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Mapping concrete and abstract meanings to new words using verbal contexts

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Abstract

In three experiments, we examine the effects of semantic context and word concreteness on the mapping of existing meanings to new words. We developed a new-word-learning paradigm in which participants were required to discover the meaning of a new-word form from a specific verbal context. The stimulus materials were manipulated according to word concreteness, context availability and semantic congruency across contexts. Overall, participants successfully learned the meaning of the new word whether it was a concrete or an abstract word. Concrete word meanings were discovered and learned faster than abstract word meanings even when matched on context availability. The present results are discussed considering the various hypotheses that have been used to try to explain the 'concreteness effect'. We conclude that the present investigation provides new evidence that the concreteness effect observed in learning is due to the different organization of abstract and concrete conceptual information in semantic memory.

Keywords

concreteness, imageability, meaning acquisition, semantic context, word learning

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I Introduction

Over many years, studies have shown that concrete and abstract words exhibit performance differences. In contrast to abstract concepts, concepts to which concrete words refer can be easily inferred from sensory experiences. For example, the concept *cake* and its corresponding word are associated with many sensory properties (taste, shape, etc.). In contrast, the meaning of an abstract word (e.g. *truth*) is not associated with sensory qualities, and therefore is difficult to imagine. In fact, in order to describe an abstract word we need other abstract concepts, and the contexts and situations that are associated with that word. Concrete words typically show a processing advantage over abstract words (hereafter referred to as the 'concreteness effect'). For example, the processing of concrete words presented in isolation is faster (Kroll and Merves, 1986; Schwanenflugel and Shoben, 1983), and concrete paired associates are usually remembered better than abstract paired associates (Paivio, 1971). Moreover, abstract word naming is slower, and recall is impaired when words are presented without a supportive context (Schwanenflugel and Stowe, 1989; Wattenmaker and Shoben, 1987), likewise, it takes longer to read sentences constructed of abstract words (De Groot, 1989b; De Groot and Keijzer, 2000; Schwanenflugel and Shoben, 1983; Schwanenflugel et al., 1988).

In the present study we investigated if the concreteness effect extends also to discovering the meaning of novel words from a verbal context. Specifically, participants had to discover the meaning of a new concrete or abstract word in a contextual learning task. The present introduction is organized with the aim of integrating pertinent information from different research fields, namely first and second language learning, cognitive psychology and neuropsychology. First, we review the main theoretical accounts for the concreteness effect from cognitive psychology and neuropsychology. We then describe findings from first and second language acquisition literature relevant to concrete vs. abstract word learning and processing. Finally, we introduce the contextual learning approach and discuss the main problems associated with this type of learning.

1 Different theoretical accounts of the concreteness effect

Schwanenflugel et al. (1983) found similar lexical decision times for abstract and concrete words when presented as the last word of a sentence. A follow-up study showed that final abstract sentences of a paragraph exhibited no differences in free recall when compared to concrete sentences, which was not the case when sentences were presented without the paragraph (Wattenmaker and Shoben, 1987). The authors proposed the context availability theory, which argues that the difference between concrete and abstract words is only quantitative: the key process in comprehension of an isolated word is assigning a framework or context to that word. This is easier for concrete words because more contextual information exists in semantic memory (Schwanenflugel and Shoben, 1983; Schwanenflugel and Stowe, 1989). When abstract words are provided with an external context, such as a supportive sentence stem, they are processed as efficiently as concrete words. A further confirmation of this hypothesis came from a study in which concreteness effects disappeared in lexical decision when concrete and abstract words were matched on context availability (Schwanenflugel et al., 1988; Van Hell and De Groot, 1998a).

From the context availability theory perspective, the difficulty in recruiting the context of abstract words is thought to derive from the fact that these words tend to appear in a wider range of contexts and have more facets of meaning (Schwanenflugel and Shoben, 1983). Considering a spreading activation model of semantic memory (Collins and Loftus, 1975), the recruitment of a specific piece of information is more difficult if more information is connected to a concept (the 'fan effect'; Anderson, 1983; Schwanenflugel and Shoben, 1983). A supporting context helps to focus on specific information in the case of abstract words. In other words, concrete words do not benefit as much from an external context because they already have strong and stable core meanings (Schwanenflugel and Shoben, 1983; Schwanenflugel and Stowe, 1989; see also Saffran et al., 1980).

An alternative quantitative account of the concreteness effect postulates that it arises because concrete words are supported by more semantic features that are consistently accessed than abstract words (Plaut and Shallice, 1993). This hypothesis was proposed in order to explain the strong concreteness effect observed in deep dyslexia patients (Coltheart et al., 1980). In these patients, reading concrete errors was easier when compared to reading abstract ones, this difference being very large in some patients (73% vs. 14% in the patient described in Shallice and Warrington, 1975). In the connectionist model of reading developed by Plaut and Shallice (1993), concrete words are endowed with more semantic features than abstract words. When the word-processing system in their model is 'damaged', abstract words are more difficult to retrieve because they have fewer semantic features. This model has also been able to explain the reverse pattern, i.e. a processing advantage for abstract words which has been observed in some neuropsychological patients (Warrington, 1981; see also Bonner et al., 2009; Breedin et al., 1994).

These different approaches could be joined together considering the proposal that concrete and abstract words might have differences in the density of their conceptual networks in memory (Schwanenflugel and Shoben, 1983). Interestingly, the density among proximal semantic representations has been proposed as one of the main factors affecting semantic retrieval (Rogers et al., 2004). These differences in the density of semantic representations of both types of words might be reflected in the differences in the context availability ratings. Concrete words are strongly associated to a relatively small number of concepts, and they therefore develop more consistent and denser information than abstract words, which might facilitate the assignment of a specific context to the target word. In this case, contextual information is not further required and does not facilitate concrete word comprehension (Wattenmaker and Shoben, 1987). Instead, abstract conceptual representations are more branched and elaborated, more weakly associated with many concepts in the semantic memory, and therefore the conceptual network developed might become less dense. This organization might explain the dependency of abstract words on linguistic contexts (context-dependent properties) in order to specify their correct meaning (Barsalou, 1982; Breedin et al., 1994), while concrete words have more context-independent properties that are more easily accessed when the words occur in isolation.

In contrast to the previous approaches, which emphasize quantitative differences between concrete and abstract words, other models feature qualitative differences. Among these, Paivio's dual coding theory (Paivio, 1971, 1986, 2006) has received much attention. It attributes the disadvantage of abstract words to a lack in direct sensory referents that is typical for concrete words (Paivio, 1971). The theory assumes two cognitive subsystems: one specialized for the representation and processing of nonverbal objects/events (i.e. imagery), and the other specialized in verbal information. According to this account, the difference between concrete and abstract words results from image representations stored only for concrete words. In this sense, concrete and abstract words are qualitatively different, as each system is supposed to be functionally distinct, although some connectivity exists between them. Both verbal semantic information and nonverbal imagistic information are stored for concrete words, while abstract words are associated mainly with information stored in the verbal system. Processing concrete words activates linguistic semantic information as well as imagistic information, resulting in faster processing. In a similar fashion, Allport (1985) proposed a model for high-imaginable words in which a multimodal representation exists based on their sensory properties, with connections between them established by their natural co-occurrence (see also Breedin et al., 1994; Damasio, 1989; Martin, 2007; Saffran and Sholl, 1999).

Congruent with this approach, activation in the fusiform gyrus has recently been reported when learning new concrete words (Mestres-Missé et al., 2009). The fusiform gyrus is a region of the inferior temporal cortex associated with high-level visual processing (Ishai et al., 2000). Therefore, its activation for concrete words might be attributed to the easiness of mental generation of the visual features represented by concrete concepts. This result is congruent with several neuroimaging studies that have reported greater involvement of this region for concrete words (D'Esposito et al., 1997; Mellet et al., 1998; Mestres-Missé et al., 2009; Wise et al., 2000; for a recent review, see Wang et al., 2010). Moreover, neuropsychological studies of patients with lesions in the inferior temporal cortex tend to show a selective preservation of abstract compared to concrete concepts (Breedin et al., 1994; Marshall et al., 1996; Warrington, 1981; Warrington and Shallice, 1984). Thus selective activation of this region for concrete words, and new concrete word learning in Mestres-Missé et al. (2009), directly confirmed the predictions of the dual-coding theory (Paivio, 2006), which proposes that the nonverbal imagery symbolic system in concrete words should activate several brain regions of the ventral visual, or 'object properties processing' pathway. Previous studies also have supported the involvement of these regions in visual imagery (see meta-analysis in Thompson and Kosslyn, 2000).

From a different perspective, Wiemer-Hastings and Xu (2005) also proposed that abstract concepts are relational concepts characterized by their links to external concepts, rather than to intrinsic properties. As these relational concepts vary widely across situations, their properties are quite unspecific, more linked to personal experiences, interactions and situations. On the contrary, concrete concepts represent objects along with all their attributes, functions, parts, actions, relations to other objects and so on (see also Barsalou and Wiemer-Hastings, 2005).

Corroborating a qualitative distinction between concrete and abstract words, Crutch and Warrington (2005) suggested that concrete and abstract words have different principles of organization in semantic memory: The organizational principle of abstract words is associative, while concrete words show a categorical organization (Crutch, 2006; Crutch and Jackson, 2011; Crutch and Warrington, 2005, 2007, 2010; Crutch et al., 2009). The authors studied a patient with semantic refractory access dysphasia, which is a semantic memory access impairment characterized by refractoriness. Refractoriness has been described as 'the reduction in the ability to utilize the system for a period of time following activation' (Warrington and McCarthy, 1983: 874). Typically performance is facilitated if the delay between a response and the presentation of the next stimulus is increased. Refractoriness can be observed between related concepts because the activation of one representation leads to the partial activation of other related representations that presumably share neural space. The authors tested semantic similarity and semantic association as competing principles of organization of abstract and concrete word semantics. For concrete words, semantic similarity was measured by the membership to a common semantic category (*melon – peach*); for abstract words, this relationship was measured using synonyms and groups of words that formed coherent semantic clusters (*divine – religious*). Semantic association was defined as those words whose meanings are not synonymous but which are often bound together in real world sentential contexts (e.g. *farm – tractor; eat – bite*). Interestingly, the authors did not detect semantic relatedness effects among synonymous abstract words, while in contrast this effect was clearly observed for concrete word stimuli. Abstract words showed larger refractoriness effects for associated than synonymous abstract words, suggesting that these types of words are represented in an associative neural network. In contrast, the reverse pattern was observed for concrete words, which provided evidence for their categorical organization in semantic memory (Crutch and Warrington, 2005).

In sum, all these previously exposed models postulate that the representation of concrete words includes an additional component that facilitates its access, activation and further remembering: (1) an additional nonverbal (image-like) representation linked to sensorimotor information, (2) more semantic features, (3) greater availability of contextual information, or (4) a categorical vs. associative organization. Nonetheless, it should be noted that the qualitative vs. quantitative distinctions proposed between concrete and abstract words oversimplify matters. Depending on its degree of abstractness, an abstract word may give rise to one or several mental images (e.g. the word *love* could be associated to a kissing couple). Thus, instead of a strict categorical distinction between concrete and abstract words, abstractness/concreteness might be better conceptualized as a quantitative trait (more imaginable/concrete vs. less imaginable/concrete).

This distinction between the perceptual-based representation vs. the pure linguistic-representation of concrete and abstract words have been recently used as a test-bed for the embodied theories of language representation, according to which language is grounded in perception, action and emotional systems (Barsalou, 2008; Fischer and Zwaan, 2008; Gallese, 2008; Scorolli et al., 2011). Importantly, a neglected aspect in this type of research is the learning process: how words and their underlying conceptual representations are learned across life. A crucial, but sometimes forgotten distinction is that abstract words are mostly learned later during infant development due to the requested support of extended semantic contextual information. This feature is critical and denotes the important ability of infants and adults to infer the meaning of new words from verbal mediated information (discourse, contexts, etc.). The neural processes involved in this extraordinary capacity have recently been the target of several studies (Mestres-Missé et al., 2007, 2008), as well as others related to language learning in adults (Breitenstein et al., 2005; Davis and Gaskell, 2009; Dobel et al., 2010; De Diego-Balaguer et al., 2011).

2 Language acquisition of concrete and abstract words

The different theories reviewed above emphasize that the main difference between the representation of concrete and abstract concepts is that the former entail additional information. These differences might reflect the way in which these words have been learned. Young children learn concrete and abstract words at different rates. Children's first vocabularies are formed mostly of concrete words, as they are restricted to the information that is accessible through observation of the material world (extralinguistic information), that is, to the world-to-word pairing (Bloom, 2000; Gillette et al., 1999; Snedeker and Gleitman, 2004).

Specifically, Gillette et al. (1999) pointed out that only a small and limited stock of nouns can be acquired solely from extralinguistic information, whereas learning other types of words (such as verbs or conjunctions) requires, in addition, the linguistic context information (sentence-to-world pairing). In order to test this idea, Gillette et al. investigated word learning (nouns vs. verbs) from several information sources. To evaluate the effect of information change independent of conceptual change, they employed the human simulation approach. These experiments are conceived as 'simulations' in which an adult learner is exposed to information of the kind naturally received by the infant learner being simulated. The underlying objective is to observe how well the adult simulation emulates the real child learning. Parallel findings in infants and adult second language learners would dismiss the possibility that the effects observed are due to limitations of immature cognitive mechanisms during the period of life in which infants are evaluated (Gillette et al. 1999). In a sense this approach is an analogy of computer simulations, but instead of computers, human adults are used as simulation devices. In these experiments, adult participants had to identify simple words (masked by a beep or a nonsense word) under varying informational circumstances. Words were chosen from those most frequently encountered by English-learning children during the first 2 years of life. Nouns were identified more efficiently than verbs and concrete verbs more efficiently than abstract verbs, if the information provided to participants was limited to extralinguistic observation (videotaped recordings of mother–infant interactions).

Even though Gillette et al.'s experiment was aimed at studying the learning of nouns vs. verbs, imageability of the target words best explained the results. In a second experiment imageability was controlled and concrete items were learned better than abstract items. The authors concluded that in the first stages of life an infant is limited to the information provided by the environment, and thus the words labeling concrete concepts (mostly nouns but also some concrete verbs, such as *throw*) are easier to acquire. Abstract words on the other hand cannot be learned until a certain representational capacity is reached that permits the utilization of linguistic contexts in order to unravel the meaning of these words (Bloom, 2000).

Effects of word concreteness have also been shown in second language acquisition (De Groot and Keijzer, 2000; Van Hell and Candia-Mahn, 1997). Importantly, second-language learners (compared to infants) do not begin the learning process from scratch because concepts for most concrete and abstract words to be learned (together with their first language labels) are already stored in memory. Adults more easily acquire concrete words of a second language, and recall them better and faster (De Groot, 2006; De Groot and Keijzer, 2000; Van Hell and Candia-Mahn, 1997). Moreover, fluent bilinguals translate concrete words faster and more accurately (De Groot and Poot, 1997; Van Hell and De Groot, 1998a, 1998b). De Groot and Keijzer (2000) suggested that these effects stemmed from differences between the memory representation of concrete and abstract words. Whereas corresponding concrete words in the first and second language may share larger parts of the conceptual representation, abstract concepts might not share exactly the same meaning representation across languages and cultures due to their dependence on extrinsic features (Dong et al., 2005; Kroll and Tokowicz, 2001; Van Hell and De Groot, 1998b).

3 Contextual new-word-learning approach

We devised a new-word-learning task, which required young Spanish speaking adults to infer the meaning of concrete and abstract new words solely from contextual information. Using self-paced reading, we simulated the on-line mapping of existing concrete and abstract concepts, inferred from verbal contexts, onto new words. Although many studies have addressed the processing advantage of concrete words, differences in adults' learning of concrete and abstract words from verbal contextual information have not been fully investigated.

Contextual learning of new words is a powerful mechanism that permits the discovery of the meaning of new words across the lifespan. Children need to learn thousands of words, and it is supposed that most of them are learned through contextual information. It has been estimated that students in the middle grades encounter between 16,000 and 24,000 new words (Nagy et al., 1987; Nation, 2001) within the approximately one million words of text to which they are exposed annually (Nagy et al., 1985). This means that a typical seventh grader has to learn the meaning of 10 to 15 new words per day, and mostly by using contextual information during reading because (1) the majority of English words are used only in print and not in normal speech, (2) most of the words usually used in normal speech have already been acquired, and (3) children learn to use fewer than one new word per day by direct instruction of its meaning (Durkin, 1979).

Other estimations see a less pivotal role for contextual learning (for a clarifying exposition, see Landauer and Dumais, 1997). Some studies have reported that children do not discover more than one new meaning every 20 paragraphs. As children normally read an average of 50 paragraphs per day (Carver, 1990), no more than 2.5 words per day could be learned from context. Some authors have even stated that word meanings might not be learned from ordinary reading (Carver and Leibert, 1995). This conclusion was drawn because students who read relatively easy library books during six weeks did not improve reading level, vocabulary.

Some authors have proposed that the way in which the different studies evaluated the degree of learning of new words may not have been appropriate, and that children accrue only partial semantic knowledge of the new words, which will be filled and completed with additional exposures (see Landauer and Dumais, 1997; McGregor et al., 2002). This 'slow mapping' process is supposed to occur in children among several new words and their corresponding referents and meanings. Although this contrasts with the well-known fast mapping process (the acquisition of a new word meaning from one or a very small number of incidental exposures; Carey, 1978), slow mapping may be triggered subsequent to the fast mapping process. Initially, a fragile new word representation is created in the lexical memory, and the child might begin to hypothesize about its meaning, updating this semantic representation until it perfectly maps the relationship between the word, the referent, and its related concepts. From this perspective, word learning is considered a more gradual process in which word representations are progressively developed and refined over time through multiple exposures (Bloom, 2000; McGregor et al., 2002; Snedeker and Gleitman, 2004). Curtis (1987) proposed four stages of the development of word knowledge: (1) no knowledge of the new word is present ('I never saw it before'), (2) some emerging knowledge is possible (e.g. 'I've heard this word, but I do not know what it means'), (3) describing contextual knowledge ('I can recognize it in context …'), and (4) referencing full knowledge ('I know it').

In order to study how word meaning is determined from reading, several studies presented new words (low frequency or unknown words at that particular age) and embedded them in carefully controlled sentences or contexts (e.g. Jenkins et al., 1984; Sternberg, 1987). Here, to study the concreteness effect, we embedded new words referring to concrete and abstract meanings in three- or two-sentence contexts and evaluated the mean reading times when participants encountered the target new words. In a previous study, we evaluated whether new concrete words could be learned from semantic information provided by sentence contexts (i.e. contextual learning) (Mestres-Missé et al., 2007; see for a review, Rodriguez-Fornells et al., 2009) (see Figure 1). Whereas in one condition the meaning of a new concrete word could be learned from contextual information, an incongruent semantic context was presented in the second condition, which precluded the discovery of the meaning of the new word. Contextual information was provided by three different sentences with increasing degrees of contextual constraint or cloze probability. The results of this experiment showed that reading times in our contextual learning paradigm were driven by the possibility of meaning extraction across the three sentences. As sentences proceeded, reading times for the new word embedded in an incongruent context progressively increased, while differences between new words in congruent contexts and real concrete words disappeared by the third sentence. These results suggest that the meaning of a new concrete word can be inferred from congruent contextual information very quickly with the result that this new word is processed as quickly as a real concrete word on its third exposure.

Based on previous hypotheses related to the existence of qualitative differences in the representations of concrete vs. abstract words and their organization in semantic memory (Breedin et al., 1994; Crutch, 2006; Crutch and Jackson, 2011; Crutch and Warrington, 2005, 2007, 2010; Crutch et al., 2009; Dunabeitia et al., 2009; Wiemer-Hastings and Xu, 2005), we would predict a facilitation for learning the meaning of concrete compared to abstract new words independently of equally supportive linguistic context and/or context availability. On the other hand, based on the context availability theory, we would predict either no difference between concrete and abstract new words when contextual information is provided, or that if a difference is demonstrated, it would disappear when context

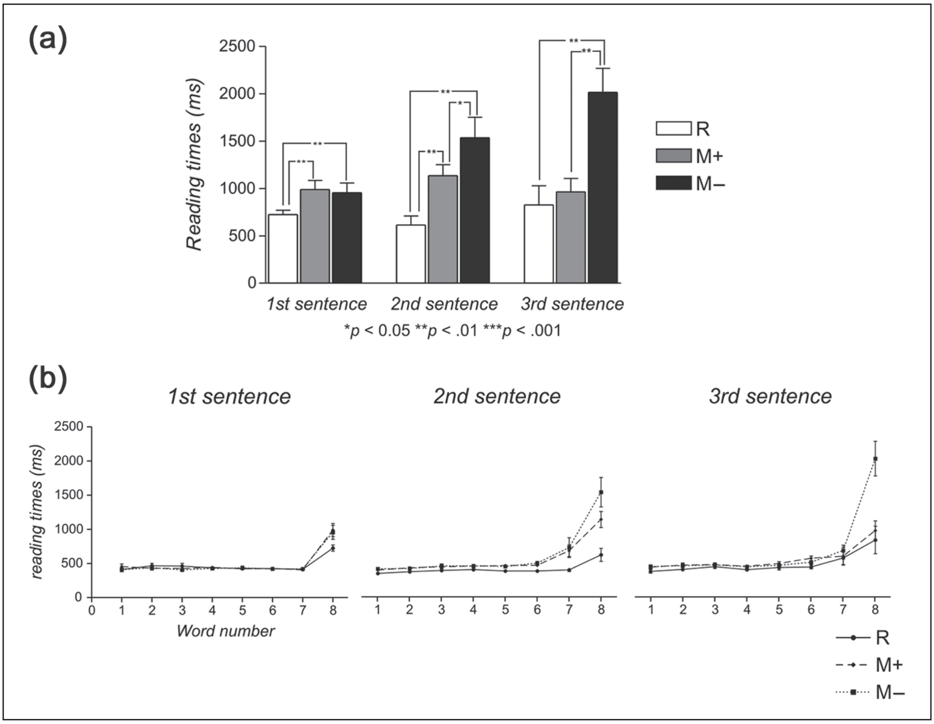

Figure 1. (a) Mean reading times to the target concrete word (8th word) in each sentence for each condition in a previous experiment (Mestres-Missé et al., 2007). (b) Mean self-paced reading times for different word positions and sentences.

availability is matched. In Experiment 1 we examined the effects of semantic congruency in learning abstract new words from contextual information; this experiment was then compared to a previous one in which we had studied concrete word learning using the same paradigm. Experiment 2 investigated in the same experimental set-up concrete and abstract word learning. Finally, Experiment 3 directly tested the context availability theory by comparing the learning of concrete and abstract words with balanced context availability.

II Experiment 1: New abstract word learning

The question we asked in this experiment was whether the learning of an abstract new word from contextual information followed the same acquisition pattern as that shown for concrete items in a previous experiment (Mestres-Missé et al., 2007).

1 Method

a Participants. Eighteen undergraduate Spanish–Catalan[1] bilingual students from the University of Barcelona (mean age 21.2 ± 1.6 years; 6 men; 12 women) participated in this experiment for bonus credits in psychology courses.

b Task and design. Participants were required to read triplets of sentences in order to discover the meaning of a novel word, which appeared at the end of each sentence. Two conditions were created, one in which a new-word meaning could be extracted and created, or the meaningful condition (Ma+):

(1) a. Estos dos grupos siempre compiten por el pepo. [*These two groups always compete for pepo.*]
b. El esquiador bajaba por la ladera sin pepo. [*The skier went down the slope out of pepo.*]
c. No te preocupes tanto, todo está bajo pepo. [*Don't worry too much, everything is under pepo.*]

And one condition in which the new-word meaning could not be resolved across the sentences, or the non-meaningful condition (Ma–):

(2) a. Hizo todo este esfuerzo para demostrar su pesea. [*He made all this effort to demonstrate his pesea.*]
b. Después de la absurda guerra llegó la pesea. [*After the absurd war came the pesea.*]
c. Juan es muy mentiroso nunca dice la pesea. [*Juan is a liar; he never tells the pesea.*]

Hereafter, 'M' stands for new-word meaning, 'R' stands for real-word, '+' for congruent, '–' for incongruent, 'c' for concrete and 'a' for abstract. In this regard, for example, Ma+ stands for a condition in which a congruent context (+) exists that permits the inference of the meaning (M) of an abstract (a) new word.

Novel words (like 'control' for *pepo*) respected the phonotactic rules of Spanish and were thus pronounceable and corresponded to abstract Spanish nouns of medium frequency. A third condition was presented in which real words (Ra) were used. In order to minimize possible differences due to phrase construction, sentences were systematically rotated among the three critical conditions (Mestres-Missé et al., 2007).

Two pilot studies were carried out in order to determine the 'cloze probability' of each sentence and meaning inference. Cloze probability was assessed by presenting each sentence in isolation to 75 first-year psychology students. Participants were required to complete the sentence with the first word that came to their mind and that fit well with the sentence. A second pilot study was conducted in order to determine the percentage of correct meaning identification after reading the three sentences sequentially. The groups of three sentences were presented to 19 first-year psychology students, who were asked to report the word that fitted after reading the three sentences. These results were used to match the different experimental conditions.

c Stimuli. The target words were 36 new words corresponding to abstract nouns (Appendix 1). All of them were frequent words in Spanish (mean frequency of 130.5 per million). On seven-point Likert-scales (1 = low, 7 = high) all of the words were rated to be low imageability (mean score 3.6) and low concreteness (mean score 3.4). In all reported experiments, the database BuscaPalabras (Davis and Perea, 2005) was used for frequency, imageability and concreteness measures. Three lists of 12 sets of three sentences were created (36 sentences per list). Each list presented to the participants was comprised of 12 meaningful triplets, 12 non-meaningful triplets and 12 triplets of real sentences. Mean cloze probability was: first sentence (low constraint) 5.9% (SD = 7.4), second sentence (medium constraint) 45.7% (SD = 15.7), and third sentence (high constraint) 86.7% (SD = 12.2). The probability of meaning identification was 97.85% (SD = 3.74). The assignment of the experimental condition (Ma+, Ma– and Ra) was systematically rotated among the three groups of 12 sentences in the three lists created. In order to build the sentence triplets for Ma–, the sentences were mixed to result in a different combination of sentences 1, 2, and 3. Thus, the meaning of the new word could not be resolved across the three sentences. For the control condition, we used the same triplets of meaningful sentences but replaced the new word by the corresponding real word.

d Procedure. We used a non-cumulative moving-window methodology (Mitchell, 1984) because it ensures that the participants carefully read each word. Sentences were presented sequentially in triplets in a one-word-at-a-time window format. After the presentation of the three sentences, a prompt was shown requiring the participants to write down the meaning of the new word or a synonym in the case of real words.[2] When a sentence appeared on the screen all characters were replaced by a dash (e.g. ---- --- ---- ---). The participants pressed the space bar to reveal the first word (The ---- --- ----) and each subsequent button press revealed the next word and replaced the previous word with dashes (e.g. --- house --- ----). The participants read the three sentences of a triplet in this manner and then reported the meaning of the new word. One-word-at-a-time reading latencies were recorded as the time interval between successive button presses.

2 Results

Two participants were removed from the analysis, because their percentage of meaning extraction was below 65%. The remaining participants identified the meaning of the new words in 85.4% (± 9.9%). Contexts where the participant could not discover the meaning of the new word, as determined by either omissions or incorrect responses, were excluded from the analysis (14.5%). In addition, reading times more than 2.0 standard deviations above or below the mean for a given participant in all conditions were also excluded (4.8%).

Reading time analysis for the target word (8th word in each sentence) was performed (Figure 2a, Table 1). Participants (*F*1) and items (*F*2) ANOVAs were conducted based on a 3 × 3 ANOVA design introducing Condition (Ma+ vs. Ma– vs. Ra) and Learning (1th vs. 2nd vs. 3rd sentence).

The analysis showed a main effect of Condition [$F1(2,30) = 30.2$, $p < .001$, η_p^2 .67; $F2(2,70) = 59.5$, $p < .001$, η_p^2 .63], a main effect of Learning [$F1(2,30) = 15.1$, $p < .001$, η_p^2 .50; $F2(2,70) = 64.3$, $p < .001$, η_p^2 .65], and a significant interaction between these factors [$F1(4,60) = 13.8$, $p < .001$, η_p^2 .48; $F2(4,140) = 21.98$, $p < .001$, η_p^2 .38]. Separate ANOVAs for each condition showed a learning effect in the Ma+ condition [$F1(2,30) = 13.5$, $p < .001$, η_p^2 .47; $F2(2,70) = 5.87$, $p < .008$, η_p^2 .14], Ma– condition [$F1(2,30) = 15.8$, $p < .001$, η_p^2 .51; $F2(2,70) = 58.01$, $p < .001$, η_p^2 .62], and Ra condition [$F1(2,30) = 6.3$,

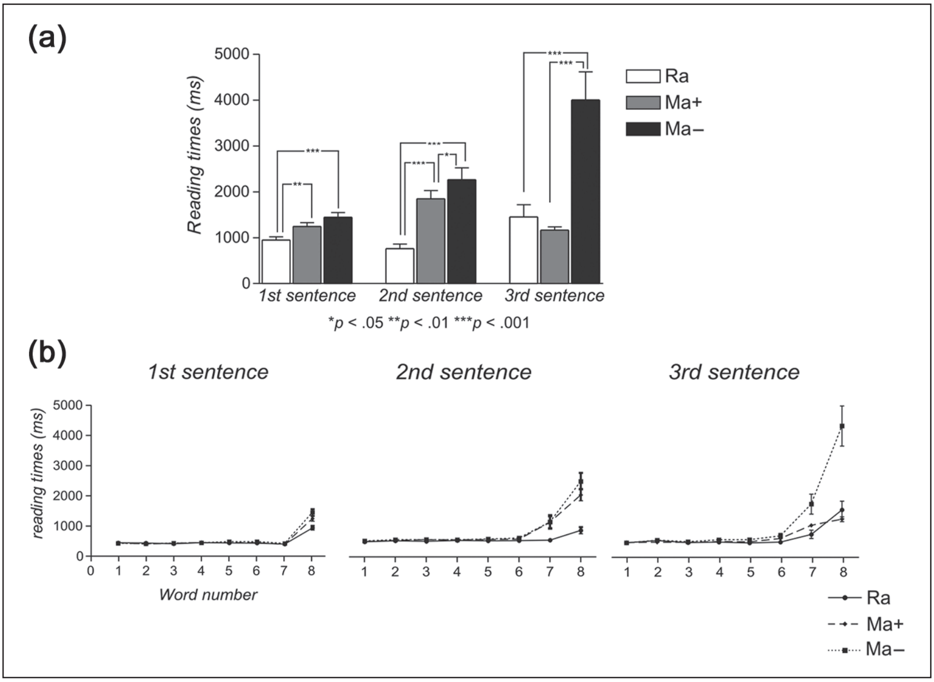

Figure 2. (a) Mean reading times to the target abstract word (8th word) in each sentence for each condition (Experiment 1). (b) Mean self-paced reading times for different word positions and sentences.

$p < .02$, η_p^2 .30; $F2(2,70) = 18.96$, $p < .001$, η_p^2 .35]. For the Ma– condition, a pattern of increasing reading times was observed as sentences proceeded. Ma+ and Ra showed a different pattern of reading times. For Ma+, there was an increase in reading times on the second sentence followed by a decrease on the third sentence. Contrary to what was found in the Ma+ condition, real words showed a decrease in reading time on the second sentence followed by an increase on the third sentence (see Figures 2a and 2b).

Significant differences were also found when comparing reading times to the target word in the different conditions for the 1st sentence [$F1(2,30) = 15.5$, $p < .001$, η_p^2 .51; $F2(2,70) = 13.9$, $p < .001$, η_p^2 .28], as well as in the 2nd [$F1(2,30) = 29.4$, $p < .001$, η_p^2 .66; $F2(2,70) = 48.29$, $p < .001$, η_p^2 .58] and 3rd sentence [$F1(2,30) = 19.3$, $p < .001$, η_p^2 .56; $F2(2,70) = 35.4$, $p < .001$, η_p^2 .50].

Pairwise comparisons on participants means ($t1$) and items means ($t2$) for the 1st sentence showed significant differences between both new-word conditions and real words [Ma+ vs. Ra: $t1(15) = 3.6$, $p < .002$; $t2(35) = 4.01$, $p < .001$; Ma– vs. Ra: $t1(15) = 7.08$, $p < .001$; $t2(35) = 6.1$, $p < .001$], but not between new-word conditions ($t1 = -1.7$; $t2 < 1$) (see Figure 2a left).

These differences between new-word and real-word conditions were maintained in the 2nd sentence, with larger reading times for new-word conditions [Ma+ vs. Ra:

Table 1. Reading times to the target word in each sentence for the three experiments presented in this article and a previous experiment.

	Reading times last word (target) (ms)		
	1st sentence	2nd sentence	3rd sentence
Experiment 1:			
New-word meaning	1245 (83)	1850 (179)	1166 (70)
New-word no-meaning	1442 (104)	2264 (260)	4003 (610)
Real-word	948 (69)	760 (101)	1450 (267)
Experiment 2:			
New-word meaning concrete	890 (80)	779 (65)	–
New-word meaning abstract	1052 (103)	1617 (135)	–
Real-word concrete	670 (50)	659 (49)	–
Real-word abstract	754 (47)	892 (98)	–
Experiment 3:			
New-word meaning concrete	1357 (96)	1087 (90)	–
New-word meaning abstract	1218 (91)	1449 (125)	–
Experiment in Mestres-Missé et al., 2007:			
New-word meaning	992 (96)	1130 (118)	966 (141)
New-word no-meaning	954 (102)	1535 (216)	2014 (253)
Real-word	725 (45)	614 (96)	927 (201)

Notes. Performance data (reading time) in Mestres-Missé et al. (2007) were reanalysed using the same cleaning procedure as in the experiments reported here. Standard error of the mean are given in parentheses.

$t1(15) = 6.8$, $p < .001$; $t2(35) = 9.7$, $p < .001$; Ma– vs. Ra: $t1(15) = 6.2$, $p < .001$; $t2(35) = 8.6$, $p < .001$]. Furthermore, differences between both new-word conditions appeared [$t1(15) = -2.08$, $p < .05$; $t2(35) = -1.8$, $p < .07$]. Ma– was the condition that showed longer reading times for the target word (see Figure 2a middle).

Finally, in the third sentence, participants showed significantly longer reading times to the target word in the Ma– condition when compared to the other two conditions [Ma+ vs. Ma–: $t1(15) = -4.9$, $p < .001$; $t2(35) = -6.8$, $p < .001$; Ma– vs. Ra: $t1(15) = 4.3$, $p < .001$; $t2(35) = 7.3$, $p < .001$], which did not show differences in this third sentence ($t1 < 1$; $t2 < 1$) (see Figure 2a right).

3 *Discussion*

The present results showed differences in the processing of sentences depending on the possibility of meaning extraction for abstract words across the three sentences. As was the case for concrete words in a previous experiment, new abstract words were successfully learned from congruent contextual information and were processed as fast as real abstract words on their third exposure. Thus, a similar pattern as in the concrete words experiment was observed.

A closer inspection of the results suggests that the difference in reading times between new-word meaning and real-word conditions for the second sentence is larger than the difference observed for concrete words (Figure 1). This apparent difference between the concrete and abstract word experiments disappeared for the third sentence, for which the new-word meaning condition was processed as fast as the real word in both experiments. In the next section we briefly evaluate these differences in new concrete and abstract word learning by comparing both experiments directly.

4 Comparison of Experiment 1 (abstract word learning) vs. Mestres-Missé et al., 2007 (concrete word learning)

Based on previous literature (De Groot, 2006; De Groot and Keijzer, 2000; Van Hell and Candia-Mahn, 1997), we expected that the identification of the meaning for abstract new words would be slower than for concrete words (a main concreteness effect; Kroll and Merves, 1986; Paivio, 1971; Schwanenflugel and Shoben, 1983; Schwanenflugel and Stowe, 1989). The context availability theory (Schwanenflugel and Shoben, 1983; Schwanenflugel and Stowe, 1989) would predict longer reading times for abstract words only in the first sentence if not enough contextual information is provided. However, as contextual information accrues, concrete and abstract words should be processed equally fast; thus, no differences between both should be found on the second sentence according to this theory.

Although abstract words had a lower percentage of meaning extraction when compared to concrete words, this difference was not significant ($t = -1.54$, $p = .1$; concrete: 91.6 ± 9.5%; abstract: 85.4% ± 9.9%). A repeated measures ANOVA with Learning (3 levels, 1st sentence, 2nd sentence and 3rd sentence) and Condition (M+, M– and R) as within-participant factors and Imageability/Concreteness (concrete and abstract) as a between- participant factor showed that, in general, abstract words were processed slower than concrete words. Furthermore, real words were processed faster than new words and significant differences in reading times were observed across the three sentences (see Table 2).

Concreteness effects (faster reading times for concrete than abstract words) were further evaluated using direct pairwise comparisons of the target word in each sentence position. The reading time for the real abstract word was longer than for the real concrete word only in the first sentence [R condition: 1st sentence $t1(32) = -2.7$, $p < .009$; $t2(70) = -4.7$, $p < .001$; 2nd sentence $t1 = -1.04$, $p = .303$; $t2(70) = -3.7$, $p < .001$; 3rd sentence $t1 = -1.8$, $p = .06$; $t2(70) = -5.08$, $p < .001$]. In the new-word meaning (M+) condition, this effect was observed during the first (marginally) and the second sentences but not in the third sentence: 1st sentence $t1 = -2.01$, $p = .053$; $t2(70) = -3.5$, $p < .001$; 2nd sentence $t1(32) = -3.4$, $p < .002$; $t2(70) = -4.9$, $p < .001$; 3rd sentence $t1 = -1.2$, $p = .22$; $t2(70) = -2.3$, $p < .01$. In contrast, in the new-word no-meaning (M–) condition, the concreteness effect was observed across the three sentences [1st sentence $t1(32) = -3.3$, $p < .002$; $t2(70) = -6.02$, $p < .001$; 2nd sentence $t1(32) = -2.1$, $p < .03$; $t2(70) = -3.9$, $p < .001$; 3rd sentence $t1(32) = -3.1$, $p < .004$; $t2(70) = -6.09$, $p < .001$].

Table 2. Three-way repeated measures ANOVAs for Experiment 1 compared to experiment in Mestres-Missé et al. (2007) and Experiment 2.

	Experiment 1 vs. Mestres-Missé et al., 2007			Experiment 2		
	df	*F* value	η_p^2 value	df	*F* value	η_p^2 value
Learning	*F1*(2,64)	24.93***	.44	*F1*(1,23)	7.96**	.26
	F2(2,140)	83.64***	.54	*F2*(1,38)	6.22*	.14
Condition	*F1*(2,64)	45.18***	.58	*F1*(1,23)	20.88***	.47
	F2(2,140)	124.68***	.64	*F2*(1,38)	47.08***	.55
Imageability/ concreteness	*F1*(1,32)	14.6***	.31	*F1*(1,23)	65.27***	.74
	F2(1,70)	109.5***	.61	*F2*(1,38)	14.54***	.28
L × C	*F1*	ns		*F1*	ns	
	F2	ns		*F2*	ns	
L × I/C	*F1*(2,64)	5.1**	.14	*F1*(1,23)	37.12***	.62
	F2(2,140)	19.8***	.22	*F2*(1,38)	12.72***	.25
C × I/C	*F1*(2,64)	5.4**	.14	*F1*(1,23)	14.7***	.39
	F2(2,140)	8.07**	.10	*F2*(1,38)	6.54*	.15
L × C × I/C	*F1*(4,128)	4.1**	.11	*F1*(1,23)	9.64**	.29
	F2(4,280)	5.07**	.07	*F2*(1,38)	8.43**	.18

Notes. learning (L); condition (C); imageability/concreteness (I/C); df = degrees of freedom; *F1* = participants analysis; *F2* = items analysis; *$p < .05$; **$p < .01$; ***$p < .001$; ns = not significant.

However, as can be observed, the analysis on items showed concreteness effects throughout all sentences and conditions.

Whereas both concrete and abstract word meanings were derived from contextual information, the largest concreteness effects were observed in the second sentence in the M+ condition, but this effect disappeared at the end of the third sentence. Most likely participants had discovered the meaning of most new words at the end of the second sentence, and therefore no concreteness effect arose at the end of the third sentence. Nevertheless, the item analysis showed significant differences on the third sentence and, in consequence, the concreteness effect might have remained throughout the three sentences. The pronounced concreteness effect in the second sentence in the M+ condition cannot be explained by a greater cloze probability of the second sentence in the concrete condition.[3]

The results for the third sentence suggest that sufficient contextual information is already available, which facilitates the integration of the meaning of concrete and abstract new words. This is evidenced by the fact that reading times were similar for new words and real words in the third sentence.

Finally, striking differences were observed between the new words embedded in incongruent abstract and concrete sentences (M–) for all three sentences. For example, the reading time for the new-word abstract M– condition at the third sentence was approximately twice as long as that for the concrete sentence condition (4,003 ms vs. 2,014 ms). We will further expand on the possible implications of this interesting finding in the general discussion.

III Experiment 2: Concrete vs. abstract word learning

To more directly compare the learning of concrete and abstract words, a second experiment was performed in which imageability/concreteness was manipulated using a within-participant design. As in the previous experiments, participants were asked to discover the meaning of new concrete or abstract word forms from a verbal context, which were randomly intermixed. The general design and procedures of this experiment were similar to the previous experiments, but to avoid an overly long experiment the M– condition was removed and only two sentences instead of three were used.

For new words we predicted an interaction between Imageability/Concreteness (concrete, abstract) and Learning (1st, 2nd sentence presentations). A large increase in the reading times should be observed for the new-word abstract condition at the end of the second sentence when compared to the concrete new-word condition.

1 Method

a Participants. Twenty-four undergraduate Spanish–Catalan bilingual students from the University of Barcelona (mean age 21 ± 1.3 years; 8 men; 16 women) participated in this experiment for bonus credits in psychology courses.

b Task and design. Participants were required to read pairs of sentences. Two conditions were created, one in which the new words appearing in the terminal position were concrete (Nc) and one condition in which the new words were abstract (Na). New words respected the phonotactic rules of Spanish and were thus pronounceable and corresponded to concrete (like ‘belt’ for *tucalo*) or abstract (like ‘example’ for *vermo*) Spanish nouns of medium frequency. Two more conditions were used in which real words were presented (Rc and Ra).

c Stimuli. The target words comprised 20 concrete (mean frequency of 41.18 per million occurrences) and 20 abstract (mean frequency of 45 per million occurrences) ($t < 1$) words (see Appendix 1). When rated on seven-point Likert-scales, concrete/abstract words differed with regard to imageability (6.2/3.5; $t(38) = 16.8$; $p < .001$) and concreteness (5.9/3.4; $t(38) = 14.05$; $p < .001$). Two lists of 40 sentence pairs were created (80 sentences per list). Each list comprised 10 abstract new-word pairs, 10 concrete new-word pairs, 10 abstract real-word pairs, and 10 concrete real-word pairs. Mean cloze probability for the concrete/abstract sentences was: first sentence (low constraint) 11.9%/11.2% (SD = 7.0/8.4; $t < 1$) and second sentence (high constraint) 89.4%/88.1% (SD = 6.2/10.3; $t < 1$). The probability of meaning resolution after reading both sentences of a pair was 100%/92.3% (SD = 0/9.2; $t(38) = 3.7$; $p < .001$) for concrete/abstract conditions.

The two lists were matched in frequency, concreteness, and imageability for the target word, abstract words were matched with abstract words and the same for concrete words. In addition, abstract and concrete words were also matched for frequency both within and between lists. The assignment of the experimental condition (Nc, Na, Rc and Ra) was systematically rotated among the four groups of 10 sentences in the two lists created.

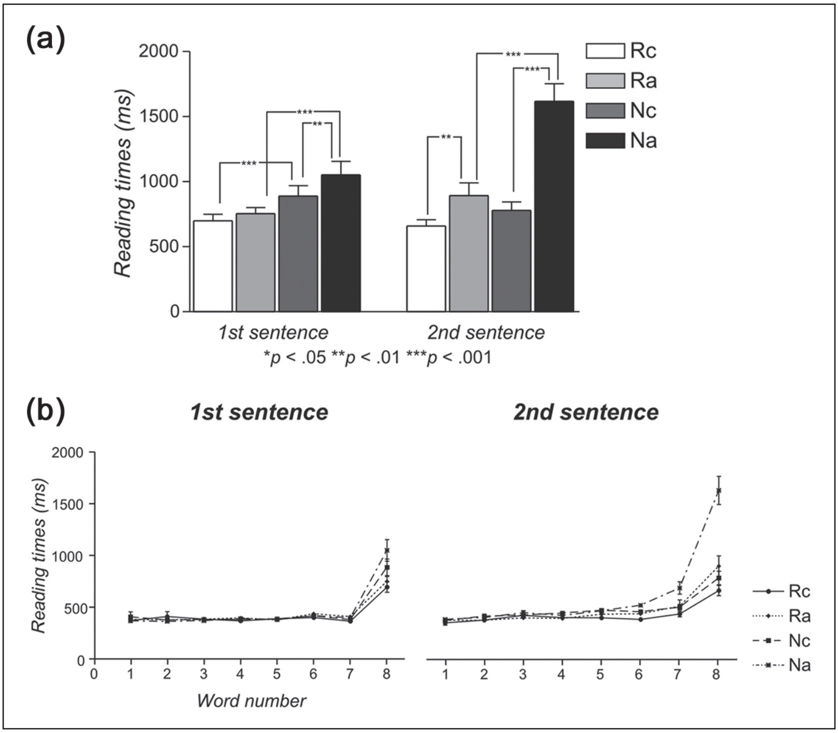

Figure 3. (a) Mean reading times to the target word (8th word) in each sentence for each condition (Experiment 2). (b) Mean self-paced reading times for different word type positions and sentences.

d Procedure. The same experimental procedure as in the previous experiment was used.

2 Results

Meaning identification of concrete and abstract new words was similar [concrete words (93.3 ± 6.4%) and abstract words (90 ± 7.8%); ($t = 1.6$; $p = .11$)]. Sentences where the participant could not discover the meaning of the new word, as determined by either omissions or incorrect responses, were excluded from the analysis (11.6%). In addition, reading times more than 2.0 standard deviations above or below the mean for a given participant in all conditions were also excluded (6.1%).

Reading time analysis of the target word (8th word) in each sentence was performed on participants and items means (Figure 3a, Table 1) with Learning (1st and 2nd sentence), Condition (new-word vs. real-word), and Imageability/Concreteness (concrete vs. abstract) as factors of a 2 × 2 × 2 ANOVA (see Table 2). In order to decompose the significant triple order interaction, a 2 × 2 ANOVA design for each sentence was conducted introducing Condition (new-word vs. real-word) and Imageability/Concreteness (concrete vs. abstract). For the 1st sentence a main effect of Condition [$F1(1,23) = 20.12$,

$p < .001$, η_p^2 .47; $F2(1,38) = 43.47$, $p < .001$, η_p^2 .53] and Imageability/Concreteness only in the participants analysis [$F1(1,23) = 8.97$, $p < .006$, η_p^2 .28; $F2 = 2.01$, $p = .16$], but no significant interaction ($F1 = 3.4$, $p = .078$; $F2 = 1.47$, $p = .23$) were observed. Real words were read faster than new words, and concrete words were faster than abstract words (see Figures 3a and 3b, left). For the 2nd sentence, in addition to main effects of Condition [$F1(1,23) = 14.65$, $p < .001$, η_p^2 .39; $F2(1,38) = 19.83$, $p < .001$, η_p^2 .34] and Imageability/Concreteness [$F1(1,23) = 68.83$, $p < .001$, η_p^2 .75; $F2(1,38) = 14.9$, $p < .001$, η_p^2 .28] a significant interaction between these factors was found [$F1(1,23) = 13.72$, $p < .001$, η_p^2 .37; $F2(1,38) = 8.32$, $p < .006$, η_p^2 .18]. This interaction reflects the fact that Nc were read as fast as Rc (see pairwise comparisons in Figure 3a), but Na showed longer reading times than Ra (see Figures 3a and 3b, right). In spite of the fact that participants were equally successful at inferring the meaning of new concrete and abstract words, new concrete but not abstract words were processed as fast as their real-word counterparts. Thus, these newly learned new words showed the classical concreteness effect.

A further analysis was restricted to new words (Table 3), as we predicted based on the reanalysis of the previous experiments, a significant interaction between Imageability/Concreteness and Learning was revealed. Nc were read faster than Na in the 1st sentence [$t1(23) = -2.8$, $p < .009$; $t2 < 1$] and 2nd sentence [$t1(23) = -6.7$, $p < .001$; $t2(38) = -3.6$, $p < .001$]. Even though the information provided by the context of the first sentence was not sufficient to extract an unequivocal meaning, differences were already observed between concrete and abstract new words. Moreover, only Na showed a drastic increase in reading times from the first to the second sentence [$t1(23) = -5.01$, $p < .001$; $t2(19) = -3.06$, $p < .006$].

A similar analysis in real words (Table 3) showed only a significant main effect of Imageability/Concreteness. Further pairwise comparisons showed that, whereas no differences between real-word conditions regarding imageability/concreteness were observed in the first sentence ($t1 = -1.66$, $p = .110$; $t2(38) = -2.2$, $p = .036$), Ra showed longer reading times than Rc on the second sentence in the analysis by participants [$t1(23) = -2.61$, $p < .015$; $t2 = -1.2$, $p = .24$]. Contrary to what we found for new words, neither Rc ($t1 < 1$; $t2 < 1$) nor Ra ($t1 = -1.33$, $p = .196$; $t2 < 1$) showed a reading time difference between the first and the second sentence.

3 Discussion

To summarize, as in the previous experiments both concrete and abstract new words were successfully learned. Moreover, a significant Imageability/Concreteness × Learning interaction was seen for the new-word conditions, which replicated the previous results from the between-participant comparison. As expected, the on-line learning pattern of concrete and abstract new words differentiated at the second sentence. In fact, only Na showed an increase in reading times from the first to the second sentence. This result implies that the information accrued from the first sentence did not provide enough clues or contextual information for defining which concept the new word was referring to. A possible interpretation of this pattern is that for Na participants had to gather, compare and recheck the information provided by both sentences in order to correctly infer its meaning, while for Nc no or less re-checking was required in the second sentence.

Table 3. Two-way repeated measures ANOVAs for Experiment 2 and Experiment 3.

	df	Learning		Imageability/ concreteness		L × I/C	
		F value	η_p^2 value	*F* value	η_p^2 value	*F* value	η_p^2 value
Experiment 2:							
Nw	*F*1(1,23)	11.18**	.33	42.76***	.65	32.88***	.59
	*F*2(1,38)	5.67*	.13	12.84***	.25	11.82***	.24
Rw	*F*1(1,23)	ns		10.68***	.32	ns	
	*F*2	ns		ns		ns	
Experiment 3:							
Nw	*F*1(1,33)	ns		4.8*	.13	12.64***	.28
	*F*2	ns		ns		ns	

Notes. new word (Nw); real word (Rw); learning (L); imageability/concreteness (I/C); df = degrees of freedom; *F*1 = participants analysis; *F*2 = items analysis; $^*p < .05$; $^{**}p < .01$; $^{***}p < .001$; ns = not significant.

As in the previous experiments real words (712 ms) were read faster than new words (971 ms) in the first sentence of a pair. As in the previous experiments we also observed a concreteness effect for the new words during the first sentence. Even though these sentences had a low cloze probability, new concrete words were processed faster than new abstract words. This is an interesting result, which will be further discussed in the general discussion.

Lastly, we also observed what seems like an emerging concreteness effect in real-word conditions at the end of the second sentence (concrete 659 ms, abstract 892 ms). However, this effect was only observed at the participant level but not at the item level analysis. This is surprising because the second real-word sentence was highly informative and had a greater cloze probability than the first sentence, which, according to the context availability theory, should lead to a leveling of reading times. A similar (marginally significant) difference was also seen for the previous experiments (concrete 927 ms, abstract 1,450 ms). Whereas these results seem at odds with the context availability theory, we would like to point out that the participants had to perform a synonym generation task in the real-word condition, which entailed writing down a synonym for the terminal word. This task was arguably more difficult for the abstract words. This interpretation, even though it is post-hoc, is further corroborated by the fact that in the previous experiments reading times decreased from sentence 1 to 2 but increased again for sentence 3.

IV Experiment 3: Concrete vs. abstract word learning matched by context availability

In order to discern if the differences observed between concrete and abstract words in the previous experiments are due to imageability/concreteness differences or context availability differences, we performed a third experiment in which concrete and abstract new words were matched by context availability, while differing in imageability and concreteness. Real-word contexts were not used in the present experiment due to the difficulty in finding words that could be matched for context availability. Based on the results from the previous experiment, we expected longer reading times for abstract new words compared to concrete new words in the second sentence regardless of context availability.

1 Method

a Participants. Thirty-four undergraduate Spanish–Catalan bilingual students from the University of Barcelona (mean age 21 ± 1.7 years; 11 men; 23 women) participated in this experiment for bonus credits in psychology courses.

b Task and design. The same task and design as Experiment 2 was used. However, this experiment only featured two conditions, namely, concrete new word (Nc) and abstract new word (Na).

c Stimuli. The target words comprised 12 concrete (mean frequency of 54.48 per million occurrences) and 12 abstract (mean frequency 68.75 per million occurrences) ($t < 1$) words (see Appendix 1). When rated on seven-point Likert-scales, concrete/abstract words were similar with regard to context availability (4.63/4.46; $t < 1$) but differed with regard to imageability (5.26/3.49; $t(22) = 11.2$; $p < .001$) and concreteness (4.92/3.67; $t(22) = 3.8$; $p < .001$). Context availability was assessed by asking 50 people to indicate on a seven-point scale 'how easy or difficult it is to come up with a particular context or circumstance in which the word might appear' (1 = very difficult to think of a context; 7 = very easy to think of a context) (Schwanenflugel and Shoben, 1983; Schwanenflugel et al., 1988). The experiment comprised 12 concrete new-word and 12 abstract new-word sentence pairs. Mean cloze probability for the concrete/abstract sentences was: first sentence 13.3%/14.7% (SD = 4.2/10.1; $t < 1$) and second sentence 85%/86% (SD = 9.1/9.1; $t < 1$). The probability of meaning resolution after reading both sentences of a pair was 90.5%/94.2% (SD = 11.5/10.1; $t < 1$) for concrete/abstract conditions.

d Procedure. The same experimental procedure as in the previous experiments was used.

2 Results

Participants correctly inferred more concrete than abstract new-word meanings [88.5 ± 7.7% vs. 83.8 ± 7.9%; $t(33) = 2.5$; $p = .016$]. Sentences where the participant could not discover the meaning of the new word, as determined by either omissions or incorrect responses, were excluded from the analysis (6.9%) as well as reading times more than 2.0 standard deviations above or below the mean (5.8%).

Reading time analysis of the target word in each sentence was performed on participants and items means (Figure 4a, Tables 1 and 3) with Learning (1st and 2nd sentence) and Imageability/Concreteness (concrete vs. abstract) as factors of a 2 × 2 ANOVA. The results showed a main effect of Imageability/Concreteness and a significant interaction between Learning and Imageability/Concreteness (see Table 3) (for the interaction in the

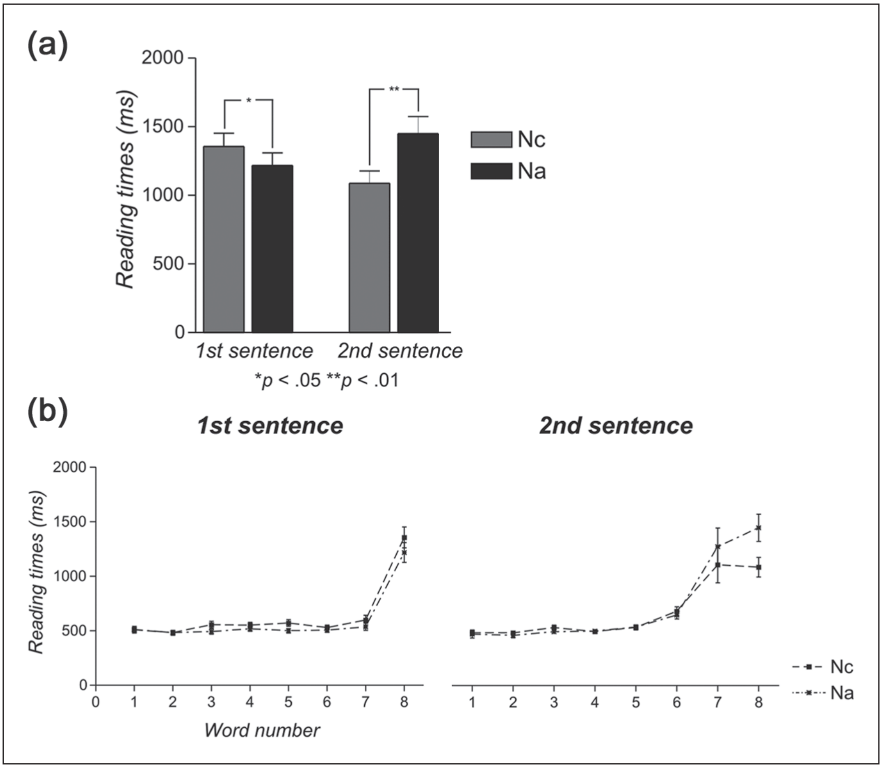

Figure 4. (a) Mean reading times to the target new-word (8th word) in each sentence for each condition (Experiment 3). (b) Mean self-paced reading times for different new-word type positions and sentences.

by items analysis we observed a trend towards significance, $F2(1,22) = 3.34$, $p = .081$). Na were read faster than Nc in the 1st sentence [$t1(33) = 2.51$, $p < .017$; $t2 < 1$]. The reverse pattern was observed in the 2nd sentence where Nc were read faster than Na [$t1(33) = -3.29$, $p < .002$; $t2 = -1.5$, $p = .15$] (see Fig. 4). Furthermore, Nc showed a decreased in reading times from the first to the second sentence [$t1(33) = 2.75$, $p < .010$; $t2(11) < 2.63$, $p = .023$], while Na showed a marginally significant increase [$t1 = -2$, $p = 0.054$; $t2 < 1$]. Therefore, these results show that new concrete words are learned better and faster than new abstract words despite equivalent context availability.

3 Discussion

The present results showed that differences between concrete and abstract new-word learning were present even when context availability was equated. Moreover, we observed a similar reading times pattern as in the previous experiments, namely, the reading pattern of concrete and abstract new words largely differentiated at the second sentence. As in the previous experiments, Na showed an increase in reading times from the first to the second sentence and slower reading times than Nc. Therefore, these results do not support the context availability theory when learning the meaning of new words. Nevertheless, in contrast to the previous experiments, Nc displayed longer reading times than Na in the first sentence. This result is interpreted as reflecting the context availability manipulation effect on the imageability/concreteness variable, and will be further discussed in the next section.

V General discussion

Reading times in the new-word conditions provide an estimate of the time required to search semantic memory for possible meanings, to select the meaning, and, if possible, to integrate it with the preceding context. We found that both concrete and abstract meanings were successfully inferred from congruent contextual information. Although only few studies have addressed meaning acquisition from contextual information, there are a few findings that are consistent with the present data. We will concentrate on two main results: (1) larger differences in the reading times for the M–for abstract contexts when compared to concrete contexts, and (2) longer reading times observed for acquiring the meaning of abstract new words especially during the last sentence.

1 Why did incongruent semantic contexts differ between concrete and abstract conditions?

In our first experiment and in Mestres-Missé et al., 2007 we manipulated the congruency of information across sentences. It is important to bear in mind that these experiments entailed a M+ condition in which contextual information was congruent across sentences (thus, warranting meaning discovery of the new word) and a M– condition for which incongruent contextual information across sentences made the task of discovering the meaning of the new word impossible. The results showed that mean reading time in the M– condition was the longest one (last word of the third sentence) for concrete and abstract words but larger for abstract words (see Figures 1 and 2).

While no differences between M+ and M– conditions were found for the first sentence, differences emerged at the second sentence and were greatest for the third sentence, for which reading times of terminal words were roughly 4 (abstract) and 2 (concrete) seconds. Why did participants require so much time in the incongruent abstract context to give up trying to infer the meaning of the new word? It has been shown previously that participants come up with more contexts that can be associated with abstract compared to concrete words (Galbraith and Underwood, 1973). This variable (‘associate set size’ or ‘connectivity’) can be obtained by asking the participant to rate how many contexts he or she could think of in which, for example, the word *peace* could appear. This result does not contradict the finding that a specific context is associated faster with a concrete than an abstract word (Schwanenflugel and Shoben, 1983). In fact, Wattenmaker and Shoben (1987) studied the influence of contextual information on the recall of abstract and concrete sentences and found that concrete and abstract sentences were recalled equally well when presented in a coherent paragraph. Because the conceptual information associated with an abstract concept is more variable and unspecific, and its appearance can be predicted in many contexts (situations, agents, experiences, emotions, etc.), the retrieval of a specific context or information might take longer (Wiemer-Hastings and Xu, 2005). This effect can therefore be attributed to the less dense organization of abstract representations in semantic memory, which are linked less strongly to more branched associated information, involving other unspecific features or abstract concepts. In fact, many abstract concepts are probably relational concepts with rich interconnections to other concepts (Gentner, 1981; Markman and Stilwell, 2001) instead of intrinsic properties, as it is the case for concrete concepts. Many of the core features that define an abstract concept are also abstract concepts by themselves. Concrete concepts on the other hand are strongly associated with specific contexts and have denser conceptual networks. This idea is captured by the view of Crutch and Warrington (2005) about the more associative nature of the representation of abstract words in semantic memory. Similarly, the Distributed Feature Model of bilingual processing also uses the distinction between the semantic representations of abstract and concrete words to explain the relative advantage of bilinguals in translating concrete vs. abstract words across languages (De Groot, 1992; Van Hell and De Groot, 1998b). Considering that abstract words are more context dependent (Schwanenflugel and Shoben, 1983), and that the context in which words are processed differs across languages and cultures, the authors predicted that the translation of abstract words would be slower because their meaning could be instantiated in different semantic features across languages. These previous proposals coincide with the fact that abstract words have a more diffused and context-dependent representation. Therefore, in the present study, the presentation of three abstract incongruent sentences might prime multiple interconnected concepts in semantic memory, and therefore rejecting any of these multiple potential meanings might require more time as greater interference occurs between competing concepts. The underlying qualitative (nature of semantic representation) and quantitative (context dependence) differences of concrete and abstract concepts could explain this interesting effect.

2 Are abstract meanings identified slower than concrete meanings from a verbal context?

The most compelling result of the present experiments is that longer reading times were required for abstract new words when compared to concrete new words regardless of equivalent context availability. This effect was already observed for the first sentence ($\Delta t = 162$ ms, Experiment 2), and it was maximal for the second sentence ($\Delta t = 839$ ms and $\Delta t = 362$ ms, Experiments 2 and 3, see Figures 3a and 4a). Nevertheless, this difference in reading times between concrete and abstract new words decreased when context availability was matched. This might be due to an increase in reading times for concrete new words in Experiment 3 (for a comparison of reading times across experiments, see Table 1). One has to consider that context availability and imageability/concreteness are highly and positively correlated (Van Hell and De Groot, 1998a), which in turn posed great difficulty in finding concrete words with equal context availability as abstract words but unmatched imageability/concreteness. In fact, imageability and concreteness ratings for concrete words in Experiment 3 were lower than in the other experiments. If we consider a continuum from most to least imaginable/concrete, the concrete words from Experiment 3 might be a gradation closer to less imaginable/concrete than the concrete words from the other experiments, and hence the longer reading times and reduced difference with abstract new words. In any case, the better and faster learning of concrete words is consistent with several studies (De Groot, 2006; De Groot and Keijzer, 2000; Gillette et al., 1999; Van Hell and Candia-Mahn, 1997). This result in adults indirectly suggests that the learning differences already observed in children (Bloom, 2000) might remain in adulthood in spite of having a full representational and conceptual capacity (Antonucci and Alt, 2011; Gillette et al., 1999; Medina et al., 2011).

The context availability model (Schwanenflugel and Shoben, 1983; Schwanenflugel and Stowe, 1989; Schwanenflugel et al., 1992) proposes that comprehension of abstract and concrete words is supported by the activation of the contextual information related to the linguistic input leveling processing differences in situations with sufficient contextual information. This is not the case in our experiments. Even though the context availability model has not been developed to explain the learning of new words, we have demonstrated differences between new concrete and abstract word learning despite equal context availability.

Following the categorical (similarity-based) vs. associative distinction proposed by Crutch and colleagues (Crutch, 2006; Crutch and Jackson, 2011; Crutch and Warrington, 2005, 2007, 2010; Crutch et al., 2009), representations of concrete words share more semantic features, which might help to identify the target concrete concepts for the new words in the present contextual learning task. In fact, the meanings of concrete words tend to be constant across many contexts. In contrast, the meanings of abstract words tend to be more variable and less redundant across contexts, frequently having related but distinct meanings. As the principle of organization for these types of words is more associative, then they might be sharing less semantic features with neighboring concepts, it therefore being more difficult to identify the target abstract concept from the features shared with other concepts in the same network.

This proposal is not in contradiction with the idea that differences in information density and semantic overlap (amount of semantic features shared across contexts) in the representations of concrete and abstract words might explain the slower recognition of the meaning of the abstract new words in the present experiments. This explanation is also reminiscent of the original context availability account proposed by Schwanenflugel and colleagues (Schwanenflugel and Shoben, 1983; Schwanenflugel and Stowe, 1989). The process of searching the meaning of a new word might depend on the assignment of certain semantic propositions and representations that are related to the frames or contexts conveyed by the sentences. In this regard, this process tries to link the new word to an already existing semantic feature in semantic memory. If there is a significant overlap between the semantic features recruited by the contexts that include the new word, the assignment of the meaning will be faster and easier, as is the case for concrete new-word sentences. The new word will be mapped directly to the dense and more rigidly organized semantic space of concrete representations (most probably represented in a categorical network; Crutch and Warrington, 2005). As we stated in the introduction, the density of the semantic representations has been raised as an important factor in order to explain the structure and dynamics of semantic memory (Rogers et al., 2004) and to understand the differences between concrete and abstract semantic networks (De Groot, 1989; De Groot and Keijzer, 2000; Schwanenflugel and Shoben, 1983; Schwanenflugel et al., 1988). In contrast, the semantic features activated for contexts including the abstract new words will be more variable, and thus the attachment of a meaning more difficult. In some sense the flexibility of the representations of abstract concepts is the price that has to be paid if words have different but related meanings in different contexts. By extension, this will be reflected by the extra costs occurring during the mapping of a new abstract word on the existing semantic space.

3 New-word-learning approach considerations

One caveat of the present study that we would like to discuss is that the present word-learning task might represent more accurately L2 learning than L1 learning. Although meaning is extracted from a linguistic context in a similar way as in L1 (child or adult) incidental contextual learning, it is different from infant word learning in the sense that the learner in our task already possesses a label for each of the word meanings to be learned. Thus it could be conceptualized as a simulation of the process of acquiring a new label for an already existing concept, and also conceived more as a second-language (L2) word-learning task than an L1 word-learning one. Nonetheless, it also represents the process of contextual word learning (for instance, rare words or neologisms) in the learner's native language, that is, when the learner has achieved a certain degree of proficiency that allows him or her to use contextual information to infer the meaning of an unknown word. Our task was constructed as a simulation of vocabulary learning using the participants' native language in order to avoid individual differences in L2 proficiency, which could interfere with the main aim of the study which was to simulate the process of inferring the meaning of the new word from a verbal context (Mestres-Missé et al., 2007). Previous neuroimaging studies from our group using this task have clearly shown that activation is observed in several brain regions traditionally related to memory encoding and learning, as for instance parahippocampal and hippocampal medial temporal regions (Mestres-Missé et al., 2008; Mestres-Missé et al., 2010; for the participation of these regions in word learning, see Davis and Gaskell, 2010). These results from different studies (for a review, see Rodriguez-Fornells et al., 2009) suggest unequivocally that in our word-learning task the association between the contextual meaning of the new word and its new label is learned by encoding the new association. Most probably the first encounter with the new word in the first sentence builds a semantic representational space, and this leads to a certain hypothesis about the possible meaning of the new word. New encounters and contexts are needed to finally derive the correct meaning of the new word using a hypotheses testing process (see Medina et al., 2011). Further studies might be required to study in more detail the process of inferring the meaning of new words but using L2 contexts (and varying L2 proficiency levels) and to compare them with L1 contextual learning.

VI Conclusions

The current experiments demonstrate that both concrete and abstract new-word meanings can be successfully learned from contextual information. Nevertheless, new concrete word meanings were derived faster than new abstract word meanings. This difference was maintained albeit equal context availability. Even though, in a strict sense, our results do not support the context availability model, the weight and importance of this theory should not be diminished. The present investigation evidenced that imageability/concreteness is not a dual feature, but a continuum with highly asymmetric words at opposing ends but growing concurrence as one approaches the middle point. In this sense, concrete and abstract words with similar context availability exhibited, respectively, lower and higher imageability/concreteness, and smaller learning differences than concrete and abstract words with unlike context availability. Furthermore, we conclude that the concreteness effect observed in learning is due to the different organization of abstract and concrete conceptual information in semantic memory, with concrete words depending more on semantic similarity information, and abstract words on associative information.

Declaration of conflicting interest

The author declares that there is no conflict of interest.

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Notes

1. Because in Catalonia both Spanish and Catalan are official languages, and schooling is in Catalan and Spanish, the population is bilingual (however, usually with dominance towards one language is based on the maternal/familiar language). All participants can be considered highly proficient in Spanish, which was the language used in the current experiments. Because the samples included university students, partial knowledge of English is also expected, although the variability in the proficiency of this language is very large. Even though bilingualism has been shown to improve word learning (Kaushanskaya and Marian, 2009; Kaushanskaya and Rechtzigel, 2012), we do not expect differences in the absolute performance of bilinguals and monolinguals, as we are evaluating the capacity to infer the meaning of a new word in a language in which participants are highly competent. Additionally, our samples had similar linguistic backgrounds throughout the different experiments. We believe that further investigation on the role of bilingualism on language learning processes might be especially relevant; however, these aspects were out of the scope of the present study.
2. The performance of the synonym generation task was difficult to quantify due to the variability of the synonyms produced across participants. Indeed, for Experiment 1 interparticipant synonym agreement was 35.6% (SD = 18.2), and for Experiment 2 it was 29.5% (SD = 16.2) [concrete words 33.2% (SD = 18.2); abstract words 26% (SD = 13.3)].
3. There were neither significant differences between the cloze probability of the three sentences for the concrete words and abstract words (1st sentence: concrete 6.3% (10.3), abstract 5.9% (7.4), $t < 1$; 2nd sentence: concrete 38.8% (19), abstract 45.7% (15.7), $t = -1.6$; $p = .1$; 3rd sentence: concrete 84.8% (11.2), abstract 86.7% (12.2), $t < 1$), nor between

correct meaning identification after reading the three sentences (concrete 97.1%; abstract 95.6%; $t = 1.08$; $p = .28$). Likewise, there were no significant differences between the mean frequency of concrete (82.7 per million of occurrences) and abstract words (130.5 per million of occurrences) ($t = -1.5$; $p = .12$).

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Appendix 1. Words used in Experiments 1, 2 and 3.

Experiment 1	Experiment 2		Experiment 3	
Abstract	Concrete	Abstract	Concrete	Abstract
acea – *seguridad* (security)	**apina** – *bufanda* (scarf)	**abula** – *mentira* (lie)	**apina** – *fiebre* (fever)	**abula** – *broma* (joke)
afima – *vergüenza* (shame)	**atigo** – *pez* (fish)	**anduna** – *vergüenza* (shame)	**butea** – *manga* (sleeve)	**aduna** – *seguridad* (security)
alcazo – *silencio* (silence)	**batate** – *dedo* (finger)	**balloro** – *plan* (plan)	**edaro** – *polvo* (dust)	**atigo** – *curso* (course)
areo – *dolor* (pain)	**camolo** – *botón* (button)	**butea** – *presión* (pressure)	**enima** – *pregunta* (question)	**camola** – *talla* (size)
atual – *error* (error/mistake)	**derento** – *ordenador* (computer)	**cabio** – *destino* (destiny)	**ferte** – *hambre* (hunger)	**cupeta** – *adopción* (adoption)
camira – *magia* (magic)	**efeto** – *café* (coffee)	**cupeta** – *adopción* (adoption)	**igal** – *arte* (art)	**derento** – *resultado* (result)
cartuno – *milagro* (miracle)	**enima** – *bicicleta* (bicycle)	**deseto** – *humor* (humor)	**memra** – *valla* (fence)	**grafa** – *edad* (age)
cinca – *reserva* (reservation)	**igal** – *fútbol* (soccer)	**edao** – *trozo* (piece)	**mepo** – *hierro* (iron)	**lorpa** – *venganza* (revenge)
coreto – *tiempo* (time)	**litano** – *aceite* (oil)	**epecia** – *diferencia* (diference)	**proca** – *vista* (sight)	**otena** – *prueba* (test)
cunto – *ejemplo* (example)	**marpo** – *ascensor* (elevador)	**ferte** – *milagro* (miracle)	**relca** – *viga* (beam)	**rilta** – *vergüenza* (shame)

(Continued)

Appendix 1. (Continued)

Experiment 1	Experiment 2		Experiment 3	
decasa – *culpa* (blame/guilt)	**memra** – *escalera* (stairs/ladder)	**grafa** – *versión* (version)	**saria** – *garganta* (throat)	**senco** – *paro* (unemployment)
demosa – *razón* (reason/rightness)	**metepo** – *oído* (ear)	**ibaja** – *reserva* (reservation)	**sela** – *altura* (height)	**verma** – *información* (information)
desuba – *educación* (education)	**otena** – *nariz* (nose)	**larso** – *infinito* (infinite)		
diera – *presión* (pressure)	**prical** – *cuchillo* (knife)	**mucaco** – *significado* (meaning)		
difo – *infinito* (infinite)	**relca** – *película* (movie)	**pefeto** – *curso* (course)		
diper – *gusto* (taste)	**sanre** – *mapa* (map)	**polica** – *magia* (magic)		
espel – *deseo* (wish)	**sela** – *abeja* (bee)	**proca** – *sed* (thirst)		
etudo – *futuro* (future)	**subio** – *cine* (movie theater)	**saria** – *culpa* (guilt)		
findo – *sueño* (dream)	**tucalo** – *cinturón* (belt)	**sencio** – *error* (error/mistake)		
gamila – *fuerza* (strength)	**vorlo** – *anillo* (ring)	**vermo** – *ejemplo* (example)		
herno – *miedo* (fear)				
imgeo – *amor* (love)				
madida – *idea* (idea)				
masuo – *humor* (humor)				
milaca – *diferencia* (diference)				
miloma – *fe* (faith)				
motra – *sed* (thirst)				
murada – *solución* (solution)				
neceita – *esperanza* (hope)				

Appendix 1. (Continued)

Experiment 1	Experiment 2	Experiment 3
oviro – *valor* (value)		
pepo – *control* (control)		
pesea – *verdad* (truth)		
pusofa – *paz* (peace)		
ralida – *política* (politics)		
recea – *cultura* (culture)		
risuta – *sociedad* (society)		

Notes. New word in bold; Corresponding Spanish word in italics; English translation in brackets.