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Abstract

Very few studies exist on the role of cross-language similarities in cognate word acquisition. Here we sought to explore, for the first time, the interplay of orthography (O) and phonology (P) during the early stages of cognate word acquisition, looking at children and adults with the same level of foreign language proficiency, and by using two variants of the word-association learning paradigm (auditory learning method vs. auditory + written method). Eighty participants (forty children and forty adults, native speakers of European Portuguese [EP]), learned a set of EP-Catalan cognate words and non-cognate words. Among the cognate words, the degree of orthographic and phonological similarity was manipulated. Half of the children and adult participants learned the new words via an L2 auditory and written-L1 word association method, while the other half learned the same words only through an L2 auditory-L1 word association method. Both groups were tested in an auditory recognition task and a go/no-go lexical decision task. Results revealed a disadvantage for children in comparison to adults, which was reduced in the auditory learning method. Furthermore, there was an advantage for cognates relative to non-cognates regardless of the age of participants. Importantly, there were modulations in cognate word processing as a function of the degree of O and P overlap which were restricted to children. The findings are discussed in light of the most relevant bilingual models of word recognition.

Keywords: second language acquisition, cognate and non-cognate words, phonological and orthographic overlap, participants' age

Introduction

In recent decades, the way in which different languages are represented and processed in the bilingual memory has been studied extensively (e.g., Comesaña, Perea, Piñeiro, & Fraga, 2009; Comesaña et al., 2015; Dijkstra el al., 2010; Kroll, Van Hell, Tokowicz & Green, 2010; Van Heuven & Dijkstra, 2010). Most of these studies have shown a simultaneous activation of words from both languages, that is, a non-selective language activation due to the existence of a common representation for both languages, at least at some level (Dijkstra et al., 2010). Indeed, a vast number of studies focusing on bilingual visual word recognition and production have shown the cognate facilitation effect as an index of non-selective language activation. The cognate facilitation effect refers to a differential processing of translation equivalents that share identical form (i.e., identical cognates, such as *clima-clima* [climate], in European Portuguese [EP]) and Catalan, respectively) or non-identical form (i.e., non-identical cognates such as *setembro-setembre* [September]) with respect to those that only share meaning (i.e., non-cognates such as e*squena-costas* [back]). Accordingly, cognates are acquired (e.g., Comesaña, Soares, Sánchez-Casas, & Lima, 2012a; de Groot & Keijzer, 2000; Lotto & De Groot, 1998; Comesaña, Moreira, Valente, Hernández & Soares, under review; Rogers, Webb, & Nakata, 2014; Tonzar, Lotto, & Job, 2009), recognized (e.g., Dijkstra, Grainger, & Van Heuven, 1999; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998) and translated (e.g., De Groot, 1992; De Groot, Dannenburg, & Van Hell, 1994; Kroll & Stewart, 1994) faster than non-cognates. However, when studies on cognate processing take into consideration the role played by orthographic (O) and phonological (P) information (Comesaña et al., 2012a, 2015; Dijkstra et al., 2010; Schwartz, Kroll, & Diaz, 2007), the results are inconsistent, either regarding the direction of the cognate effect (facilitation vs. inhibition) or regarding the interplay of O and P (see Comesaña et al., 2015, for a recent overview). This raises the question as to the precise representation and processing of cognate words in the bilingual memory. The present study was designed to shed light on this issue. Specifically, it aimed to explore the processing of non-identical cognates during the early stages of new vocabulary acquisition by manipulating the degree of O and P overlap of EP (first language -L1) and Catalan (new language[1]) cognates. To this end, we employed a word learning paradigm, typically used in the literature to identify those variables that facilitate word acquisition (see de Groot, 2011). In this paradigm participants have to learn new words which are presented along with their L1 translation equivalents.

The role played by the degree of O and P overlap in the processing of non-identical cognate words was explored recently by Comesaña et al. in 2015 (Experiment 2). In this study, balanced Catalan-Spanish bilinguals were asked to perform a lexical decision task in Spanish in which they had to decide whether a chain of letters presented was a real word in Spanish or not. Cognates were distributed into four experimental conditions according to the degree of O and P overlap (O+P+, O+P-, O-P+ and O-P-; + and – stand for high and low overlap, respectively). Interestingly, the results revealed an interaction between O and P information, as P facilitated the processing of cognates with high O overlap (O+P+ faster than O+P-) but hampered that of cognates with low O overlap (O-P+ slower than O-P-) (see Comesaña et al., 2012a for converging electrophysiological evidence). This result, a priori, seems to fit well with the tenets of the Bilingual Interactive Activation Plus model (BIA+, Dijkstra & van Heuven, 2002; Dijkstra et al., 2010). This model assumes an integrated lexicon with non-selective access for the two languages, in which cognates are differently processed compared to non-cognates because they share more O and P features. In this integrated lexicon, there is not only a set of facilitative connections between different levels of processing (sublexical, lexical, language nodes and semantic levels), but also inhibitory

[1] We cannot talk about a second language because the participants had already learned or were learning a second language at school, namely English.

connections between O and P lexical representations of L1 and L2 which affect lexical access. The degree of inhibition not only varies as a function of the degree of word form overlap but also as a function of L2 proficiency. Thus, low proficiency bilinguals would be more affected by word form than high proficiency bilinguals because the latter benefit more from semantic co-activation (i.e., despite lateral inhibition, both O and P lexical representations send activation to the same meaning). A series of studies have provided evidence for such a prediction. For instance, Brenders, van Hell and Dijkstra (2011) examined the processing of cognates and false friends (words that are similar for L1 and L2 in form, but not in meaning, such as boot, which means 'boat' in Dutch, and angel, which means 'stinger' in Dutch) by manipulating the composition of the stimulus list in different groups of Dutch children who were learning English as an L2. The groups differed in age (10.5, 12.6 and 14.3 years old) as well as in L2 proficiency (i.e., they belonged to different grades in primary and secondary school, and thus had been receiving English lessons for different amounts of time). In Experiment 1, cognates and non-cognates made up the list whereas in Experiment 3, cognates, false friends and non-cognates were all included. In both experiments participants were asked to do a lexical decision task in English. Results from Experiment 1 revealed a cognate facilitation effect (cognate words were recognized faster than non-cognate words) which was relatively constant across age groups. However, the pattern of results for cognates was reversed in the third experiment (i.e., there was an inhibitory effect). This contrasts with the results from previous studies with Dutch-English adults (Dijkstra et al., 1998, 1999) in which a cognate facilitation effect was observed regardless of the presence or absence of false friends in the list. Brenders et al. (2011) claimed, by following the tenets of the BIA+ model, that because the adult bilinguals tested by Dijkstra et al. (1998, 1999) were more proficient than the different groups of children in their study, they were less affected by word form overlap (see Bultena, Dijkstra, & van Hell, 2014, for convergent eye-tracking evidence for modulations of the cognate effect as a function of L2 proficiency, and also Casaponsa, Antón, Pérez, & Duñabeitia, 2015). In other words, adult bilinguals had robust L2 cognate representations which were more strongly activated at a meaning level, reducing the influence of the L1 on L2 processing. It should be noted, however, that an alternative explanation of these data is possible: it could be that the differences in cognate processing between adults (Dijkstra et al., 1998, 1999) and children (Brenders et al., 2011) were due to the effect of age and reading expertise rather than to L2 proficiency. In fact, there are studies conducted with children that have failed to find a clear effect of proficiency on cognate processing. For instance, Poarch and van Hell (2012) investigated the effect of participants' proficiency in cross-language activation during speech production. The authors tested German children who had different levels of L2 (English) proficiency, but they were matched on L1 (German) proficiency. In particular, there were L2 learners of English, German-English bilinguals, and trilinguals (L3 was another language, apart from German and English). The results failed to show any effect of proficiency in L2 cognate processing. Proficiency affected performance only when children did the task in L1, as L2 learners did not show the cognate advantage in this condition, while bilingual and trilingual children did. These results constitute evidence of cross-language activation in children exposed to multiple languages, showing that proficiency had a relevant role only when the task was in L1, but not in L2. Of note, the study also included a group of German-English adult bilinguals. Although the authors didn't evaluate the effects of age on the cognate effect (i.e., they did not statistically compare the performance of the adults with that of children), a visual inspection of the average reaction times suggests that the magnitude of the facilitation for cognate words was higher in children than in adults.

A study that directly addressed the effects of age in cognate processing was that of Duñabeitia, Ivaz and Casaponsa (2015), who tested bilingual children ranging from 8 to 15 years in a translation recognition task. All the children supposedly had the same proficiency level, as all were Spanish [L1] – Basque [L2] bilinguals immersed in a bilingual environment. However, the authors did not assess the level of proficiency directly. Results revealed that the cognate facilitation effect decreased as reading proficiency (and age) increased. In other words, as reading proficiency increases the sensitivity to cross-language orthographic overlap diminishes. Besides, similarly to what was observed with adults in previous studies in which the degree of O overlap was manipulated (Comesaña et al., 2015; Dijkstra et al., 2010), latency responses decreased from cognates with low O overlap to cognates with high O overlap. The authors explained these results by adducing maturational changes of the mechanisms responsible for language interference suppression, as developmental models of bilingual lexical access hold (e.g., BIA-d model, Grainger et al., 2010). BIA-d is an interesting model that combines the postulates of two relevant models of bilingual word processing: the Bilingual Interactive-Activation model (BIA; Grainger & Dijkstra, 1992; van Heuven, Dijkstra, & Grainger, 1998) and the Revised Hierarchical Model (RHM; Kroll & Stewart, 1994; Kroll, van Hell, Tokowicz, & Green, 2010). It tentatively explains the underlying mechanisms of the changes in connectivity between the L2 and L1 lexical representations and the conceptual system that occurs as L2 proficiency increases. According to BIA-d, during the early stages of L2 acquisition, excitatory connections between translation equivalents are enhanced in the presence of orthographic overlap. However, as L2 proficiency increases, these connections are weakened due to the development of lateral inhibition between lexical representations and top-down inhibitory connections. Hence, if we take into account that as bilingual children get older their expertise with both languages increases and the strength of excitatory connections between translation equivalents is reduced, the BIA-d model may account for a decrease in the size of the cognate effect found in adults in comparison to children, as well as for a decrease in the sensitivity to cross-language form overlap.

Duñabeitia et al. (2015) suggest that bilinguals' age can have an effect on cognate processing, probably because reading expertise causes a developmental change that affects the way words are processed. This is in fact consistent with what is observed in the monolingual domain. Indeed, studies in word acquisition and consolidation with elementary-school children have shown that there are developmental changes in the way in which the orthographic lexicon of novice readers is organized. When the structure of the mental lexicon is well established and the reading skills are consolidated (later stages of reading development), the lexical competition between near orthographic representations is reduced (e.g., Castles, Davis, & Forster, 2003; Duñabeitia & Vidal-Abarca, 2008; Laxon, Coltheart, & Keating, 1988; Perea & Estévez, 2008).

It should be noted, however, that the results of Duñabeitia et al.'s study with bilingual children are not entirely clear, because some kind of confound may occur between age and proficiency. That is, older and younger child bilinguals do not only differ in age, but usually also in language experience and proficiency. In order to avoid this confound, and to disentangle the effects of age and proficiency in cognate word processing, one of these variables has to be manipulated while the other remains constant. This was the approach taken in the present study, in which children and adult participants were matched in proficiency (that is, both groups were in the very early stages of a new language learning). Indeed, they participated in a novel word learning experiment in which the acquisition and processing of non-identical cognates was investigated, by manipulating the degree of O and P overlap of European Portuguese (EP)-Catalan cognates.

Hitherto, we have focused on the literature relating to cognate word processing. Regarding cognate word acquisition, research is scarcer. To the best of our knowledge, only eight studies on this topic have been carried out: five with adults (de Groot & Keijzer, 2000; Ellis & Beato, 1993; Kroll, Michael, & Sankaranarayanan, 1998; Lotto & de Groot, 1998;

Rogers et al., 2014) and three with children (Comesaña et al., 2012b; Comesaña et al. under review; Tonzar et al., 2009). Most of these studies have used a word-learning paradigm, involving the visual presentation of either pairs of words (L2-L1 words) or pictures together with L2 words during acquisition. The results of these studies are clear-cut: a facilitation effect for cognates over non-cognates exists in both children and adults. However, these studies were not designed to study the effect of either participants' age or the formal overlap of cognates. Indeed, in none of these studies were adults and children compared in the same experiments, nor was the degree of O and P overlap of cognates manipulated separately (i.e., the criterion to select the experimental cognate words was orthographic similarity, and it usually covariates with phonological similarity). In order to address these issues, these two variables were manipulated independently in the present study in an attempt to clarify the interplay of O and P during cognate word acquisition and processing in children and adults.

In sum, the main aim of the present research was to examine, for the first time, the interplay of O and P during the early stages of new cognate word acquisition by using a word association learning paradigm in both adult and children populations. The new language to be learned was Catalan, a Romance language which is spoken in the northeast of Spain. We selected this language because (i) there is a high percentage of cognates between EP and Catalan that allowed us to select cognate words varying in the degree of O and P overlap, and (ii) it is rare to find EP speakers who have any knowledge of it. The experiment had two phases: the learning phase and the test phase. Importantly, two variants of the word-association learning method were employed during the learning phase to explore further their influence on the process of lateral inhibition between L2 and L1 lexical representations postulated by the BIA+ and BIA-d models. In one learning method (method 1 – M1), the new Catalan words were presented both in written and auditory modalities, and in the other learning method (method 2 – M2) they were presented only in the auditory modality.

Therefore, the only difference between the two methods was the presence or absence of the orthographic representation of the new Catalan words to be learned. The rationale for the manipulation of the learning method was the following: if word processing is more affected by form when proficiency in the new language is low (as is the case here), the competition between NL and L1 orthographic lexical representations can probably be reduced by teaching the new words exclusively in an auditory modality, at least during the early stages of NL word acquisition. Note that this is the natural way of learning the L1, that is, to learn words first in auditory modality before learning their corresponding written forms (see Sloutsky & Napolitano, 2003 for evidence of a privileged processing of auditory input over visual input in children). The effect of learning method would be stronger for children than for adults, since children are more sensitive to cross-language similarities (see Duñabeitia et al. 2015).

In the test phase, learning was assessed through an auditory recognition task and an auditory lexical decision task. The first task was administered to evaluate the new words acquisition and the second task to evaluate whether these newly acquired words showed the effects of cognate facilitation and that of formal overlap (in terms of O and P).

Taking all of the above into account, and also in light of the literature reviewed, we expected not only a processing advantage for cognates over non-cognates, as previous studies on vocabulary acquisition have shown (e.g., Comesaña et al, 2012a; de Groot & Keijzer, 2000; Ellis & Beato, 1993; Kroll et al., 1998; Lotto & de Groot, 1998; Comesaña et al., under review; Rogers et al., 2014; Tonzar et al., 2009), but also modulations on cognate processing as a function of the degree of O and P overlap. Concerning the effects of age, on the one hand we expected to observe a decrease in the size of the cognate effect as age or reading expertise increases. On the other, we expected to find a higher effect of O and P overlap in children than in adults, since children seem to be more sensitive to cross-language interference (Duñabeitia et al., 2015; Poarch & van Hell, 2012). Regarding the learning method, we expected children from the auditory method (M2) to have a better performance than those from the written + auditory method (M1). The reason for this is as follows: since these children are at the beginning/intermediate stages of reading development, lexical competition between neighboring O representations across (Duñabeitia et al., 2015) or within languages (Acha & Perea, 2008; Castles et al., 2003; Duñabeitia & Vidal-Abarca, 2008; Laxon et al., 1988; Perea & Estévez, 2008) is higher. If we avoid presenting the O representations of the new words to be learned (as in the case of the M2), cross-language interference at an orthographic level might be reduced. Conversely, when it comes to adults we expected either smaller differences across methods or no differences at all. This is because they are in later stages of reading development (in which there is less lexical competition between neighboring O representations) and the orthographic information will not interfere as much as in children (e.g., Duñabeitia et al., 2015).

Method

Ethics Statement

The experiments were conducted with the approval of the Ethics Committee for Human Research (CEHUM 022-2014) of the Research Center on Psychology (CIPsi) at the University of Minho (Braga, Portugal).

Participants

Our sample comprised two different groups: adults and children. Fifty-seven university students from the School of Psychology, University of Minho (Braga, Portugal), and fifty fifth-grade children from two private schools in northern Portugal participated in the experiment. Participants with a percentage of errors higher than 15% in the auditory recognition task or with a % of errors higher than 30% in the lexical decision task were eliminated. Thus, the final sample included 40 adults that were 19-34 years old (M_{age} = 22.06, *SD* = 3.68, 36 female) and 40 children that were 10-11 years old (M_{age} = 10.60, *SD* = .49, 16 female). All were native speakers of EP without any prior knowledge of Catalan (note that they had some knowledge of English because learning English is part of the compulsory school curriculum). None of the children had: a) learning or intellectual disabilities, and/or b) had repeated a school year.

Materials

Fifty-two EP words (48 experimental words + 4 for practice purposes) were selected. Half of the words were EP (L1)-Catalan cognates and the other half were EP-Catalan noncognates.

Three conditions of cognates were created according to the degree of O and P overlap: O-P+ (e.g., *piedade-pietat* [piety]), O-P- (e.g., *fêmea-femella* [female]) and O+P+ (e.g., *blusa-brusa* [blouse]). It was not possible to perform a complete orthogonal manipulation of O and P because the number of possible words in the O+P- condition was not large enough to allow for the control of all the sublexical and lexical variables above considered. Thus, this condition was not included. It should be noted, however, that our design allowed us to test the effects of O when P was matched (O-P+ and O+P+) as well as the effects of P when O was matched (O-P+ and O-P-).

The degree of O and P overlap of cognates was computed using objective measures. Regarding O overlap, we used the normalized Levenshtein distance (NLD) (Schepens, Dijkstra, & Grootjen, 2012) achieved through use of the NIM software (Guasch, Boada, Ferré, & Sánchez-Casas, 2013). The score varied between 0 and 1 (the greater the score, the higher the degree of O overlap). Thus, O+ pairs (O+P+) had a value of .77 (*SD* = .10), whereas O- pairs (O−P+/O−P−) had a value of .41 (*SD* = .15). There were significant differences in O overlap between the O+P+ and O-P+ conditions and between the O+P+ and O-P- conditions (all $p_s < .001$). The degree of P similarity was rated by an expert in phonetics with the following criteria: vowel quality of the stressed syllable, number of syllables that the two words had in common, position of the stressed syllable, and preceding and following phonological contexts of the stressed syllable. The algorithm varied between 0 and 1, and was of .76 (*SD* = .13) for P+ translation pairs (O+P+/O−P+) and of .27 (*SD* = 0.22) for P− translation pairs (O−P−). Self-ratings of phonological similarity performed by participants after the experiment were positively correlated with the objective scores ($r = .81$, $p < .001$). The mean of the subjective scores was .64 for O-P+ condition, .24 for O-P- condition and .67 for O+P+ condition. There were significant differences, both for objective and subjective scores, in P overlap between O+P- and O-P+ conditions and between O-P- and O+P+ conditions (all $p_s < .001$).

EP cognate and non-cognate words were matched in logarithm word frequency, biphone frequency, contextual diversity, length (in number of letters), and number of orthographic neighbors (all $p_s > .24$) (see Table 1).

<INSERT HERE THE TABLE 1>

The EP words from the three conditions (O-P+, O-P-, O+P+) were also matched in logarithm frequency, biphone frequency, contextual diversity, length, and orthographic neighbors (all $p_s > .39$) (see Table 2). The values of logarithm word frequency and contextual diversity for EP words were taken from ESCOLEX (Soares et al., 2014; an EP grade-level lexical database that gives numerous word frequency statistics for 1st to 6th grade children [6- to 11-year-olds] computed from elementary textbooks) and the values of biphone frequency and length were retrieved from P-PAL (Soares et al., 2015; an EP lexical database that gives numerous word frequency statistics and the computation of several other lexical and sublexical objective and subjective metrics for adults).

<INSERT HERE THE TABLE 2>

The Catalan cognate and non-cognate words to-be-learned were matched in logarithm frequency, length and orthographic neighbors (all p_s > .68) (see Table 1). The same matching was conducted among the Catalan words from the three experimental conditions (O-P+, O-P-, O+P+) (all p_s >.91) (see Table 2). These values were taken from the NIM software (Guasch et al., 2013). Furthermore, in order to be sure that the Catalan words from the different conditions were matched in terms of difficulty, we counted the orthographic sequences in the Catalan words that were illegal in EP. We also computed the average token frequency of bigrams in EP that the Catalan words had. These values were retrieved from the P-PAL database (Soares et al., 2015). No differences were found between cognate and non-cognate words in these two measures (p_s > .23). Moreover, no significant differences were found between the Catalan words in the three cognate conditions either in number of illegal sequences or in the average token frequency of bigrams (both p_s > .45; p = 1).

We also compared the EP words with the Catalan words in logarithm frequency, length and orthographic neighbors. The results showed that there were no differences between EP cognates and non-cognates and Catalan cognates and non-cognates in these variables (all p_s > .61). The same comparison was done between the Catalan and EP words included in the three cognate conditions. The three experimental conditions (O-P+, O-P-, O+P+) were matched with respect to these variables (all p_s > .60).

Finally, fifty-two pseudowords were created for the purposes of the auditory lexical decision task by changing the first letter of a set of Catalan words from the same population of the experimental words. Afterwards, an expert in psycholinguistics who was also a native speaker of Catalan guaranteed that the generated pseudowords did not exist in that language but followed its phonotactic rules. Pseudowords were created from a pool of Catalan words from the same population as the experimental words. Thus, half of the Catalan pseudowords were orthographically/phonologically similar to EP words, since they were created from CGs words between EP-Catalan. For instance, we created the pseudoword "*zeradís*" from the Catalan word *paradís* [paradise], which was a cognate translation of the EP word *paraíso*. The other half were created from non-cognate words between EP-Catalan (e.g., *"roixell"*, created from *barco-vaixell* [boat]. There were no significant differences in either length or frequency in both languages between the cognate words used to create the cognate pseudowords and the non-cognate words used to create the non-cognate pseudowords (all p_s > .32). Furthermore, cognate and non-cognate pseudowords were created mimicking the cognate and non-cognate words, according to the degree of O and P overlap. Thus, the cognate words used to create the cognate pseudowords had a NLD value of .65 (SD = .15) and the non-cognate words used to create the non-cognate pseudowords had a NLD value of .19 (SD = .20), being this difference statistically significant ($p < .001$). On the other hand, the algorithm of the degree of P similarity was of .75 (SD = .11) for the cognate words used to create the cognate pseudowords and of .24 (SD = .11) for the non-cognate words used to create the non-cognate pseudowords, being this difference also significant ($p < .001$).

Procedure

The experiment was run individually for each participant in a quiet room. Detailed instructions were displayed in the center of a laptop screen. There were two phases (learning phase and test phase). In the learning phase, a total of 52 critical words were presented to participants (48 experimental words + 4 for practice trials). Participants were randomly assigned to one of the two learning methods (M1 and M2). In M1, Catalan words were presented in a written and auditory modality (recorded by a native speaker of Catalan) along with their L1 translations (e.g., *Taronja –Laranja* [orange]). In M2, Catalan words were presented in an auditory modality along with their L1 translation and a mask (e.g., XXXXXXX–*Laranja* [orange] -note that the mask replaced the corresponding Catalan written word and was also displayed to match the quantity of physical input presented across methods [Rogers et al., 2014]). Presentation of the stimuli was controlled using Powerpoint. Thus, in each slide, six sequences (i.e., 6 pairs of Catalan-EP words or 6 pairs of XXXX-EP words in M1 and M2, respectively) were presented for 5 minutes (the time given to learn the words). Participants controlled the auditory presentation of Catalan words by pushing a button as many times as they wanted until the 5 minutes per slide elapsed. The entire learning phase took about 60 minutes.

Afterwards, word learning was assessed with a recognition task in which each Catalan word was presented in auditory modality. Participants were asked to select its correct EP translation from a set of seven visually displayed words (i.e., the correct translation together with six L1 distractor words that were translations of other Catalan words learned during the learning phase). Among the distractors, there was an equal number of cognate and non-cognate words. Three distractors were EP translations of other learned non-cognate words and the other three were EP translations of other learned cognate words (one EP translation from each cognate condition: O+P-, O-P- and O+P+). Subsequently, participants performed an auditory go/no-go lexical decision task in which they had to decide, as fast and as accurately as possible, if each stimulus was a previously learned Catalan word or to refrain from responding if not. In this task, the Catalan words were mixed with the created pseudowords. In each trial, participants had to press a button on the keyboard when the response was positive (a previously learned Catalan word) and refrain from responding if not (a pseudoword).

Stimuli presentation and response recording were controlled by the DMDX software (Forster & Forster, 2003). The auditory recognition task and the go/no-go lexical decision task were followed by a phonological similarity rating task in order to assess if the objective measure of P overlap used for stimuli categorization correlated with a subjective measure of P overlap. In this task, participants had to assess the degree of P overlap of experimental translation equivalents, using a 5-point Likert scale (from lowest (1) to highest overlap (5)). Overall, this second phase lasted approximately 30 minutes.

Results

The results regarding the Auditory Recognition Task are presented here first, followed by the results of the go/no-go lexical decision task. Since four cognate words were mistakenly selected as non-cognate words, they were excluded from the stimulus list as well as from the analyses (the final sample was thus made by 24 cognates and 20 non-cognates). In any case, cognate and non-cognate words were still well matched in the relevant variables across conditions after removing those words (all $p_s > .10$).

Auditory Recognition Task

The analyses are organized as follows: Firstly, we present the results of a repeated measures analysis of variance (ANOVA) considering participants (F_1) and items (F_2) in terms of the percentage of errors (%E). The analyses were based on a 2 (age: children, adults) × 2 (learning method: M1, M2) × 2 (wordtype: cognate, non-cognate) mixed design to explore whether there were differences in processing between cognates and non-cognates as a function of learning method and age. In F_1 analyses, wordtype was treated as a within-group factor, and learning method and age as between-group factors. In F_2 analyses, wordtype was considered a between-group factor, whereas age and learning method were treated as within-group factors. Secondly, we present the results of another ANOVA in which only cognates were considered as a means of exploring whether the acquisition and processing of cognates were modulated by the degree of O and P overlap (note that non-cognates have no formal overlap). This analysis was based on a 2 (age: children, adults) × 2 (learning method: M1, M2) × 3 (degree of cross-language overlap: O-P+, O+P+, O-P-) mixed design. In F_1 analyses, the degree of cross-language overlap was considered as a within-group factor, and learning method and age as between-group factors. In F_2 analyses, the degree of cross-language overlap was considered a between-group factor, whereas learning method and age were treated as within-groups factors. Finally, in all the analyses, planned Bonferroni comparisons were conducted when necessary. Mean %E per experimental condition is presented in Table 3.

<INSERT TABLE 3 ABOUT HERE >

The results of the first analysis revealed a main effect of Wordtype, $F_1(1, 76) = 68.12$, $MSE = 39.66$, $\eta^2_p = .47$ $p < .001$, F_2 $(1, 42) = 9.99$, $MSE = 295.03$, $\eta^2_p = .192$, $p = .003$, as participants made more errors with non-cognates (9.94) than with cognates (1.72) (i.e. a cognate facilitation effect). There was a significant interaction between Method and Age, although only by items, $F_1(1, 76) = 1.05$, $MSE = 61.47$, $\eta^2_p = .014$, $p = .309$, $F_2(1, 42) = 5.01$, $MSE = 13.38$, $\eta^2_p = .107$, $p = .031$, as there were more errors for items in the M2 in the children's sample than in the adults' sample (6.79 and 3.35, respectively, $p = .044$). In addition, items from M1 had more errors than items from M2 in the adults' sample (6.10 and 3.35, respectively, $p = .006$). Also, the three-way interaction between Method, Wordtype and Age was only significant in the analysis by items, $F_1(1, 76) = 1.30$, $MSE = 51.56$, $\eta^2_p = .017$, $p = .258$, $F_2(1, 42) = 4.21$, $MSE = 13.38$, $\eta^2_p = .091$, $p = .047$, as non-cognates from M1 had more errors than non-cognates from M2 in the adults´ sample (10.75 and 6.5, respectively, p = .004). Moreover, non-cognates from M2 had more errors in the children´s sample than in the adults´ sample (11.5 and 6.5, respectively, p = .048). Besides, the interaction also showed a cognate facilitation effect (more errors for non-cognates than for cognates) in both samples regardless of method (all $p_s < .05$).

Regarding the second analysis, in which only cognates with different degrees of O and P overlap were included, a main effect of Cross-language overlap reached significance in the analysis by participants, $F_1(2, 152) = 8.34$, $MSE = 22.72$, $\eta^2_p = .10$, $p < .001$, $F_2(1, 21) = 1.25$, $MSE = 60.52$, $\eta^2_p = .11$, $p = .31$. This indicated that participants made more errors with items from the O-P- and O-P+ conditions than with items from the O+P+ condition (2.19, 2.97 and .00, respectively; all $p_s < .01$), whereas there were no differences between O-P+ and O-P- conditions ($p = 1$). A main effect of Age was significant in the analysis by participants and approached significance in the analysis by items, $F_1(1, 76) = 6.21$, $MSE = 30.33$, $\eta^2_p =.08$, $p = .015$, $F_2(1, 21) = 3.73$, $MSE = 20.21$, $\eta^2_p = .15$, $p = .067$, showing that children (2.60) made more errors than adults (.83). There was a significant interaction between Cross-language overlap and Age, only by participants, $F_1(2, 152) = 3.12$, $MSE = 22.72$, $\eta^2_p =.04$, $p = .047$, $F_2(2, 21) = 1.41$, $MSE = 20.21$, $\eta^2_p = .12$, $p = .27$, since differences across cognate conditions were restricted to children. They made more errors in the O-P- and in the O-P+ conditions than in the O+P+ (4.06, 3.75 and 1.5, respectively, $p_s < .001$). No differences between O-P+ and O-P- conditions were found ($p = 1$). Besides, children made more errors to words from condition O-P- than adults (4.06 and .31, respectively, $p = .010$).

Go/no-go Lexical Decision Task

Incorrect responses and responses with recognition times falling outside the cut-off points (higher than 2000 ms and lower than 200 ms) were excluded from the analysis (3.8%).

Taking into account the a priori differences in RTs between children and adults, we computed a relative measure to allow the comparison between these two populations. Thus, RTs were inverse transformed (RT => 1/RT) to normalize the RT distributions, transforming the classic latency measure (seconds per word) into a speed measure (words per second) (see Ratcliff, 1993; also Ziegler, Bertrand, Lété, & Grainger, 2014). The analyses are organized as in the Auditory Recognition Task. Mean reaction times (RTs) and %E per experimental condition are presented in Tables 5 and 6. The results of the first analysis (considering cognates and non-cognates) are presented in Table 5, and the results of the second analysis, restricted to cognate words (O-P-, O-P+ and O+P+), are presented in Table 6.

<INSERT TABLE 5 AND 6 ABOUT HERE>

The first analysis of RTs revealed a main effect of Age, $F_1(1, 76) = 17.45$, MSE = 5.754E-9, $\eta^2_p = .19$, $p < .001$, $F_2(1, 42) = 23.70$, MSE = 4.358E-9, $\eta^2_p = .36$, $p < .001$, as adults recognized words faster than children. There was also a main effect of Wordtype, F_1 (1, 76) = 105.11, MSE = 1.250E-9, $\eta^2_p = .58$, $p < .001$, $F_2(1, 42) = 11.80$, MSE = 1.035E-8, $\eta^2_p = .22$, $p = .001$, showing that responses were faster for cognates than for non-cognates (i.e., a cognate facilitation effect). A significant interaction between Age and Method was found, only by items, $F_1(1, 76) = 1.08$, MSE = 5.754E-9, $\eta^2_p = .014$, $p = .303$, $F_2(1, 42) = 4.16$, MSE = 1.424E-9, $\eta^2_p = .090$, $p = .048$. This interaction revealed that, although items from M1 and from M2 were recognized more slowly in the children's sample than in the adults´ sample, the magnitude of the difference was marginally higher in M1 than in M2, t (86) = 1.78, $p = .078$.

Concerning the analysis of the E%, results revealed a main effect of Age, $F_1(1, 76)$ = 44.06, MSE = 203.41, $\eta^2_p = .37$, $p < .001$, $F_2(1, 42) = 60.71$, MSE = 161.04, $\eta^2_p = .59$, $p <$ .001, since the adults made less errors than children (14.74 vs. 29.71). The effect of Wordtype was significant by participants and approached significance by items, $F_1(1, 76) = 19.69$, *MSE* = 83.91, $\eta^2_p = .21$, $p < .001$, $F_2(1, 46) = 3.13$, *MSE* = 575.97, $\eta^2_p = .07$, $p = .08$, as the %E was lower for cognates than for non-cognates (19.01 vs. 25.44). There was also a significant interaction between Wordtype and Age, $F_1(1, 76) = 16.63$, *MSE* = 83.91, $\eta^2_p = .18$, $p < .001$, $F_2(1, 42) = 9.45$, *MSE* = 161.038, $\eta^2_p = .18$, $p = .004$. This interaction revealed that the difference in percentage of errors between cognates (M = 25.34) and non-cognates (M = 35.88) was restricted to children ($p < .001$). A significant interaction between Wordtype and Method was also found, $F_1(1, 76) = 4.03$, *MSE* = 83.91, $\eta^2_p = .050$, $p = .048$, $F_2(1, 42) = 6.39$, *MSE* = 57.68, $\eta^2_p = .13$, $p = .015$, showing that participants in the M2 made more errors with non-cognates (27.25) than with cognates (17.92) ($p < .001$), whereas there were no differences between non-cognates and cognates in M1 ($p = .09$).

Regarding the second analysis, in which only cognates with different degrees of O and P overlap were included, RTs revealed a main effect of Age, $F_1(1, 76) = 11.30$, *MSE* = 1.314E-8, $\eta^2_p = .13$, $p < .001$, $F_2(1, 21) = 29.40$, *MSE* = 1.885E-9, $\eta^2_p = .26$, $p < .001$, as adults were faster than children. A main effect of Cross-language overlap also appeared, although only by participants, $F_1(2, 152) = 13.35$, *MSE* = 2.609E-9, $\eta^2_p = .149$, $p < .001$, $F_2(2, 21) = 1.43$, *MSE* = 1.029E-8, $\eta^2_p = .12$, $p = .262$, since participants were slower in the O-P- condition than in both the O-P+ ($p = .048$) and the O+P+ conditions ($p < .001$). Additionally, participants were slower in O-P+ condition than in O+P+ condition ($p = .029$). There was also a significant interaction between Cross-language overlap and Age, $F_1(2, 152) = 6.79$, *MSE* = 2.609E-9, $\eta^2_p = .08$, $p < .001$, $F_2(2, 21) = 3.67$, *MSE* = 1.89E-9, $\eta^2_p = .26$, $p = .043$. This interaction showed that differences across cognate conditions were restricted to children. Indeed, children were slower in the O-P- condition than in both the O-P+ ($p < .001$) and the O+P+ conditions ($p < .001$). They were also slower in the O-P+ condition than in the O+P+

condition ($p < .001$). In contrast, for adults, differences across conditions were not significant (all $p_s = 1$).

The analysis of the %E revealed a main effect of Age, $F_1(1, 76) = 16.02$, MSE = 307.67, $\eta^2_p = .17$, $p < .001$, $F_2(1, 21) = 11.10$, MSE = 177.64, $\eta^2_p = .35$, $p = .003$, showing that children made more errors (23.54) than adults (14.48). A main effect of Cross-language overlap was also found, although significant only in the analysis by participants, $F_1(2, 152)$ = 13.45, MSE = 181.02, $\eta^2_p = .15$, $p < .001$, $F_2(2, 21) = 1.83$, MSE = 532.25, $\eta^2_p = .15$, $p = .148$. It showed that participants made more errors in the O-P- condition (24.06) than in the O+P+ (13.13) ($p < .001$) condition, and they made more errors in O-P+ condition (19.84) than in O+P+ condition (13.13) ($p = .002$). There were no differences between O-P+ and O-P- conditions ($p = .224$). In addition, a relevant interaction emerged between Age and Cross-language overlap, $F_1(2, 152) = 8.75$, MSE = 181.02, $\eta^2_p = .10$, $p < .001$, $F_2(2,21) = 3.57$, MSE = 177.64, $\eta^2_p = .25$, $p = .046$, showing that the percentage of errors made by children was significantly higher in the O-P- condition (32.50) than in both the O-P+ (25.31) ($p < .001$) and the O+P+ (12.81) ($p < .001$) conditions. In contrast, for adults there were no differences between the three conditions. Furthermore, this interaction revealed that adults made fewer errors than children in the O-P+ (14.38 vs. 25.31 for adult participants and children, respectively) ($p < 001$) and in the O-P- conditions (15.63 vs. 32.50) ($p < 001$), but not in the O+P+ condition (13.44 vs. 12.81) ($p = .82$).

Discussion

The main aim of the present research was twofold: a) to explore, for the first time, the interplay of O and P during the early stages of new cognate word acquisition by using two variants of the word-association learning paradigm, and b) to examine the role of age in cognate processing when L2 proficiency is controlled for. Participants learned a set of cognate words and non-cognate words between European Portuguese and Catalan. Among the cognate words, the degree of orthographic similarity (O) and phonological similarity (P) was manipulated. Half of the children and adult participants learned the new words via L2 (auditory and written)-L1 word association (Method 1) and the other half via L2 (only auditory)-L1 word association (Method 2). Participants were tested (via an auditory recognition task and an auditory go/no-go task) immediately after the learning phase. Importantly, the results of the recognition task were congruent with those found in the go/no-go lexical decision task. Thus, and leaving aside the global advantage of adults over children, the cognate facilitation effect was observed in both tasks regardless of age group. Besides, and as expected, modulations on cognate processing as a function of O and P overlap were greater in children than in adults. Finally, there was a slight reduction of the disadvantage of children with respect to adults when the Method 2 was used.

The typical cognate facilitation effect observed in literature on new vocabulary acquisition (see Comesaña et al, 2012a; de Groot & Keijzer, 2000; Ellis & Beato, 1993; Lotto & de Groot, 1998; Comesaña et al., under review; Rogers et al., 2014; Tonzar et al., 2009) was here replicated regardless of the age and task requirements. Concerning the influence of age on the size of the effect, the cognate effect was more robust for children than for adults on error data in the go/no-go lexical decision task. However, there were no differences between children and adults either in the percentage of errors in the auditory recognition task or in reaction times in the go/no-go lexical decision task. Therefore, considering the overall pattern of results, we cannot conclude with any certainty that the effect is higher in children than in adults, as previous studies have reported (Duñabeitia et al., 2015), at least when L2 proficiency is directly matched for (note that neither group had any knowledge of Catalan at the moment of learning).

A clearer influence of age was, however, observed in the effects of the degree of O and P overlap of cognate words, to which children were more sensitive than adults. Thus, whereas no differences across-conditions of cognate words [O+P+, O-P+, O-P-] were observed in the adult data in either of the two tasks, data from children revealed differences across the three conditions. This effect was stronger in the LDT than in the auditory recognition task, as it was observed in both latency and error data and in both analyses (participants and items). Note that in the ART, the effect was only significant by participants. Importantly, the different patterns of findings in adults and children cannot be explained by variations in L2 proficiency, since the two age groups were matched for this variable. Rather, it seems to indicate that children are more responsive to and reliant on orthographic similarities than adults, as Duñabeitia et al. (2015) have pointed out, and this is consistent with what has been observed in the monolingual domain (Castles et al., 2003; Duñabeitia & Vidal-Abarca, 2008; Laxon et al., 1988; Perea & Estévez, 2008)[2]. This result led us to suggest age as an important factor to be considered for bilingual models in the explanation of lexical organization and processing. Indeed, according to the tenets of the BIA+ (Dijkstra & van Heuven, 2002; Dijkstra et al., 2010) and BIA-d (Grainger et al. 2010) models, a greater form similarity between the two readings of a cognate word leads to a more strongly activated shared semantic representation, regardless of age. However, age seems to modulate interference across lexical competitors, this probably being the case because language control mechanisms vary not only as a function of L2 proficiency but also as a function of the stage of reading development of the participant. Note that children's skills related to language control and attentional mechanisms are not totally defined and developed (see Antón et al., 2014, and also Diamond, 2013). This is consistent with findings in developmental studies on reading and consolidation: a differential use of recoding strategies as a function of the reader's level. That is, readers who are at an initial or intermediate level of reading development rely more on recoding strategies based on small ortho-phonological units, whereas skilled readers rely on larger size units (see Ziegler & Goswani, 2005, 2006 for more details; also Ziegler, Bertrand, Lété, & Grainger, 2014). This might also explain why children are more sensitive to subtle differences between translation equivalents.

Another interesting finding in the present study was observed in the analysis of RTs in the LDT, as the role of P when the degree of O was low (O-) was one of facilitation (faster and more precise responses to cognate words with high P overlap [P+] than to cognate words with low P overlap [P-]). Although this finding was restricted to one measure in one of the tasks, it is important to mention that it is at odds with what was found in previous studies on cognate processing that manipulated the degree of O and P overlap. For instance, Comesaña et al. (2015) and Dijkstra et al. (2010), observed inhibition rather than facilitation in a written lexical decision task. In our opinion, this can be explained in terms of the task used (auditory in the present study vs. written in the studies of Comesaña et al., 2015, and Dijkstra et al., 2010). Indeed, if we consider previous auditory lexical decision studies on the effects of P overlap on a non-native language, we find a similar pattern of results, that is, a facilitation effect (Boukrina & Marian, 2006). Overall, these data support the postulates of the BIA+ and BIA-d models. According to these models, although there is an automatic co-activation of different codes of information (O, P and semantic) during L2 word recognition, the nature of the task at hand determines when these codes are activated (see Dijkstra & van Heuven, 2002 for more detail; see also Ziegler, Petrova, & Ferrand, 2008).

One last finding that merits our attention here is the differential effect of learning method on L2 word acquisition and processing. On the one hand, the cognate advantage was restricted to the auditory method (M2) when considering the error data of the go/no-go lexical decision task. On the other hand, the overall disadvantage for children with respect to adults was slightly reduced in the same task when considering the latency data, although only in the analysis by items (see Sloutsky and Napolitano, 2003 for similar results). This result seems to suggest that, as we hypothesized in the introduction, during the first stages of new vocabulary acquisition in L2 it is better to minimize the information coming from the L1 in order to reduce lexical competition between neighboring orthographic representations, especially for children. Further research should be conducted with other paradigms and experimental materials in order to test the generalizability of this conclusion.

Overall, what these results suggest is that not only variables related to the person who is learning, such as age, but also variables related to the way words are taught, seem to modulate the type of connections established between lexical representations (see for instance Comesaña et al., 2009, for converging evidence on the influence of learning method in lexico-semantic connections during early stages of word acquisition with children).

In sum, in this study we observed a cognate facilitation effect during the first stages of vocabulary acquisition in a new language. Modulations on this effect as a function of the degree of O and P overlap of cognate words were restricted to children. Moreover, there was a slight advantage in the auditory learning method over the auditory and written method, mainly in children. These findings suggest, in accordance with developmental approaches of reading acquisition and consolidation, that the greater the linguistic experience, the lower the sensitivity to neighboring orthographic lexical representations.

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FOOTNOTE

2-An anonymous reviewer wondered if the effects of cross-language overlap found in this study may be a result of differences across conditions in the degree of orthographic overlap between the experimental words and their English translations.

Our participants had some knowledge of the English language, because learning English is part of the compulsory school curriculum. The difference in ages between the two groups obviously makes the exposure to English higher for the adult group than for children (note that in Portugal movies, for instance, are not dubbed). If exposure to English had any influence on participants' performance, it would be observed mainly in the conditions in which the stimuli overlap in form with their English translations. Thus, in order to examine if this was the case, we decided to analyze the degree of orthographic overlap between our experimental Portuguese-Catalan words and their translation equivalents in English. Results revealed a higher degree of overlap in the O+P+ condition than in the O-P+ and O-P- conditions (ps < .01), whereas no difference was observed between O-P+ and O-P- conditions. We thus consider that the results obtained in our study concerning the effects of the degree of cross-language overlap (i.e., the degree of O and P similarity) cannot be attributed to this variable. On the one hand, if the similarity with English words was the cause of the effects of cross-language overlap, we should have observed that adult participants were the most affected by this variable (as they had more extensive knowledge and experience of English compared to children). On the contrary, the effects of cross-language overlap were restricted to children, who supposedly have a lower level of English proficiency than adults. On the other hand, if we look at the go/no-go lexical decision task, the effects of cross-language overlap reveal differences between the O-P+ and O-P- conditions. Of note, both conditions had the same degree of orthographic overlap with their English translations.

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