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## Time in language: Event duration in language comprehension

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### ABSTRACT

This work investigates how we process and represent event duration in on-line language comprehension. Specifically, it examines how events of different duration are processed and what type of knowledge underlies their representations. Studies 1–4 examined verbs and phrases in different contexts. They showed that durative events took longer to process than non-durative events and that the duration attributed to the stimulus events correlated with on-line processing times. Studies 5 and 6 indicated that durative events occur in semantically more diverse contexts and elicit semantically more diverse associations than non-durative events. Semantic and contextual diversity also correlated with attributed durations and processing times. Results indicate that (a) event-specific durations are computed on-line from multiple unfolding cues, (b) processing cost and duration representations emerge from semantic and contextual diversity reflecting our experience, and (c) key components of duration representations may be situation-specific knowledge of causal and contingency relations between events.

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### 1. Introduction

Every day people hear or read about events in the world and effortlessly understand how long these events go on for. In reading *Pirates stormed a cargo vessel*, for example, we quickly understand that there was a sudden attack and capture of the vessel. In contrast, when reading *Pirates held two foreign hostages*, we understand that hostages were held for some period of time during which other likely events happened, e.g., a ransom request. How are people able to understand the duration of

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events from linguistic descriptions? Although little is known about this issue, temporal aspects of event representations are central to human cognition, because event duration in language is likely to be linked to the representation of time more generally. Moreover, the duration of events appears to be an elusive concept, as it is not clear that concrete grounding in sensory experience such as motion is necessary, particularly when non-physical actions are talked about, as in *The hostages feared death*. Nevertheless, it is likely that experience with the world and the language plays a role in our understanding of event durations. It has indeed been argued that people's understanding of time is dependent on their experience of space and motion (Boroditsky & Ramscar, 2002; Matlock, Ramscar, & Boroditsky, 2005). Consistent with this claim, fictive motion sentences such as *The road runs through the valley* in the context of slow and difficult travel elicit longer semantic decisions compared to those in easy or short travel contexts (Matlock, 2004; Richardson & Matlock, 2007). However, non-metaphorical language uses such as *The road is in the valley* do not elicit this pattern of response, even though we are able to understand that the state described (the road's location) is long lasting.

In the present work, we investigate how we process and represent event duration in on-line language comprehension. Specifically, we examine whether inflected verbs and verb phrases referring to events of different duration are processed differently, and if so, what type of experience-based knowledge underlies their processing and representation. We hypothesize that understanding events on-line recruits situation-specific representations that include duration information. Following previous work on event representations, we argue that these representations are situation-specific in that they are dependent on the linguistic and situation context in which they occur, rather than being invariably attached to a lexical item (Ferretti, McRae, & Hatherell, 2001; McRae, Ferretti, & Amyote, 1997; McRae, Hare, Ferretti, & Elman, 2001). Moreover, we hypothesize that the representation of event duration derives from experience of real world situations and their mapping onto language, which over time becomes stored in semantic memory (although not necessarily under conscious control). The knowledge so acquired includes thematic roles concepts and features of the entities taking part in the event (Ferretti et al., 2001; McRae, Ferretti, Amyote, 1997). Critically for event duration representations, however, we argue that this knowledge also includes statistical regularities between events such as their temporal, causal and contingency relationships (Moens & Steedman, 1988). Consider the following examples:

- (a) Mary went in to see her advisor this morning. They talked about her thesis.
- (b) Mary went in to see her advisor this morning. A copy of her thesis was on the desk.

In reading the discourse in (a), we understand that the talking event occurred later than the going-in event because the latter event is contingent on the former (talking presupposes some sort of encounter or connection between the talkers). However, the durative state of being on the desk in (b) is independent of the meeting, and therefore, it is not interpreted to occur after the going-in event (Kamp & Reyle, 1993). Rather, this durative state may temporally precede, overlap or even follow the going-in event, and in turn establishes contingency relationships with other preceding events, e.g., someone leaving the copy on the desk. Existing evidence indeed suggests that non-durative events and durative states establish different temporal and contingency relations and thus are more or less difficult to locate in time depending on the probability of such relations in the world (Gennari, 2004).

The knowledge of temporal and contingency relations in the world is related to representations of event duration because, given an event, the understanding of other likely concurrent, preceding and following events provides information as to the internal temporal development of the event in question. Event concepts, like object concepts, are learned and stored in connection to other co-occurring objects, situations or properties, whether in real world experience or in linguistic experience (Vigliocco, Vinson, Lewis, & Garrett, 2004). The contexts in which we experience events and their descriptions thus provide a myriad of associations – some strong, some weak according to their frequency – which are then activated when understanding those events. Processing event concepts indeed activate the events' typical participants, instruments and locations (e.g., *arrest* primes *policeman* and *skating* primes *arena*) because such participants and properties tend to co-occur with the events in our experience (Ferretti, Kutas, & McRae, 2007; Ferretti et al., 2001; McRae, 2004; McRae, de Sa, & Seidenberg, 1997).

A durative state such as *owing 50 euros* may in principle occur in connection to a variety of situations: situations recurring over time (e.g., attempts to save or gather money), concurrent states (e.g., being worried) and other events with which it establishes contingency relations (getting a loan, paying the debt, etc.). In contrast, non-durative punctual events such as *losing 50 euros* occur in well-defined contingency-bound situations such as those leading to or resulting from the event (gambling, searching for the money), sometimes establishing common contingency links (e.g., having money, gambling, loosing it, search for more, etc.). This suggests that besides event-participant knowledge, durative states may elicit, and be represented by, more diverse associated knowledge, compared to shorter events. In this view, representing event duration entails qualitative differences in associated knowledge, but not necessarily quantitative ones: longer events are represented in terms of more diverse contingency and temporal relations with other events, as dictated by the variety of situations in which they are experienced, whereas short punctual events mostly establish similar well-defined contingency dependencies with other events (Moens & Steedman, 1988).

The present knowledge-based approach makes a number of predictions that are tested in the studies below. The first set of predictions, tested in Studies 1–4, concerns on-line processing: if on-line comprehension recruits situation-specific representations that include duration information, different processing times should be observed when understanding events of different durations and critically, processing cost should vary as a function of the perceived duration of the referred event. Differences in processing should furthermore occur regardless of whether the events are expressed by verb phrases or verbs within or outside narrative contexts, as they should be driven by interpretation rather than specific word forms. More specifically, if longer events activate more diverse knowledge or associated situations, processing times should be longer for durative events compared to non-durative ones because more time would be required to establish their interpretation. This follows if one assumes, as previously shown in word processing literature, that diversity of associations may entail more competition or weaker connection strengths to the word forms (due to less frequent co-occurrence with any given association or situation), thus requiring more retrieval time (Schwanenflugel, 1991; Simpson, 1984). The second set of predictions, tested in Studies 5 and 6, concerns the type of knowledge underlying the representation and processing of event duration: if this knowledge is diverse in nature for longer events, people should provide more diverse associations for durative events than non-durative ones, and this knowledge should be proportionally related to processing times. Moreover, if the knowledge associated with events derives from our experience of events, durative events should occur in more diverse situations than punctual events.

## 2. Study 1: Verb phrase processing in sensuality judgments

This study compared the processing of verb phrases referring to either durative states (e.g., *to owe 50 euros*) or non-durative punctual events (e.g., *to lose 50 euros*) and tested the prediction that durative phrases would take longer to process than punctual ones. This contrast may appear at first glance similar to that investigated in Gennari and Poeppel (2003), which compared verbs referring to causally complex events (e.g., *build, solve, paint*) with non-causal states (e.g., *love, adore, own*). However, this previous work did not manipulate event duration and included many potentially long activity verbs, making these verbs similar in duration to non-causal states. Thus, the present study targets a dimension of events that although related, is orthogonal to that previously invested (see also Section 8 on this point).

We used Spanish verb phrases (verbs plus noun objects) in infinitival form to exclude the possibility that tense morphemes would influence the interpretation of the event duration. These verb phrases provide more specific situation information than isolated verbs, which sometimes do not carry specific information about duration. A verb like *meet*, for example, could refer to a punctual event in the context of meeting someone for the first time. However, the same verb can also apply to habitual situations, e.g., meeting someone every week. Participants in the study were asked to indicate whether the phrases made sense by pressing a key on the keyboard. This ensured that they paid attention to the meaning of the phrase. Response times were recorded.

## 2.1. Method

### 2.1.1. Participants

Forty volunteer students and lecturers from the Open University of Catalonia (Barcelona) participated in this study (mean age = 36). All were native speakers of Spanish and some also spoke Catalan natively (30%).

### 2.1.2. Materials

Twenty pairs of verbs were matched for frequency, character length, imageability, argument structure and number of senses. Durative states and punctual events were selected according to existing linguistic classifications and simple linguistic tests such as the verbs' acceptability when occurring with temporal adverbs like *since* (e.g., *knowing someone since last year* vs. *?finding a coin since last year*) (Dowty, 1979; Vendler, 1967; Verkuyl, 1993). A rating study reported below (see Study 4) also demonstrated that durative and punctual stimulus events indeed differed in duration, as judged by independent participants. Verb frequencies were obtained from *Lexesp Corpus* (Sebastián-Gallés, Martí, Cuetos, & Carreiras, 2000). The number of senses for each verb was obtained from *Spanish WordNet* (<http://adimen.si.ehu.es/cgi-bin/wei/public/wei.consult.perl>). For argument structure matching, we made sure that verbs in each pair (e.g., *owe* vs. *lose*) had similar argument structures (most of the verbs in the stimulus take a noun phrase or a prepositional phrase as a complement) and that this structure was equally frequent. For this, we computed the proportion of verb occurrences in the experimental argument structure from a syntactically annotated database (*Arthus Corpus, Base de Datos Sintácticos del Español Actual* (<http://www.bds.usc.es/>) see also Rojo (2001)). Statistical comparisons across verb classes revealed no significant difference in character length, verb frequency, verb senses, and proportion of occurrences in the experimental argument structure (all  $p$ 's > 1). The characteristics of the stimulus verbs are listed in Table 1. To obtain the stimulus phrases, verbs in each pair were coupled with the same noun objects. Example stimuli (and their translations) are provided in Table 2. Phrase likelihood was also matched across condition, as shown by a pre-test study below. The full set of materials is provided in Appendix A. Forty nonsense phrases were used as foils (e.g., *to cure the sunlight*).

*Verb imageability pre-test:* To ensure that our stimulus verbs did not differ in imageability, we asked 50 students from the Open University of Catalonia who did not participate in the main study to complete an on-line questionnaire. The questionnaire was arranged in two different lists so that each participant only saw one verb per item (durative or punctual). Participants were asked to indicate in a scale from 1 to 7 how easy it was to imagine the meaning of the verb, i.e., to create a sensory or physical mental image of its meaning. Ratings indicated that the verbs did not differ in imageability ( $t(1, 39) = .79, p = .43$ ). Mean ratings and standard deviations are reported in Table 1.

*Phrase likelihood pre-test:* To control for the possibility that the verbs (e.g., *owe* and *lose*) would be unequally likely to occur with the noun object (*50 euros*), we asked 40 native Spanish-speaking students from the Open University of Catalonia and the University of York to provide likelihood judgments in a scale from 1 to 7. They were asked to indicate how likely it was that the situation described by the phrase would occur, e.g., how likely it was that someone would lose 50 euros or would owe 50 euros. Since the object accompanying the verbs was the same for a given item (*to lose 50 euros* vs. *to owe 50 euros*), these judgments captured the likelihood of the verb and objects occurring together. Stimuli were arranged in two lists so that participants never saw the same item twice.

**Table 1**  
Matched properties of stimulus phrases in Study 1.

Stimulus properties	Mean (SD)	
	Durative state	Punctual event
Phrase character length	26.05 (11.08)	26.1 (11.17)
Verb log frequency	2.66 (0.52)	2.58 (0.58)
Verb number of senses	4.20 (2.40)	5.35 (4.46)
Corpus proportion of used argument structure	0.79 (0.17)	0.74 (0.14)
Verbs' imageability rating	4.84 (0.70)	5.04 (0.88)

**Table 2**  
Examples of stimulus items in Experiment 1.

Item	Durative state	Punctual event
1	deber 50 euros 'to owe 50 euros'	perder 50 euros 'to lose 50 euros'
2	admirar a un escritor famoso 'to admire a famous writer'	toparse con un escritor famoso 'to run into a famous writer'
3	poseer una piscina 'to own a pool'	caer en una piscina 'to fall into a pool'
4	apreciar a un viejo amigo 'to appreciate an old friend'	reconocer a un viejo amigo 'to recognize an old friend'
5	merecer el premio Nobel 'to deserve the Nobel Prize'	recibir el premio Nobel 'to receive the Nobel Prize'

Note: English phrases in quotes are translations from the Spanish items used in the study.

Results indicated that durative states were rated as more likely than punctual events (mean 4.77 vs. 4.12,  $t(38) = 2.16$ ,  $p = .04$ ). Note that this difference would predict that the more likely durative phrases should be faster to process, the opposite prediction to the one tested here.

### 2.1.3. Design and procedure

Stimuli were arranged in two lists so that participants never saw the same item twice. Each list contained an equal number of items for each condition (latin-square design) and the items in each list were presented in random order. Participants read the phrases on the computer screen one by one. Each trial consisted of a fixation cross of randomly variable duration, followed by the presentation of the whole phrase. Participants were instructed to indicate whether the phrase made sense by pressing a key. The number of “yes” and “no” responses were counterbalanced throughout the study. Judgment times larger than two and half standard deviations from each condition’s mean were replaced by the cut-off value. These replacements constituted 1.8% of the data (note that the results are the same whether or not outliers are removed). Only trials in which participants had responded correctly were included in the analysis. (On average, participant responded correctly 97% of the time both for the entire data set including foils and for the experimental items.)

## 2.2. Results

To test whether durative phrases take longer to process than punctual phrases, a repeated measure ANOVA was conducted with judgment times as dependent variable and phrase type (durative vs. punctual) as main factor. These tests indicated a significant main effect of phrase type ( $F_1(1, 39) = 107.41$ ,  $MSE = 626,552$ ,  $p < .0001$ ;  $F_2(1, 19) = 28.83$ ,  $MSE = 338,292$ ,  $p < .0001$ , means 1626 vs. 1442). Results are shown in Fig. 1. To check for the possibility that phrase likelihood (which was higher for durative phrases, as indicated above) may have an influence on judgment times, a step-wise multiple regression was conducted with phrase type as a categorical variable and likelihood as continuous variable. This analysis revealed that whereas likelihood had no relationship with judgment times ( $R^2 = .03$ ,  $p = .28$ ), phrase type significantly increased the variance accounted for by likelihood ( $R^2$  change = .10;  $F$  change (1, 37) = 4.01;  $p = .05$ ). This indicates that phrase type accounts for a significant amount of variance in judgment times, whether or not likelihood judgments are taken into account. Note in any case, that the higher likelihood of durative phrases would predict faster processing times, rather than slower, which is the opposite pattern to that obtained.

## 2.3. Discussion

The results of Study 1 indicated, as predicted, that sensibility judgments are longer for durative states than punctual events. Known factors that could potentially have an effect on these judgments such as verb imageability, phrase likelihood, verb frequency or argument structure were controlled

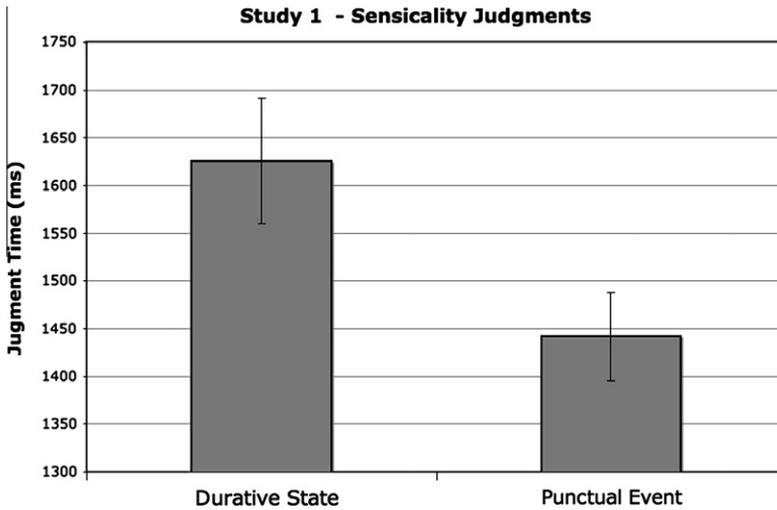


Fig. 1. Judgment times as a function of event duration conditions. Error bars indicate standard error.

for. The results are thus consistent with the hypothesis that durative phrases may entail more diverse types of knowledge, activating more relations to other associated co-occurring or contingently related situations, and thus they require more processing time, compared to punctual phrases.

The results however might be susceptible to two possible objections. First, despite our efforts to control for potentially confounding variables, it is possible that comparisons across different verbs are unduly influenced by unforeseen properties. Verbs like *owe* and *lose* not only differ in duration but also differ in other semantic properties, for example, in entailing a physical relationship between their participants. Second, it is possible that judgment times reflect rapid inferences or decision-making processes in providing sensicality judgments and therefore may not reflect natural reading comprehension. In the next two studies, we address these issues by investigating reading comprehension and comparing reading times across the same verbs.

### 3. Study 2: Inflected verb processing in discourse contexts

Study 2 investigated the role of event duration in on-line sentence comprehension by examining the processing of different Spanish verb + morpheme combinations referring to either durative or non-durative events. Aspectual morphemes such as English past progressive and simple past are well known for their differential effects on interpretation. The progressive marker (e.g., *was skating*) focuses on the middle in-progress component of the referred action, whereas the simple past (e.g., *skated*) focuses on the whole action as already completed (Smith, 1991). Previous studies have shown that imperfective verbs, but not simple past or perfective ones, prime characteristics of the ongoing event (Ferretti et al., 2007) and in narrative comprehension, they facilitate access to information still current in the narrative (Carreiras, Carreido, Alonso, & Fernández, 1997).

Spanish imperfective and perfective past markers roughly correspond to English progressive and simple past tenses respectively but there are some notable differences. Spanish imperfective markers may elicit some interpretations that are not always possible with English progressive – for a discussion of Spanish past tenses, see (Cipria & Roberts, 2000). Verbs such as *cover* or *hide*, which refer to changes of states, receive an *action-in-progress* interpretation with English progressive, whereas in appropriate contexts, the imperfective forms of the corresponding Spanish verbs allow a state interpretation equivalent to English *was covered/hidden* or *remained covering/hiding*. (In their perfective form, these verbs are similar to English *hid/covered*). Moreover, Spanish imperfect markers can be applied to state verbs. Whereas the verb *know* in English cannot occur with progressive, the Spanish

imperfective counterparts of this verb (*conoc-ía, sab-ía*) refer to an ongoing state in the past (as English *knew*). In contrast, in their perfective forms (*conoc-íó, supo*), these verbs refer to the non-durative event in which one met someone else (*conoc-íó*) or learnt about something (*supo*). The perfective and imperfective markers can thus co-occur with an alternation between durative and non-durative interpretations.

Not all Spanish verbs allow this alternation between durative and non-durative interpretations, but some do because of their lexical meanings (or senses). The alternation may occur with verbs of various lexical types and often depends on the type of noun with which they occur. Example verbs exhibiting this alternation in interpretation are *tapar* ('cover'), *esconder* ('hide') *afectar* ('affect'), *bloquear* ('block'), *superar* ('surpass'), *incluir* ('include'), *integrar* ('make up, include'), *formar* ('form, make up'), *implicar* ('implicate'), *aparecer* ('appear'), *conocer* ('know'), *saber* ('know'), *rodear* ('surround'), *llegar* ('reach'). In their imperfect form, these verbs refer to an event in which someone or something remains in a given state, whereas in their perfect form, they indicate a punctual or non-durative change in which something or someone does something (see Table 3 for examples). The English verb *include* exemplifies how co-occurring nouns may have an influence on the interpretation: *the teacher included some hints in the test* refers to a change caused by the teacher, whereas *the constitution included the abolition of the death penalty* refers to a states of affairs (i.e., the content of the constitution). In many Spanish cases, the combination of the noun type (inanimate or collective nouns) and the imperfect morphology gives rise to the durative interpretation.

In Study 2, we exploited this durative vs. non-durative alternation in interpretation to investigate whether the imperfective and perfective forms of the same verb differ in processing. In particular, we examined two related questions: whether a verb's imperfective form would take longer to process than its perfective form, as predicted by the hypothesized differences between durative and non-durative events, and more generally, whether event duration has an impact on the representations entertained on-line as soon as the verb is encountered. To address these questions, the study measured

**Table 3**  
Examples of stimulus items in Study 2.

Item	Durative state – Imperfect verb form	Non-durative event – Perfect verb form
1	Algunos edificios del casco antiguo contenían objetos y joyas de la edad media. <i>El ayuntamiento escondía un pergamino muy valioso.</i> 'Some buildings of the old town centre had objects and jewels from the Middle Ages. <i>The town hall kept/was hiding a very valuable scroll.</i>	Las tropas del bando contrario habían invadido la ciudad. Para evitar el robo, <i>el ayuntamiento escondió un pergamino muy valioso.</i> 'The enemy troops had invaded the town. To avoid theft, <i>the town hall hid a very valuable scroll.</i>
2	Juan solía decir que hacía horas extras en la oficina, pero era evidente que tenía una amante. <i>Su esposa sabía la verdad.</i> 'John used to say that he was working overtime at the office, but it was obvious that he had a lover. <i>His wife knew the truth.</i>	Juan intentó ocultar durante meses la historia de su amante, pero no lo logró. <i>Su esposa supo la verdad.</i> 'For months, John tried to conceal his love story but he didn't managed. <i>His wife found out the truth.</i>
3	Los clientes de la discoteca no podían ver el horario que colgaba de la puerta ya que, sin darse cuenta, <i>el portero tapaba el cartel.</i>  'The nightclub clients could not see the timetable hanging from the door. Without realizing it, <i>the doorman was covering the sign.</i>	Mis amigas llegaron demasiado tarde a la discoteca. El local ya estaba cerrando. En la entrada había un rótulo que indicaba que aún estaba abierto, pero justo en ese momento, <i>el portero tapó el cartel.</i> 'My girlfriends arrived too late to the nightclub. The place was already closing. At the entrance, there was a sign indicating that it still was open. But just then, <i>the doorman covered the sign.</i>
4	La zona afectada por el incendio era enorme. <i>El fuego llegaba hasta el pueblo.</i>  'The area affected by the blaze was enormous. <i>The fire was reaching the town.</i>	No había manera de apagar el incendio. Seguía esparciéndose incesantemente. Finalmente, <i>el fuego llegó hasta el pueblo.</i> 'There was no way to extinguish the blaze. It kept growing incessantly. Finally, <i>the fire reached the town.</i>

Note: English translations are provided below each Spanish item. Sentences in italics indicate the sentence containing the critical verb also used in Study 3 without the preceding context.

reading times in a word-by-word fashion and presented the verbs and their sentences within the context of short narratives. A verb and its sentence were alternatively presented in perfective and imperfective forms (e.g., *the doorman was covering the sign* vs. *the doorman covered the sign*), and each version appeared within a natural discourse context leading to the appropriate durative or non-durative interpretation (see examples in Table 3). Previous studies in narrative comprehension have shown that readers are sensitive to violations of expected event durations or temporal relationships within the narrative (Madden & Theriault, 2009; Zwaan, 1996; Zwaan & Radvansky, 1998). The use of leading context thus naturally generates expectations about the events in the narratives and therefore minimizes the impact of potential out-of-context likelihood differences between the verb forms.

### 3.1. Method

#### 3.1.1. Participants

Thirty-four native Spanish speakers at the University of York participated in the study. These students were from Spain and South America and were studying in York (mean time in the UK = 7 months).

#### 3.1.2. Materials

Thirty items were constructed each containing a perfect and imperfect sentence paired with an appropriate narrative context (60 sentence-context pairs in total). Contexts were created on the bases of naturally occurring corpus examples to make sure that the critical perfect or imperfect sentence fit the preceding narrative context. Examples of stimulus sentences are provided in Table 3. Appendix B lists the complete set of items. To guarantee that the stimulus items (the sentence-context pairs) preferentially receive a non-durative and a durative interpretation in each of their morphological instances, they were selected according to a pre-test study described below (see Interpretation pre-test). As a result of this pre-test and because we wanted as many items as possible to increase statistical power, 13 verbs in the stimuli were used twice in different sentences and discourse contexts. Across the 30 items, there were roughly equal proportions of animate subjects (e.g., *my sister knew the editor*), collective subjects (e.g., *the crowd blocked the entrance*) or inanimate subjects (e.g., *the letter implicated rich people*).

To control for potential confounding variables, the inflected verbs were matched by sense frequency and verb + morpheme co-occurrence frequency. To establish sense frequency, we used the tagged corpora SenSem (<http://grial.uab.es/sentits/>) (Alonso, Capilla, Castellón, Fernández, & Vázquez, 2007) and Adesse (<http://webs.uvigo.es/adesse/>) (García-Miguel & Albertuz, 2005), which have been tagged by lexicographers and provide verb sense information according to most common semantic categories (e.g., stative vs. eventive interpretations). From these corpora, we extracted the number of times in which the same verb had an eventive or a stative meaning. Mean log frequencies and standard deviations across conditions are listed in Table 4. For co-occurrence frequencies, we computed the number of times that the verb root occurred with either perfect or imperfect past tense from the largest on-line Spanish corpus compiled by the Spanish Royal Academy (Real Academia Española: <http://www.rae.es>). Table 4 provides the mean and standard deviations of the verb + morpheme co-

**Table 4**  
Matched properties of stimulus verbs in Studies 2 and 3.

	Stimulus properties	Mean (SD)	
		Durative state	Non-durative event
Study 2	Verb-morpheme log frequency	2.99 (0.63)	3.14 (0.62)
	Sense log frequency	1.46 (0.45)	1.26 (0.42)
Study 3	Verb-morpheme frequency	2.98 (0.64)	3.13 (0.62)
	Sense log frequency	1.49 (0.44)	1.23 (0.42)

Note: Sense frequency refers to the frequency with which the verbs occur in stative or eventive interpretations.

occurrence frequencies. Comparisons across these stimulus properties revealed no significant difference ( $t < 1$ ). Note that the overall type frequency of perfect or imperfect morphemes independently of their base verb (e.g., the frequency of all imperfect morphemes such as *-aba* or *-ía* combined) could not be computed for lack of an appropriately tagged corpus. However, these frequencies are unlikely to exert a major influence in reading times in the present study because verb root and morphemes were presented together in narrative contexts so that the inflected verbs were globally perceived and the expectancy of individual morphemes was most likely modulated by context. Finally, to control for word length, we computed residual reading times, as the perfect and imperfect verb forms significantly differed in length. This length difference could not be avoided because the imperfect form of some verbs is longer than the perfect one (e.g., *tapó* vs. *tapaba*) (mean for imperfect forms = 7.67, mean for perfect forms = 6.47;  $t(29) = 6.8$ ,  $p < .05$ ).

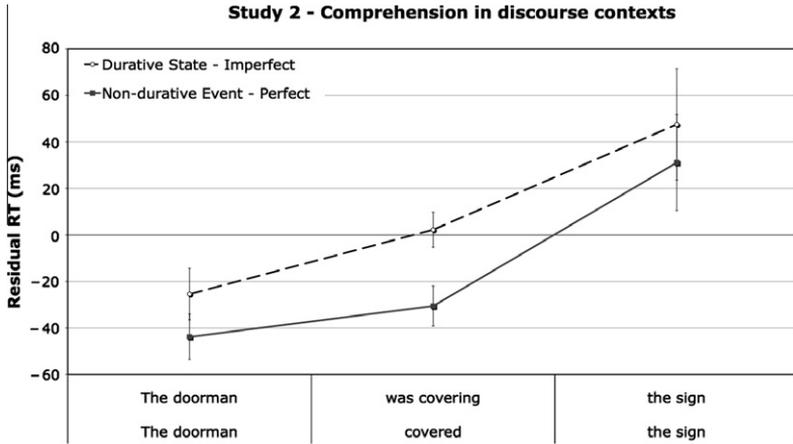
*Interpretation pre-test:* A pre-test study was conducted to guarantee that our stimulus sentences within their respective narrative contexts were indeed preferentially associated with the intended interpretations. The materials were arranged in two different lists so that each participant only saw the perfect or the imperfect version of each item. Forty participants who did not participate in other studies completed a web questionnaire. They were instructed to read each item carefully and indicate which interpretation, A or B, they attributed to the underlined verb. The definitions provided were dictionary sense definitions for the verbs in question. For example, for a sentence such as *the truck blocked the road* in a given context, the choices of interpretation were (A) *to be in the way of someone or something, preventing access*, (B) *the action of preventing someone or something from passing through or accessing somewhere*, each of which corresponds to the durative or non-durative interpretation of the Spanish verb *bloquear*. Participants' choices were recorded and items that had more than 75% of agreement across participants were used as experimental items. This pre-test thus excluded ambiguous items for which durative and non-durative interpretations were both available.

### 3.1.3. Design and procedure

Every participant saw only one version of each item but equal number of cases in each condition (latin-square design). Items were arranged in two lists, each with a different random order that counterbalanced the order of presentation of the repeated verbs. There were 40 filler items, all containing a variety of phrase structures and tense markers (e.g., present and future). The stimulus sentences were presented using a self-paced moving-window paradigm and were preceded by a paragraph providing a small narrative context. In each trial, participants first saw a small paragraph and a series of dashes standing for the words of the critical sentence. Once the paragraph was read, participants pressed a key to see the first word of the dashed sentence while the context paragraph disappeared from the screen. At each key press, the next phrase appeared and the previous one went back to dashes. Reading times were thus collected for each position in the sentence (the subject noun phrase –article + noun–, the verb, the object noun phrase –article + noun– and other phrases, if any). After every sentence, participants answered comprehension questions (e.g., *was the truck blocking the road?*). Residual reading times were computed for each word position and each subject by regressing the words' lengths onto the reading times across all items. For a given word position, residual reading times longer than 2.5 standard deviations from the condition mean were replaced by the cut-off value. This encompassed less than 3% of the data (note that the results are the same whether or not outliers are removed). Only trials with correct responses were included in the analyses. On average, participants responded correctly to 96% of these questions.

## 3.2. Results

We tested the hypothesis that verbs in imperfect form would take longer to read than verbs in perfect form by conducting a statistical test directly at the verb position within the sentence. A repeated measure ANOVA with residual reading times at the verb position as dependent variables and interpretation as a repeated factor (durative state-imperfect vs. non-durative event-perfect) revealed a main effect of condition ( $F_1(1, 33) = 5.23$ ,  $MSE = 12659.20$ ,  $p = .03$ ;  $F_2(1, 29) = 4.38$ ,  $MSE = 14277.27$ ;  $p = .05$ ). Further tests in subject and object positions revealed no significant differences. There was a 30.85 ms difference between the conditions' means in the by-item analysis. Mean residual reading times and standard errors are shown in Fig. 2. Table 5 also displays the raw reading times.



**Fig. 2.** Residual reading times at different word positions from Study 2 as a function of event duration condition. Error bars indicate standard error.

**Table 5**

Mean raw reading times and standard errors for Studies 2 and 3.

	Condition	Reading times at word position			
		Verb		Object	
		Mean	SE	Mean	SE
Study 2 – Context	Durative state	588.16	23.17	974.56	55.29
	Non-durative event	528.18	19.30	953.13	50.32
Study 3 – No context	Durative state	750.27	24.30	1057.69	51.73
	Non-durative event	642.58	15.35	945.88	43.82

### 3.3. Discussion

The results of this study indicated that during on-line comprehension, inflected verbs referring to durative states take longer to process than those referring to non-durative events. This is consistent with the expectation that situation-specific temporal representations are entertained on-line as soon as the unfolding sentence permits, rather than being post-sentential inferences. The present results also suggest that the effect of event duration at the verb position may be independent of the overall (out-of-context) perfect vs. imperfect probability of occurrence. The natural narrative context most likely led to expectations of certain event properties and consequently, specific verb forms (cf. Madden & Therriault, 2009; Zwaan & Radvansky, 1998). Therefore, the results appear to be due to semantic processing *per se*, rather than to out-of-context form frequencies.

### 4. Study 3: Inflected verb processing in the absence of discourse contexts

Study 2 indicated that inflected verbs in appropriate sentence and discourse contexts show differences in processing times as a function of event duration. One question that arises from this result is whether effects of duration emerge solely as a function of verb interpretation. In Study 2, the changes in discourse contexts co-occurred with changes in verb form. It is thus possible that the discourse context was primarily responsible for the change in interpretation and the consequent differences in processing time. However, if duration representations are situation-specific, as hypothesized, they

should impact processing times as soon as the durative and non-durative interpretations are available, independently of discourse contexts. Specifically, processing time differences should be observable at the verb position (and possibly later), the point at which the verb, its morphology and the subject noun are integrated. To address this issue, we manipulated event duration and verb inflections as before, but removed the narrative context. Because out of context, a given verb morpheme can be more or less expected, we specifically controlled for the influence of morpheme likelihood by conducting a pre-test study.

#### 4.1. Methods

##### 4.1.1. Participants

Thirty-four native Spanish speakers from the Open University of Catalonia (Barcelona) participated in this study (mean age = 33). Some of the participants also spoke Catalan natively (25%).

##### 4.1.2. Materials

Twenty-three items were constructed from the items of Study 2. Each item had a perfect and an imperfect version, yielding a total of 46 experimental sentences respectively. 20 out of 23 items were out-of-context versions of Study 2 items, and 3 contained some modifications to increase plausibility. Across the 23 items, there were roughly equal proportions of animate, collective and inanimate subjects. Examples of stimulus sentences for study 3 are provided in Table 3. Appendix C lists the complete set of items.

Materials were matched for the same stimulus characteristics as those in Study 2 using the same corpora. Mean log sense frequencies and verb + morpheme co-occurrence frequencies are listed in Table 4 for each condition. Comparisons across these stimulus properties revealed no significant difference ( $t < 1$ ). As in Study 2, materials were selected according to a pre-test study that established the preferred interpretation in each case, as reported below. To increase power, seven verbs in the stimuli were used twice in different sentences. Unlike Study 2, materials were also controlled for morpheme probability in the experimental sentences to rule the possibility that imperfect markers are less expected out of contexts. Finally, we controlled for word length by computing residual reading times because the perfect and imperfect verb forms significantly differed in length (mean 7.78 vs. 6.39;  $t(22) = 7.48$ ;  $p < .05$ ).

*Interpretation pre-test:* Ninety participants who did not participate in other studies completed a web questionnaire. The procedure and design of the questionnaire were as in Study 2, except that only sentences, rather sentence-context pairs were presented. Participants' choices in interpretation were recorded and items that had more than 75% of agreement across participants were used as experimental items.

*Morpheme likelihood pre-test:* To control for whether the perfect or the imperfect morpheme was more or less likely to occur in the context of the sentential items, a sentence completion study was conducted. 16 students from the Open University of Catalonia who did not participate in other studies filled out a web questionnaire. They were instructed to follow the sentence prompts to create a full sentence that referred to a past event using the verb provided in brackets for each case. For example, an item could be *el portero... {tapar}* ('the doorman... {cover}'), which instructed participants to use the verb 'cover' in a past form to finish the sentence. For each of these completions we counted the proportion of cases in which an imperfect or perfect marker was used, excluding cases of other alternative past forms. We then subtracted one proportion from the other and computed a one-sample  $t$ -test on the score differences to see whether they were significantly different from 0. The test revealed a marginally significant difference ( $t(22) = 1.8$ ;  $p = .09$ ). There was a small preference for the perfect forms outside narrative contexts. On average, 57% of cases were perfect forms and 43% were imperfect. We controlled for the potential effect of this variable in the analyses by regressing the proportion of occurrence onto the reading times.

##### 4.1.3. Design and procedure

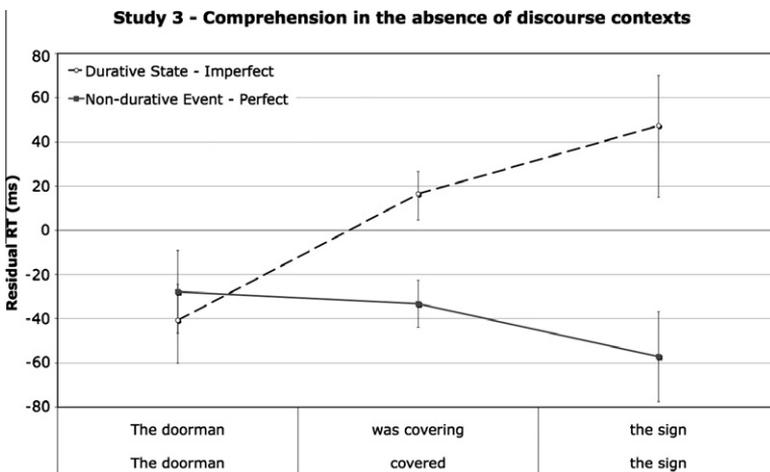
The arrangement of materials into lists was as in Study 2. There were 25 filler items, all containing a variety of phrase structures and tense markers (e.g., present and future). The stimulus sentences were presented using a self-paced moving-window paradigm. In each trial, participants first saw a

series of dashes standing for the words of the sentence. Then, participants pressed a key to see each phrase of the dashed sentence, while the previously read materials went back to dashes. Reading times were thus collected for each position in the sentence as in Study 2. After every sentence, participants answered comprehension questions (e.g., was the truck blocking the road?). Residual reading times were computed for each word position and subject by regressing the words' lengths onto the reading times across all items. For a given word position, residual reading times longer than 2.5 standard deviations from the condition mean were replaced by the cut-off value. This encompassed less than 3% of the data (note that as before, the results are the same whether or not outliers are removed). Only trials with correct responses were included in the analyses. On average, participants responded correctly to 95% of these questions.

#### 4.2. Results

Because this study presented sentences in isolation, it was likely that the introduction of objects that were not previously mentioned or implied in the discourse would result in differences in reading times, as the verb semantics is integrated with that of the object. For this reason, we included the verb and the object position in our analysis of residual reading times. A repeated measure ANOVA with residual reading times as dependent variable and word position (verb or object) and verb interpretation (durative state-imperfect vs. non-durative event - perfect) as main factors revealed a main effect of interpretation ( $F_1(1, 33) = 13.24$ ,  $MSE = 202205.65$ ,  $p = .001$ ;  $F_2(1, 22) = 13.90$ ,  $MSE = 150860.79$ ,  $p = .001$ ) and no main effect of word position or interaction. Further contrasts indicated that there was a significant difference between durative and non-durative verb phrases at both the verb and the subsequent object position in both by-item and by-subject analyses (all  $p$ 's < .02). There was a 51.20 ms difference between the conditions' means at the verb position in the by-item analysis. Mean and standard errors for all positions are reported in Fig. 3. Raw mean reading times are reported in Table 5.

To see whether the proportion of perfect and imperfect responses in the completion study (i.e., the probability of producing a perfect or imperfect form in the sentence context) explained the residual reading times at the verb position, we regressed the completion proportions for each verb form onto the residual reading times. The relationship between these variables was not significant ( $R^2 = .02$ ) and it did not eliminate the main effect of interest: a step-wise multiple regression including the completion proportions as covariate and the event interpretation (durative vs. non-durative) as categorical variable showed a significant increase in the variance accounted for by the interpretation condition relative to that accounted for by the completions ( $F(1, 43) = 4.64$ ,  $p = .04$ ,  $R^2$  change = .10, an increase



**Fig. 3.** Residual reading times at different word positions from Study 3 as a function of event duration condition. Error bars indicate standard error.

from 2% to 11% of the variance accounted for). This indicates that the residual reading times at the verb position were not explained by the probability of encountering a perfect or imperfect morpheme with the verb. Rather perfect and imperfect forms involved different processing times due to other factors over and above the expectation of one or another form.

#### 4.3. Discussion

The results of this study indicated that in on-line sentence comprehension, inflected verbs give rise to different processing times as a function of event duration in the absence of narrative contexts, even when the likelihood of aspectual markers is controlled for. Together with the results of Study 2, this suggests that the presence or absence of contextual expectations do not eliminate event duration effects at the verb position. Interestingly, the duration effect at the object position appears context-dependent, since they did not occur in Study 2. This is likely due to the fact that the narrative contexts of Study 2 allowed readers to anticipate discourse entities or to form situation models that already contained them (e.g., a football game context already implies the presence of football teams). Therefore, the processing of the objects was greatly facilitated. In absence of context, in contrast, new entities must be introduced into the situation being built and their meanings must be integrated with that of the verb, thus contributing to the construction of the durative or non-durative situation. Taken together, all studies so far support the hypothesis that event duration representations are situation-specific in that they emerge whenever the relevant interpretations are conveyed, independently of narrative contexts or the linguistic expressions used to convey them (verb phrases or inflected sentences).

### 5. Study 4: Relationship between processing times and events' specific durations

The studies so far have shown differences in processing times as a function of the durative or non-durative nature of the event described, suggesting that the representations activated on-line include temporal aspects of the events. In this study, we sought to confirm the temporal nature of these representations. Specifically, we examined whether the contrast between durative and non-durative events is related to the duration of these events in our mental representations, as hypothesized. If temporal aspects of the events were indeed processed on-line in the studies above, the durations attributed to the events should be different for durative and non-durative materials, because duration representations should be grounded in our more or less varied experiences with these events. Critically, these attributions should positively correlate with the processing times on an item-by-item basis (the longer the event, the greater the reading times).

To test these predictions, we asked independent participants to rate in a scale from 1 to 7 the duration of the events described by the materials of Studies 1 and 3, and then correlated these ratings with the processing times of these studies. We used the sentence materials of Study 3 (without discourse contexts) because they are more likely than the Study 2 narratives to convey most of the events' temporal properties at the verb position (it is possible that relevant event properties were pre-activated at different points in the narratives in Study 2). Investigating the processing times from Studies 1 and 3 thus provide the strongest test for the present predictions.

#### 5.1. Method

##### 5.1.1. Participants

Two sets of 48 and 34 Spanish-speaking students from the Open University of Catalonia who did not participate in other studies each completed a different web questionnaire.

##### 5.1.2. Materials and design

There were two questionnaires. One questionnaire contained the stimulus phrases of Study 1, the other contained the sentence materials of Study 3. The materials in each questionnaire were arranged in two lists so that a given participant never saw the two versions of the same item (e.g., *to receive the Nobel Prize* and *to deserve the Nobel Prize* in Table 2) but each participant saw equal number of cases in

each condition. The questionnaire with perfect and imperfect sentences included 18 fillers using a variety of verbs and morphological forms (e.g., present, future) to prevent participants from noticing the repetition of the perfect and imperfect verb forms. There were about 12 cases of each perfect and imperfect forms in each list.

### 5.1.3. Procedure

In both questionnaires, participants were instructed to indicate on a scale from 1 to 7 how long the situation described by the phrase (or sentence) would last. The questionnaire was arranged in sections, one for each item to be rated. At the top of the section, a phrase or sentence appeared, e.g., *to receive the Nobel Prize*. Underneath it, there was a question (*how long is the action or situation described?*). Underneath the question, there was a visual scale from 1 to 7, which had *very little time* and *much time* written on the extreme ends. Underneath the scale, there was a box, labeled “Response” where participants entered their rating.

Responses were recorded and the mean rating was calculated for each individual stimulus. Statistical comparisons across conditions were then performed and the ratings were correlated with the processing times obtained in Study 1 (whole phrase judgment) and Study 3 (reading times at verb position).

## 5.2. Results

### 5.2.1. Duration ratings

Study 1 phrases categorized as durative were perceived to last longer than those categorized as non-durative ( $t(19) = 5.85, p < .0001$ ). The mean rating for durative phrases was 4.75 (SD = 1.15), and that of punctual phrases was 2.95 (SD = 1.04). For example, *to appreciate an old friend* was given a mean rating of 6.35, whereas *to recognize an old friend* was given a mean rating of 2.3. Likewise, the imperfect sentences of Study 3 receiving a durative interpretation were rated higher than perfect sentences receiving a non-durative interpretation ( $t(22) = 4.74, p < .0001$ ). The mean rating for imperfect sentences was 4.14 (SD = 1.43) and that for perfect sentences was 3.26 (SD = 1.16). For example, *my sister knew the editor* was given a mean rating of 5.24, whereas *my sister met the editor* was given a mean rating of 2.24. Mean and standard errors are reported in Fig. 4.

### 5.2.2. Correlations

Two correlations were conducted, one for each set of materials (Study 1 or Study 3). The correlation between duration ratings and sensuality judgment time from Study 1 was significant ( $R = .37, p = .02$ ).

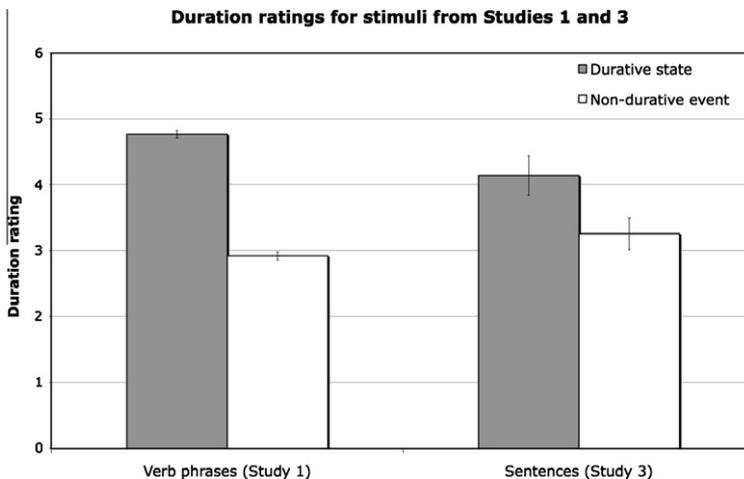


Fig. 4. Duration ratings for stimuli of Studies 1 and 3. Error bars indicate standard error.

The correlation between duration ratings and verbs' residual reading times from Study 3 also reached significance in a one-tailed test ( $R = .24$ ,  $p$  (one-tailed) = .05). Although we are justified in running a one-tailed correlation because the prediction was in a particular direction, this relationship was weaker than that in Study 1. This may be due to the nature of the tasks used to obtain each measure: on-line sentence processing (unlike whole phrase reading) involves quickly integrating each word with its preceding contexts as the sentence unfolds (Kamide, Altmann, & Haywood, 2003), whereas durations judgments were off-line and therefore, unlikely to capture on-line integration processes. The correlations for each study are depicted in Fig. 5. It should be noted that the relationship between duration ratings and reading times of Study 3 was much stronger when the ratings were correlated directly onto the raw reading times, rather than the residuals ( $R = .37$ ,  $p = .008$ ), suggesting that there was indeed a relationship between reading times and attributed duration.

### 5.3. Discussion

The results of this study indicated that durative phrases and sentences are perceived as taking longer than non-durative phrases and sentences. This confirms that our materials indeed differed in duration, and further suggests that at least for some verbs, aspectual morphemes in appropriate contexts convey a change in temporal duration. More critically, the degree to which the attributed duration increased co-varied with increases in processing times. This suggests that representations of event duration make a significant contribution to on-line processing, which appear graded in nature: the longer the duration attributed to the event, the longer the processing times. Therefore, the event representations that are entertained in on-line language comprehension reflect the duration of the events in our perception of the real world.

## 6. Study 5: Unrestricted associations for events of different durations

In this study, we investigate further the nature of the semantic representations that are elicited by durative and non-durative events. In particular, we examined the kind of knowledge that people associate with these types of events. We hypothesized in the introduction that durative events require the retrieval of more diverse types of knowledge, because they occur in more varied temporal and contingency relations than punctual events. Durative states, by virtue of persisting in time, co-occur and are associated with a variety of other properties (individuals' properties, events and states), whereas short non-durative events primarily establish contingency relationships with temporally preceding and following events (Moens & Steedman, 1988). If this is the case, it predicts that durative events should elicit more diverse associated knowledge than non-durative ones.

The knowledge associated with durative and non-durative events was also hypothesized to play a role during processing, as more diverse properties may engender more retrieval difficulty due to the

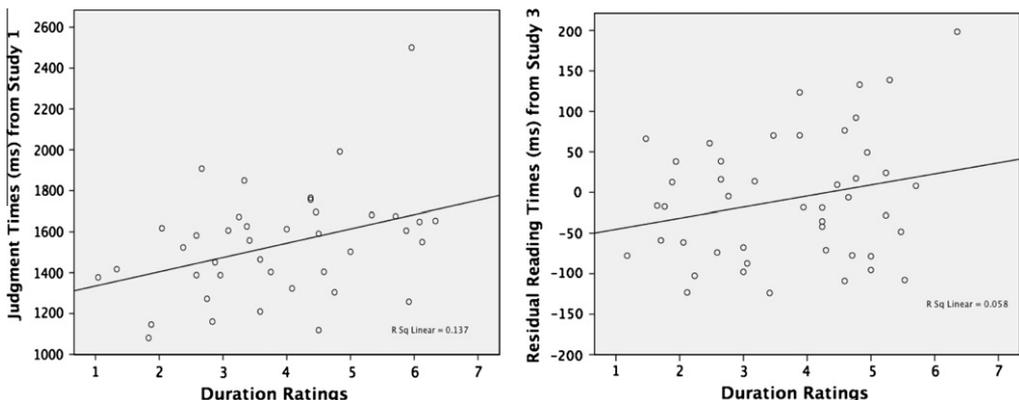


Fig. 5. Correlations between duration ratings and processing times from Studies 1 and 3.

fact that multiple relatively weak (less frequent) associations operate for durative events. If semantic characteristics of durative and non-durative events partly explain our understanding of event duration and the processing of event descriptions, the knowledge associated with these events should correlate with both reading times and duration ratings, because this knowledge should underlie the representations elicited by language, whether in a duration judgment task or in a reading task. In other words, similar types of knowledge should be activated whenever we read event descriptions, notwithstanding differences in tasks.

To test these predictions, we asked participants in this study to provide all the associations that came to mind when reading the phrase stimuli of Study 1 and the inflected verbs of Studies 2 and 3 (the verbs of Studies 2 and 3 were the same, except for two). Free associations of this kind have been extensively used in psychology as an index of lexical knowledge that is derived from experience of the language and the world. Words (or events in the world) that tend to co-occur with each other become associated so that encountering one word brings the other to mind. Measures based on associations have been shown to correlate with behaviors such as priming and lexical decisions (Hutchison, 2003), recall and recognition memory (Nelson, Dyrdal, & Goodman, 2005; Nelson & Goodman, 2002; Nelson, McEvoy, & Schreiber, 2004) and other types of semantic decisions (de Groot, 1989). Because it is difficult to investigate the properties that people associate with complex actions and events beyond their potential participants (e.g., Ferretti et al., 2001), we reasoned that this method was well suited to begin to approximate the representation of rather intangible event properties such as their duration.

## 6.1. Method

### 6.1.1. Participants

Twenty students from the Open University of Catalonia participated in this study. All were native speakers of Spanish and they did not participate in previous studies.

### 6.1.2. Materials and design

A web questionnaire contained the stimulus phrases of Study 1 and the inflected verbs of Studies 2 and 3, arranged in two lists, as in the previous studies. A given participant thus only saw one version of each item (either the durative or the non-durative version of a verb or verb phrase). The inflected verbs of Studies 2 and 3 were presented in isolation, because the reading studies suggested that the verb themselves carry duration information and the presentation of the whole-sentence (or subject plus verb) would have elicited many associations related to the sentential nouns, rather than the verbs. Moreover, by using the inflected verbs only, we can correlate their reading times to their associated knowledge, although the verbs' reading times not only reflect the retrieval of verb properties but also their integration with the subject noun. Similarly, we used the whole phrase for stimuli in Study 1 because the decision times in that study represented comprehension of the whole phrase.

### 6.1.3. Procedure

Participants were asked to write down everything that occurred to them in relation to the event described by each phrase or inflected verb. Participants were also explicitly told that there was no restriction as to the number or type of association to be used and were instructed to enter their answers in a text box, separating the associations by commas.

### 6.1.4. Data analysis and coding

Data were analyzed separately for the phrase stimuli (Study 1) and the verb stimuli (Studies 2 and 3) by computing for each item the proportion of association types provided. We focused on proportions of associations calculated for each item because this allows correlating the associations with the reading times of the studies above on an item-by-item basis. However, we checked that the distributions obtained across items were similar to those obtained in analysis across participants.

For coding purposes, we considered two responses to be the same association when the same word form was provided by different participants. The word *money* for example, was often produced in association with the phrase *to owe 50 euros* (see Table 6), and all the instances of this word were

**Table 6**  
Example of associations and coding scheme from Study 5.

Condition	Stimulus	Example responses per subject	English translation	Semantic type			
				Property	Entity	State	Event
Durative	<i>deber 50 euros</i> 'to owe 50 euros'	moroso, deuda, deudor	slow to pay, debt, debtor	1	1	1	
		faltar, monedero, hosco, fastidio deuda, anticipo, préstamo, amistad malestar, agradecimiento	lack, wallet, surly, annoyance/displeasure debt, advance, loan, friendship discomfort, gratitude	1	1	2 2 2	2
Non-durative	<i>perder 50 euros</i> 'to lose 50 euros'	solo dinero, jugar, despiste	only money, play/gamble, slip		1		2
		un pequeño contratiempo, un despiste lástima, juego, descuido putada, dinero, caer al suelo	a little setback, a slip pity, gambling, slip bugger, money, to fall on the ground	1		1 1	2 3 2
Durative	<i>escondía</i> 'was hiding'	amagaba, juego, tesoro, pirata, isla	was threatening, game, treasure, pirate, island		4	1	1
		ocultaba, dinero, pruebas secreto, algo furtivo, ilegal futuro, camino, transparencia sorpresa, secreto, personal	was hiding, money, proofs secret, something furtive, illegal future, path, transparency surprise, secret, personal	3 1 2	2	1 1	1
Non-durative	<i>escondió</i> 'hid'	tapó, vergüenza, estrategia	covered, shame, strategy			1	2
		tapar, escondite, rincón, juego juego, niño, buscar amagó, ocultó niño, juguete, anciano, medicamento, ocultar, información	to cover, hiding place, corner, game game, child, seek threatened, hid child, toy, elder, medicine, to hide, information		3 2	1 1	1 2 2

Notes: Example stimuli from Study 1 are exemplified in the top portion of the table, and inflected verb stimuli from Studies 2 and 3 are exemplified in the bottom portion. Only responses from four or five subjects are listed in each case.

considered one association. A few cases of synonym words or phrases (20 cases) for the stimuli of Study 1 were also conflated into one association (e.g., *ir justo de dinero, tener poco dinero*, 'have little money'). There were many cases in which participants provided morphologically related words, e.g., *to bind* and *bound*, or *to sum* and *the sum*. Such cases were considered as different associations because they provide different semantic information, although alternative analyses in which these cases were conflated into one association were also conducted with no differences in the pattern of results.

For the semantic coding of the data, we assigned a semantic category to each association in a way that was guided by the word class but included more fine-grained distinctions. With a few exceptions, word class in Spanish is unambiguously indicated by the word endings (nouns occur with number markers and gender markers, verbs are marked for person, number, tense and other verbal markers and adjectives occur with variable gender and number markers). Since nouns can refer to objects or events, we coded whether nouns refer to an entity (including concrete or abstract ones, e.g., *scientist, money, truth*), to an event (e.g., *the training, the reading*), to a state (e.g., *value, fear, anxiety*) or in a few cases to a property (e.g., *intelligence, indecision*). Likewise, verbs and verb phrases were subcategorized as states (e.g., *to be courageous, to be frightened, to be someone*), actions/events (e.g., *to win, to get to understand, to pay*) or sometimes properties (e.g., *to lack clarity, to be isolated*). Adjectives were categorized as properties. For this semantic classification of words, we used dictionary definitions that provide major semantic categories, e.g., *anxiety* is defined as a state of agitation, rather than an event or occurrence of some kind.

These four categories (objects, events, states and properties) are typically considered basic ontological types in semantics (Dowty, 1979; Jackendoff, 1991) and provide an approximation to the type of knowledge people associate with different events. Because sometimes a word can be interpreted in different ways, e.g., the noun *information* in Spanish, can refer to the act of informing or to the content being transferred, it can be classified as an entity or an event. These ambiguities are also reflected in the different senses of dictionary definitions, e.g., the act of informing, and the knowledge communicated (Real Academia Española, 2001). For cases like this, the associations were coded as both an entity and an event. Examples of the coding scheme are shown in Table 6.

#### 6.1.5. Data set characteristics

For the phrase stimuli (Study 1), 506 associations were provided for durative state phrases and 538 for non-durative phrases. The mean proportion of responses across items (calculated from the total responses for each item) was .48 for durative phrases and .52 for non-durative ones. These means were the same when the proportions were calculated across participants. For the verb stimuli (Studies 2 and 3), there were 384 associations for durative (imperfect) verbs and 369 for non-durative (perfect) ones. The mean proportion of responses across items or participants (calculated from the total responses for each item or each participant) was .51 for durative verbs and .49 for non-durative ones. These proportions did not differ significantly for both stimulus sets in either by-items or by-participants analyses (Wilcoxon non-parametric Signed Ranks Tests: all  $p$ 's > 1).

## 6.2. Results

### 6.2.1. Semantic type of associations

Analyses were carried out independently for each data set (Study 1 and Studies 2 and 3). To test whether the types of knowledge associated with our stimuli differed for durative and non-durative events, we computed the proportion of semantic types from the total number of productions in each stimulus condition. We reasoned that if durative states have more diverse associations than non-durative events, they should have relatively equally frequent types, i.e., more distributed associations across the different types, whereas non-durative events should have highly frequent associations of fewer types. As shown in Fig. 6, durative states were associated to relatively similar degrees with all semantic types, whereas non-durative events were more strongly associated with entities and events.

To statistically test for differences in the distribution (or relative frequency) of semantic types across conditions, we computed a difference measure between the proportions of semantic types (where the proportions of semantic types were computed from the total of associations in each

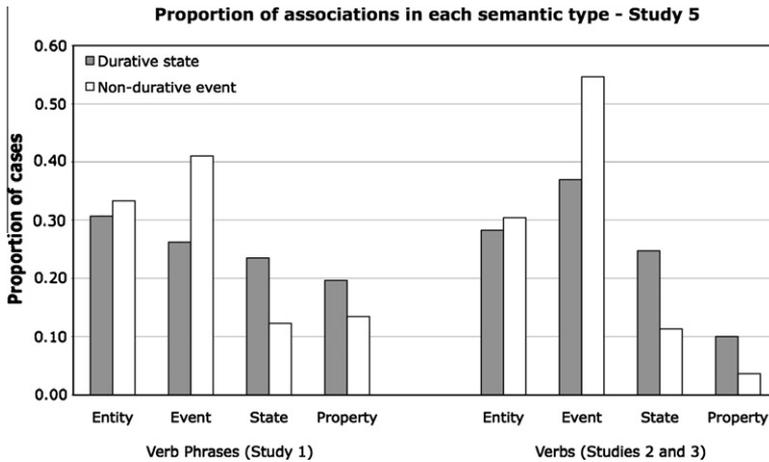
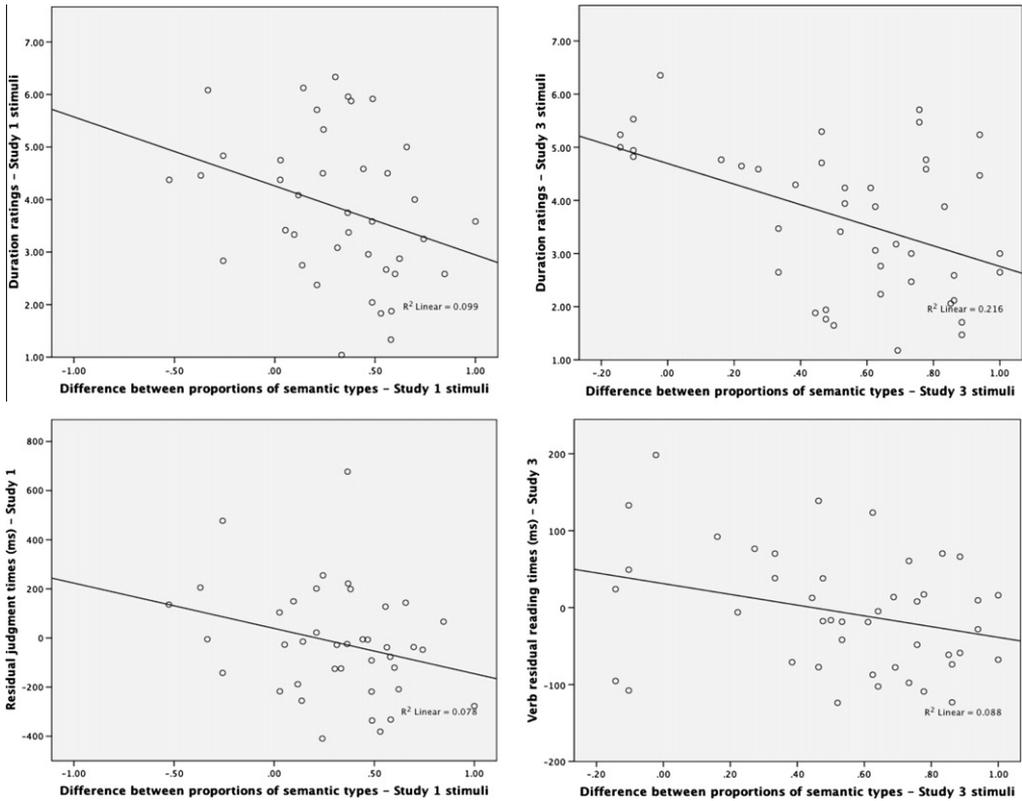


Fig. 6. Proportions of associations for each semantic type as a function of event duration conditions.

condition for a given item or participant). As can be seen in Fig. 6, entity and event associations were consistently provided for both durative and non-durative events. So for each item (or participant) in each stimulus set, we computed the difference between the sum of entity and event proportions and the sum of states and property proportions (i.e.,  $(\text{entity} + \text{event}) - (\text{state} + \text{property})$ ). For example, for the phrase *to lose 50 euros*, the type proportions were distributed as follows: event associations = .59, entity associations = .18, property associations = .12 and state associations .12. The difference defined above then was  $(.59 + .18) - (.12 + .12) = .53$ , indicating that for this phrase, there was a relatively large difference between the semantic types. A number closer to 0 would indicate a smaller difference between the types, thus reflecting a more even distribution of proportions across the types. We thus reasoned that if associations for durative states are more distributed across different types, then the differences between the types in the durative condition should be smaller than the non-durative conditions. Indeed, for the phrases of Study 1, the mean difference across durative items was .14, whereas it was .50 across the non-durative items. (Means computed across participants were similar: .11 for durative phrases and .48 for non-durative phrases.) Likewise, for the inflected verbs of Studies 2 and 3, the mean difference between the types across durative items was .32, and the mean difference across non-durative events was .70 (with similar values obtained in the analysis across participants: .32 and .71 respectively). Wilcoxon (non-parametric) Signed Ranks Tests confirmed the difference between the durative and non-durative distributions were significant in by-item analyses (for the phrase stimuli of Study 1,  $z = -3.57, p < .0001$ ; for verbs in Study 2,  $z = 4.78, p < .0001$  and for the verbs of Study 3,  $z = -4.11, p < .0001$ ), with nearly identical results in by-participant analyses. This result thus suggests that for non-durative items, entity and event associations tended to be more frequent than others, as suggested by Fig. 6, whereas for durative items, the frequency of event and entity association did not differ as much from other types.

### 6.2.2. Correlations

We hypothesized that the representations entertained during reading rely on more or less diverse semantic representations, as the representations of durations do. We thus predicted that semantic type differences should negatively correlate with residual reading times from Studies 1, 2 and 3 because the smaller the difference between the types (i.e., the more variable their distribution), the longer the reading times. To test this prediction, for each study, we separately correlated the semantic type differences for each item (obtained as indicated above) with its residual reading times. The correlation was significant for the items of Study 1 (Study 1:  $R = -.28, p = .04$ , one-tailed) and those of for Study 3 ( $R = -.30, p = .05$ ), but not for the items of Study 2. Correlations with reading times are shown in the bottom panel of Fig. 7. The lack of a significant correlation in Study 2 is perhaps due to the fact that



**Fig. 7.** Correlations of proportions of association types with processing times and duration ratings for stimuli from Studies 1 and 3. The top panel displays the correlation with duration ratings. The bottom panel displays the correlations with processing times.

processing the verbs within narrative contexts does not require as much semantic retrieval as in the absence of context, due to priming by the preceding context.

Given the distribution of semantic types shown in Fig. 6, one may ask whether the proportion of event or state associations, which are different for durative and non-durative events, is responsible for differences in processing times, thus undermining the claim that semantic diversity plays a role in on-line processing. It is indeed possible that the type of associations, rather than their diversity, explains the differences between durative and non-durative events. To address this issue, we checked whether the proportions of each association type individually correlate with processing times. Although our composite measure of semantic diversity is derived from the proportion values that entered into its calculation, none of the individual proportion measures significantly correlated with reading times in a consistent manner across Studies 1 and 3. All correlations but one were not significant (Study 1: entity proportions:  $R = .12$ ,  $p = .47$ ; event proportions:  $R = -.20$ ,  $p = .21$ ; state proportions:  $R = .25$ ,  $p = .13$ ; property proportions:  $R = .13$ ,  $p = .43$ ; Study 3: entity proportions:  $R = -.08$ ,  $p = .57$ ; event proportions:  $R = -.24$ ,  $p = .12$ ; state proportions:  $R = .23$ ,  $p = .14$ ; property proportions:  $R = .33$ ,  $p = .03$ ). However, other composite measures did tend to correlate with processing times in both studies: the sum of events and entities was negatively related with processing times (Study 1:  $R = -.28$ ,  $p = .08$ ; Study 3:  $R = -.30$ ,  $p = .03$ ) and the sum of states and properties was positively correlated with processing times (Study 1:  $R = .28$ ,  $p = .08$ ; Study 3:  $R = .30$ ,  $p = .03$ ). These measures are the mirror image of each other: the more the event + entity associations, and the fewer the state + property associations, the faster the processing times and vice versa. These relations are thus equivalent to our diversity measure: the more the differences between the semantic types, the more the processing times. These observations therefore suggest that it is not any particular association type (or sum of

types) that relates to processing times, but rather the relationship between the types, as hypothesized. Note incidentally that the difference measure used in the present analysis was not correlated with the imageability rating collected in Study 1 ( $R = .23, p < 1$ ), thus suggesting that the information underlying this measure is not related to this variable.

Recall that we have argued that diversity of semantic knowledge underlies the representation of durative events, as compared to non-durative ones, and thus should also play a role when making duration judgments. To test whether variability in association types co-varies with the duration ratings that were obtained in Study 4, we correlated the mean difference in proportion for each item in each condition (as reported above) with their corresponding duration ratings. We expected that an increase in attributed duration should co-vary with a decrease in differences between the types (a negative correlation), because by hypothesis, more diverse semantic associations (i.e., smaller differences between the types) should underlie the representation of durative events. The correlations for items of Studies 1 and 3 (the only studies for which we collected duration ratings) were both significant (Study 1 stimuli:  $R = -.314, p = .05$ , Study 3 stimuli:  $R = -.465, p = .001$ ). These correlations are shown in Fig. 7 on the top panels and clearly indicate a relation between semantic diversity and attribution of duration.

Given that both semantic diversity and duration ratings correlate with processing time, one may reasonably ask which variable has more weight in explaining processing. However this question cannot be conclusively answered because the measures that we have correlated with processing times come from non-comparable tasks. The unconstrained association task for example, may bias participants to think for longer and provide a lot more knowledge than they would use in providing a rating or they would be able to quickly activate during on-line processing. Thus, a weaker correlation for semantic diversity compared to duration ratings may only indicate that the association task was too open ended. With this caveat, nevertheless, we conducted analyses to evaluate the relationship between these variables, and in particular, examine whether duration ratings explain unique variance in processing times over and above that explained by variability in semantic types and vice versa. To this end, we conducted step-wise regressions and examined the  $R^2$  change statistics, which indicates whether the variable entered last significantly increases the amount of variance accounted for by the variable entered first. For the processing times of Study 1 stimuli, duration ratings did not significantly increase the variance accounted for the variability in semantic types ( $R^2$  change: .06,  $F$  change (1, 37) = 2.56,  $p > .1$ ), and the variability in semantic types also did not significantly increase the variance accounted for the duration ratings ( $R^2$  change: .04,  $F$  change (1, 37) = 1.54,  $p > .1$ ). The processing times of Study 3 stimuli revealed the same pattern (duration ratings entered after semantic diversity:  $R^2$  change: .04,  $F$  change (1, 37) = 1.71,  $p > .1$ ; semantic diversity entered after duration ratings:  $R^2$  change: .02,  $F$  change (1, 37) = 1.03,  $p > .1$ ). This suggests that duration ratings or variability in semantic types have a similar contribution in explaining processing times, which is consistent with our hypothesis that both measures should be grounded in similar types of knowledge, despite differences in tasks. Overall, the present correlations indicate that the diversity of semantic types associated with durative and non-durative events co-varies with duration attribution and processing times, suggesting that semantic diversity may indeed underlie both duration attribution and on-line processing.

### 6.3. Discussion

The results of this study have shown that the knowledge associated with durative states differs in semantic type and diversity from those of punctual events. Specifically, durative events were frequently associated with different types of associations (entities, events, states and properties) whereas non-durative events were mostly associated with entities and events. A corollary of this result is that durative states received more property and state associations than non-durative events (see Fig. 6). These findings are consistent with the hypothesis that differences in knowledge diversity underlie the representation of non-durative and durative events.

Importantly, unlike measures based on a single semantic type, a measure of variability in association types (operationalized as the difference in proportions between semantic types) correlated with duration ratings and processing times: For the two types of stimuli investigated, verb phrases or inflected verbs, increases in association variability co-varied with increases in event duration and processing times. Because the associations were obtained in an unconstrained off-line task, it might be

expected that many of the associations listed in such a task do not necessarily play a role in on-line sentence processing, where quick integrations take place as the sentence unfolds (Kamide et al., 2003). This may indeed explain some of our results (e.g., a weak relationship among associations and processing times within sentences). Our findings are nevertheless consistent with the view that associations may reflect distributional co-occurrence frequencies (Nelson et al., 2004), so that at least some of the associations produced in unconstrained tasks are partially activated in on-line processing.

Taken together, the present results are consistent with our hypothesis that durative states, by virtue of their longer duration, establish contingency relations with a variety of other occurrences, including properties of individuals and other co-occurring states. This difference in semantic diversity appears to play a role both in the attribution of duration to descriptions of events and in on-line language processing, suggesting that (a) representing event durations involves retrieving semantic information that varies in diversity, and (b) the processing cost associated with event duration in on-line comprehension varies as a function of semantic diversity.

## 7. Study 6: Occurrence contexts of durative and punctual events

We have claimed in the introduction that the knowledge associated with event durations derives from our experience with these events. Since the knowledge associated with durative events appears more varied, compared to punctual ones, this might be explained by the diversity of the situations in which such events are encountered. In the present study, we test this claim by conducting a corpus analysis of the verbs of Study 1 and examining whether the contexts in which durative verbs occur are indeed more diverse than those of punctual verbs. In doing so, we take the words co-occurring with the verbs in a sentence both as a proxy for characteristics of the events in the real world and as an indication of the linguistic contexts of use. For example, sentences such as *the doctor had gotten the prognosis right* or *He fired four times and got them all right* (a translation of Spanish corpus sentences with the verb *acertar* 'get right') provide information about the event participants and about the situational context more generally, e.g., making predictions about an illness or hitting a target while shooting. At the same time, the sentential contexts also provide linguistic information typically associated with the verbs, for example, punctual verbs may tend to occur with perfective auxiliaries such as *have* as in *had gotten it right* or certain kinds of temporal adverbs such as dates. All these sorts of information contribute to distributional properties of verbs and events that have been linked via experience with the verb themselves.

Corpus-based semantic measures have already been used in the literature to explain processing and semantic properties of words. Measures such as contextual diversity (the number of contexts in which a word occurs, or the similarity/dissimilarity between words' contexts), number of semantic features, number of semantic neighbors, and contextual dispersions (the number of content areas in which a word occurs) have been correlated with recognition and semantic decision times (Adelman, Brown, & Quesada, 2006; Burgess & Lund, 2000; McDonald & Shillcock, 2001; Pexman, Hargreaves, Siakaluk, Bodner, & Pope, 2008). Similar measures have also been used in the concrete-abstract literature, with more diverse contexts characterizing abstract words (Audet & Burgess, 1999; Barsalou & Wiemer-Hastings, 2005; Galbraith & Underwood, 1973; Schwanenflugel & Shoben, 1983). The measures used by Burges and colleagues are the closest to that used here, where similarity between contexts provides an index of their dispersion or diversity. In this approach, similarity is based on co-occurrence frequencies of vocabulary items: the more words are shared across contexts, the more similar they are and vice versa. These co-occurrence frequencies can then be subject to Multidimensional Scaling (MDS), which essentially maps similarities into spatial distances that can be visually inspected or further analyzed (Green, Carmone, & Smith, 1989).

### 7.1. Methods

#### 7.1.1. Materials

We conducted the corpus analysis on the verbs of Study 1. We did not use the whole phrases because there was an uneven number of instances of all the items (and very few in some cases) in the corpus used. This move is not problematic because our stimulus verbs themselves unambiguously convey duration information, e.g., the verbs *admire* and *discover* clearly differ in referring to a durative

state or a punctual event. Moreover, we did not conduct analyses on our perfective vs. imperfective cases (Studies 2 and 3) because a blind search of perfect and imperfect forms does not necessarily reflect durative or non-durative interpretations, as this depends on the verbs and nouns with which they occur.

### 7.1.2. Procedure

We used a Spanish corpus of 4 million words containing texts from two major Spanish newspapers (*La Vanguardia*, *El Periódico*). These newspapers cover a variety of topics: politics, current events, culture, economy, sports, technology, opinion, etc. From this corpus we randomly extracted 20 example sentences for each of our 40 verbs, yielding 800 cases to be used in our analyses. In the data set, each verb is used in 20 sentences, i.e., it occurs in 20 different contexts. Because the selection of cases was random, they are likely to be representative of some of the common contexts in which the verbs are used. The extracted sentences tended to be long, as it is common in Spanish writing. In total, there were 22,500 words in the data set.

Each word of the data set was reduced to its lemma form, i.e., they were stripped of their morphological inflection (singular or plural for nouns, verbal inflection for verbs) so that variants of the same word (e.g., *dog* and *dogs*) would be counted as occurrence of the lemma *dog*. The sentences were also stripped of articles such as *el*, *la* “the”, given that high co-occurrence would result from counting them (all nouns are typically preceded by articles in Spanish). Two different analyses were conducted.

*Verb-based analysis:* The first analysis treated the verb lemmas as objects of comparison. A computer program ran through all the lemmas in the corpus and computed the number of times that a verb’s context-words co-occurred with the context-words of every other verb. For example, if a word in the context of *acertar* ‘get right’ (e.g., *doctor* in the example above) also occurred in the contexts of another verb, a co-occurrence was computed between the verbs. This thus involves comparing every context-word of every verb with every other context-word of all other verbs. The end results was a  $40 \times 40$  matrix (each row and column representing a verb) where each cell in the coordinate positions of the matrix is the number of times the context-words of the verb in the *x*-axes co-occurred with the context-words of verb in the *y*-axes. This matrix was then entered into MDS as described below.

*Context-based analysis:* An alternative analysis was also conducted treating the verbs’ contexts (i.e., the sentences) as objects of comparison. Here, the computer program ran through the corpus counting the number of times each context-sentence share words with every other context-sentence. The result was a matrix of  $800 \times 800$  cases (each row and column representing a sentence), with each cell providing the number of shared words between two sentences.

These matrices were then subject to MDS (Audet & Burgess, 1999). This algorithm uncovers underlying dimensions based on distance measures. We used Euclidean distance (within the ASCAL and PROXAL procedures) as a distance measure. The outputs of these procedures are perceptual maps in which the axes represent the underlying dimensions and the data points are the objects of comparisons (the verbs or the contexts). The distance between the points reflects the similarity between the verbs’ contexts where more similarity is closer distance.

### 7.2. Results

We reasoned that verbs that tend to share context-words (i.e., have similar linguistic contexts and occur in similar situations) should cluster together in space. In particular, durative verbs should share less context-words with other verbs and thus be more distant from other durative or punctual verbs. Results of the verb-based analysis are shown in Fig. 8. As can be observed, durative verbs (labeled “D”) are spread out across the quadrants, whereas punctual verbs (labeled “P”) tend to cluster with other verbs (some punctual, some durative) around the center of the space. To compute statistics on these distances, we calculated the mean Euclidean distance between each durative verb and every other verb in the matrix (yielding 20 numbers, one per durative verb) and the mean distance between each punctual verb with every other verb (yielding again 20 numbers, one per punctual verb). These two distributions thus represent the averaged distance of every durative or punctual verb to every other verb. A Mann–Whitney non-parametric test comparing these distributions revealed a significant difference (Mann–Whitney  $U = 85$ ,  $p < .005$ ). The averaged distance of durative verbs to other verbs

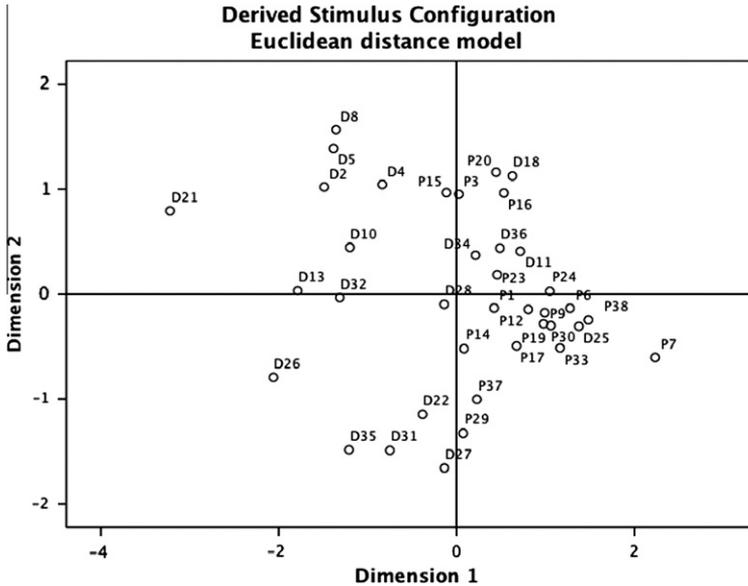


Fig. 8. MDS solution representing similarity between verb contexts.

was higher than that of punctual verbs, because their contexts are more diverse and are on average, less shared with those of other words.

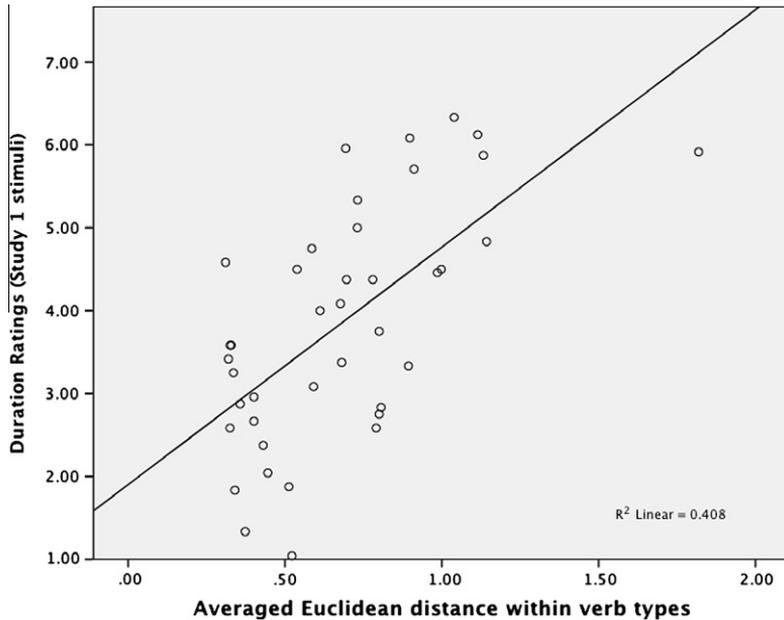
Results for the context-based analysis were similar. The spatial maps however are less informative than that of Fig. 8 because there are too many objects (800) whose labels are superimposed on each other in the map. Yet, comparisons across the contexts' distances were conducted. We reasoned that durative-verbs' contexts should be less similar between themselves (even though they share the verbs) than the contexts corresponding to uses of punctual verbs. To test this prediction, we computed for each durative sentence, its average distance to all other durative contexts and compared this distribution to the average distance of each punctual sentence to all other punctual sentences. A Mann–Whitney non-parametric test comparing these distributions indicated that indeed the similarity among the durative contexts was lower than that between punctual contexts (Mann–Whitney  $U = 40,270$ ,  $p < .0001$ ).

### 7.2.1. Correlations

Since associations should emerge from the contexts of use, as should the understanding of event durations, we checked that contextual diversity is related to both duration judgments and diversity in associations. We thus correlated the distances obtained above with these measures. A correlation between duration ratings and the averaged Euclidean distances within verb types (the averaged distances of every durative or punctual verb to every other durative or punctual verb respectively) revealed a highly significant correlation ( $R = .64$ ,  $p < .0001$ ) displayed in Fig. 9. Moreover, the measure of semantic diversity obtained in Study 5 (the difference in proportions of associated semantic types) was also significantly correlated with this distance measure ( $R = -.34$ ,  $p = .03$ ). These correlations indicate that (a) the higher the duration rating, the more the distance between the verbs' contexts, and (b) the more diverse associations (due to a more disperse distribution), the higher the semantic distance between the verbs' contexts.

### 7.3. Discussion

These results suggest that the linguistic and situation contexts in which we experience verbs and events differ for durative and punctual cases. Durative verbs and events occur in contexts that share



**Fig. 9.** Correlation between duration judgments and the averaged Euclidean distance of each durative or punctual verb to every other durative or punctual verb (Study 1 verbs).

fewer characteristics with the contexts of other verbs or events (including durative events themselves), whereas punctual events tend to occur in contexts that share properties with those of other verbs. Moreover, correlations suggested that the understanding of duration (from the duration rating task) is linked to diversity in contexts of use, thus suggesting that representations of event duration may emerge from experience of the world and the language. Finally, the unfamiliar measure of semantic diversity used in Study 5 was also linked to contextual diversity (an unbiased objective measure), suggesting that associations and contexts are all grounded in the same knowledge base. Overall, the findings are consistent with the view that representations of event duration in memory are grounded in multi-modal and probabilistic knowledge acquired via linguistic and world experience.

## 8. General discussion

The present work has shown that verb phrases and inflected verbs referring to events of different duration yielded parallel results: expressions referring to durative events took longer to process than those referring to non-durative events, irrespective of whether or not the inflected verbs occurred in narrative contexts (Studies 1–3). The duration attributed to durative and non-durative events was also found to be different in off-line rating studies and was correlated with reading times, confirming the temporal content of the semantics activated on-line (Study 4). Additionally, durative and non-durative expressions from the reading studies elicited different types of associations with different frequencies, suggesting that durative states are associated with more varied and similarly frequent semantic properties. A measure of variability obtained from these associations also correlated with duration ratings and reading times, indicating a relationship between semantic diversity, event duration and processing cost (Study 5). Finally, corpus Study 6 showed that durative verbs occur in more semantically diverse contexts than punctual verbs, and that a measure of distance between verbs' contexts correlated with duration judgments and associations' diversity, suggesting that contextual and association diversity, as well as event duration, are grounded in world and linguistic experience. The fact that independent stimulus types yielded parallel effects in reading times, duration ratings, association

patterns and correlations substantiates the results and excludes alternative explanations such as potential form-based confounds. Overall, the results indicate that (a) event duration has immediate consequences in on-line language comprehension, suggesting that representations of events' temporal properties are entertained on-line and (b) such duration representations derive from probabilistic knowledge in semantic memory acquired via linguistic and world experience. Our results have several implications for theories of processing and semantic representations in language comprehension, to which we turn next.

### 8.1. Processing events' temporal properties on-line

The present results are the first to show that event temporal properties play a role in word-by-word sentence comprehension. Most previous studies dealing with time in language comprehension have focused on the temporal ordering and distance between events in the discourse using whole-sentence reading paradigms (Kelter, Kaup, & Claus, 2004; Rinck & Bower, 2000; van der Meer, Beyer, Heine, & Badel, 2002; Zwaan, 1996; Zwaan & Radvansky, 1998). Our findings in contrast suggest that temporal properties of the events are entertained on-line as soon as sufficient information has accrued in the unfolding sentence or context, rather than being inferred later on or not processed at all due to them being irrelevant or inconsequential to the task. It is therefore quite possible that event-specific temporal representations are integral to the comprehension process.

Insights into how event-specific temporal representations are computed on-line can also be inferred from our results. One characteristic of such computations is that temporal event properties emerge from combinations of verbs, nouns and morphemes specific to the contexts at hand. In Study 1, verbs were integrated with their object nouns in order to perform the task. In Studies 2 and 3, processing differences were observed as soon as the inflected verb was read. Although this may suggest a direct influence of perfect or imperfect morphology, it is nonetheless unlikely that this alternation is solely responsible for the changes in interpretation and processing times. The aspectual morphemes elicited different duration interpretations for the same verb because the verbs admitted durative and non-durative interpretations in the first place that are also available with other tenses, i.e., their lexical meanings have different senses (e.g., *llegar*, *incluir*, *rodear*, 'reach, include, surround' are ambiguous between the two interpretations in the present tense). Moreover, in some cases, the type of noun used as subjects (e.g., collectives or inanimates) provided the appropriate context to elicit a durative interpretation of the verb together with the imperfect morphology (e.g., the band included/had two saxophonists). As many researchers have argued, perfective vs. imperfective alternations typically involve a change in perspective or focus on certain parts of the events, but need not elicit changes in event duration (Carreiras et al., 1997; Dowty, 1979; Ferretti et al., 2007; Madden & Therriault, 2009; Madden & Zwaan, 2003; Smith, 1991). For example, the difference in interpretation between English progressive and simple past (e.g., *was running* vs. *ran*), like that between the corresponding Spanish tenses, does not necessarily entail differences in duration, because the two forms could in principle apply to the same event in the world (*John was running this morning*, *John ran this morning*). Therefore, the results of Studies 2 and 3 most likely reflect a combination of factors: the verb lexical meaning, the aspectual morpheme and the preceding sentential and discourse context. This observation contrasts with previous studies that have emphasized the role of verbs in carrying structured event information such as causal structure (Gennari & Poeppel, 2003; McKoon & Macfarland, 2002) and is consistent with more flexible approaches indicating that the linguistic and narrative contexts provide situation-specific information being integrated on-line (Ferretti et al., 2001, 2007; McRae, Ferretti, Amyote, 1997; Tanenhaus, Carlson, & Trueswell, 1989).

The most intriguing characteristic of on-line computations in our results is that durative states took longer to process than non-durative events. What processing mechanism may account for such an effect? One possibility is that durative states are inherently more difficult to process simply because they are longer and thus take longer to comprehend. This is in line with simulation theories of processing according to which comprehenders mentally re-enact the events described (Barsalou, Simmons, Barbey, & Wilson, 2003; Zwaan, 2008; Zwaan & Taylor, 2006). In this view, a longer event would take longer to simulate because the representations retain an analogical relation to the multi-modal experience of those events (Matlock, 2004; Matlock et al., 2005; Richardson & Matlock, 2007; Zwaan,

2008). Durative states may be simulated perceptually, emotionally, or by means of related actions, whereas non-durative events may primarily involve sensory-motor simulations. Our association and corpus results may perhaps fit this view because they can be taken as a reflection of the simulations engaged in processing each event type, with durative states engaging qualitatively more complex simulations.

An alternative explanation, grounded in attested probabilistic processing mechanisms, is that durative states take longer to process because their associated meanings engage a variety of features and related knowledge, ultimately derived from experience of the world and the language. The semantic diversity of durative states can then give rise to longer processing times in two ways that are not mutually exclusive: On the one hand, equally frequent semantic properties, which tend to be activated to similar degrees, may enter in competition with each other during their retrieval and/or integration with previous discourse. On the other hand, the relatively weak activation strength of a semantic property (which is determined by its co-occurrence frequency with the target form) may be more difficult to retrieve from memory than other strongly associated properties, thus engendering longer processing times. Since durative expressions have diverse associations and occur in diverse contexts, any given association is likely as strong as any other, giving rise to difficulty in comparison with the strong associations of punctual expressions. These types of mechanism have been amply demonstrated in the word ambiguity literature (MacDonald, Pearlmuter, & Seidenberg, 1994; Simpson, 1984, 1994). Meanings that co-occur with a word equally frequently compete with each other, thereby increasing processing time. Weakly associated meanings (so-called subordinate meanings) are also more difficult to activate, even in priming contexts. Moreover, words with weaker (and more diverse) semantic associates such as abstract words take longer to process outside facilitating contexts (Barsalou & Wiemer-Hastings, 2005; de Groot, 1989; Gee, Nelson, & Krawczyk, 1999; Schwanenflugel, 1991; Schwanenflugel & Shoben, 1983). Note that we are not claiming that durative states are ambiguous or abstract, but that the diverse/distributed nature of their associated knowledge can give rise to processing mechanisms similar to those in other well-studied domains, thus explaining the greater processing cost of durative states.

More research is needed to conclusively support either alternative. To the extent that simulations are understood as activating stored experiential knowledge associated with the events in question, both alternatives can be maintained, each providing an equivalent explanation that uses different descriptive vocabularies. However, we do not have direct evidence indicating that readers indeed partially re-enact the events described by the sentence, particularly for states such as *to deserve the Nobel Prize* or *to admire a writer*. Moreover, the simulation view remains unspecified as a mechanism for on-line language comprehension. Within this approach, it is unclear how linguistic markers such as perfective and imperfective tense, verb meanings and contexts come to be integrated into specific event simulations during on-line language comprehension. It is also unclear why and how the temporal scale of the re-enactments or simulations is very different from those of real world events. Surely, *John owns a house* can be true for a long period of time, but it does not take this long to understand this sentence. Finally, simulation approaches have typically emphasized sensory-motor properties for concrete concepts (e.g., object, locations, affordances) or introspective and social aspects for abstract concepts (e.g., emotions, communicative acts) (Barsalou & Wiemer-Hastings, 2005), with linguistic experience playing a minimal role (if any).

In contrast, probabilistic approaches provide specific mechanisms for word and sentence processing that are ultimately rooted in computational models of various kinds, including those modeling competition between interpretations as lexical, morphological and contextual information accrues in the sentence (Altmann & Mirkovic, 2009; Elman, 2004, 2009; Kawamoto, 1993; MacDonald, 1994; McRae, Spivey-Knowlton, & Tanenhaus, 1998; Tabor, Juliano, & Tanenhaus, 1997; Tabor & Tanenhaus, 1999). Experiential knowledge in this approach need not be limited to sensory-motor, subjective or social experience, and allows for word and sentence meanings to emerge from experienced regularities in real world situations and words-to-world mappings. Our finding that event durations correlate with contextual diversity in the corpus indeed suggests that linguistic experience and experience of word-to-world mappings is an important component of our representations, at least in language comprehension. Whichever the preferred mechanism, our results indicate that situation-specific information is quickly accessed and combined to determine semantic interpretations specific

to the unfolding linguistic context (Ferretti et al., 2001; McRae, Ferretti, Amyote, 1997; Tanenhaus & Trueswell, 1995; Trueswell, Tanenhaus, & Garnsey, 1994), and furthermore, they demonstrate the role of temporal information, previously unexplored in on-line sentence comprehension.

## 8.2. Representing time in language comprehension

Our findings also provide important insights as to the representation of temporal information. They suggest that representations of event duration are grounded in multiple types of experiences – real world situations containing entities, properties and relationships between events and the linguistic contexts in which events are referred to. These experiences are likely generalized over time into probabilistic representations of events in memory. Object, events and properties that tend to co-occur with one another become associated, so that the occurrence of one association member reactivates the other, depending on their association strength (co-occurrence frequency). We have shown that events of different duration elicit associations that vary in semantic diversity. Critically, durative events elicited equally frequent event and state associations, and more properties of individuals, than punctual events (e.g., *slow to pay*, *loan* and *debtor* is associated with *owing 50 euros*). Such associations indicate links to co-occurring and contingently related situations (one becomes a debtor when owning money, one owes money because of getting a loan, etc.). Non-durative events in contrast, mostly bring to mind entities taking part in the event as well as other events with which they establish contingency relationships (e.g., *money* and *gambling* are associated with *losing 50 euros*, where losing is contingent on gambling). These observations suggest that knowledge of causal and contingency relations established between events in the world may be particularly relevant for our understanding and representation of event durations. This is because these relations provide information about events' internal temporal development: we understand an event as long lasting because it tends to co-occur with a variety of situations in the world, establishing diverse temporal, causal and contingency relations. The representation of event duration in memory may be primarily composed of higher order contingencies between situations.

One possible concern with this knowledge-based view is that differences in event duration in fact correlate with differences in event causal structure, thus excluding an explanation solely based on temporal properties. In Study 1, durative states such as *to deserve the Nobel Prize* differ from non-durative events such as *to receive the Nobel Prize* not only in their duration but also in their causal structure: states do not entail changes in the world, whereas non-durative events do (Dowty, 1979). However, previous studies manipulating causal structure but not event duration have found that causally complex events take longer to process than causally simpler ones (Gennari & Poeppel, 2003; McKoon & Macfarland, 2002), suggesting that the effects of duration and causal complexity may be dissociable. Moreover, the stimuli of Studies 2 and 3 differ from lexically-specified states in that they do imply changes: the Spanish imperfective forms imply that the event causing the particular state being referred to has already occurred (i.e., they imply that the described state is the results of some past event). For example, the imperfect sentences *un camión bloqueaba la carretera* (“the truck was blocking the street”) and *el equipo rodeaba al entrenador* (“the team was encircling the coach”) imply that the event of blocking the street or surrounding the coach had taken place, as in the English versions *the truck remained blocking the street* or *the team remained encircling the coach*. The imperfect morphology focuses on there being a block or on a particular arrangement of players, but there must have been previous events resulting in the described state. Finally, the fact that processing times were correlated on an item-by-item basis with the duration ratings suggests that duration differences are not categorical but graded in nature, unlike the causal vs. non-causal distinction.

It is nevertheless possible that causal structure contributed to the present effects to some extent because durative and non-durative events, by their very nature, are bound to differ in causal structure. One may think that it is possible to distinguish causality from duration by keeping causal structure constant while varying duration. Experimental manipulations that come to mind include varying the properties of the objects to which actions apply, e.g., drinking a glass of water vs. drinking a bottle of water, or varying duration explicitly, e.g., running for one hour vs. running for two hours. Researchers have indeed started to generate results of this sort. Husband, Stockall, and Beretta (2008), for example, manipulated the specificity of the object reference (e.g., drink a beer vs. drink beer) and

found correlates of duration at the object position (Husband et al., 2008). In our own lab, we have collected eye-tracking data indicating that knowledge of the typical duration of events such as *mounting a horse* vs. *brushing a horse*, which differ in duration, results in different probability of fixating on the named entity, even though the two events are causally complex (Joergensen, 2008). Note however, that the convergence of time and causal structure in these events is inevitable, because longer events entail more sub-actions (e.g., more motor movements), and therefore more complex cause-effect relations.

Even outside the internal structure of an event, duration is difficult to disentangle from causal and contingency relations. Studies in narrative comprehension investigating temporal distance between events have shown that temporally distant events in the narrative take longer to read (or to retrieve from memory) than those closer in time (Gennari, 2004; Kelter et al., 2004; Rinck & Bower, 2000; Zwaan, 1996). Zwaan (1996) for example investigated time shifts in narratives and found longer reading times for sentences that were introduced by short intervals such as *a moment later*, compared to longer ones such as *an hour later*. Similarly Gennari (2004) found that in sentences like *The senator admitted today that the state of Texas executed an innocent person last year/last month*, the temporal reference *last year* takes longer to process than *last month*. These findings suggest that establishing relations between more distant events (e.g., between the admission and the execution) requires bringing about more world knowledge contingently linking them, and in particular, other events that could have happened in between. Thus, the representation of time itself, whether internal or external to an event, appears to be inherently dependent on causal and contingent relations.

The knowledge-based view of time advocated here contrasts with other approaches suggesting that time is an abstract domain that must be understood with reference to concrete ones. The metaphorical-extension view, for example, argues that the relational structure of the time domain is imported from that of space or motion (Boroditsky, 2000; Boroditsky & Ramscar, 2002; Matlock et al., 2005). Although there is undoubtedly a relationship between space, motion and time in our experience, particularly, during learning, very little is known about the role of concrete experience in processing temporal information. In particular, it is not clear whether concrete experience of motion and space is necessary to understand sentences referring to punctual events such as *recognize a friend* or states such as *owing money*. Moreover, it is not clear to date that space and motion ought to have a more privileged place than other experiences in the representation and/or learning of temporal relations and event durations. Sequences of events in the world, and contingency relations between them, can be very concrete experiences, and humans from a very young age are capable of tracking such contingent probabilities, whether they are linguistic or non-linguistic in nature (Aslin, Saffran, & Newport, 1998, 1999; Fiser & Aslin, 2002; Saffran, Johnson, Aslin, & Newport, 1999; Saffran, Newport, Aslin, Tunick, et al., 1997). It has also been suggested that time perception shares neural mechanisms with motor sequence planning (Meegan, Aslin, & Jacobs, 2000; Schubotz, Friederici, & von Cramon, 2000), and more generally, that representations of duration may emerge from the interaction of multiple sensory sources (Bueti, Bahrami, & Walsh, 2008; Ivry & Schlerf, 2008; van Wassenhove, Buonomano, Shimojo, & Shams, 2008). Our knowledge-based approach to duration representations is consistent with these alternative views to the extent that diverse kinds of experiences contribute to the representation of duration.

In sum, our results suggest that representations of event durations are grounded in knowledge built over time from linguistic and world experiences of events. This knowledge appears to critically include causal and contingency relations between events, as more diverse contingency relations to entities and events signify more duration. To the extent that language shares representations with other domains of cognition, this suggests that representations of time more generally may also stem from our experience of contingent probabilities between events in the world.

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**Appendix A. Stimulus items from Study 1**

		Spanish items	English translations
1	a	deber 50 euros	to owe 50 euros
	b	perder 50 euros	to lose 50 euros
2	a	admirar a un escritor famoso	to admire a famous writer
	b	toparse con un escritor famoso	to run into a famous writer
3	a	poseer una piscina	to own a pool
	b	caer en una piscina	to fall into a pool
4	a	apreciar a un viejo amigo	to appreciate an old friend
	b	reconocer a un viejo amigo	to recognize an old friend
5	a	pertenecer a una secta	to belong to a sect
	b	descubrir una secta	to discover a sect
6	a	preferir una bicicleta	to prefer a bicycle
	b	chocar con una bicicleta	to crash into a bicycle
7	a	costar una fortuna	to cost a fortune
	b	heredar una fortuna	to inherit a fortune
8	a	persistir una duda	to persist a doubt
	b	surgir una duda	to come up with a doubt
9	a	confiar en una operación	to trust an operation
	b	enterarse de una operación	to find out about an operation
10	a	residir en el centro de la ciudad	to live in the city centre
	b	localizar el centro de la ciudad	to locate the city centre
11	a	temer un tumor	to be afraid of a tumor
	b	detectar un tumor	to detect a tumor
12	a	desear la primera posición	to wish for first place
	b	alcanzar la primera posición	to reach first place
13	a	ignorar el resultado del partido	to ignore the score of the match
	b	acertar el resultado del partido	to ascertain the score of the match
14	a	merecer el Premio Nobel	to deserve the Nobel Prize
	b	recibir el Premio Nobel	to receive the Nobel Prize
15	a	necesitar una pista	to need a clue
	b	hallar una pista	to find a clue
16	a	tener un bulto en la cabeza	to have a lump on the head
	b	notar un bulto en la cabeza	to notice a lump on the head
17	a	aspirar a la independencia	to aspire to independence
	b	lograr la independencia	to achieve independence
18	a	tolerar la leche	to tolerate the milk
	b	cortarse la leche	to curdle the milk
19	a	necesitar una silla	to need a chair
	b	tropezar con una silla	to trip over a chair
20	a	sospechar la existencia de pesticidas	to suspect the presence of pesticides
	b	detectar la existencia de pesticidas	to detect the presence of pesticides

## Appendix B. Stimulus items from Study 2

	Spanish items	English translations
1	<p>a Los clientes de la discoteca no podían ver el horario que colgaba de la puerta. Sin darse cuenta, <i>el portero tapaba el cartel.</i></p> <p>b Mis amigas llegaron demasiado tarde a la discoteca. El local ya estaba cerrando. En la entrada había un rótulo que indicaba que aún estaba abierto, pero justo en ese momento, <i>el portero tapó el cartel.</i></p>	<p>The nightclub clients could not see the timetable hanging from the door. Without realizing it, <i>the doorman was covering the sign.</i></p> <p>My girlfriends arrived too late to the nightclub. The place was already closing. At the entrance, there was a sign indicating that it still was open. But just then, <i>the doorman covered the sign.</i></p>
2	<p>a El alumno tenía problemas para seguir la explicación ya que no podía ver las ecuaciones. Sin darse cuenta, <i>el profesor tapaba la pizarra.</i></p> <p>b Los alumnos hicieron un ejercicio de memorización. Tenían cinco minutos para leer veinte palabras. Una vez transcurrido el tiempo de lectura, <i>el profesor tapó la pizarra.</i></p>	<p>The student had difficulties following the explanation because he could not see the equations. Without realizing it, <i>the teacher was covering the blackboard.</i></p> <p>The students carried out a memory exercise. They had five minutes to read twenty words. Once the reading time elapsed, <i>the teacher covered the blackboard.</i></p>
3	<p>a Conseguimos entradas gratis para la obra de teatro. Desde hacía muchos años, <i>mi amiga conocía al director.</i></p> <p>b Después de la obra de teatro fuimos a una fiesta. A última hora, <i>mi amiga conoció al director.</i></p>	<p>We got free tickets for the play. For many years, <i>my girlfriend had known the director.</i></p> <p>After the play we went to a party. At the last minute, <i>my friend met the director.</i></p>
4	<p>a Tuve la oportunidad de publicar unos cuantos artículos en la revista T3. Desde hacía muchos, <i>mi hermana conocía al editor.</i></p> <p>b Después de la presentación del libro, los asistentes fueron invitados a un refrigerio. Esa tarde, <i>mi hermana conoció al editor.</i></p>	<p>I had the chance to publish several papers in the T3 Journal. For many years, <i>my sister had known the editor.</i></p> <p>After the book presentation, the audience was invited to have some snacks. That afternoon, <i>my sister met the editor.</i></p>
5	<p>a Cuando llegué a casa me di cuenta de que no podría entrar, ya que había una manifestación en la calle. <i>La multitud bloqueaba la entrada del edificio.</i></p> <p>a Había una manifestación delante del parlamento. Empezó bastante tranquila, pero poco a poco se fue calentando. <i>La multitud bloqueó la entrada del edificio.</i></p>	<p>When I arrived home, I realized that I could not enter because there was a demonstration in the street. <i>The crowd kept blocking /was blocking the entrance of the building.</i></p> <p>There was a demonstration in front of the parliament. At the beginning it was quiet but, gradually, it became more aggressive. <i>The crowd blocked the entrance of the building.</i></p>
6	<p>a El tráfico estaba colapsado y no se podía avanzar. <i>Un camión bloqueaba la carretera.</i></p> <p>b Fue un gran accidente. Varios coches chocaron. Además, <i>un camión bloqueó la carretera.</i></p>	<p>The traffic was jammed and it was impossible to move forward. <i>A truck kept blocking the road.</i></p> <p>It was a big accident. Several cars crashed. Besides, <i>a truck blocked the road.</i></p>

(continued on next page)

**Stimulus items from Study 2** (continued)

	Spanish items	English translations
7	<p>a La recepcionista verificó en el ordenador que el cliente estaba en la lista. <i>Su nombre aparecía en la pantalla.</i></p> <p>b La camarera estaba esperando una llamada de su novio. Estaba nerviosa y no dejaba de mirar el móvil. <i>Su nombre apareció en la pantalla.</i></p>	<p>The receptionist checked that the guest was on the list on the computer. <i>His name was showing on the screen.</i></p> <p>The waitress was waiting for a call from her boyfriend. She was anxious and she couldn't stop looking at the mobile. <i>His name appeared on the screen.</i></p>
8	<p>a Mi familia estaba invitada a un estreno en el cine más importante de la ciudad. <i>Mi hermano aparecía en la película.</i></p> <p>b Ayer fui al cine a ver una película que se había rodado en mi ciudad. No os podéis imaginar la sorpresa que me llevé cuando, de repente, <i>mi hermano apareció en la película.</i></p>	<p>My family was invited to a movie opening in the most important cinema of the city. <i>My brother appeared/was in the movie.</i></p> <p>Yesterday I went to the cinema to see a movie that was filmed in my city. You can't imagine how surprised I was when, suddenly, <i>my brother appeared in the movie.</i></p>
9	<p>a Era un negocio muy rentable en el que estaban implicados miles de socios. <i>La empresa formaba la distribuidora más poderosa del país.</i></p> <p>b Era un negocio muy antiguo. Al principio era tan sólo un pequeño proyecto familiar, pero en el año 1990, <i>la empresa formó la distribuidora más poderosa del país.</i></p>	<p>It was a very profitable business in which thousands of partners were involved. <i>The company amounted to/constituted the most powerful distributor of the country.</i></p> <p>It was an old business. At the beginning it was just a small family project, but in 1990, <i>the company formed/established the most powerful distributor of the country.</i></p>
10	<p>a Era una empresa de hostelería conocida internacionalmente. <i>La compañía formaba la cadena hotelera más prestigiosa del mundo.</i></p> <p>b Una famosa empresa de hostelería se fundó en esa isla. En concreto, en el año 1980, <i>la compañía formó la cadena hotelera más prestigiosa del mundo.</i></p>	<p>It was an internationally renowned hotel business. <i>The company amounted to/constituted the most prestigious hotel chain in the world.</i></p> <p>A famous hotel business was set up on that island. Specifically, in 1980, <i>the company formed/established the most prestigious hotel chain in the world.</i></p>
11	<p>a Juan solía decir que hacía horas extras en la oficina, pero era evidente que tenía una amante. <i>Su esposa sabía la verdad.</i></p> <p>b Juan intentó ocultar durante meses la historia de su amante, pero no lo logró. <i>Su esposa supo la verdad.</i></p>	<p>John used to say that he was working overtime at the office, but it was obvious that he had a lover. <i>His wife knew the truth.</i></p> <p>For months, John tried to conceal his love story but he didn't managed. <i>His wife found out the truth.</i></p>
12	<p>a El jefe de la oficina había sido encarcelado. Sólo uno de sus empleados estaba al corriente de lo que había pasado. <i>La secretaria sabía la historia del secuestro.</i></p> <p>b El jefe de la empresa tenía un pasado oscuro. Intentó ocultarlo, pero finalmente uno de sus empleados se enteró. <i>La secretaria supo la historia del secuestro.</i></p>	<p>The office boss had been jailed. Only one of his employees was aware of what had happened. <i>The secretary knew about the kidnapping.</i></p> <p>The office boss had a dark past. He tried to conceal it but one of his employees heard. <i>The secretary found out about the kidnapping.</i></p>

**Stimulus items from Study 2** (continued)

	Spanish items	English translations
13	<p>a La empresa dónde trabajaba mi padre había perdido mucho dinero durante el último año. Más de la mitad de los empelados tendrían que ser despedidos. <i>La situación afectaba a mi padre.</i></p> <p>b Mi padre presenció un asesinato mientras estaba caminado tranquilamente por la calle. La escena era terriblemente dura. <i>La situación afectó a mi padre.</i></p>	<p>The company where my father worked had lost a lot of money in the last year. More than half of the employees would have to be fired. <i>The situation had consequences for my father.</i></p> <p>My father witnessed a murder while he was walking peacefully along the street. The situation was terribly hard. <i>The situation moved/affected my father.</i></p>
14	<p>a Por ese entonces, una gran controversia envolvía el instituto. Cuatro profesores estaban implicados en una red de pornografía infantil. <i>La polémica afectaba al director.</i></p> <p>b Ayer se supo que algunos de los profesores del instituto estaban implicados en una red de pornografía infantil. Al enterarse de la noticia, la profesora de matemáticas se puso a llorar. <i>La polémica afectó al director.</i></p>	<p>In those days, a big controversy surrounded the school. Four teachers were involved in a child pornography network. <i>The controversy had consequences for the director.</i></p> <p>Yesterday it was revealed that some teachers of the school were involved in a child pornography network. When the mathematics teacher heard the news she started crying. <i>The controversy moved/affected the director.</i></p>
15	<p>a Eran pocos y era difícil organizarse cuando había un incendio. <i>La brigada integraba diez bomberos.</i></p> <p>b El incendio era enorme. Necesitaban más personal. <i>La brigada integró a diez bomberos.</i></p>	<p>They were a small group and it was difficult to get organized when there was a fire. <i>The brigade consisted of ten firemen.</i></p> <p>The fire was huge. More staff was required. <i>The brigade incorporated ten firemen.</i></p>
16	<p>a Era una entidad deportiva más bien pequeña. En total, <i>la federación integraba tres equipos.</i></p> <p>b Cada año la entidad deportiva tenía alguna nueva incorporación. El año pasado, <i>la federación integró tres equipos.</i></p>	<p>It was quite a small sport organization. Altogether, <i>the federation consisted of three teams.</i></p> <p>Every year the sport organization had a new member. Last year, <i>the federation incorporated three teams.</i></p>
17	<p>a Los espectadores del partido de básquet se estaban aburriendo. Sin intención de moverse, desde hacía más de diez minutos, <i>el equipo rodeaba al entrenador.</i></p> <p>b Era un partido de básquet con mucho ritmo. El árbitro pitó falta a un jugador y el entrenador solicitó tiempo muerto. En un instante, <i>el equipo rodeó al entrenador.</i></p>	<p>The spectators of the basketball match were getting bored. With no intention of moving, for more than ten minutes, <i>The team kept encircling the coach.</i></p> <p>It was a lively match. The referee called a foul on a player and the trainer requested time out. Right away, <i>the team surrounded the trainer.</i></p>
18	<p>a La disposición del teatro era perfecta. <i>El público rodeaba el escenario.</i></p> <p>b Mucha gente esperaba para entrar al teatro. Finalmente, se abrieron las puertas y, en un instante, <i>el público rodeó el escenario.</i></p>	<p>The theatre layout was perfect. <i>The audience was located around the stage.</i></p> <p>Many people were waiting to go into the theatre. Eventually, the doors were opened and, in a moment, <i>the audience surrounded the stage.</i></p>

(continued on next page)

**Stimulus items from Study 2** (continued)

	Spanish items	English translations
19	<p>a Era una banda realmente innovadora, ya que fusionaba jazz y música tradicional. <i>La banda incluía a dos saxofonistas.</i></p> <p>b La banda de música del pueblo era muy pequeña. El año pasado recibió una subvención del ayuntamiento para ampliar la formación. <i>La banda incluyó a dos saxofonistas.</i></p>	<p>It was a really innovative band because it merged jazz and traditional music. <i>The band had/included two saxophonists</i></p> <p>The village band was very small. Last year it received a loan from the city council to increase the group. <i>The band incorporated/included two saxophonists.</i></p>
20	<p>a El centro contaba con varios grupos de investigación. Había muchos grupos interdisciplinarios. <i>El grupo de ciencias económicas incluía a dos psicólogos.</i></p> <p>b La universidad contrató a muchos profesionales el año pasado, aumentando así el número de investigadores en cada grupo de investigación. <i>El grupo de ciencias económicas incluyó a dos psicólogos.</i></p>	<p>The centre had several research groups. There were many interdisciplinary groups. <i>The economics group had/included two psychologists.</i></p> <p>Last year the university hired a lot of professionals, thus increasing the number of researchers in each group. <i>The economics group incorporated/included two psychologists.</i></p>
21	<p>a Años atrás no había metro en la ciudad, sólo una pequeña compañía de autobuses que funcionaba de lunes a viernes. <i>La compañía constituía el medio de transporte más importante de la ciudad.</i></p> <p>b La compañía fundó la primera línea de metro en Barcelona. Exactamente, en el año 1920, <i>la compañía constituyó el medio de transporte más importante de la ciudad.</i></p>	<p>Years ago, there was no tube in the city. There was only a small bus company that worked from Monday to Friday. <i>The company was /constituted the most important public transport of the city.</i></p> <p>The company established the first tube line in Barcelona. Exactly, in 1920, <i>the company set up the most important public transport of the city.</i></p>
22	<p>a En aquella época había otras empresas en la ciudad, pero no tan importantes. <i>El equipo vasco constituía la empresa telefónica más importante de la ciudad.</i></p> <p>b Durante los años ochenta no había ninguna empresa de comunicación en la ciudad. En el año 1991, <i>el equipo vasco constituyó la empresa telefónica más importante de la ciudad.</i></p>	<p>In that period, there were other companies in the city, but they were less important. <i>The Basque team was / constituted the most important telephone company of the country.</i></p> <p>In the eighties, there was no communication company in the city. In 1991, <i>the Basque team set up the most important telephone company of the country.</i></p>
23	<p>a La zona afectada por el incendio era enorme. <i>El fuego llegaba hasta el pueblo.</i></p> <p>b No había manera de apagar el incendio. Seguía esparciéndose incesantemente. Finalmente, <i>el fuego llegó hasta el pueblo.</i></p>	<p>The area affected by the blaze was enormous. <i>The fire was reaching/was near the town.</i></p> <p>There was no way to extinguish the blaze. It kept growing incessantly. Finally, <i>the fire reached the town.</i></p>
24	<p>a Algunos edificios del casco antiguo contenían objetos y joyas de la edad media. <i>El ayuntamiento escondía un valioso pergamino.</i></p>	<p>Some buildings of the old town centre had objects and jewels from the Middle Ages. <i>The town hall kept/was hiding a very valuable scroll.</i></p>

**Stimulus items from Study 2** (continued)

	Spanish items	English translations
	b Las tropas del bando contrario habían invadido la ciudad. Para evitar el robo, <i>el ayuntamiento escondió un valioso pergamino.</i>	The enemy troops had invaded the city. To avoid looting, <i>the city council hid a valuable scroll.</i>
25	a La policía recibió una carta. Al parecer, incluía los nombres de algunos involucrados en el atentado. <i>La carta implicaba a gente muy rica.</i>	The police received a letter. It seems that it included the names of those involved in the attack. <i>The letter implicated very rich people.</i>
	b La asociación contra el cáncer escribió una carta en el periódico dónde solicitaba dinero para impulsar nuevos programas de investigación. <i>La carta implicó a gente muy rica.</i>	The association against cancer wrote a letter in the newspaper where it requested money to promote new research projects. <i>The letter got very rich people involved.</i>
26	a La liga de fútbol era muy aburrida. Hacía ya un mes que los equipos permanecían en la misma posición. <i>El Barça superaba al Real Madrid en dos puntos.</i>	The football league was very boring. The teams remained in the same position for a month. <i>Barça was ahead of Real Madrid by two points.</i>
	b El partido de fútbol de este fin de semana fue muy emocionante. <i>El Barça superó al Real Madrid en dos puntos.</i>	The football match this weekend was very exciting. <i>Barça beat Real Madrid by two points.</i>
27	a El cocinero era un hombre extremadamente gordo. Su cintura medía casi tanto como el marco de las puertas del restaurante. <i>Afortunadamente, el cocinero entraba por la puerta principal.</i>	The cook was extremely fat. His waist was almost as big as the frame of the restaurant doors. Fortunately, <i>the cook could fit through the main door.</i>
	b Cuando llegó al restaurante, <i>El cocinero entró por la puerta principal.</i>	When he arrived at the restaurant, <i>the cook entered through the main door.</i>
28	a Era una furgoneta extremadamente alta y ancha. Por suerte, el techo medía más de tres metros y <i>la furgoneta entraba en el garaje.</i>	The van was extremely tall and wide. Fortunately, the ceiling was more than three meters and <i>the van could fit in the garage.</i>
	a Una furgoneta paró justo delante del edificio. Un hombre vestido de blanco bajó del vehículo y <i>la furgoneta entró en el garaje.</i>	The van stopped just in front of the building. A man in white got off the vehicle and <i>the van entered the garage.</i>
29	a Durante la clase de debate se presentaron diferentes opiniones sobre el tema. <i>El alumno coincidía con el profesor.</i>	In the class debate, different opinions about the topic were presented. <i>The student agreed with the teacher.</i>
	b No se habían visto desde el instituto. Muchos años más tarde, en un congreso de psicología, <i>el alumno coincidió con el profesor</i>	They had not seen each other since school. Many years later, in a psychology conference, <i>the student ran into the teacher.</i>
30	a Dos miembros del jurado tenían la misma opinión acerca del libro. <i>El crítico coincidía con la escritora.</i>	Two members of the jury had the same opinion about the book. <i>The critic agreed with the writer.</i>

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**Stimulus items from Study 2** (continued)

Spanish items	English translations
b Se habían conocido durante la presentación de un libro, y no se habían vuelto a ver. Muchos años más tarde, <i>el crítico coincidió con la escritora</i> .	They met during the presentation of a book, and they had not seen each other again. Many years later, <i>the reviewer ran into the writer</i> .

**Appendix C. Stimulus items from Study 3**

Spanish items	English translations
1 a El portero <i>tapaba</i> el cartel. b El portero <i>tapó</i> el cartel.	The doorman <i>was covering</i> the sign. The doorman <i>covered</i> the sign.
2 a El profesor <i>tapaba</i> la pizarra. b El profesor <i>tapó</i> la pizarra.	The teacher <i>was covering</i> the blackboard. The teacher <i>covered</i> the blackboard.
3 a Mi amiga <i>conocía</i> al director. b Mi amiga <i>conoció</i> al director.	My girlfriend <i>knew</i> the director. My girlfriend <i>met</i> the director.
4 a Mi hermana <i>conocía</i> al editor. b Mi hermana <i>conoció</i> al editor.	My sister <i>knew</i> the editor. My sister <i>met</i> the editor.
5 a La multitud <i>bloqueaba</i> la entrada del edificio. b La multitud <i>bloqueó</i> la entrada del edificio.	The crowd <i>kept blocking/was blocking</i> the entrance of the building. The crowd <i>blocked</i> the entrance of the building.
6 a Un camión <i>bloqueaba</i> la carretera. b Un camión <i>bloqueó</i> la carretera.	A truck <i>kept blocking</i> the road. A truck <i>blocked</i> the road.
7 a Su nombre <i>aparecía</i> en la pantalla. b Su nombre <i>apareció</i> en la pantalla.	His name <i>was showing</i> on the screen. His name <i>appeared</i> on the screen.
8 a La empresa <i>formaba</i> la distribuidora más poderosa del país. b La empresa <i>formó</i> la distribuidora más poderosa del país.	The company <i>amounted to/constituted</i> the most powerful distributor of the country. The company <i>formed/established</i> the most powerful distributor of the country.
9 a La compañía <i>formaba</i> la cadena hotelera más prestigiosa del mundo. b La compañía <i>formó</i> la cadena hotelera más prestigiosa del mundo.	The company <i>amounted to/constituted</i> the most prestigious hotel chain in the world. The company <i>formed/established</i> the most prestigious hotel chain in the world.
10 a Su esposa <i>sabía</i> la verdad. b Su esposa <i>supo</i> la verdad.	His wife <i>knew</i> the truth. His wife <i>found out</i> the truth.
11 a La situación <i>afectaba</i> a mi padre. b La situación <i>afectó</i> a mi padre.	The situation <i>had consequences for</i> my father. The situation <i>moved/affected</i> my father.
12 a La federación <i>integraba</i> tres equipos. b La federación <i>integró</i> tres equipos.	The federation <i>consisted of</i> three teams. The federation <i>incorporated</i> three teams.
13 a La brigada <i>integraba</i> a diez bomberos. b La brigada <i>integró</i> a diez bomberos.	The brigade <i>consisted of</i> ten firemen. The brigade <i>integrated/incorporated</i> ten firemen.

**Stimulus items from Study 3** (continued)

	Spanish items	English translations
14	a El equipo <i>rodeaba</i> al entrenador. b El equipo <i>rodeó</i> al entrenador	The team <i>was located around</i> the trainer. The team <i>surrounded</i> the coach.
15	a La banda <i>incluía</i> a dos saxofonistas. b La banda <i>incorporó</i> a dos saxofonistas.	The band <i>included/had</i> two saxophonists. The band <i>incorporated</i> two saxophonists.
16	a La compañía <i>constituía</i> el medio de transporte más importante de la ciudad. b La compañía <i>constituyó</i> el medio de transporte más importante de la ciudad.	The company <i>was/constituted</i> the most important public transport of the city. The company <i>set up</i> the most important public transport of the city.
17	a El equipo vasco <i>constituía</i> la empresa telefónica más importante del país. b El equipo vasco <i>constituyó</i> la empresa telefónica más importante del país.	The Basque team <i>was/constituted</i> the most important telephone enterprise of the country. The Basque team <i>set up/constituted</i> the most important telephone enterprise of the country.
18	a El agua <i>llegaba</i> hasta la ventana. b El agua <i>llegó</i> hasta la ventana.	The water <i>was at/kept reaching</i> the window. The water <i>reached</i> the window.
19	a El fuego <i>llegaba</i> hasta el pueblo. b El fuego <i>llegó</i> hasta el pueblo.	The fire <i>kept reaching/was at</i> the village. The fire <i>reached</i> the village.
20	a El ayuntamiento <i>escondía</i> un valioso pergamino. b El ayuntamiento <i>escondió</i> un valioso pergamino.	The city council <i>kept hiding/hid</i> a valuable scroll. The city council <i>hid</i> a valuable scroll.
21	a El informe <i>implicaba</i> a muchos políticos. b El informe <i>implicó</i> a muchos políticos.	The report <i>implicated</i> a lot of politicians. The report <i>got</i> a lot of politicians <i>involved</i> .
22	a El Barça <i>superaba</i> al Real Madrid en dos puntos. b El Barça <i>superó</i> al Real Madrid en dos puntos.	Barça <i>was ahead of</i> the Real Madrid by two points. Barça <i>beat</i> Real Madrid by two points.
23	a Su marido <i>aceptaba</i> las reglas del juego. b Su marido <i>aceptó</i> las reglas del juego.	Her husband <i>was accepting</i> the rules of the game. Her husband <i>accepted</i> the rules of the game.

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