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Semantic Priming Effects in a Lexical Decision Task: Comparing third Graders and College Students in two Different Stimulus Onset Asynchronies

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Differences in the semantic priming effect comparing child and adult performance have been found by some studies. However, these differences are not well established, mostly because of the variety of methods used by researchers around the world. One of the main issues concerns the absence of semantic priming effects on children at stimulus onset asynchrony (SOA) smaller than 300ms. The aim of this study was to compare the semantic priming effect between third graders and college students at two different SOAs: 250ms and 500ms. Participants performed lexical decisions to targets which were preceded by semantic related or unrelated primes. Semantic priming effects were found at both SOAs in the third graders' group and in college students. Despite the fact that there was no difference between groups in the magnitude of semantic priming effects when SOA was 250ms, at the 500ms SOA their magnitude was bigger in children, corroborating previous studies. Hypotheses which could explain the presence of semantic priming effects in children's performance when SOA was 250ms are discussed, as well as hypotheses for the larger magnitude of semantic priming effects in children when SOA was 500ms.
Keywords: semantic priming, lexical decision, children, adults, stimulus onset asynchrony.

Algunos estudios han encontrado diferencias en la comparación del efecto de facilitación semántica entre adultos y niños. No obstante, estas diferencias no están bien establecidas, mayoritariamente debido a la variedad de métodos utilizados por los investigadores de todo el mundo. Uno de los aspectos principales concierne a la ausencia de efectos de facilitación semántica en niños con intervalos entre estímulos (stimulus onset asynchrony; SOA) menores de 300ms. El objetivo de este estudio fue comparar el efecto de facilitación semántica entre alumnos de tercer grado y alumnos de bachillerato con dos SOAs: 250 ms y 500ms. Los participantes completaron decisiones léxicas ante objetivos que fueron precedidos por primes relacionados o no relacionados. Se encontraron efectos de facilitación semántica en los dos SOAs en alumnos de tercer grado y de bachillerato. Pese al hecho de que no hubo diferencias entre los grupos en la magnitud del efecto de facilitación cuando el SOA era de 250 ms, con SOA de 500 ms la magnitud era mayor en niños, corroborando previos estudios. Se discuten las hipótesis que podrían explicar la presencia de efectos de facilitación semántica en la ejecución de niños cuando el SOA era de 250ms, así como las hipótesis para mayor magnitud de efectos de facilitación semántica en niños cuando el SOA era de 500ms.
Palabras clave: facilitación semántica, decisión léxica, niños, adultos, asincronía de presentación de estímulos.

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The semantic priming paradigm is employed as an evaluation of implicit memory and also as a methodological resource to study other cognitive processes, such as semantic memory and meaning access in word reading. The semantic priming effect (SPE) can be understood as an improvement in performance derived from the context, in which a target processing is facilitated by the preceding stimulus (prime) because of a semantic association between them. Once these semantic associations are built throughout development (Hirsh & Tree, 2001), it is supposed that the SPE is not the same in individuals with different ages. For example, Macizo, Gómez-Ariza, and Bajo (2000) compared word associative norms between children and adults and they found a smaller percentage of associates in the adult sample. According to these authors, as age increases, the relations among concepts are refined, reducing the number of associates and the idiosyncratic answers. Besides, reading proficiency is changed by formal education experience, which is reflected in the evaluation of the SPE in written verbal tasks.

In a standard semantic priming experiment, participants are required to perform a lexical decision task (decide if the target is a word or a pseudoword) or a pronunciation/naming task (say the target aloud). Each trial is formed by one prime and one target, but usually the prime demands no response, only the participant's attention. When the target is a word, primes could be related (experimental condition) or unrelated to it (control condition). The interval between the appearance of the prime and the target is called Stimulus Onset Asynchrony (SOA). The SPE is usually analyzed through reaction times (RTs) and accuracy (percentage of errors). When the trials with the unrelated prime context are used as baseline of the comparison, the resulting difference is called overall semantic priming effect. In studies which added a neutral prime context (e.g., ###) and used it as a baseline for comparison, the resulting difference is called facilitation (when reaction time is smaller in the related condition) or inhibition (when reaction time is bigger in the related condition) (Neely, 1991).

Several theories have been proposed to explain the SPE found so far. According to Neely (1991), none of these theories provides an explanation for all the existing data, and probably no new theory would be able to do so (for more details see McNamara, 2005; Neely, 1991;). It was decided to present here just some of the most important theories which have tried to understand the SPE: Automatic Spreading Activation; Expectancy-based priming; and Distributed Network Models.

The Automatic Spreading Activation theory (Collins & Loftus, 1975) postulates that semantically/associatively related nodes have strong links and are "stored close together". When the prime is processed, the activation spreads to the nodes of semantically related targets. Thus, the recognition of these targets is facilitated by the reduction in the time required to activate them. In other words, an SPE occurs. Automatic spreading activation would be responsible for the data found when the SOA is short, because the small interval between the prime and the target requires an automatic process to explain the SPE (Neely, 1991). Although until recently SPE was considered to be driven by automatic processes with SOAs smaller than 300ms, in the last few years evidence has suggested that it should be preferably be less than 150ms to rely on the automatic process (Altarriba & Basnight-Brown, 2007).

With a longer SOA (more than 150ms considering Altarriba & Basnight-Brown, 2007; more than 300ms, according to Neely, 1991), the Expectancy-based priming theory (Becker, 1980) seems to provide a better account for the SPE (Neely 1991). This theory suggests that when the subject processes the prime, (s)he creates a set of possible targets which are related to the prime. When the presented target is one of the expected words, its recognition is facilitated (Nievas & Justícia, 2004). This process demands a conscious relation between the prime and the target, differing from the automatic processes.

However, in the last few years, distributed network models have also been proposed to explain SPE. According to McNamara (2005), these models can be divided into two categories. The first one, "proximity models", postulates that SPE exists because primes and targets which are related are closer to each other in a high-dimensional semantic space when compared with prime and targets which are unrelated (e.g., Masson, 1995; McRae, de Sa, & Seindenberg, 1997; Plaut & Booth, 2000). The second, "learning models", proposes that SPE happens by learning. Every time a word is recognized, all network connections are altered and there is an increased probability of producing the same response to the same input. So, this process facilitates the recognition of the word which reappears and the processing of semantically related words (e.g., Becker, Moscovitch, Behrmann, & Joordens, 1997).

The first two theories presented above, Automatic spreading activation and Expectancy-based priming theory, have been the ones most used to understand data provided by studies which have evaluated and compared the SPE at different SOAs in child and adult performance. SPE has not been usually found among children when the SOA is less than 300ms, while this effect has been obtained among teenagers and adults (Nievas & Justicia, 2004; Simpson & Foster, 1986). It has been speculated that cortical representations are still being built and connected in childhood, which justifies the absence of the SPE in short SOAs. But when there is a longer SOA and priming is a consequence of expectancy-based processes, all age groups show SPE (Nievas & Justicia, 2004.

Several studies were developed to verify the SPE in healthy adults (e.g., Basnight-Brown & Altarriba, 2007; Coney, 2002; Davenport & Potter, 2005; Ferrand & New, 2003; Frost & Bentin, 1992; Hutchison, 2007; McNamara, 1994; McRae & Boisvert, 1998; Nobre & McCarthy, 1995;

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Perea & Gotor, 1997; Perea & Rosa, 2002; Sánchez-Casas, Ferré, García-Albea, & Guasch, 2006; Valdés, Catena, & Marí-Beffa, 2005). A small number of studies were established for the same purpose with children as participants (e.g., Assink, Bergen, Teeseling, & Knuijt., 2004; Hala, Pexman, & Glenwright, 2007; Schvaneveldt, Ackerman, & Semlear, 1977; Simpson & Lorsbach, 1987; Torkildsen, Syversen, Simonsen, Moen, & Lindgren, 2007).

Despite the differences found between SPE in children and adults, few studies have aimed to compare it among different ages to understand this phenomenon throughout development (e.g., Nievas & Justicia, 2004; Schwantes, Boesl, & Ritz, 1980; Simpson & Foster, 1986; Simpson & Lorsbach, 1983). One of the first published studies to compare the SPE between ages (Schvaneveldt et al., 1977) used a lexical decision task in second and fourth graders. Despite researchers' concern to create the right list of words and their associates for the participants (a concern not followed by the majority of similar studies), the results found only a marginal interaction effect between grade and context, suggesting that the effect appears to decrease as age increases. Unfortunately, the SOA employed in the experiment was not mentioned by the authors.

Other studies also found this pattern, in which the SPE decreases as age increases (Plaut & Booth, 2000; Schwantes et al., 1980; Simpson & Foster, 1986; Simpson & Lorsbach, 1983). In 1980, Schwantes et al. investigated the lexical decision speed varying the amount of preceding-sentence context presented to third and sixth grade and college students. The SOA employed varied between 500ms and 1000ms. Their results showed that when the context was congruent with the target the lexical decision was facilitated for all participants. However, they found a bigger facilitation for third grade students.

Also comparing different ages, Simpson and Lorsbach (1983) analyzed the SPE in Elementary School students (second, fourth and sixth grades) and in adults in a pronunciation task. There were three kinds of primes in that experiment: semantically related, not related to the target and neutral (no linguistic primes - XXX). The SOA was 2000ms. Facilitation was found in all educational groups, but it decreased as a function of the participants' age. Once again, the same result was found by Simpson and Foster (1986) in their first experiment. The participants in this study were also second, fourth and sixth graders, but the SOA was 500ms. Primes were words with more than one meaning and the targets were related to the more or less frequent meaning or not related at all. Data showed that second and fourth graders derived facilitation for both meanings of the primes. On the other hand, sixth graders only had SPE for the more frequent meaning. The authors concluded that "older children maintained only a single meaning of an ambiguous word, whereas younger children showed activation of both meanings" (Simpson & Foster, 1986, p. 150).

However, in their second study, Simpson and Foster (1986) kept the characteristics of the participants the same, manipulated the SOA (150ms, 300ms and 750 ms) and added neutral primes (####) to the task. They found no facilitation when the SOA was 150ms, whereas they found it when the SOA was 300ms and 750ms. Concerning the meanings of the prime, data demonstrated that at the 300ms SOA, both meanings were activated in all groups of children. But, at the 750ms SOA, results replicated their first experiment, in which older children were facilitated only for the most frequent meaning of the word.

This absence of SPE in children when the SOA is short (smaller than 300ms) was also investigated by Nievas and Justicia (2004), who evaluated through a lexical decision task different groups (fifth and eighth graders, first and third year of secondary and college students) using a 250ms SOA. Trials were composed of primes, which were all homographs, and targets, which could be related to the more frequent dominant meaning of the homograph, the less frequent subordinate meaning or could be a pseudoword. They found no SPE in fifth and eighth graders' performance, while the older participants' results showed the effect.

In general, studies published so far seem to agree with the fact that younger children's performance is not facilitated by the context with an SOA less than 300ms, while older student and adult performance is. But, at a longer SOA, younger children show SPE and it appears to be larger than the SPE found in older ones. Two hypotheses can be proposed to understand these findings. One of them is related to the meaning access and the other to the decoding processes development.

In the meaning access hypothesis, the spreading activation is what allows the semantic processing and it depends on the strength of the connections among nodes. This strength is modeled through experience (McClelland & Rogers, 2003) and so it tends to change over time (Assink et al., 2004). This lack of SPE can also be a consequence of the smaller number of nodes connected to the target (Nievas & Justicia, 2004). Thus, children would need more time to process the prime in order to compensate the still weak association strength between it and the target.

On the other hand, children have less automatic lexical access compared with adults. This lexical access automatism will be developed over time, with reading experiences. In the children word reading processes, the strategy for lexical access tends to be predominantly phonological (in Dual-Rote reading models, e.g., Coltheart, Rastle, Perry, Langdon, & Ziegler , 2001). So, the meaning access will be mediated by the phonological access. It will also affect SPE at short SOA because children will need more time to process the prime in order to obtain a semantic facilitation.

This same hypothesis is used to explain why children usually derive more benefit from context than adults at long SOAs (Nievas & Justicia, 2004). As they have this slower process to word meaning access in word reading, they rely more on context to facilitate lexical access. Younger students have more difficulties in the decoding processes which are not automatized (Schwantes, 1981). Pratarelli, Perry and Galloway (1994) stated that the prime needs to be presented long enough in order to bring all semantic and contextual (top-down processes) mechanisms into play.

However, as already mentioned, these differences between short and long SOAs and between child and adult performance have not been well established mainly because of the specific characteristics of each study: language of participants, types of prime and target, the manner by which the association pairs are selected, among other characteristics. So, our goal was to provide new evidence for the comparison of SPE in children and in adults: 1) for the first time in a Brazilian sample, with stimuli in Portuguese; 2) in a lexical decision task in which both, prime and target, had only one meaning (no homographs were used); 3) in which all the related pairs had a strong associative strength; and 4) with norms carefully collected for this specific sample (3rd graders).

The aim of the present study was to evaluate the overall SPE in 3rd graders and college students at two different SOAs (250ms and 500ms) in a lexical decision task. Thus, we also aimed to verify the influence of the SOA in the two groups and the interaction between the variables SOA and educational group in the SPE. Moreover, we aimed to evaluate if the SPE decreased or not as a function of formal educational experience.

According to the revised data (Nievas & Justicia, 2004; Schwantes et al., 1980; Simpson & Foster, 1986; Simpson & Lorsbach, 1983), we expected to find, at a 250ms SOA, no SPE in children, just among college students. However, when the SOA is 500ms, we hypothesized that both educational groups would show SPE, and that children's performance would reflect bigger facilitation than that of adults.

Method

Participants

Fifty-seven students at the third grade in Elementary School (minimum 8 years; maximum 9 years; *M* = 8.39 years old; *SD* = 0.49) and 60 college students (minimum 17 years; maximum 38 years; *M* = 21.15 years old; *SD* = 3.58) participated in the experiment. The sample of children was composed of 20 girls (35%) and 37 boys (65%), whereas the adult group was composed of 47 women (78%) and 13 men (22%). We selected third grade students from a private school in Porto Alegre, Brazil. College students were selected from a public university also situated in that city. All participants were native speakers of Brazilian Portuguese. As an inclusion criterion participants could have no reading difficulty, according to the teacher`s evaluation in the case of children, and according to self-report in college students. Participants with a history of failure at school and with neurological diagnoses were not included in the sample.

Design

A 2 X 2 X 2 mixed factorial design was used, with factors corresponding to education group (3rd grade and college students) and SOA (250 and 500 ms) as between-participants variables and relatedness (semantic related and unrelated) as within participants variable.

Stimuli

The material set consisted of 78 stimulus pairs (Appendix 1). Half of these trials were composed by word (prime) – word (target) and the other half by word (prime) - pseudoword (target). The 39 words used as targets were selected from a list of stimuli, all of them with up to 6 letters (minimum length of 3 letters). Most of them were nouns (*N* = 35), concrete and abstract, but there were some adjectives (*N* = 10) and adverbs (*N* = 4) too. Words known by third grade students were chosen (Salles, Machado, & Holderbaum, 2009). There were 19 low, 12 high and 6 average frequency words according to norms for third graders in Portuguese (Pinheiro, 1996). Their total set size varied from 8 to 38 neighbors (*M* = 17.6, *SD* = 7.93). Pseudoword targets were formed by replacing letters of the word targets while keeping a similar structure and maintaining pronounceability. They were preceded by words evoked by only one child in the study of Salles and colleagues (idiosyncratic answers). These words, therefore, were not used in the word-word trials.

Primes which preceded the word targets were semantically related or unrelated to them. The semantically related ones were created based on the norms published in Salles et al. (2009). In this study, third grade students answered the following question for a total of 78 words: "What is the first word which comes to your mind when you think of the word __________?" The word selected to precede the target was the one most produced by the children. For the selection of semantic associative pairs, an association strength superior to 25% was required. In other words, at least 25% of the children should have produced the same word. The selected pair with larger association strength was provided by 86% of the children. The mean of association strength for the selected targets was 53.5% (*SD* = 17.1%) Unrelated primes were chosen within the data of the same study, just like the primes of the pseudowords. They were carefully selected to have a similar length when compared to the semantically related prime and no structural or semantic relation with the target.

Five practice trials (3 word-word and 2 word-pseudoword) were formed using words easily read by third graders. These words were not used in any experimental trial. Thus, we aimed to guarantee that all the words in the task were part of the lexicon of the third grade students.

Procedure

This study was approved by the Psychology Institute Ethics Committee of the Federal University of Rio Grande do Sul. Participants were informed of all ethical principles through an informed consent. In the case of the children, their parents or another person in charge signed the informed consent, allowing them to participate in the experiment.

Two different but equivalent versions of the task were created with the stimuli. In the first version 20 word targets were presented with semantically related primes and the other 19 with unrelated ones (total of 39 word targets). In the second version, the same 20 word targets were presented with unrelated primes, while the 19 others were preceded by semantically related ones. So, the same stimulus was not seen twice by any participant. Trials with pseudoword as target remained the same in both versions. All trials were randomly presented for each participant. This procedure was done to control any order or pairs effect.

These versions were presented with the 250ms SOA to half of each educational group and with the 500ms SOA to the other half. When the SOA was 250 ms, each trial began with the prime, which stayed on the screen for 150ms, followed by a cross for 100ms and then the target, which remained on the screen until the participant performed the lexical decision. The same procedure was executed when the SOA was 500 ms, except that the prime remained on the screen for 400ms. Between each trial there was a three-second interval when a white screen was displayed.

The experiment was presented using an E-prime computer program, which also recorded the answers and latencies. Stimuli were seen in the center of the screen, in black letters (font Arial 24) on a white background. Primes appeared in lowercase letters while targets were shown in uppercase ones.

Participants were tested individually, in a quiet room, seated approximately 60 cm from the screen. The whole session lasted no more than 15 minutes for each participant. They were asked to rest their fingers of the dominant hand on two buttons of the keyboard. Half of the children and half of the college students answered '1' for 'YES' and '3' for 'NO'. The other half answered the other way around: '1' for 'NO' and '3' for 'YES'. This procedure was chosen following several studies that asked participants to use only the dominant hand, or the preferred hand (e.g., Blumstein, et al., 2000; Hagoort, 1997; Milberg & Blumstein, 1981; Milberg, Blumstein, & Dworetzky, 1987; Nakamura, Ohta, Okita, Ozaki, & Matsushima, 2006).

Before starting the experiment, participants read the following instruction: "You have to pay attention to each stimulus which appears on the screen of the microcomputer. Try to read silently the first word (presented in lowercase letters). After that, a cross (+) will appear on the screen, which means that the next stimuli will be presented. You have to decide, in the fastest and most accurate way as possible, if this second stimuli (presented in uppercase letters) is a real word, pushing the 'YES' button, or a word which does not exist, pushing the 'NO' button". When the participant finished reading the instruction, the researcher explained it again to ensure the comprehension of the task.

Data analyses

Mean reaction times and percentage of errors were analyzed through a mixed ANOVA. Six participants (all children) were excluded from all analysis because they presented an abnormal rate of errors (97 percentile) in the lexical decision task (fifteen or more errors for the total of 39 words or pseudowords). It was done because few correct answers could invalidate the RT analyses of these participants. Latency analyses were done just with correct trials. A trial was considered an error when the participant chose the wrong answer during that lexical decision. We also excluded trials in which the reaction time was more than 3*SD* away from the participant mean RT, because it was considered as a technical issue. A total of 129 trials were discarded with this trimming procedure (54 in the child and 75 in the adult sample, which is respectively 1.3% and 1.6% of the total of trials of each group).

Results

Mean reaction times and error percentage in each experimental condition are shown in Table 1. This data was analyzed in a 2 (educational group: 3rd graders and college students) x 2 (SOA: 250ms and 500ms) x 2 (relatedness: related and unrelated prime) mixed ANOVA. The interaction between relatedness and SOA was also analyzed separately by group through 2 (related and unrelated prime) x 2 (250ms and 500ms) mixed ANOVAs. Further analyses were done using t tests. Educational group and SOA were between subjects factors, while relatedness was a within subjects factor.

Accuracy analysis showed a main effect of relatedness, $F(1,107) = 4.55$, $p < .05$, in which related primes were more likely to be followed by correct lexical decisions than unrelated ones, considering the total sample. No other main effect or interactions were significant concerning error proportions.

Mean reaction times showed a main effect of educational group, $F(1,107) = 171.05$, $p < .05$, and relatedness, $F(1,107) = 98.40$, $p < .05$, which means that college students demonstrated faster reaction times than third graders and that targets preceded by related primes were answered faster than the ones preceded by unrelated primes, considering

Table 1
Mean lexical decision times (M) and standard deviation (SD), in ms; error percentage (EP) and the difference between related and unrelated primes conditions (U – R) – SPE

SOA	RELATEDNESS							
	RELATED PRIME			UNRELATED PRIME			U - R	
	M	*SD*	*EP*	*M*	*SD*	*EP*	*M*	*EP*
250ms								
3rd graders	1336	401	2.6	1423	389	3.3	87	0.7
college students	713	249	2	773	260	4	60	2
500ms								
3rd graders	1216	245	3.4	1420	239	5.1	204	1.7
college students	631	124	2.3	697	123	2.8	66	0.5

both SOAs. The main effect of SOA and the interaction between educational group and SOA were not significant. The interaction between relatedness and educational group was significant, $F(1,107) = 15.30$, $p < .05$. Data showed that both educational groups had faster reaction times in the related prime condition, but the difference between the relatedness conditions was larger for children. The interaction of relatedness x SOA was also significant, $F(1,107) = 8.65$, $p < .05$. Although mean latencies decreased in the related prime context with both SOAs, mean reaction times demonstrated that this decrease was more pronounced at 500ms SOA.

The three-way interaction relatedness x educational group x SOA was also significant, $F(1,107) = 7.08$, $p < .05$. In order to understand these interactions, we carried out a separate ANOVA for each group.

Third graders analyses showed a significant main effect of relatedness, $F(1,49) = 46.52$, $p < .05$, a non-significant main effect of SOA and a significant interaction relatedness X SOA, $F(1,49) = 7.64$, $p < .05$. We performed *t* tests to disjoin the relatedness X SOA interaction. The results suggest that RTs were significantly faster in the related condition than in the unrelated one when SOA was 250ms, $t(24) = 2.65$, $p < .05$, and when SOA was 500ms, $t(25) = 7.40$, $p < .05$. In other words, general semantic priming effect was found in children in both SOAs.

On the other hand, college students analyses showed only a significant main effect of relatedness, $F(1,58) = 82.30$, $p < .05$. Both main effect of SOA and interaction relatedness X SOA were not significant. It means that college students had faster RTs in the related condition independently of the SOA.

Further *t* tests were done to compare the magnitude of the SPE (values of the unrelated condition minus values of related ones) between groups and in each group between SOAs. It confirmed that there was no significant difference in the magnitude of the SPE between children and adults at the 250ms SOA, but there was a difference at the 500ms SOA, $t(30,10) = 4.77$, $p < .05$, with children showing a larger magnitude. Besides, it showed that for third graders there was a significant difference between the magnitude of the SPE when the SOA was 250ms and when it was 500ms, $t(49) = 2.76$, $p < .05$. Results proved that there was a larger facilitation at the 500ms SOA. For college students, there was no difference in the magnitude of the SPE between SOAs.

Summarizing, the main results are that both third graders and college students showed SPE in both SOAs and children demonstrated higher SPE at the 500ms SOA.

Discussion

The majority of our results corroborate previous studies concerning SPE in adults (e.g., Basnight-Brown & Altarriba, 2007; Coney, 2002; Davenport & Potter, 2005; Ferrand & New, 2003; Frost & Bentin, 1992; Hutchison, 2007; McNamara, 1994; McRae & Boisvert, 1998; Nobre & McCarthy, 1995; Perea & Gotor, 1997; Perea & Rosa, 2002; Sánchez-Casas, et al., 2006; Valdés, et al., 2005), children (e.g., Assink, et al., 2004; Hala, et al., 2007; Schvaneveldt, et al., 1977; Simpson & Lorsbach, 1987; Torkildsen, et al., 2007), and the comparison between them (e.g., Nievas & Justicia, 2004; Schwantes, et al., 1980; Simpson & Foster, 1986; Simpson & Lorsbach, 1983). Among these results, we would like to emphasize the fact that adults had faster RTs than children; that in the related context RTs were faster than in the unrelated one; the presence of SPE in adults with both SOAs; and finally that at the 500ms SOA, the presence of SPE in children was of a larger magnitude than that observed in adults.

Interaction analyses demonstrated that there was a significant effect of group and of relatedness at both SOAs concerning reaction times. As expected, data showed college students had faster reaction times than third graders and that targets preceded by related primes were answered faster than the ones preceded by unrelated primes. Similar results have been found by several researchers since Meyer and Schvaneveldt (1971).

The presence of SPE in adults has countless confirmation in recent decades. This effect was found with very short SOAs (e.g., Valdés et al., 2005), and with long SOAs (e.g., Hutchinson, 2007). It was also found with associative relations between prime and target (e.g., McNamara, 1994) and with unassociated semantic relations (e.g., Ferrand & New, 2003; Sánchez-Casas et al., 2006; and the reviews, Lucas, 2000, and Hutchinson, 2003).

Regarding children´s performance, various studies found SPE in children when the SOA was larger than 300ms (Assink et al., 2004; Hala et al., 2007; Plaut & Booth, 2000; Schwantes, et al., 1980; Simpson & Lorsbach, 1983), but the two studies which tried to find it at SOAs smaller than 300ms did not succeed (Nievas & Justicia, 2004; Simpson & Foster, 1986). According to Nievas and Justicia, the absence of this effect could be explained by the automatic processes involved in SPE at short SOAs. The same authors explain that since associative strength, which is responsible for the SPE at short SOAs, increases among nodes as age increases, younger children would have no SPE because the link among nodes would still be under development.

So how can one explain that in our study third graders showed SPE at the 250ms SOA? We decided to compare the details of the methods used by Nievas and Justicia (2004) and Simpson and Foster (1986) with our method. The first difference noticed was the students' educational level. These two previous studies investigated SPE in children from different educational levels than ours: fifth and eighth graders (Nievas & Justicia, 2004), and second, fourth and sixth graders (Simpson & Foster, 1986). However, educational level by itself cannot account for the different pattern of results across studies, since both younger and older children were evaluated and did not show evidence of SPE. A second difference across the studies refers to the SOA. Simpson and Foster employed a 150ms SOA, while we and Nievas and Justicia, an SOA of 250ms. Given that Nievas and Justicia`s results are the same as those reported by Simpson and Foster, our different pattern of results cannot be due to the SOA we used.

On the other hand, the analysis of the methods also pointed to differences which should help us explain our results. First, in order to create the pairs (prime-target), Nievas and Justicia (2004) and Simpson and Foster (1986) previously decided which homographs to use and then asked children for single-word free association. So, they determined the primes and the answers of the children determined the targets, which can be understood as a forward association. We did the opposite in our study, using a backward association. The targets were previously and carefully selected. Then we asked the children to say the first word that came to their minds for each of these targets (Salles et al., 2009). Although some authors have found that both types of association can generate semantic priming effects (e.g., Chwilla, Hagoort, & Brown, 1998, others have failed to do so (e.g., Hutchinson, 2002), so the type of association between the prime and target related pairs (forward vs. backward) may be a factor to consider when trying to account for the different pattern of results across studies.

Second, the primes in Nievas and Justicia (2004) and Simpson and Foster (1986) were all homographs. In our study primes were formed by words with only one meaning. This is an important difference since it is known that homographs are processed differently (Gorfein, 2001) and show less semantic facilitation (Milberg, Blumstein, & Dworetzky, 1987) than words with only one meaning. It is plausible that children showed no SPE when primes were homographs at shorter SOAs because they have differences in memory structure representations compared with adults (Nievas & Justicia, 2003).

One last difference concerns to the associative strength between related prime and target. Simpson and Foster (1986) did not control the associative strength, whereas Nievas and Justicia (2004) and we did. However, the associative strengths between related prime and target in the study of Nievas and Justicia were mostly weak (about 9%) according to the association criteria established by Coney (2002) and Van Erven and Janczura (2004). Unlike Nievas and Justicia, following the same criteria, the related prime – target trials of the present study were composed only of pairs with strong associative strength (more than 25%). Although Cañas (1990) has postulated that the associative strength did not affect the priming effects at short SOAs, recent studies have shown that there is a correlation between associative strength and the magnitude of priming effect even at short SOAs (Anaki & Henik, 2003; Perea & Rosa, 2002). Besides, there is also evidence that the relative strength of association between two items (prime and target) modulates the strength of the priming effect (Pratarelli, Perry & Galloway, 1994). So, the strong associative strength in the semantically related trials could also be the responsible for the SPE we found in children at a short SOA.

Our results also showed different SPE patterns in the comparison between groups. The magnitude of SPE was not different between children and adults when the SOA was 250ms. However, when the SOA was 500ms, children had larger SPE. This data replicated other studies which found the same result in SOAs larger than 300ms (Schwantes et al., 1980; Simpson & Foster, 1986; Simpson & Lorsbach, 1983). This suggests that when they have time to process the stimuli children rely more on context to take lexical decisions than adults, whose reading proficiency is already established (Schwantes, 1981). Another difference was found in the magnitude of SPE in each group between the SOAs. There was no difference in the magnitude of SPE in adults between the SOAs, but the SPE was larger in children when the SOA was 500ms than when it was 250ms.

Conclusions and final considerations

This study aimed to compare SPE in third graders and college students at two different SOAs (250ms and 500ms). Among the results found, one has differed from the results found so far by other researchers: the presence in children of SPE at the 250ms SOA. The relevance of prime and target characteristics was discussed in order to explore possible explanations for this finding.

Further studies should investigate the age of SPE onset. According to Gathercole (1998), despite consistent results of priming effects in tasks such as word identification and figure fragmentation, there is no consistency in the results when semantic relations are involved. Therefore, other studies have to be carried out in order to analyze how age affects or modulates the SPE.

Besides, this was the first study to compare SPE which used words in Portuguese and that evaluated Brazilian child and adult performance. Taking our study as a starting point, further studies could be designed to investigate the SPE in other grades, ages, neuropsychological and neuropsychiatric conditions. For example, studies have already been done to evaluate SPE in bilinguals (e.g., Perea, Duñabeitia, & Carreiras, 2008), elderly people (e.g., Giffard et al., 2008; Hernández, Costa, Juncadella, & Sebastián-Gallés, 2008), those with Alzheimer`s Disease (e.g., Giffard et al., 2008; Hernández et al., 2008), brain injuries (e.g., Chiarello, Burgess, Richards, & Pollock, 1990) and poor readers (e.g., Betjemann & Keenan, 2008). Furthermore, knowledge of the profile of SPE in different samples allows its application in intervention programs such as in dyslexia and other reading disabilities. Finally, once implicit memory is preserved even in severe cases of explicit memory impairment (e.g., Bolognani, Gouveia, Brucki, & Bueno, 2000; Del Vecchio, Liporace, Nei, Sperling, & Tracy, 2004; Leritz, Grande, & Bauer, 2006), the semantic priming paradigm can be also used in cognitive rehabilitation of various samples of brain-damaged patients.

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APPENDIX 1

Complete listing of stimuli

Word targets	Related primes	Unrelated primes	Primes preceding pseudowords	Pseudoword targets
ABERTO (open)	fechado (closed)	segundo (second)	máquina (machine)	ABARTA
RICO (rich)	pobre (poor)	pilha (pile)	mundo (world)	RUCA
LEVE (light)	pesado (heavy)	tomada (plug)	espaço (space)	LIVA
BRASA (ember)	fogo (fire)	ponto (dot)	sobe (climb)	BRESE
SAL (salt)	açúcar (sugar)	partida (departure)	chapéu (hat)	GAR
DENTE (tooth)	boca (mouth)	cedo (early)	cruz (cross)	DANTO
FRUTA (fruit)	maça (apple)	arma (gun)	rolo (roll)	FRATO
FEIO (ugly)	bonito (beautiful)	branco (white)	concha (shell)	FAIE
FEBRE (fever)	doente (sick)	pacote (packet)	parede (wall)	FETRI
DENTRO (inside)	fora (outside)	azul (blue)	vida (life)	DONTRE
FÁCIL (easy)	difícil (difficult)	piscina (pool)	gravata (tie)	FICEL
NOITE (night)	dia (day)	boi (ox)	ler (read)	NEITO
ANTES (before)	depois (after)	noiva (bride)	blusa (blouse)	ENTOS
ONTEM (yesterday)	hoje (today)	rede (net)	duro (hard)	ANTOM
FINAL (final)	começo (begin)	tomate (tomato)	enxada (hoe)	FONEL
SUL (south)	norte (north)	prova (test)	cinco (five)	DUM
ALEGRIA (joy)	feliz (happy)	lixo (garbage)	lama (mud)	ALOGREA
SAPO (frog)	pular (jump)	pintar (paint)	gritar (scream)	SAMO
MÊS (month)	ano (year)	pia (sink)	rua (street)	MUS
SUJO (dirty)	limpo (clean)	calor (heat)	motor (motor)	SAJO
MAGRO (slim)	gordo (fat)	pedra (stone)	lomba (ramp)	MEGRI
ISCA (bait)	peixe (fish)	padre (priest)	placa (plate)	OSTA
RÁDIO (radio)	música (music)	murcho (withered)	sangue (blood)	RÍDIA
FRALDA (diaper)	bebê (baby)	nome (name)	real (real)	FROLPA
FACA (knife)	garfo (fork)	livro (book)	vidro (glass)	FECO
AREIA (sand)	terra (land)	tema (subject)	vale (valley)	ARAIO
SEDE (thirst)	água (water)	fino (fine)	gibi (comic)	SADU
TOSSE (cough)	gripe (flu)	caixa (box)	avião (airplane)	TASSO
MÃE (mother)	pai (father)	lua (moon)	paz (peace)	NÕE
REI (king)	rainha (queen)	janela (window)	inseto (bug)	RAE
VAZIO (empty)	cheio (full)	louça (dishes)	corda (rope)	VUZIA
FORTE (strong)	fraco (weak)	saída (exit)	faísca (spark)	FARTI
FRIO (cold)	quente (hot)	óculos (glasses)	peças (pieces)	FRAI
LONGE (distant)	perto (near)	caule (stalk)	ração (fodder)	LENGI
TOALHA (towel)	banho (bath)	dúzia (dozen)	pedir (ask)	TAULHA
NATAL (christmas)	presentes (gifts)	cabelos (hairs)	buzinas (horn)	CATOL
ERVA (herb)	chimarrão (mate)	palhaço (clown)	gigante (giant)	IRPA
BOLA (ball)	futebol (soccer)	legume (vegetable)	tijolo (brick)	POBA
MEIA (socks)	pé (foot)	céu (sky)	mil (thousand)	MUIA

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