus Unrelated) (see Table 10) showed that the interaction was not significant as can be seen in table 3; repetition priming for Low Frequency word targets was not higher than priming for High Frequency word targets. That is, the frequency attenuation effect was not significant in repetition priming.

The comparison between Target Frequency (Low and High) x Relatedness (Identical versus Unrelated) x Group (3a versus 3b) showed that the interaction also was not reliable (see Table 10). The frequency attenuation effect did not differ between condition 3a and 3b. That is, the frequency attenuation effect was not present in condition 3a or 3b for repetition priming.

It is important to report that identity priming was reliable for both groups (3a and 3b).

Target Frequency (Low and High) x Relatedness (Associated versus Unrelated) showed that the interaction was not significant; associative priming for Low Frequency word targets was not higher than priming for High Frequency word targets. The frequency attenuation effect was not reliable in associative priming.

The comparison between Target Frequency (Low and High) x Relatedness (Associated versus Unrelated) x Group (3a versus 3b) showed that the interaction was not significant (see Table 10). The frequency attenuation effect did not differ between condition 3a and 3b. That is, the frequency attenuation effect was not present in condition 3a or 3b for associative priming.

Again, associative priming was not reliable for either group (3a or 3b).

Discussion

With prime durations less than MTT, the episodic trace between prime and target is not constructed; therefore, even when allowing sufficient processing time, SOA = MTT or SOA = MTT + 17, the frequency attenuation effect does not appear.

General Discussion

The main theoretical view of priming was that there are two mechanisms for explaining word priming effects that can explain short- and long-term effects of repetition priming. Short-term effects are characterized by the following: (1) *rapid onset,* (2) *short-lived*, (3) *automatic*. However, long-term effects are mediated by the episodic component and are typified as: (1) *slow onset,* (2) *long-lived*, (3) *non-automatic* (with prime identification or awareness).

Many authors have taken a position which assumes that word repetition priming effects result from more than one mechanism, as was mentioned above. One mechanism is a short-term effect (prospective view) mediated by lexical activation, and another mechanism is a long-term effect (retrospective view), based on episodic memory trace retrieval (e.g. Durgunoglu & Neely, 1987; Feustel, Shiffrin, & Salasoo, 1983; Forster, Booker, Schacter, & Davis, 1990; Forster & Davis, 1984; Humphreys, Besner, & Quinlan, 1988; McKone, 1995; Ratcliff, Hockley, & McKoon, 1985; Schacter & Graf, 1986; Versace & Nevers, 2003; Whitlow, 1990; Whitlow & Cebollero, 1989; Woltz, 1990).

Other authors (e.g. Bodner & Masson, 2001), by contrast, believe that repetition priming is the result of a single mechanism (the retrospective point of view) which is based on retrieval of the episodic trace. Our data do not defend this point of view for repetition priming. We have verified with these experiments that for a prime duration of PD ≥ MTT, the episodic composite between prime and target is constructed, and when there is enough time for processing (e.g. with a long SOA), the frequency attenuation effect appears. This effect is assumed to be a marker that verifies the existence of episodic processing. However, this mechanism cannot explain priming effects (e.g. the absence of the frequency attenuation effect) for prime durations less than the minimum interval for subjective awareness (PD < MTT). With such intervals, it is the prospective point of view that can explain the priming effect for repetition.

Therefore, our data support the point of view that two mechanisms are needed in order to explain repetition priming: one for short-term, where lexical activation intervenes (PD < MTT), and another for long-term,

Table 10

ANOVA results for mean response latency (ms) and percentage error in Experiment 3

	Latency							
	Participants				Ítems			
Effect	MS_e	*df*	F_1	*p* <	MS_e	*df*	F_2	*P* <
G(3a,3b)	13529	(1.58)	4.1	.047	1309	(1.58)	38.7	.001
TF(L,H)	1014	(1.58)	73.9	.001	10506	(1.58)	8.8	.004
R(I,A,U)	943	(2.116)	10.5	.001	1336	(2.116)	7.1	.001
TF(L,H)xG(3a,3b)	1014	(1.58)	1.2	.288	1309	(1.58)	1.3	.253
R(I,A,U)xG(3a,3b)	943	(2.116)	3.4	.037	1371	(2.116)	1.8	.179
TF(L,H)xR(I,A,U)	1186	(2.116)	1.0	.357	1336	(2.116)	.6	.559
TF(L,H)xR(I,A,U)xG(3a,3b)	1186	(2.116)	3.1	.047	1371	(2.116)	2.7	.069
G(3a,3b)	8810	(1.58)	2.5	.122	1282	(1.58)	16.2	.001
TF(L,H)	1196	(1.58)	34.3	.001	8642	(1.58)	6.1	.017
R(I,U)	1192	(1.58)	5.6	.021	1065	(1.58)	7.7	.007
TF(L,H)xG(3a,3b)	1196	(1.58)	5.0	.030	1282	(1.58)	5.4	.024
R(I,U)xG(3a,3b)	1192	(1.58)	.3	.613	1237	(1.58)	.1	.787
TF(L,H)xR(I,U)	1000	(1.58)	1.1	.291	1065	(1.58)	.5	.496
TF(L,H)xR(I,U)xG(3a,3b)	1000	(1.58)	.2	.657	1237	(1.58)	.3	.586
G(3a,3b)	9806	(1.58)	5.1	.028	1314	(1.58)	33.0	.001
TF(L,H)	1094	(1.58)	43.1	.001	7626	(1.58)	8.0	.007
R(A,U)	826	(1.58)	4.1	.049	1789	(1.58)	1.1	.302
TF(L,H)xG(3a,3b)	1094	(1.58)	.1	.910	1314	(1.58)	.1	.997
R(A,U)xG(3a,3b)	826	(1.58)	4.2	.045	1471	(1.58)	2.0	.160
TF(L,H)xR(A,U)	1246	(1.58)	1.9	.175	1789	(1.58)	.9	.356
TF(L,H)xR(A,U)xG(3a,3b)	1246	(1.58)	3.6	.064	1471	(1.58)	2.7	.103

	Error							
	Participants				Ítems			
Effect	MS_e	*df*	F_1	*p* <	MS_e	*df*	F_2	*p* <
G(3a,3b)	.007	(1.58)	.7	.405	.003	(1.58)	1.9	.178
TF(L,H)	.004	(1.58)	17.5	.001	.019	(1.58)	3.2	.081
R(I,A,U)	.003	(2.116)	.1	.939	.002	(2.116)	.1	.924
TF(L,H)xG(3a,3b)	.004	(1.58)	.1	.790	.003	(1.58)	.1	.754
R(I,A,U)xG(3a,3b)	.003	(2.116)	.1	.939	.003	(2.116)	.1	.936
TF(L,H)xR(I,A,U)	.004	(2.116)	.7	.489	.002	(2.116)	1.1	.336
TF(L,H)xR(I,A,U)xG(3a,3b)	.004	(2.116)	.1	.935	.003	(2.116)	.1	.919
G(3a,3b)	.005	(1.58)	.9	.344	.003	(1.58)	1.6	.211
TF(L,H)	.004	(1.58)	15.2	.001	.014	(1.58)	3.8	.056
R(I,U)	.003	(1.58)	.1	.812	.002	(1.58)	.1	.795
TF(L,H)xG(3a,3b)	.004	(1.58)	.1	.999	.003	(1.58)	.1	.999
R(I,U)xG(3a,3b)	.003	(1.58)	.1	.812	.002	(1.58)	.1	.762
TF(L,H)xR(I,U)	.003	(1.58)	.8	.380	.002	(1.58)	1.1	.301
TF(L,H)xR(I,U)xG(3a,3b)	.003	(1.58)	.1	.999	.002	(1.58)	.1	.999
G(3a,3b)	.006	(1.58)	.4	.557	.003	(1.58)	.7	.407
TF(L,H)	.004	(1.58)	1.7	.002	.015	(1.58)	3.0	.087
R(A,U)	.003	(1.58)	.1	.906	.002	(1.48)	.1	.891
TF(L,H)xG(3a,3b)	.004	(1.58)	.1	.768	.003	(1.58)	.1	.722
R(A,U)xG(3a,3b)	.003	(1.58)	.1	.906	.004	(1.58)	.1	.915
TF(L,H)xR(A,U)	.003	(1.58)	1.5	.228	.002	(1.58)	2.3	.135
TF(L,H)xR(A,U)xG(3a,3b)	.003	(1.58)	.1	.741	.004	(1.58)	.1	.750

G = Group; **TF** = Target Frequency; **R** = Relatedness; **I** = Identical; **A**= Associated; **U** = Unrelated; **L** = Low; **H** = High.

Table 11
ANOVA results for mean response latency (ms) and percentage error in Experiment 3a

	Latency							
	Participants				Ítems			
Effect	MS_e	*Df*	F_1	*p* <	MS_e	*df*	F_2	*p* <
Latency								
TF(L,H)	796	(1.29)	59.5	.001	7736	(1.58)	7.7	.007
R(I,A,U)	1075	(2.58)	10.9	.001	1584	(2.116)	6.2	.003
TF(L,H)xR(I,A,U)	1331	(2.58)	.9	.422	1584	(2.116)	.7	.500
TF(L,H)	1113	(1.29)	35.1	.001	6267	(1.58)	7.8	.007
R(I,U)	1325	(1.29)	3.7	.063	1228	(1.58)	4.9	.048
TF(L,H)xR(I,U)	1037	(1.29)	1.1	.302	1228	(1.58)	.7	.405
TF(L)xR(U-I)	1167	(1.29)	.6	.455	1103	(1.29)	.8	.384
TF(H)xR(U-I)	1195	(1.29)	4.5	.042	1353	(1.29)	3.7	.064
TF(L,H)	1144	(1.29)	19.9	.001	5691	(1.58)	5.3	.024
R(A,U)	1030	(1.29)	6.6	.016	2039	(1.58)	2.4	.128
TF(L,H)xR(A,U)	1282	(1.29)	.1	.721	2039	(1.58)	.1	.708
TF(L)xR(U-A)	1185	(1.29)	2.0	.164	1781	(1.29)	.8	.385
TF(H)xR(U-A)	1126	(1.29)	4.0	.054	2298	(1.29)	1.6	.211
Error								
TF(L,H)	.004	(1.29)	7.9	.009	.010	(1.58)	3.5	.067
R(I,A,U)	.003	(2.58)	.1	.999	.003	(2.116)	.1	.999
TF(L,H)xR(I,A,U)	.004	(2.58)	.2	.808	.003	(2.116)	.3	.746
TF(L,H)	.005	(1.29)	5.9	.022	.009	(1.58)	3.0	.087
R(I,U)	.003	(1.29)	.1	.999	.002	(1.58)	.1	.999
TF(L,H)xR(I,U)	.003	(1.29)	.4	.514	.002	(1.58)	.6	.458
TF(L)xR(U-I)	.004	(1.29)	.2	.690	.003	(1.29)	.2	.645
TF(H)xR(U-I)	.002	(1.29)	.4	.536	.002	(1.29)	.4	.536
TF(L,H)	.004	(1.29)	6.6	.015	.007	(1.58)	3.9	.055
R(A,U)	.002	(1.29)	.1	.999	.004	(1.58)	.1	.999
TF(L,H)xR(A,U)	.004	(1.29)	.4	.546	.004	(1.58)	.4	.545
TF(L)xR(U-A)	.004	(1.29)	.2	.677	.004	(1.29)	.2	.702
TF(H)xR(U-A)	.002	(1.29)	.4	.536	.003	(1.29)	.2	.625

TF = Target Frequency; **R** = Relatedness; **I** = Identical; **A**= Associated; **U** = Unrelated; **L** = Low; **H** = High; **R(U-I)** = Identity priming; **R(U-A)** = Associative priming.

where development of an episodic memory trace takes place (PD ≥ MTT).

Also verified is our hypothesis that feedback from the semantic to the lexical memory system is not responsible for the appearance of the frequency attenuation effect (e.g. see Stolz & Neely, 1995). Specifically, in experiment 2, the frequency attenuation effect does not appear in associative priming; however, it does appear in repetition priming; this demonstrates that the appearance of the frequency attenuation effect in repetition priming does not have to do with feedback from the semantic system.

Conclusions

The results of these experiments show that priming effects in word repetition result from more than one mechanism: the short-term effect (prospective view) occurs through lexical activation and the long-term effect (retrospective view) is due to retrieval of the episodic memory trace. Effects observed in the repetition masked paradigm using the frequency attenuation effect—assumed to be a marker of episodic component—support the double mechanism. With PD ≥ MTT, long-term

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Table 12
ANOVA results for mean response latency (ms) and percentage error in Experiment 3b

	Latency							
	Participants				Ítems			
Effect	MS_e	*Df*	F_1	*p* <	MS_e	*df*	F_2	*p* <
Latency								
TF(L,H)	1232	(1.29)	23.3	.001	4078	(1.58)	8.4	.005
R(I,A,U)	810	(2.58)	1.7	.195	1123	(2.116)	1.7	.181
TF(L,H)xR(I,A,U)	1041	(2.58)	3.7	.032	1123	(2.116)	3.1	.051
TF(L,H)	1279	(1.29)	6.1	.019	3657	(1.58)	2.9	.092
R(I,U)	1058	(1.29)	2.0	.172	1074	(1.58)	3.1	.085
TF(L,H)xR(I,U)	962	(1.29)	.2	.658	1074	(1.58)	.1	.947
TF(L)xR(U-I)	1092	(1.29)	.5	.503	1248	(1.29)	1.2	.278
TF(H)xR(U-I)	929	(1.29)	1.9	.179	901	(1.29)	2.0	.171
TF(L,H)	1044	(1.29)	23.4	.001	3249	(1.58)	9.3	.003
R(A,U)	623	(1.29)	.1	.981	1221	(1.58)	.1	.832
TF(L,H)xR(A,U)	1210	(1.29)	5.5	.026	1221	(1.58)	4.3	.042
TF(L)xR(U-A)	1115	(1.29)	2.9	.098	1632	(1.29)	1.3	.262
TF(H)xR(U-A)	718	(1.29)	4.7	.039	810	(1.29)	4.0	.056
Error								
TF(L,H)	.003	(1.29)	10.2	.003	.012	(1.58)	2.2	.141
R(I,A,U)	.003	(2.58)	.1	.891	.002	(2.116)	.2	.849
TF(L,H)xR(I,A,U)	.003	(2.58)	.6	.542	.002	(2.116)	.9	.423
TF(L,H)	.003	(1.29)	10.7	.003	.008	(1.58)	3.4	.069
R(I,U)	.003	(1.29)	.1	.745	.002	(1.58)	.2	.674
TF(L,H)xR(I,U)	.004	(1.29)	.4	.555	.002	(1.58)	.7	.402
TF(L)xR(U-I)	.005	(1.29)	.3	.599	.003	(1.29)	.5	.476
TF(H)xR(U-I)	.002	(1.29)	.1	.745	.001	(1.29)	.2	.662
TF(L,H)	.004	(1.29)	4.2	.049	.011	(1.58)	1.7	.194
R(A,U)	.004	(1.29)	.1	.887	.002	(1.58)	.1	.848
TF(L,H)xR(A,U)	.003	(1.29)	1.3	.269	.002	(1.58)	1.8	.184
TF(L)xR(U-A)	.005	(1.29)	.3	.586	.003	(1.29)	.5	.501
TF(H)xR(U-A)	.002	(1.29)	1.2	.293	.001	(1.29)	2.1	.161

TF = Target Frequency; **R** = Relatedness; **I** = Identical; **A**= Associated; **U** = Unrelated; **L** = Low; **H** = High; **R(U-I)** = Identity priming; **R(U-A)** = Associative priming.

effects appear, that is, the frequency attenuation effect is shown. With PD < MTT, short-term effects were present, that is, the frequency attenuation effect was absent, with SOA ≥ MTT.

The retrospective view of a unified explanation of masked and long-term priming, proposed by Bodner and Masson (2001), does not explain short- and long-term effects in this series of experiments. However, the NST (MacKay, 1987, 1990) with two processes (*activation* and *prolonged activation*) can explain short- and long-term effects.

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APPENDIX A

HIGH- AND LOW-FREQUENCY TARGET WORDS USED TO CONSTRUCT THE 120 TRIALS: 60 FOR WORD/WORD AND 60 FOR WORD/PSEUDOWORD FOR THE EXPERIMENTS.

Abbreviations: Sy = number of syllables; *L* = number of letters; *F* = lexical frequency (from the Juilland & Chang-Rodriguez (1964) data base, which reports the number of occurrences of a word per 1 million); *N* = number of the prime; *As* = Associative strength between prime and target (from the Algarabel, Sanmartin, García & Espert (1985) data base, in which associative strength is measured in percentages)

High-frequency for target words (trials word/word)

Primes	*Sy*	*L*	*F*	*N*	*Targets*	*Sy*	*L*	*As*	*F*
vaso	2	4	9	1	agua	2	4	40.9	136
vista	2	5	125	2	ojo	2	3	45.6	178
edad	2	4	88	3	años	2	4	31.8	557
zona	2	4	67	4	lugar	2	5	30.8	136
lector	2	6	64	5	libro	2	5	46.2	206
nación	2	6	44	6	país	2	4	43.3	158
pasión	2	6	52	7	amor	2	4	34.7	186
costa	2	5	39	8	mar	1	3	32.8	96
jardín	2	6	44	9	flores	2	6	51.6	76
rato	2	4	42	10	tiempo	2	6	41.9	452
fecha	2	5	41	11	día	2	3	30.3	555
templo	2	6	10	12	iglesia	3	7	37.3	52
visión	2	6	38	13	ojo	2	3	32.1	178
labio	2	5	31	14	boca	2	4	40.4	49
hogar	2	5	38	15	casa	2	4	32.6	367
plata	2	5	30	16	oro	2	3	49.8	72
inglés	2	6	44	17	francés	2	7	37.6	72
viento	2	6	27	18	aire	2	4	44.4	87
rosa	2	4	24	19	flor	1	4	38.1	76
tono	2	4	30	20	voz	1	3	34.9	81
bosque	2	6	25	21	árbol	2	5	49.6	44
llave	2	5	14	22	puerta	2	6	41.9	112
reloj	2	5	1	23	hora	2	4	54.7	244
banco	2	5	35	24	dinero	3	6	53.0	62
temor	2	5	20	25	miedo	2	5	63.5	41
prosa	2	5	16	26	verso	2	5	54.7	41
puente	2	6	19	27	río	1	3	44.0	82
auto	2	4	12	28	coche	2	5	57.3	47
humo	2	4	12	29	fuego	2	5	32.4	53
marco	2	5	13	30	cuadro	2	6	57.5	41
Mean	2.0	5.1	35.1			1.9	4.5	42.9	151.2
SD	.0	.8	25.6			.5	1.2	9.3	146.0

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Low-frequency for target words (trials word/word)									
Primes	***Sy***	***L***	***F***	***N***	***Targets***	***Sy***	***L***	***As***	***F***
verdad	2	6	187	1	mentira	3	7	42.5	12
mano	2	4	195	2	dedo	2	4	31.3	20
doctor	2	6	67	3	médico	3	6	42.5	9
cielo	2	5	72	4	azul	2	4	46.2	29
joven	2	5	76	5	viejo	2	5	36.6	20
mesa	2	4	41	6	silla	2	5	42.5	11
norte	2	5	24	7	sur	1	3	60.7	17
error	2	5	37	8	fallo	2	5	32.4	1
suma	2	4	12	9	resta	2	5	54.8	1
pobre	2	5	30	10	rico	2	4	50.0	10
lente	2	5	5	11	gafas	2	5	37.2	1
puerto	2	6	34	12	barco	2	5	39.2	32
rostro	2	6	21	13	cara	2	4	69.9	8
tabla	2	5	23	14	madera	3	6	36.4	23
muro	2	4	30	15	pared	2	5	44.1	25
perro	2	5	18	16	gato	2	4	36.1	10
arco	2	4	19	17	flecha	2	6	45.1	4
barba	2	5	21	18	pelo	2	4	42.3	31
hierro	2	6	23	19	metal	2	5	30.6	17
punta	2	5	20	20	lápiz	2	5	30.5	6
ropa	2	4	18	21	vestido	3	7	33.1	23
calor	2	5	24	22	frío	1	4	31.6	24
humor	2	5	19	23	risa	2	4	44.8	16
julio	2	5	18	24	agosto	3	6	38.9	14
pastor	2	6	18	25	oveja	3	5	64.7	1
negro	2	5	15	26	blanco	2	6	37.5	28
nieto	2	5	10	27	abuelo	3	6	54.6	19
copa	2	4	7	28	vino	2	4	36.8	20
playa	2	5	7	29	arena	3	5	34.8	8
ritmo	2	5	10	30	música	3	6	35.8	24
Mean	2.0	5.0	36.7			2.2	5.0	42.1	15.5
SD	.0	.7	45.6			.6	1.0	10.2	9.5

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Prime words (trials word/pseudoword)					
Primes	***Sy***	***L***	***F***	***N***	***Targets (pseudowords)***
hoja	2	4	36	1	PLAMU
pluma	2	5	36	2	ROSTE
resto	2	5	36	3	TRIAPA
patria	2	6	37	4	ÑANI
niña	2	4	37	5	TOCOR
corto	2	5	37	6	NOFI
fino	2	4	38	7	OSU
uso	2	3	38	8	NECAR
carne	2	5	39	9	VEBRE
breve	2	5	40	10	PLONE
pleno	2	5	40	11	ZAPLA
plaza	2	5	41	12	FEJE
jefe	2	4	41	13	CIBO
cabo	2	4	41	14	PUCO
poco	2	4	41	15	PANE
pena	2	4	41	16	FACHE
fecha	2	5	41	17	MADA
dama	2	4	42	18	TAME
tema	2	4	43	19	TANO
nota	2	4	44	20	CAZPA
capaz	2	5	45	21	LATRE
letra	2	5	45	22	MIAR
arma	2	4	45	23	LLOBE
bello	2	5	48	24	FOVAR
favor	2	5	48	25	GLARIO
gloria	2	6	52	26	VOVI
vivo	2	4	52	27	LORDO
dolor	2	5	53	28	HETOL
hotel	2	5	49	29	FILEZ
feliz	2	5	56	30	GRODA

Prime words (trials word/pseudoword)					
Primes	***Sy***	***L***	***F***	***N***	***Targets (pseudowords)***
grado	2	5	35	31	SANTE
santa	2	5	35	32	MOLLIN
millón	2	6	34	33	SOCE
seco	2	4	34	34	SOBIA
sabio	2	5	34	35	TOJUN
junto	2	5	34	36	PASER
pesar	2	5	34	37	MORUL
moral	2	5	33	38	TOJUS
justo	2	5	32	39	CEFA
café	2	4	32	40	NEBLO
noble	2	5	32	41	VALLI
villa	2	5	31	42	GELPO
golpe	2	5	31	43	TENO
tono	2	4	30	44	GINEO
genio	2	5	30	45	CENDO
conde	2	5	30	46	DELCU
dulce	2	5	29	47	TERRO
torre	2	5	28	48	TADO
dato	2	4	28	49	TOGRI
grito	2	5	27	50	ZARO
raza	2	4	27	51	QUEDU
duque	2	5	26	52	LAIS
isla	2	4	26	53	FROTU
fruto	2	5	26	54	RAINE
reina	2	5	25	55	BEILA
baile	2	5	25	56	POTIA
patio	2	5	25	57	ENGAL
ángel	2	5	24	58	LACOR
calor	2	5	23	59	LONSA
salón	2	5	22	60	JAHO
Mean	2.0	4.7	36.1		
SD	.0	.6	8.2		

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APPENDIX B

HIGH- , MEDIUM- AND LOW-FREQUENCY WORDS USED TO CONSTRUCT THE H-THRESHOLD, M-THRESHOLD AND L-THRESHOLD TASKS.

Abbreviations: Sy = number of syllables; *L* = number of letters; *F* = lexical frequency (from the Juilland & Chang-Rodriguez (1964) data base, which reports the number of occurrences of a word per 1 million).

High-frequency words (H-THRESHOLD task)

Words	***Sy***	***L***	***F***
noche	2	5	149.5
tratar	2	6	154.1
claro	2	5	157.4
medio	2	5	163.3
calle	2	5	164.1
razón	2	5	171.3
mirar	2	5	174.1
amigo	3	5	174.4
mayor	2	5	191.4
cinco	2	5	219.1
gente	2	5	145.2
campo	2	5	129.3
cuenta	2	6	128.5
forma	2	5	127.0
color	2	5	124.5
orden	2	5	120.8
tarde	2	5	119.5
madre	2	5	113.6
único	2	5	113.0
crear	2	5	112.4
Mean	2.05	5.1	147.6
SD	.22	.31	29.4

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Medium-frequency words (M-THRESHOLD task)

Words	***Sy***	***L***	***F***
viaje	2	5	85.6
carta	2	5	84.7
falta	2	5	83.1
dicho	2	5	82.8
causa	2	5	82.3
grupo	2	5	81.0
andar	2	5	80.4
sacar	2	5	80.3
pesar	2	5	79.5
bastar	2	6	77.8
lejos	2	5	76.7
joven	2	5	76.4
libre	2	5	75.0
ganar	2	5	73.3
cielo	2	5	72.3
sufrir	2	6	71.7
tocar	2	5	70.6
echar	2	5	68.0
brazo	2	5	66.8
frase	2	5	66.8
Mean	2.0	5.1	76.8
SD	.0	.31	6.0

Low-frequency words (L-THRESHOLD task)

Words	***Sy***	***L***	***F***
fruta	2	5	16.1
precio	2	6	16.1
mejor	2	5	16.1
abril	2	5	16.4
norma	2	5	16.7
ciego	2	5	17.0
busca	2	5	17.4
rogar	2	5	17.4
amiga	3	5	17.5
ruido	2	5	17.8
ataque	3	6	16.0
débil	2	5	16.0
tesis	2	5	15.9
agudo	3	5	15.7
copia	2	5	15.7
latín	2	5	15.5
trato	2	5	15.4
venta	2	5	15.3
medir	2	5	15.3
chino	2	5	15.0
Mean	2.2	5.1	16.2
SD	.37	.31	.8