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Interference effects as a function of semantic similarity in the translation recognition task in bilinguals of Catalan and Spanish

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Previous evidence has shown that word pairs that are either related in form (e.g., *ruc-berro*; donkey-watercress) or very closely semantically related (e.g., *ruc-caballo*, donkey-horse) produce interference effects in a translation recognition task (Ferré et al., 2006; Guasch et al., 2008). However, these effects are not observed when the words have a less close semantic relation (e.g., *ruc-oso*, donkey-bear). The lack of interference in less similar words could be due to the low level of activation of the corresponding semantic representations by the time the translation decision has to be made. The present experiments tested this possibility using the same materials as the previous studies but decreasing from 500 ms to 250 ms the presentation time of the word to be translated. Performance of highly proficient bilinguals of Spanish and Catalan was examined in two experiments. Catalan-Spanish translation direction was tested in Experiment 1 and Spanish-Catalan direction in Experiment 2. The results showed significant effects only with form and very close semantic relations, but not in the case of less closely semantically related words. The pattern of results was the same, regardless of translation direction and language dominance.

The representation and access to meaning is a central issue in current studies of bilingual memory, not only for a speaker who has learnt a second language but also for the bilingual speaker who has achieved a high level of proficiency in his/her two languages. There is a consensus among the various theoretical models of bilingual memory regarding the two levels of

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representation to be posited: a lexical level, containing information of the orthographic and phonological form of the word, and a semantic-conceptual level that represents its meaning. All these models agree that the level of semantic/conceptual representation is shared (to a greater or lesser extent) between the two languages, but while some postulate local representations (e.g. the Revised Hierarchical Model of Kroll & Stewart, 1994, or the BIA+ interactive activation model of Dijkstra & van Heuven, 2002), others propose distributed representations (e.g. the distributed representational model proposed by de Groot 1992a, 1992b). Many studies have been carried out over the last two decades in an attempt to determine the type of connections between the lexical forms of words between the two languages of the bilingual, including how these forms are linked to the corresponding, shared semantic representations within the common conceptual system (e.g. Altarriba & Matis, 1997; Ferré, Sánchez-Casas, García-Albea & Guasch, 2006; Guasch, Sánchez-Casas, Ferré, & García-Albea, 2008; Kroll, Michael & Sankaranaraanan, 1998; Linck, Kroll & Sunderman, 2009; Sunderman & Kroll, 2006; Talamas, Kroll & Dofour, 1999). However, the available evidence is not always consistent and the answers to some of these questions are still subject to controversy. This work follows the same line of research of the aforementioned studies, focusing, in particular, on how meaning is accessed from the words in the two languages by examining highly proficient bilinguals of Catalan and Spanish (with dominance in either language).

One of the proposed bilingual models that has been very influential in recent years in the study on word meaning access is the Revised Hierarchical Model (RHM, Kroll & Stewart, 1994). The RHM proposes two separate lexicons, one for each language (L1 and L2), in addition to a shared integrated conceptual system that is connected to both lexicons. This model also assumes that L1 has connections and direct access to the conceptual system, and that the strength of the connections between L2 and the conceptual system varies according to the level of proficiency. This latter assumption is based on the fact that many words in L2 are learned by lexical associations with their equivalents in L1. The model, therefore, suggests that the connections between the words in L2 and its corresponding concepts are reinforced as proficiency in L2 increases while lexical dependence on L1 decreases. As a consequence, proficient bilinguals could access the conceptual system directly from both their L1 and their L2, while second-language learners would access the system using L1 only.

Translation from L2 into L1 has received greater attention in studies that test the RHM, as differences between learners and proficient bilinguals concerning how the conceptual system is accessed are only predicted by the

model in this direction. These studies have mostly used the translation recognition task and an interference paradigm (e.g. Ferré et al., 2006; Guasch et al., 2008; Linck et al., 2009; Sunderman & Kroll, 2006). In this task, participants are presented with a word in one language followed by a second word in the other language, and have to decide whether the second word is a translation of the first (de Groot, 1992). As well as the word pairs that are translations, the task also includes critical items consisting of pairs of words that are not translations but may be related in form *(*e.g. *ruc-berro* [donkey-watercress], where *berro* [watercress] is similar to *burro* [donkey]*),* in meaning *(*e.g. *ruc–caballo* [donkey-horse]), or may not be related at all (e.g. *ruc-domingo* [donkey-Sunday]). The difference between the time taken to recognise the pairs of related words (in form or in meaning) as non-translations and the time used in this recognition for unrelated word pairs is known as the interference effect.

The first study to investigate how meaning is accessed from words in the two languages using the interference effect in the translation recognition task was performed by Talamas et al. (1999). Participants were native English (L1) speakers with varying levels of proficiency in Spanish (L2). The RHM predictions were tested by manipulating the relationship between the words in the pairs that were not translations (relationship of form: e.g. *cielo-blind (cielo=heaven, ciego =blind)*; semantically related: e.g. *sordo-blind (sordo=deaf)*; unrelated: e.g. *dueño-blind (dueño=owner)*). The results of the bilingual speakers with the highest level of L2 proficiency supported the RHM's predictions. Talamas et al. (1999) found that proficient bilinguals were slower when they had to reject as non-translations those pairs that were related in meaning (e.g. *sordo-blind*) than when the pairs were related in form (e.g. *cielo-blind*), which confirms that they access the conceptual system directly from their second language.

More recently, Sunderman and Kroll (2006) and Linck et al. (2009) also used the translation recognition task and obtained a similar pattern of results with proficient bilinguals of English (L1) and Spanish (L2). In both studies, the most proficient bilinguals showed a greater interference effect with semantically related words than with words related in form when the translation was from L2 to L1, which once again confirmed the predictions of the RHM.

Talamas et al. (1999) and Sunderman and Kroll (2006) found an additional result which was not related to the assumptions on which the RHM is based. In a post-hoc analysis, these authors compared the interference effect in the initial set of meaning-related words, dividing them into two groups according to their similarities (either more or less similar), using a judgement task. The results of this analysis showed that proficient

bilinguals presented interference effects with both the more and the less similar words, but these effects were greater in the former than in the latter; in other words, the greater the similarity in meaning, the greater the interference effect. This pattern of results is important, as it suggests that the degree of meaning similarity can be used as an index of the extent to which semantic representations are activated across the two languages. However, it should be noted that these results were obtained in an *a posteriori* analysis in both studies, and any conclusion must therefore be considered with caution.

To the best of our knowledge, the only bilingual study which has experimentally manipulated the degree of similarity using the interference paradigm is that of Ferré et al. (2006). These authors carried out a study with native, bilingual speakers of Spanish (L1) and Catalan (L2) in the critical translation direction (i.e., from L2 to L1) in order to more rigorously analyse the influence of the degree of semantic similarity on interference effects in the translation recognition task. As well as using the similarity judgement task to establish proximity in meaning, as did Talamas et al. (1999) and Sunderman and Kroll (2006), Ferré et al. (2006) also employed a feature generation task, used to calculate the semantic distance between the words in non-translation pairs according to the number of common features (see Sánchez-Casas, Ferré, García-Albea & Guasch, 2006, for a detailed description of the procedure). Based on these two measures, the words that were semantically related were categorised either as words with a very close semantic relationship, or as having a less close relationship. The words with a very close relationship shared a larger number of semantic features (e.g. *ruc-caballo* [donkey-horse]) than those that were less close (e.g. *ruc-oso* [donkey-bear]). As well as specifying the variable "degree of semantic similarity" between words more precisely, these authors also manipulated it as a factor in the experiment.

Likewise, as in the previous studies (Talamas et al., 1999; Sunderman & Kroll, 2006), they included pairs of non-translations related in form (e.g. *ruc-berro* [donkey-watercress], where *berro* [watercress] is similar to *burro* [donkey]). Finally, the authors selected three groups of bilinguals of Spanish and Catalan: early and late highly proficient bilinguals, depending on the age of acquisition of the second language (before and after puberty), and a group of late non-proficient bilinguals.

The results obtained by Ferré et al. (2006) confirmed partially the predictions of the RHM. As predicted, non-proficient bilinguals only showed form interference effects supporting a lexically mediated access to the conceptual system with lower level of proficiency in L2. The two groups of proficient bilinguals (early and late) also showed the expected

interference effects both in words related in form and in meaning. However, against the model´s predictions, these effects were of a similar magnitude in both groups. As mentioned earlier, the RHM proposes that proficient bilinguals can have direct access to the conceptual system when translating from L2 to L1; so bilinguals as the ones who participated in Ferre et al.´s study, should have shown more semantic than form interference effects.

Importantly, the pattern of interference effects reported by Ferré et al. with semantically related words also contrasts with previous studies (Talamas et al. (1999) and Sunderman & Kroll, 2006). While these studies found both very close and less close semantically related words to produce interference effects, Ferré et al. only found evidence of these effects in the very close semantic relationship (e.g. with *ruc-caballo* [donkey-horse] but not with *ruc-oso* [donkey-bear]). The same results were recently replicated by Guasch et al. (2008), who also examined proficient bilinguals of Spanish and Catalan by using the same materials. The present study was designed with the general aim of further exploring the pattern of interference effects with very close and less close semantically related words, testing also highly proficient bilinguals of Spanish and Catalan.

In its current formulation, the RHM does not explain how the degree of similarity could modulate the effect of semantic interference. Moreover, we have just reviewed some translation recognition data that are not always consistent with the model´s predictions (see Brysbaert & Duyk, 2010 for other limitations of the RHM and Kroll, van Hell, Tokowicz, & Green, 2010 for a reply). A model that could suggest a possible answer to the question under examination here, as well as to provide an alternative explanation of the different performance between non-proficient and proficient bilinguals, is the distributed representational model (DRM) (de Groot, 1992a., 1992b; van Hell & De Groot, 1998a, 1998b). The DRM represents the semantic/conceptual word level as a set of nodes which correspond to semantic features and which are connected to the corresponding lexical forms in the two languages. The model also assumes that the greater the similarity in meaning between two words, the larger the number of nodes shared by their semantic representations (e.g., Schoonbaert et al., 2009). Thus, two words which are very closely related in meaning across the two languages would be expected to activate more shared nodes than words with less close semantic relationships, and consequently, to produce greater interference effects than less close words.

Moreover, a recent version of the DRM could also explain why non-proficient bilinguals would not show evidence of semantic interference effects when translating form L2 to L1. In particular, it has been recently suggested that semantic representations would be richer for L1 than for L2

for unbalanced (proficient) bilinguals, what implies that an L1 word would activate more conceptual nodes than an L2 word (e.g., Duyck & Brysbaert, 2004; Schoonbaert et al., 2009). Based on this proposal, it seems reasonable to expect that non-proficient bilinguals will show less or no semantic interference effects. This explanation differs from that offered by the RHM since this model suggests that low proficient bilinguals will access the conceptual system via the L1 word (i.e., an interpretation in qualitative terms), while the DRM puts forward a quantitative interpretation by suggesting that the word in L2 does not activate all the nodes corresponding to the shared semantic representation.

Given that the DRM provides testable explanations regarding the influence of semantic relations across languages in translation recognition, and the role of meaning similarity in determining the magnitude of semantic interference effects, this model was adopted as the main theoretical framework in the present study.

Focusing now in the issue of very close and less close semantic relations, the majority of studies that have explored these relations both within-one-language (e.g. MacRae & Boisvert, 1998; Sánchez-Casas, et al., 2006; Vigliocco, Vinson, Lewis & Garrett, 2004), and between-languages (Guasch, Sánchez-Casas, Ferré & García-Albea, in press), used the priming paradigm. The evidence from these studies suggests that the magnitude of the priming effect is sensitive to the degree of semantic similarity (defined in terms of the number of shared semantic features). These studies found that recognition of a word (the target) was facilitated by the prior presentation of a semantically related word (the prime) in comparison with an unrelated control, and that this facilitation increases as the similarity in meaning increases. In particular, Guasch et al. (in press) obtained facilitation effects in the two types of semantic relations (very close and less close), which were greater when the semantic overlap was greater. These effects were found in proficient bilinguals of Spanish (L1) and Catalan (L2) in both directions (L1-L2 *vs*. L2-L1) in two different tasks: the lexical decision task (which involves deciding whether a sequence of letters constitutes a word or not) and the semantic decision task (where subjects must decide whether a word is concrete or abstract).

If we assume, as some data (Sunderman & Kroll, 2006; Talamas et al. 1999) appear to suggest, that the interference effect is sensitive to the degree of similarity (defined in terms of the number of shared features), as it is the case in the facilitation effect, the DRM would make the same predictions with respect to both types of effects. If the most similar word pairs (e.g. *ruc-caballo* [donkey-horse]) have more overlapping semantic features than those that are less similar (e.g. *ruc-oso* [donkey-bear]), then

more semantic nodes would be activated in the former than in the latter. This greater number of activated nodes would be reflected in an increased facilitation effect in the priming paradigm (a shorter response time and fewer errors in the most similar words), and a greater interference effect in the translation recognition task (a longer response time and more errors in the most similar words). Regardless of the paradigm, the DRM therefore predicts that the more the number of shared features, the greater the activation at the conceptual/semantic level (see Figure 1).

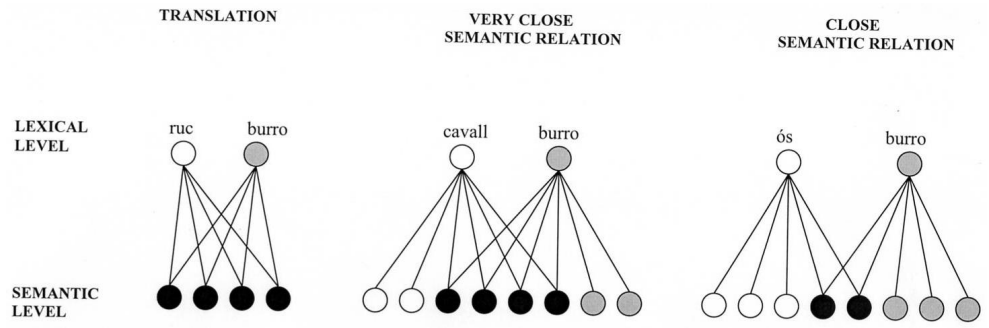

Figure 1: Explanation of the interference effects according to the DRM. The nodes activated by the two words in the pair in the semantic level are shown in black.

In the case of the interference effects, the predictions of the DRM regarding the influence of the degree of similarity (e.g. the greater the semantic similarity, the greater the interference effect) are only partially confirmed as we have seen that only the most similar words consistently produce interference effects. In the pairs with less semantic similarity, and despite sharing semantic features, the interference effects were not observed in all studies. One difference between these studies that can be important to take into account in order to explain the inconsistent results regarding the pattern of semantic interference effects, relates to the materials used. Specifically, in the studies of Talamas et al. (1999) and Sunderman & Kroll (2006), the selected word pairs had a semantic as well as an associative relationship (e.g. *ratón-queso*) [mouse-cheese]), while in Ferré et al. (2006) and Guasch et al. (2008) the relationship was purely semantic (e.g. *burro–caballo* [donkey–horse]). In the case of the priming paradigm, some data suggest that the words which have an associative as well as a semantic

relationship lead to greater facilitation that those that are only related semantically (e.g. Perea & Rosa, 2002), so such a difference might also be relevant when the interference paradigm is used (see Ferré et al, 2006 for the discussion of this possibility).

Another factor that could contribute to explain the absence of effects in less similar words could be that their degree of similarity is not sufficient to cause interference. However, there are some data that question this explanation. Firstly, the semantic similarity of less similar words in the Ferré et al.´s (2006) study is similar to that of previous studies that did find some interference in post-hoc analyses (e.g. Sunderman & Kroll 2006; Talamas et al., 1998). Secondly, and as mentioned above, these same words show effects of priming both within (Sánchez-Casas et al., 2006) and between languages (Guasch et al., in press).

A different sort of explanation for the failure to find an interference effect in less similar words could be related to the decline of the level of activation in the semantic/conceptual level of representation (hereinafter *the low activation account*). The interpretation of interference effects in the DRM suggests that when two words that are related semantically are presented, the nodes at the semantic level are activated (shared and not shared), but the level of activation is modulated by the degree of similarity in meaning. For example, when the word *ruc* [donkey] is presented, the nodes for the semantic representation of the word *caballo* [horse] (very closely related), and *oso* [bear] (less closely related), would be activated, as both *caballo* and *oso* share semantic features with *ruc.* However, the attained activation level would be comparatively higher for *caballo* than for *oso*, as there is a greater semantic overlap between *ruc* and *caballo* than between *ruc* and *oso*. Assuming that the activation level gradually declines and that it is lower in the case of the word *oso*, it is possible that by the time the decision has to be made regarding whether or not *oso* is a translation of *ruc*, the activation level for the word *oso* is already too low to compete with the correct translation. In other words, *oso* "would have already been ruled out as a possible translation". On the other hand, in the case of the word *caballo* [horse], the level of activation would still be high at the time of the decision and it would, consequently, be able to produce an interference effect. If this interpretation is correct, the question to be answered is why priming effects are observed regardless of the degree of semantic similarity, albeit of lower magnitude in words that are less closely related. In this respect, it is noteworthy that in the priming experiments, the presentation time of the first word (the prime) was 250 ms (Guasch et al., in press), while in the translation recognition experiments, which included the same words, the presentation time was 500 ms (Ferré et al., 2006) and 750 ms

(Guasch et al., 2008). It is therefore possible that these presentation times were too long and, as a result, no interference effects were observed in words that were less closely related.

The first and main aim of the present study was to test the *low activation account* as a possible explanation of the absence of interference by reducing the presentation time of the first word to 250 ms; this time of presentation was chosen because it was the same as the one used in the priming experiments. If the *low activation account* is correct, we would predict that 250 ms of exposure would lead to interference effects in both types of semantic relations, with these effects being greater when the similarity of meaning is greater.

A second aim of this study was to ascertain whether the direction of the translation recognition task affects the pattern of the interference effects. As mentioned earlier, most translation recognition studies have examined translation from L2 to L1, as that was the critical direction for testing the predictions of the RHM (e.g. Ferré, et al., 2006; Guasch, et al., 2008; Linck et al., 2009; Sunderman & Kroll, 2006). However, to examine translation direction as an experimental factor is important since it has been found to be relevant in determining different findings. For instance, in priming studies, facilitation effects tend to be of a lesser magnitude or even nonexistent when the prime is in L2 than when it is in L1 (see Schoonbaert et al, 2009, for a review). More importantly, recent studies have shown that in the case of very proficient balanced bilinguals in the two languages, as the ones who participated in the present study, facilitation is the same regardless of the language of the prime (e.g. Guasch et al., in press; Davis et al., 2010; Duñabeitia, et al., 2009; Perea, Carreiras & Duñabeitia, 2008;). According to the DRM, highly balanced proficient bilinguals, as the ones tested in the current study, would not be expected to present differences in the magnitude of the interference effect as a function of translation direction (L1-L2 *vs.* L2-L1), since in this case the model proposes that both L1 and L2 lexical forms would activate the same number of nodes at the semantic/conceptual level.

A final variable object of investigation in this study, related to the previous one, is the dominance of the bilingual speaker (Spanish or Catalan). This variable has not been considered in previous studies where unbalanced bilinguals, more or less proficient in L2, have been examined. For instance, in the studies of Talamas et al. (1999) and Sunderman & Kroll (2006), the participants were English-Spanish bilinguals that were dominant in English. In both cases, the dominant language was always the one where the bilingual had a higher level of proficiency (i.e., subjects were clearly more proficient in English than in Spanish). In the studies by Ferré et al.

(2006) and Guasch et al. (2008), the bilinguals were very proficient in both languages but were dominant in Spanish (with the exception of Perea et al, 2008, and Guasch et al., in press) this has been also the case in the priming studies). The question of interest here is to examine whether dominance affects the interference pattern when the proficiency of the bilingual speakers is high and very similar in the two languages (i.e, balanced bilinguals); that is, to test separately the effects of the two variables. As can be seen in the description of the participants (see the Method section), the bilinguals we tested are highly proficient in both Spanish and Catalan, although they have a dominant language established primarily on language use. Therefore, in our view, they provide a good opportunity to determine if these two variables have a differential effect. If the determining factor is proficiency rather than dominance, as the DRM assumes, we would expect to find the same interference pattern regardless of the dominant language. On the other hand, if dominance is the critical variable, we could observe greater interference when the translation is from a more dominant language, as this is the first language.

In sum, the aims of the present study were as follows: 1) to determine whether with a presentation time of 250 ms for the first word, there are interference effects in the close semantic relationship, by using the same words and tasks used in previous studies; 2) to ascertain whether the interference effects are observed in both translation directions (L1-L2 *vs*. L2-L1); and 3) to establish the influence of language dominance (Spanish or Catalan) on the pattern of semantic interference effect. In order to fulfil these objectives, two translation recognition experiments were undertaken, from Catalan to Spanish (Experiment 1) and from Spanish to Catalan (Experiment 2). Two groups of highly proficient Catalan and Spanish bilinguals participated in each experiment: one group was dominant in Catalan and the other was dominant in Spanish; both groups came from a similar population. In Experiment 1, the group that was dominant in Catalan had to translate from their L1 (Catalan) to their L2 (Spanish) and the group dominant in Spanish from their L2 (Catalan) to their L1 (Spanish). Experiment 2 reversed the process, with the group dominant in Catalan translating from L2 (Spanish) to L1 (Catalan) and the group dominant in Spanish from their L1 (Spanish) to their L2 (Catalan). The materials and procedure were the same in both experiments.

EXPERIMENTS

General description of the participants. Before presenting the experiments, it is necessary to describe the bilingual speakers who

participated in the study. In the two experiments carried out, the participants were bilinguals in Catalan and Spanish, and had learned both languages in a context of immersion since a young age (Catalan and Spanish are both official languages in Catalonia). In order to establish the bilingual speakers' background, all participants answered a questionnaire. In the questionnaire, they were asked about their experience with the two languages (L1, age of L2 acquisition, language spoken at home, at school, etc.) and to estimate their perceived proficiency in listening, speaking, reading and writing, as well as the frequency of use and preference in each of these four linguistic abilities. The level of Catalan and Spanish proficiency acquired in the two languages was evaluated using a scale from 1 to 7 (1= low level, 7= high level). The participants rated frequency and preference on a scale from 1 to 7, where the scores from 1 to 3 meant they used and prefer more Catalan than Spanish and 5 to 7, more Spanish than Catalan. The middle scores (4) represented that participants used and preferred both languages to an equal extent.

On the basis of the information from the questionnaire, two groups of participants were selected, one group of dominant Catalan bilinguals and the other dominant Spanish bilinguals. The main criteria to establish language dominance were: L1, proficiency, frequency of use, and preferred language. The Catalan dominant group had Catalan as their L1, and they used and preferred this language in the four abilities, while Spanish was the selected language for the Spanish dominant group. Regarding proficiency, both groups evaluated themselves as highly proficient in their two languages, although the non-dominant language received slightly lower rates than the dominant one. The data from the questionnaires obtained in each group are shown in Table 1.

EXPERIMENT 1: CATALAN – SPANISH DIRECTION

METHOD

Participants. A total of 85 third year Psychology students at Universitat Rovira i Virgili (Tarragona) participated in the experiment. The mean age of the participants was 20.3 (SD = 4.4). All had normal or corrected vision. Table 1 shows the scores (mean and standard deviation) in proficiency, frequency of use and preference in the four linguistic skills (listening, speaking, reading and writing) in two bilingual dominant groups.

Table 1: Data from the language questionnaire for the participants in Experiment1 (Catalan-Spanish direction) and in Experiment 2 (Spanish-Catalan direction). Mean and standard deviation of the proficiency, frequency of use and preference scores, in the four linguistic skills (listening, speaking, reading and writing).

	Experiment 1 (Catalan-Spanish direction)				Experiment 2 (Spanish-Catalan direction)			
	Dominant Catalan		Dominant Spanish		Dominant Catalan		Dominant Spanish	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Catalan proficiency								
Listening	7.0	0.2	6.8	0.5	7.0	0.2	6.4	0.7
Speaking	6.8	0.4	5.9	1.0	7.0	0.3	5.8	1.3
Reading	6.8	0.4	6.6	0.7	7.0	0.3	6.3	0.7
Writing	6.4	0.7	6.0	1.1	6.6	0.6	5.7	0.8
Spanish proficiency								
Listening	6.8	0.5	7.0	0.2	6.9	0.2	6.8	0.4
Speaking	6.3	0.9	6.8	0.4	6.4	0.8	6.7	0.5
Reading	6.7	0.6	6.9	0.3	6.9	0.4	6.7	0.5
Writing	6.3	0.8	6.6	0.6	6.6	0.6	5.9	1.6
Frequency of use								
Listening	3.1	0.9	4.8	0.9	2.8	1.0	4.4	1.2
Speaking	4.0	1.4	5.3	1.4	2.3	1.2	5.0	1.5
Reading	2.5	0.9	5.5	1.0	3.7	1.5	4.8	1.3
Writing	2.8	1.3	5.3	1.2	2.7	1.5	4.4	1.2
Preference								
Listening	3.0	1.3	4.7	1.0	3.1	1.2	4.2	0.6
Speaking	2.1	1.2	5.7	1.0	2.3	1.2	5.2	1.0
Reading	3.3	1.4	5.2	1.3	3.4	1.4	4.8	1.0
Writing	3.0	1.6	5.4	1.3	3.0	1.3	4.6	1.5

Catalan dominant group: The forty-eight participants in the Catalan dominant group had been born in Catalonia, where they acquired the two languages in childhood (age of acquisition of Spanish, $\overline{X}$ = 2.2, SD = 2.3). The statistical comparisons made between the measures of level of proficiency in Catalan and Spanish show that there are significant differences between Catalan and Spanish, in favour of Catalan in "listening" [t(42)=2.47, p<.05], "reading" [t(42)=2.35, p<.05] and "speaking" [t(42)=4.79, p<.05]. However, no significant differences were observed in the level of proficiency in "writing" [t(42)=1.00, p>.05]. The Catalan dominant participants considered themselves equally proficient when writing in both languages.

Spanish dominant group: Of the thirty-seven participants in the Spanish dominant group, thirty-three had been born in Catalonia, and four had arrived in Catalonia at a mean age of 2.2 (SD = 1.3) and had learned Catalan during their childhood (age of acquisition $\overline{X}$ = 2.2, SD = 1.6). The Spanish dominant participants assessed themselves as more proficient in Spanish than Catalan in "listening" [t (30)=1.98, p=.05], "reading" [t (30)=2.75, p<.05], "speaking" [t (30)=5.33, p<.05] and "writing" [t (30)=2.82, p<.05].

As regards the frequency of use, each group was found to use its first language more often than its second language. The differences between each group's scores are significant in each of the skills measured: "listening" [t (72)=7.62, p<.05], "speaking" [t (72)=3.96, p<.05], "reading" [t (72)=13.19, p<.05] and "writing" [t (72)=7.97; p.<.05] The same pattern of results was observed in the case of preference of use: "listening" [t (72)=5.90, p<.05], "speaking" [t (72)=13.44, p<.05], "reading" [t (72)=5.81, p<.05] and "writing" [t (72)=6.68; p.<.05]

Materials. The set of words previously used by Ferré et al. (2006) and Guasch et al. (2008) was used. A total of 70 sets of seven words each were selected as critical material for the experiment. All the words were specific nouns and belonged to various semantic categories. (e.g. appliances, living things, etc.). (See the Appendix for the list of materials).

The words were presented in pairs. In Experiment 1, the first word in the pair was always presented in Catalan and the second in Spanish, so that for the Catalan dominant group the first word was in its L1, while for the Spanish dominant group it was in its L2. The word in Catalan could be presented in one of the following seven experimental conditions:

1. *Translation*: the word in Catalan was followed by its Spanish translation (e.g. *ruc-BURRO*) [donkey-DONKEY].

2. *Very close semantic relationship*: the word in Catalan was presented followed by a word in Spanish that was very closely related in meaning with its correct translation (e.g. *ruc-CABALLO*) [donkey-HORSE].
3. *Control for the very close semantic relationship*: the word in Catalan was presented, and followed by a word in Spanish that was neither related in form nor in meaning (e.g. *ruc- DOMINGO*) [donkey-SUNDAY]
4. *Less close semantic relationship*: the word in Catalan was followed by a word in Spanish that was less closely related semantically (e.g. *ruc-OSO*) [donkey-BEAR].
5. *Control for the less close semantic relationship*: the word in Catalan was presented followed by a word in Spanish presented that was neither related in form nor in meaning (e.g. *ruc- SED*) [donkey-THIRST].
6. *Form*: the word in Catalan was presented followed by a word in Spanish that was orthographically similar to the translation (e.g. *ruc-BERRO*) [donkey-WATERCRESS].
7. *Control of form*: the word in Catalan was followed by a word in Spanish that was neither related in form nor in meaning (e.g. *ruc-LEJÍA*) [donkey-BLEACH].

The words in the control conditions (3, 5 and 7) were comparable in length and frequency to the words in the matching related condition (2, 4 and 6 respectively). (The data for frequency data of Spanish are taken from BPal, Davis and Perea, 2005, and those for Catalan from the IEC Dictionary). (See Table 2). None of the comparisons between these variables was significant (ts<1).

The level of similarity and semantic distance in the words of the semantic conditions (condition 2 and 4) were taken from the study by Sánchez-Casas, et al. (2006). The similarity was obtained using the same procedure as Talamas. et. al, (1999) and Sunderman & Kroll (2006), and the semantic distance from the data obtained in a feature generation task (see Sánchez-Casas et al., 2006, for details of the procedure). The data showed that the words in the very close relationship were closer to each other semantically than those in the less close relationship and were rated as significantly more similar to each other (see Table 3).

Table 2: Mean length (number of letters) and frequency of use of the words included in the experimental and control conditions in Experiment 1 (Catalan- Spanish direction).

	Relationship		Control	
Condition	Length	Frequency	Length	Frequency
Very close semantic	6.5	16.2	6.4	15.8
Less close semantic	6.3	13.2	6.3	13.3
Form	6.2	38.4	6.2	31.3

Table 3: Means (and standard deviation) of similarity ratings between words with very close and less close relationship, used in Experiment 1 and 2.

	Very close	Less close
Similarity ratings	6.19 (0.82)	4.07 (0.71)
Semantic distance	0.73 (0.21)	1.03 (0.15)

As well as the sets of critical words, there were 50 other pairs of translations, which acted as filler pairs. These translations belonged to the same semantic categories as the pairs of non-translations. The seven experimental conditions were counterbalanced, leading to seven different lists, so that each participant only saw one item in a given experimental condition, but each item appeared in each experimental condition on all the lists. All the lists consisted of 120 items: 60 translations and 60 false

translations. Each list was administered to two groups of participants (dominant in Catalan *vs*. dominant in Spanish). The 50 pairs of filler translations were the same in the seven lists.

Procedure. The participants participated in the experiment individually. Each one was randomly administered one of the seven versions of the experiment. A translation recognition task was used, in which the participants were asked to decide whether the second word in a pair was a correct translation of the first. They had to answer by pushing one of two buttons: the "YES" button, with their preferred hand, if the second word in the translation was a correct translation, or the "NO" button, with the other hand, if it was not the correct translation. The computer generated a pseudo-random order of presentation for each participant, thereby avoiding the consecutive appearance of more than two stimuli in the same condition. The stimuli were presented on a video monitor controlled by a PC, using the DMDX program (Forster & Forster, 2003). This programme enables the on-screen display time for each stimulus to be synchronised with the monitor's screen reload rate. The presentation sequence was as follows: first, a fixation point ("#") appeared for 500 ms; immediately afterwards, the first word of the pair (in Catalan) was presented for 250 ms, and immediately afterwards, the second word (in Spanish) was presented in capital letters for 1,500 ms in one of the seven experimental conditions. The participants self-administered the tests by pressing a pedal with their foot. After each test, they were given a feedback about the answer they had given. If the answer was correct, the word "*Correcto*" or "*Correcte*" [Correct] appeared on the screen, depending on the translation direction (i.e., Catalan-Spanish or Spanish-Catalan, respectively), with the reaction time in milliseconds; if the answer was incorrect, only the word "*Error*" [Error] appeared on the screen. If there was no response to the stimulus, the phrase "*No respuesta*" or "*No resposta*" [No response] was displayed.

Before starting the experiment, the participants received written instructions in their dominant language. These instructions explained the task, and emphasised that they had to answer as accurately and as quickly as possible, but not quickly enough to lead to a high percentage of errors. The experiment began with 11 practice stimuli that represented the different conditions in the experiment. The experiment lasted approximately 25 minutes.

RESULTS AND DISCUSSION

Reaction times (RTs) for the trials in which the participants made an error were not included in the analysis. Likewise, the RTs with values of more or less than two standard deviations from the participant's mean were adjusted to the values of 200 ms (minimum) and 2000 ms (maximum) established beforehand as cut-off points, to moderate the influence of extreme responses. This led to the exclusion of 4.7% of the data. Data from five participants who made more than 15% of errors were excluded from the analysis.

Data from non-translation tests: Table 4 shows the RTs and the percentage of errors (%E) in each of the three types of related words (very close semantic, less close semantic and form) in the two relationship conditions (relationship *vs.* control).

ANOVAs based on participant and item response latencies and error percentages were conducted based on a factorial design of three factors (3x2x2). The "type of relationship" factor had three levels (very close, less close and form). The "relationship" factor had two levels (related *vs.* control). Finally, the "group of participants" factor had two levels (Catalan dominance and Spanish dominance). The first two factors were repeated measures both in the analysis by participants and in the analysis by items. The third factor was between-subjects in the analysis by participants, and within-subjects in the analysis by items.

ANOVAs on the reaction times revealed a main effect of type of relationship both in the analysis by participants [F_1 (2, 166)=15.60, $p<.05$, $\eta^2=0.16$] and in the analysis by items [F_2 (2, 264)=7.51, $p<.05$, $\eta^2=0.05$]. The relationship factor was also significant in the analysis by participants [F_1 (1, 83)=79.76, $p<.05$, $\eta^2=0.49$] and in the analysis by items [F_2 (1, 132)=44.64, $p<.05$, $\eta^2=0.25$]. The dominance factor was not significant in the analysis by participants [F_1(1, 83)=2.24, $p>.05$], but was significant in the analysis by items [F_2 (1, 132)=18.71, $p<.05$, $\eta^2=0.12$]. The interaction between type of relationship and relationship was significant in both analyses [F_1 (2, 166)=6.48, $p<.05$, $\eta^2=.07$; F_2 (2, 264)=5.70 $p<.05$, $\eta^2=0.04$]. The interaction between type of relationship and dominance, and the threefold interaction between type of relationship, relationship and dominance, were not significant (Fs <1).

Table 4: Mean reaction time (RT, in ms) and percentage of errors (%E) in the different experimental conditions together with the corresponding interference effects in Experiment 1 and 2, after collapsing dominance.

	Experiment 1 Catalan- Spanish direction			**Experiment 2 Spanish – Catalan direction**	
Condition	Mean	%E		Mean	%E
Very close (e.g. *ruc-caballo) [donkey-horse]*	775	30.0		768	27.8
Control (e.g. *ruc-domingo) [donkey-Sunday]*	721	2.4		717	2.2
Interference effect	**54***	**28.6***		**51***	**25.6***
Less close (e.g. *ruc-oso) [donkey-bear].*	721	4.0		728	4.2
Control (e.g. *ruc-beso) [donkey-kiss]*	701	1.8		712	3.3
Interference effect	**20**	**2.2**		**16**	**0.9**
Form (e.g. *ruc-berro) [donkey-watercress]*	778	14.7		784	15.8
Control (e.g. *ruc-lejía) [donkey-bleach].*	711	2.0		713	2.9
Interference effect	**67***	**12.7***		**71***	**12.9***

*p.<.05. *The examples of the items in condition (very close, less close and form) are from Experiment 1.*

Due to the lack of interaction between dominance and the factors type of relationship and relationship, the data for the two dominance groups (Catalan and Spanish) were collapsed. Planned comparisons were performed with the RTs between each of the conditions of the type of relationship factor (very close, less close and form) and the specific control condition for each one. The comparisons revealed a significant interference effect on the very close semantic condition (54ms) [t_1 (84)=5.00, p<.05; t_2 (64)=4.67, p<.05], on the form condition (67ms) [t_1 (84)=8.45, p< 0.5; t_2 (68)=5.04, p<.05], and on the less close semantic condition (20ms) in the analysis by participants [t_1 (84)=2.53, p<.05] but not in the analysis by items [t_2 (69)=1.67, p=.10].

The pattern of ANOVA results for the errors is similar to that obtained in the RT analysis. The type of relationship factor was significant [F_1 (2, 166)=97.30, p<.05, η^2=0.54; F_2 (2, 276)=50.17, p<.05, η^2=0.27]. The relationship factor was also significant [F_1 (1, 83)=239.96, p<.05 η_1^2=0.74; F_2 (1, 138)=169.76, p<.05, η_2^2=0.55] as was the interaction between type of relationship and relationship [F_1 (2, 166)=91.09, p<.05, η^2=.52; F_2 (2, 276)=43.72, p<.05, η^2=0.24]. The dominance factor was neither significant in the analysis by participants [F_1(1, 83)=0.14, p>.05] nor in the analysis by items [(F_2(1, 138)=0.37, p>.05.]. As in the analysis of the RTs, the interactions between type of relationship and dominance [F_1 (2, 166)=0.64, p>.05; F_2(2, 276)=0.16, p>.05], between relationship and dominance [F_1 (1, 83)=0.05, p>.05; F_2(1, 138)=0.00, p>.05] and between type of relationship, relationship and dominance [F_1 (2, 166)=0.62, p>.05; F_2 (2, 276)=0.09, p>.05] were not significant.

After collapsing the dominance factor, the results of the planned comparisons with the error data showed a significant interference effect in the very close semantic relationship [t_1 (84)=15.40, p<.05; t_2 (69)=8.77, p<.05], and in the form relationship [t_1 (84)=8.92, p<.05; t_2 (69)=5.92, p<.05]. In the case of the less close semantic relationship, the interference effect was significant only in the analysis by participants [t_1 (84)=2.68, p<.05; t_2 (69)=1.43, p=0.16]. The pattern of results is consistent with that obtained with the RTs. The participants made more errors in the related conditions than in the control conditions.

Figure 2 shows the magnitude of the interference effect in the three experimental conditions: very close and less close semantic relationships, and relationship of form.

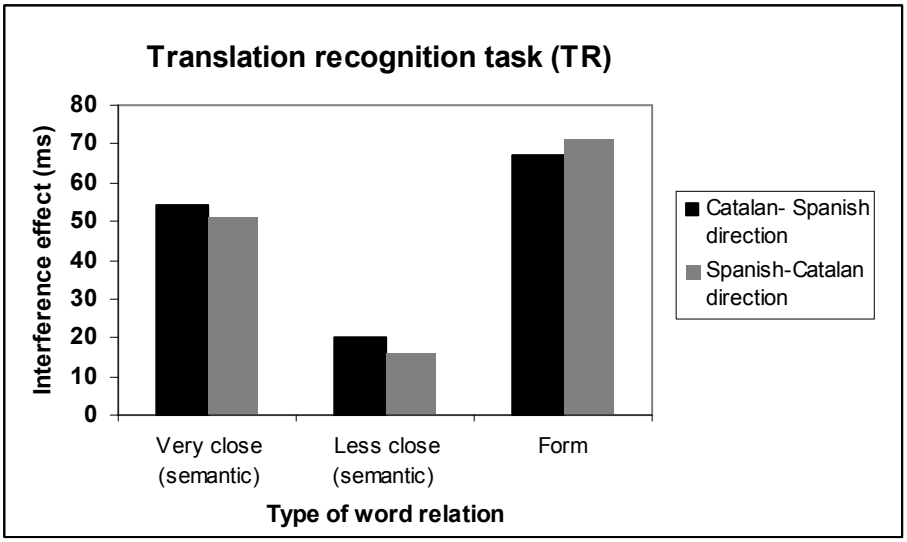

Figure 2: Magnitude of the interference effect (ms) in the three types of word relations (very close, less close, and form) and in the two translation directions (Catalan-Spanish *vs.* Spanish-Catalan)

Similarly to Ferré et al. (2006) with early highly proficient bilinguals, words with a very close semantic relationship and words related in form were found to produce interference effects. Moreover, planned comparisons between the magnitude of these effects revealed that they were of a similar magnitude in response times (54 *vs.* 67 ms, see Figure 2) [$t_1(84)=1.00$, $p>.05$; $t_2(63)=0.75$, $p>.05$], with less errors being observed with form related words [$t_1(84)=7.49$, $p<.05$; $t_2(69)=3.38$, $p<.05$]. However, unlike these authors, it is important to notice that in the present experiment less close semantic relations did produce some interference effect (20 ms significant by participants), while this was not the case in Ferré et al.´s study (a non-significant 7 ms). More relevant, the correlation between the similarity ratings[1] and the magnitude of the semantic interference was significant [$r=0.239$, $p<.05$], as well as the difference in magnitude (34 ms) between very close (54 ms) and less close semantic relationships (20 ms) [$t_1(84)=2.50$, $p<.05$; $t_2(64)=2.60$, $p<.05$ and $t_1(84)p.<.05$; $t_2(69)=8.15$,

[1] Semantic similarity ratings were used instead of semantic distances as only the former were distributed within a continuum (from 1 to 7). The classification of the very close and less close semantically related words was established dichotomically. However, the correlations between both measures is significant measures (r = -0.59, p < .001, see Sánchez-Casas, Ferré, García-Albea, & Guasch, 2006).

$p<.05$ for RT and errors respectively]. These findings can be interpreted as supporting the DRM since they showed that the greater the degree of meaning similarity between two words, the more number of shared nodes will became activated, and consequently, greater interference effects will be observed when the semantic relation is very close.

In the following experiment, we examined the interference effects in the same type of relationships but in this case, the first word was presented in Spanish and the second in Catalan.

EXPERIMENT 2: SPANISH – CATALAN DIRECTION

METHOD

Participants. A total of 71 first year Psychology students at Universitat Rovira i Virgili (Tarragona) participated in the experiment. The mean age of the participants was 19.6 (SD = 2.6). They all had normal or corrected vision and none had participated in the previous experiment (see Table 1).

*Spanish dominant group***:** The 21 participants in the Spanish dominant group had been born in Catalonia and had learned Catalan in childhood (age of acquisition $\overline{X}$ = 1.7, SD = 1.5). The Spanish dominant group assessed itself as more proficient in Spanish than in Catalan at "listening" [t (16)=2.74, p<.05], "reading" [t (16)=3.34, p<.05] and "speaking" [t (16)=2.89, p<.05]; while for "writing", it assessed itself as equally proficient in both languages [t (16)=0.53, p>.05].

Catalan dominant group: The 50 participants in the Catalan dominant group were born in Catalonia and had acquired both languages during their childhood (age of acquisition of Spanish $\overline{X}$ = 2.3, SD = 2.2). No significant differences were observed between Catalan and Spanish in "listening" [t(33)=1.00, p>.05], "reading" [t (33)=1.00, p>.05] and "writing" [t (33)=0.68, p>.05]. The only significant difference observed was in "speaking" [t(33)=4.37, p<.05].

As for the comparison of frequency and preference of use, the pattern found is identical to the bilingual speakers in Experiment 1. The first language is used more often ("listening" [t (49)=4.78, p<.05]; "speaking" [t (49)=7.17, p<.05]; "reading" [t (49)=2.80., p.<.05] "writing" [t (49)=4.09; p.<.05]); likewise, the first language obtained higher scores in preferences for use ("listening" [t (49)=3.57, p<.05]; "speaking" [t (49)=8.54, p<.05]; "reading" [t (49)=3.66, p<.05]; "writing" [t (49)=4.30; p.<.05]).

Material. In this experiment, the first word was presented in Spanish and the second one in Catalan (e.g. *burro –CAVALL, close semantic relation)* [donkey-HORSE]. The critical words were the same as those used in Experiment 1 (see Appendix). The only difference here concerns the words in the control conditions, since in this case the controls for each condition were selected so that they were matched in frequency and length to the words in Catalan. For instance, in the word pair *burro – CAVALL*, the control word *PASSAT* was the same frequency and length as the Catalan word *CAVALL.* For the Spanish dominant group, the first word was in its L1 and for the Catalan dominant group it was in its L2.

Table 5 shows the data for length and frequencies of the various types of relations in the relationship and control condition. None of the comparisons between the related condition and the control were significant (all ts < 1).

Procedure. The procedure and equipment used were the same as those used in Experiment 1.

Table 5: Mean length (number of letters) and frequency of use of the words included in the experimental and control conditions in Experiment 2 (Spanish- Catalan direction).

	Relationship		Control	
Condition	Length	Frequency	Length	Frequency
Very close semantic	6.4	31.6	6.4	30.5
Less close semantic	5.9	35.4	5.9	35.0
Form	5.9	165.4	5.9	180.2

RESULTS AND DISCUSSION

Reaction times (RTs) of the trials in which the participants made an error were not included in the analysis. Likewise, RTs with values of more or less than two standard deviations from the participant's mean were adjusted to the values of 200 ms (minimum) and 2,000 ms (maximum) established beforehand as cut-off points, to moderate the influence of extreme responses. This led to the exclusion of 4.8% of the data. Data from eight participants who made more than 15% of errors were excluded from the analysis.

Data from non-translation tests: Table 3 shows the mean reaction times (RTs) and the percentage of errors (%E) when the first word appeared in Spanish and the second in Catalan.

The results were similar to those obtained in the previous experiment. In the analysis of the RTs, both type of relationship [F_1 (2, 138)=7.58, $p<.05$, $\eta^2=0.10$; F_2 (2, 238)=7.63, $p<.05$, $\eta^2=0.06$] and relationship [F_1 (1, 69)=58.90, $p<.05$, $\eta^2=0.46$; F_2 (1, 119)=39.70, $p<.05$, $\eta^2=0.25$] were significant. The dominance factor was not significant in the analysis by participants but was significant in the analysis by items [F_1(1, 69)=0.34, $p>.05$; F_2(1, 119)=7.08, $p<.05$]. The same was observed in the interaction between the factors type of relationship and relationship [F_1 (2, 138)=4.26, $p<.05$, $\eta^2=0.06$; F_2 (2, 238)=5.80 $p<.05$, $\eta^2=0.05$]. On the other hand, neither the interaction between type of relationship and dominance [F_1 (2, 138)=0.24, $p>.05$; F_2 (2, 238)=0.74, $p>.05$], nor between relationship and dominance [F_1 (1, 69)=0.27, $p>.05$; F_2 (1, 119)=0.72, $p>.05$] nor the triple interaction [F_1 (2, 138)=0.27, $p>.05$; F_2 (2, 238)=0.03, $p>.05$] were significant.

After collapsing the dominance factor, planned comparisons showed a significant interference effect in the RTs in the very close semantic relationship (51 ms) [t_1 (70)=4.19, $p<.05$; t_2 (57)=4.12, $p<.05$]. In the less close semantic relationship, this effect was less marked (16 ms) and was marginal in the analysis by participants, and significant in the analysis by items [t_1(70)=1.77, $p=.08$; t_2 (67)=2.20, $p<.05$]. In the form relationship, the interference effect was significant in both analyses [t_1 (70)=6.78, $p<.05$; t_2 (62)=5.73, $p<.05$].

The pattern of ANOVA results for the error data revealed a main effects of type of relationship [F_1 (2, 138)=42.50, $p<.05$, $\eta^2=.38$; F_2 (2, 276)=29.89, $p<.05$, $\eta^2=0.18$], and of relationship [F_1 (1, 69)=170.32, $p<.05$, $\eta^2=0.71$; F_2 (1, 138)=102.10, $p<.05$, $\eta^2=0.43$]). The interaction between

type of relationship and relationship was also significant [F_1 (2, 138)=48.93, p<.05, η^2=.42; F_2 (2, 276)=29.66, p<.05, η^2=0.18]. The dominance factor presented no significant differences [F_1(1, 69)=2.70, p>.05; F_2(1, 138)=1.56, p>.05]. Neither the interaction between type of relationship and dominance [F_1 (2, 138)=1.09, p>.05; F_2(2, 276)=0.80, p>.05], nor the interaction between relationship and dominance [F_1 (1, 69)=1.00, p>.05; F_2 (1, 138)=0.58, p>.05], nor the triple interaction [F_1 (2, 138)=0.70, p>.05; F_2 (2, 276)=0.81, p>.05] were significant. ANOVA on the percentage of errors were generally similar to those obtained with the RTs, with the only difference being that the dominance factor was not significant in the analysis by items.

Planned comparisons of the %E showed a significant interference effect in the very close semantic relationship [t_1 (70)=11.99, p<.05; t_2 (69)=7.15, p<.05], and in the form relationship [t_1 (70)=9.27, p<.05; t_2 (69)=5.70, p<.05]. Unlike the results obtained in the RTs analysis, the differences in the less close relationship were not significant [t_1(70)=0.73, p>.05; t_2 (69)=0.66, p>0.5].

The results obtained in the Spanish to Catalan direction were very similar to those observed in the Catalan to Spanish direction examined in the previous experiment. Interference effects in both very close semantic and form relationships were obtained and they were not reliable with less closely semantically related words. As in Experiment 1, planned comparisons were performed to compare the magnitude of the interference effects across the relevant conditions (see Figure 2). The results of these comparisons in the RTs once again revealed that the effects when words were very close related in meaning were not significantly different that when words were related in form in the [t_1(70)=1.14, p>.05; t_2(51)=1.03, p>.05], and they reached significance in the case of errors [t_1(70)=4.90, p<.05; t_2(69)=2.90, p<.05].

As predicted by the DRM, the results of this experiment also showed that the interference effects are modulated by the degree of meaning similarity. Once again, the semantic interference was greater in the very close semantic relationships (51 ms.) than in the less close ones (16), both in the RT [t_1(70)=2.21, p<.05; t_2(57)=2.44, p<.05 and in the errors [t_1(70)=10.64, p<.05; t_2(69)=6.80, p<.05]. Similarly, the correlation between the semantic similarity ratings and the size of the interference effect was significant.[r=0.335, p<.05].

GENERAL DISCUSSION

The main aim of this study was to examine the effect of the degree of semantic similarity between L1 and L2 words in order to determine how words from the two languages are connected at the semantic/conceptual representation level, and to what extent meaning is activated across languages during the translation processes. In order to achieve this aim, we carried out two experiments with proficient bilinguals of Spanish and Catalan who were dominant in one of the two languages by using the translation recognition task and by manipulating the degree of similarity in meaning between the words from both languages (very close relationship and less close relationship), as well as their relationship in form.

Based on previous studies, and taking the distributed representational model (DRM) as theoretical framework, our specific objectives were as follows. First, we aimed to determine whether interference effects could be observed in the less close semantic relationship with an exposure time of 250 ms for the first word of the pair, as these effects had not been previously observed on a systematic basis with longer exposure times. Secondly, we tested, for the first time, whether the interference effects were observed in highly proficient bilinguals in both directions of translation (L1-L2 *vs*. L2-L1). Finally, we attempted to examine, also for the first time, whether the pattern of interference effects is influenced by the bilingual speaker's dominance (Spanish or Catalan) or what is relevant is to have a high level of proficiency in the two languages.

With regard to the first objective, our hypothesis, the *low activation account*, was that a presentation time of 250 ms would enable detection of the activation of the semantic representation of the less similar words, which would be apparent in the presence of interference effects. This hypothesis was not clearly confirmed by the reported findings. As predicted by the DRM and similarly to previous studies with bilinguals of Spanish and Catalan, a reliable interference effect was observed in the very close semantic relationships. Moreover, this effect (52 ms.) was of a similar magnitude to that reported in those studies (47 and 40 ms in (Ferré et al., 2006; Guasch et al., 2008, respectively).

However, the effects observed in the less close semantic relationship (e.g. *ruc-oso*) [donkey-bear], although in the expected direction, did not reach significance, contrasting with Talamas et al. (1999) and Sunderman & Kroll´s (2006) *ad hoc* analyses which revealed semantic interference effects with words both very closely and less closely related. Nevertheless, it is important to notice that in the present experiments close semantic relations did not produce null interference effects (20 and 16 ms. in the Catalan-

Spanish and Spanish-Catalan direction respectively); and the correlations between the similarity judgments and the magnitude of the semantic interference were in both cases significant. These data could be interpreted as evidence that the degree of semantic similarity may also modulate semantic activation across languages in the interference paradigm, in line with the DRM predictions.

One question that needs to be addressed before further exploring such an interpretation is why the same manipulation with the same non-associative semantic relations produced a clear modulation of the facilitation effects with Spanish-Catalan bilinguals (Guasch et al., in press). One possible explanation is that the paradigm and the demands of the tasks (translation recognition, lexical decision, or semantic categorization) used in all these studies partially determine whether interference and facilitation effects are observed in words with a less close semantic relationship. Although it is obvious that in all the tasks used the meaning of words is processed, as semantic facilitation and interference effects can be observed in all of them, the participants have to decide whether the two words have the same meaning only in the translation recognition task. This decision could require greater demands for semantic processing than either lexical decisions or concreteness judgements in the semantic categorisation task. Complementary to this explanation, it is also possible that the exposure time of 250 ms is not short enough for clear interference effects to emerge in the reaction times, as the activation level declines very quickly. One measure that has proven to be very sensitive to the time-course of processing from very early stages, and which could detect the activation caused by less similar words, is the recording of event-related brain potentials (ERPs). Various studies provide evidence that the N400 component is sensitive to semantic processing when the priming paradigm is used (e.g. Holcomb & Grainger, 2006; Kiyonaga, Grainger, Midgley & Holcomb, 2007). It would be necessary to determine whether this component is elicited in the translation recognition task, using the same type of related words as those included in our study. If less similar words lead to activation through languages, we would expect to find an N400, although perhaps one smaller than that produced by words with more similarity in meaning.

Our second aim was to test for the first time in highly proficient (balanced) bilinguals, whether the interference effects could be observed in both directions of translation (L1-L2 *vs*. L2-L1). Our data clearly show that the pattern of results is very similar, not only in terms of the pattern of interference effects, but also with respect to the magnitude of these effects. These data are consistent with those obtained in priming studies with very proficient bilinguals, where the magnitude of the semantic facilitation

effects is the same in both translation directions (e.g. Guasch et al., in press; Perea, et al., 2008). They also confirm the prediction of the DRM that proficient bilingual speakers would present no differences in the magnitude of interference effects regardless of the language they are translating from (L1 or L2), supporting the view that semantic representations are shared across languages and are activated during access from either language.

Finally, the third aim of this study was to examine, also for the first time, the possible role of dominance (Catalan or Spanish) of the bilinguals when proficiency is very high and similar in both languages. Our hypothesis was that if dominance is the critical variable in determining the pattern of interference effects, it would be possible to observe an asymmetry in the pattern of interference so that greater effects would be observed when translating from the more dominant language to the less dominant (in our case L1 to L2) than in the opposite direction (L2-L1). On the other hand, if proficiency is the determinant factor, we would expect to find the same interference pattern in the two groups of bilinguals (those dominant in Spanish and those dominant in Catalan). The results showed the same pattern of interference effects regardless of the participants´ dominant language. As well as being a new result, the absence of effects of dominance suggests that proficiency is the critical factor in determining the connections established between the lexical level and the conceptual level, as well as the extent to which meaning is activated across languages.

To conclude, this study was designed to contribute to a greater understanding of how words from L1 and L2 are connected at the semantic level of representation, and to what extent their meanings can be accessed directly from both languages. The results obtained provide evidence that confirms that there is semantic activation between languages in very proficient bilinguals, regardless of their dominance and the direction of translation. Likewise, the results have confirmed that the amount of semantic activation can vary depending on the degree of proximity in meaning, as the DRM predicts. In addition, the data also enable us to identify some factors that would be interesting to examine in future research, such as the type of semantic relationship, the demands of the task and the type of measure used to record the time course of the activation.

RESUMEN

Efectos de interferencia en función del grado de semejanza en la tarea de reconocimiento de traducciones en bilingües de catalán y castellano. Estudios previos han mostrado que pares de palabras relacionadas en forma (*ej., ruc-berro*) o con una relación semántica muy próxima (*ej., ruc-caballo*) producen efectos de interferencia en una tarea de reconocimiento de traducciones (Ferré et al., 2006; Guasch et al., 2008). Sin embargo, dichos efectos no se observan en palabras de relación semántica próxima (*ej., ruc-oso*). La ausencia de efecto de interferencia en las palabras menos semejante en el significado podría ser atribuida al bajo nivel de activation de las representaciones semánticas correspondientes en el momento de determinar si son o no traducciones. El presente estudio pone a prueba dicha posibilidad utilizando el mismo material que los estudios previos, pero disminuyendo el tiempo de presentación de la palabra a traducir de 500 ms. a 250 ms. En concreto, se examina el rendimiento de bilingües muy competentes en castellano y catalán en dos experimentos, manipulando la dirección de la traducción: catalán - castellano (Exp.1) y castellano- catalán (Exp.2). Los resultados revelan efectos de interferencia significativos únicamente en las palabras relacionadas en forma y muy próximas en el significado, pero no en aquellas con una relación semántica menos próxima. El patrón de los resultados fue similar en las dos direcciones de traducción, independientemente de la lengua dominante de los participantes.

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APPENDIX

List of critical words used, in alphabetical order, in the various relationship conditions (translation, very close semantic, less close semantic and form), both in Spanish (first word) and in Catalan (second word). The translations into English are in brackets.

Translation	Very close semantic	Less close semantic	Form
acelgas bledes (chard)	espinacas espinacs (spinach)	calabaza carbassa (pumpkin)	acacias fredes (acacias /cold)
alfombra catifa (carpet)	esterilla estora (mat)	parqué parquet (parquet)	almendra califa (almond /caliph)
atún tonyina (tuna)	lubina llobarro (sea bass)	foca foca (seal)	azul teranyina (blue /cobweb)
azúcar sucre (sugar)	canela canyella (cinnamon)	harina farina (flour)	azahar sogre (orange blossom /noose)
barco vaixell (ship)	canoa canoa (canoe)	avión avió (aeroplane)	basto vaixella (coarse /crockery)
barro fang (mud)	tierra terra (earth)	césped gespa (lawn)	tarro sang (jar /blood)
botella ampolla (bottle)	jarra gerra (jug)	plato plat (dish)	bocina amplària(megaphone /width)
búho mussol (owl)	águila àliga (eagle)	avestruz estruç (ostrich)	buzo múscul (diver /muscle)
burro ruc (donkey)	caballo cavall (horse)	oso ós (bear)	berro rec (watercress /donkey)
calabacín carabassó (courgette)	pepino cogombre (cucumber)	limón llimona (lemon)	balancín carboner (seesaw /collier)
calcetines mitges (socks)	medias mitges (tights)	bañador banyador (swimsuit)	maletines mitjans (briefcases /means)
calle carrer (street)	camino camí (path)	túnel túnel (tunnel)	valle cirerer (valley /cherry tree)
cama llit (bed)	sofá sofa (sofá)	mesa taula (table)	caña llet (reed /milk)
cerdo porc (pig)	jabalí senglar (boar)	cebra zebra (zebra)	nardo parc (nard /park)
cerilla llumí (match)	mecheroencenedor (lighter)	vela espelma (sail)	cepillo lluna (brush /moon)

Appendix (continued)

Translation	Very close semantic	Less close semantic	Form
colchón matalàs (mattress)	cojín coixí (cushion)	cortina cortina (curtain)	chichón catalans (lump /Catalans)
cordero xai (lamb)	cabra cabra (goat)	ciervo cérvol (stag)	cartero mai (postman /never)
cubo galleda (bucket)	barreño cossi (basin)	escoba escombra (broom)	cabo gallec (cape /Galician)
cuchillo ganivet (knife)	espada espasa (sword)	pistola pistola (pistol)	carrillo ganyota (cheek /grimace)
ensalada amanida (salad)	escalivada escalivada (escalivada)	potaje potatge (stew)	ensaimada ensorrada (pastry /sunken
fresa maduixa (strawberry)	cereza cirera (cherry)	nuez nou (nut)	freno madeixa (brake /hank)
garbanzo cigró (chickpeas)	lentejas llenties (lentils)	fideos fideus (noodles)	garganta mugró (throat /nipple)
gorrión pardal (sparrow)	golondrina orejeta (swallow)	ardilla esquirol (squirrel)	gorrón parlar (pebble /speak)
guisante pèsol (pea)	judía mongeta (bean)	patata patata potato	galante pesat (gallant /heavy)
gusano cuc (worm)	anguila anguila (eel)	abeja abella (wasp)	paisano cua (peasant /queue)
hielo gel (ice)	granizo calamarsa (hail)	niebla boira (fog)	cielo cel (sky/sky)
hilo fil (thread)	lana llana (wool)	cadena cadena (chain)	higo fill (fig /son)
jamón pernil (ham)	salchichón llonganissa (sausage)	tortilla truita (omelette)	jarrón peril (vase /danger)
lagartija sargantana (small lizard)	lagarto llangardaix (lizard)	ratón ratolí (mouse)	baratija tramontana (trinket /northerly)
lata llauna (tin)	bote pot (jar)	bandeja safata (tray)	lado llarga (side /long)
lavadora rentadora (washing machine)	lavaplatos rentaplats (dishwasher)	horno forn (oven)	leñadora montadora (woodcutter /fitter)
lechuga enciam (lettuce)	col col (cabbage)	champiñón xampinyó (mushroom)	lechuza encant (barn owl /charm)
lluvia pluja (rain)	nieve neu (snow)	tornado tornado (tornado)	novia truja (girlfriend /sow)
madera fusta (wood)	corcho suro (cork)	cemento ciment (cement)	madeja fosca (bundle /dark)

Appendix (continued)

Translation	Very close semantic	Less close semantic	Form
manzana poma (apple)	naranja taronja (orange tree)	coliflor coliflor (cauliflower)	manteca pota (lard /leg)
mariposa papallona (butterfly)	polilla arna (moth)	pavo titot (turkey)	marinera paperina (seafaring /cone)
mejillón muscle (mussel)	almeja cloïssa (clam)	ballena balena (whale)	mejilla mascle (cheek /male)
melocotón préssec (peach)	ciruela pruna (plum)	nabo nap (turnip)	malecón préstec (pier /loan)
merluza lluç (hake)	lenguado llenguado (sole)	sapo gripau (toad)	maleza llaç (weeds /knot)
mono mico (monkey)	gorila gorilla (gorilla)	vaca vaca (cow)	mano maco (hand /nice)
muela queixal (molar)	colmillo ullal (tusk)	cuerno banya (horn)	mueca queixar (grimace /complain)
muñeca nina (doll)	marioneta titella (puppet)	puzzle puzzle (puzzle)	muleta eina (crutch /tool)
naranjo taronger (orange tree)	limonero llimoner (lemon tree)	rosal roser (rosebush)	narciso taverner (narcissist /bartender)
paloma colom (dove)	gaviota gavina (seagull)	delfín dofí (dolphin)	pelota color (ball /color)
pañuelo mocador(handkerchief)	bufanda bufanda (scarf)	guantes guants (gloves)	señuelo mirador (bait /viewpoint)
pato ànec (duck)	ganso oca (goose)	tortuga tortuga (tortoise)	palo anar (stick /go)
peca piga (freckle)	verruga berruga (wart)	grano gra (spot)	poco figa (little /fig)
pendiente aracada (slope)	anillo anell (ring)	reloj rellotge (clock)	pariente arribada arrival (relative)
perejil julivert (parsley)	tomillo farigola (thyme)	vainilla vainilla (vanilla)	peregrino jurament (pilgrim /oath)
perro gos (dog)	hiena hiena (hyena)	buey bou (ox)	puerro cós (leek /body)
pimiento pebrot (pepper)	berenjena albergínia (aubergine)	níspero nespra (medlar)	cimiento rebrot (cement /shoot)
pulpo pop (octopus)	calamar calamar (squid)	salmón salmó (salmon)	pulso pou (pulse /well)
queso formatge (cheese)	cuajada quallada (curd)	flan flam (crème caramel)	hueso fullatge (bone / foliage)

Appendix (continued)

Translation	Very close semantic	Less close semantic	Form
rana granota (frog)	salamandra salamandra (salamander)	serpiente serp (snake)	rama granger (branch /farmer)
rodilla genol (knee)	codo colze (elbow)	ojo ull (eye)	colilla gendre(cigarette end /son-in-law)
sábana llençol (sheet)	colcha cobrellit (bedspread)	tapete tapet (tablecloth)	semana llençar (week / throw away)
servilleta tovalló (napkin)	mantel tovalles (tablecloth)	manta manta (blanket)	sirvienta medalló (maid / medallion)
silla cadira (chair)	butaca butaca (armchair)	estantería prestageria (shelf)	villa cadena (town / chain)
sombrero barret (hat)	gorra gorra (cap)	pantalón pantaló (trousers)	bombero barres (fireman / bars)
techo sostre (roof)	tejado teulada (roof)	pasillo passadís (corridor)	hecho rostre (fact / face)
tiburón tiburó (shark)	orca orca (killer whale)	cangrejo cranc (crab)	tirabuzón tauló (curl / plank)
tijeras estisoras (scissors)	alicates alicates (pliers)	destornilla tornavís (screwdriver)	literas estirades (bunks / stretched)
tormenta tempesta (storm)	hurcán huracà (hurricane)	terremoto terratrèmol (earthquake)	torpeza temporer (clumsiness /temporary)
trigo blat (wheat)	centeno civada (rye)	avellana avellana (hazelnut)	trago blau (drink /blue)
uva raïm (grape)	pasas panses (raisins)	remolacha remolatxa (beetroot)	uña raig (nail / ray)
vaso got (glass)	taza tassa (cup)	fuente font (fountain)	paso tot (step / whole)
ventana finestra (window)	puerta porta (door)	armario armari (cupboard)	ventaja sinistra (advantage /left)
yegua egua (mare)	mula mula (mule)	elefante elefant (elephant)	legua fugida (league / leak)
zanahoria pastanaga (carrot)	rábano rave (radish)	albaricoque albercoc (apricot)	zapatería pastoreta(shoe shop/shepherdess)
zumo suc (juice)	batido batut (milkshake)	aceite oli (oil)	grumo sac (lump/ bag)

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