Universidade do Minho
Escola de Psicologia

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The Role of Deviant-letter Position in Cognate Word Processing

outubro de 2015

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Dissertação de Mestrado
Mestrado Integrado em Psicologia

Trabalho efetuado sob a orientação da
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outubro de 2015

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Título da dissertação: The Role of Deviant-letter Position in Cognate Word Processing

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Ano de conclusão: 2015

Designação do Mestrado: Mestrado Integrado em Psicologia

Universidade do Minho, 16 de outubro de 2015
Assinatura: ____

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Acknowledgments

> "I sometimes find, and I am sure you know the feeling, that I simply have too many thoughts and memories crammed into my mind.... At these times... I use the Pensieve. One simply siphons the excess thoughts from one's mind, pours them into the basin, and examines them at one's leisure."
>
> J.K. Rowling in *Harry Potter and the Goblet of Fire*

First, and foremost, I would like to express my endless gratefulness to my supervisor, Professor Montserrat, for granting me the opportunity to work by with her. All words of wisdom, all the guidance, motivation, dedication and encouragement were the essential to achieve what I am achieving today. I cannot thank you enough for all the support given since the very end beginning.

I also would like to thank Professor Séverine Casalis, my co-adviser, for all the opportunities provided during the past year, for all the attention, dedication and endless concern during this whole journey.

Agradeço a todos os membros do Laboratório de Linguagem, em especial à Professora Ana Paula Soares, por todo o conhecimento transmitido e, essencialmente, pelo infinito apoio proporcionado no decurso deste processo. Um sincero obrigado.

À Daniela, por toda a imensurável amizade e companheirismo. Um muito obrigado por uma infinidade de bons momentos que passamos juntos, por toda a disponibilidade, por todas as palavras de encorajamento e por todo o indescritível apoio. Acima de tudo, sinto-me grato por nunca teres desistido nem duvidado de mim durante estes anos. Não encontro palavras que sejam capazes de se aproximar à gratidão que sinto. Foi um prazer ter a tua companhia ao longo destes anos.

Às minhas meninas, Margarida, Xana, Diana e Renata, por todos os bons momentos que passamos ao longo destes cinco anos. Agradeço toda a companhia, toda a infinda paciência, os sorrisos, os abraços, as palavras de força e agradeço, com muito apreço, a amizade incondicional. Obrigado por terem sido minhas mentoras, por terem sido as minhas melhores amigas e por me ajudarem a crescer da melhor forma possível. Agradeço-vos do fundo do coração, pois nada teria o mesmo significado se vocês não estivessem presentes. Fico feliz que diversos acasos nos tenham juntado e que nos tenhamos mantido juntos até ao final. Sinto-me privilegiado por vos ter encontrado.

Ao Vítor, por ter sido o meu porto-seguro e o meu maior suporte no decorrer deste processo. Obrigado pela indiscritível paciência e pelo esforço constante em sempre me tentar compreender e providenciar ajuda, mesmo quando não era necessário. Obrigado por seres o meu refúgio nos momentos em que mais necessitava de um e por sempre saberes como me levantar o ânimo. Obrigado por me desafiares e, consequentemente, por me fazeres crescer ainda mais. Obrigado por sempre acreditares em mim e por estimares as minhas capacidades acima do seu valor real.

Aos meus pais por serem exemplares de esforço e dedicação, por me ensinarem a ser forte e a lutar por aquilo que ambiciono e, acima de tudo, por terem proporcionado a oportunidade de estar onde estou hoje. Um obrigado por serem os melhores modelos que eu poderia ter escolhido seguir. Por fim, à minha irmã pela enorme paciência, pelo amor e pelo grande apoio que, de forma natural e inconsciente, sempre me foi entregando.

The Role of Deviant-Letter Position in Cognate Word Processing

Abstract

The Bilingual Interactive Activation Plus Model (BIA+; Dijkstra & van Heuven, 2002) is perhaps the most relevant computational model on bilingual word recognition. Although interesting it fails to explain modulations on cognate word processing as a function of deviant-letter position (Font, 2001). Thus, the present research aimed to further explore the role of deviant-letter position on cognate word processing by using a masked priming lexical decision task. To that purpose 288 stimuli (144 Portuguese-English translation words [72 cognates and 72 noncognates] and 144 pseudowords) were selected. Cognates were assigned to three experimental conditions according to deviant-letter position: 1) at end of the word (matri**z**-MATRI**X**); 2) at the beginning of the word (**c**oala-**K**OALA); and 3) at the end and at the beginning (**e**scal**a**-**S**CAL**E**). Twenty-eight proficient Portuguese-English bilinguals took part in the study. The results revealed faster responses for cognates with greater degree of cross-language overlap (Conditions 1 and 2). More important, priming effects were not modulated by deviant-letter position and thus no amendments seems to be needed in the “front-end” of the coding scheme of the BIA+ model, at least regarding cognate processing. Future studies should be developed in order to explore if these results are restricted to outer deviant-letters.

Key-words: cognate word processing; BIA+; deviant-letter; letters’ position

O Papel da Posição da Letra Desviante no Processamento de Palavras Cognatas

Resumo

O *Bilingual Interactive Activation Plus Model* (BIA+; Dijkstra & van Heuven, 2002) é, possivelmente, o modelo bilingue mais relevante acerca do reconhecimento de palavras. Porém, o modelo não é capaz de explicar modulações no processamento de palavras cognatas em função da posição da letra desviante (Font, 2001). A presente investigação procurou explorar o papel desta variável no processamento de palavras cognatas, usando uma tarefa de decisão lexical com um paradigma de *priming* mascarado. Para tal, foram selecionados 288 estímulos (144 palavras [72 cognatas e 72 nãocognatas] e 144 pseudopalavras). As palavras cognatas foram distribuídas por condições em função da posição da letra desviante: final (e.g., matri**z-**MATRI**X**); inicial (e.g., **c**oala-**K**OALA); inicial e final das palavras (e.g., **e**scal**a**-**S**CAL**E**). Participaram no estudo 28 bilingues proficientes de Português Europeu-Inglês. Os resultados revelaram respostas mais rápidas para cognatas com maior grau de sobreposição entre línguas (Condição 1 e 2). Adicionalmente, os efeitos de *priming* não foram modulados pela posição da letra desviante. Portanto, conclui-se que o sistema de codificação do modelo BIA+ encontra-se bem formulado, pelo menos no que diz respeito ao processamento de palavras cognatas. Futuras investigações devem ser conduzidas para explorar se estes resultados são restritos a letras desviantes em posições externas.

Palavras-chave: processamento de palavras cognatas; BIA+; letra que desvia; posição das letras

Theoretical Background

Bilinguals' capacity to switch between languages in speech has intrigued researchers and has led to extensive research on the organization and processing of words from both languages. Cognate and noncognate words have gained particular interest in this matter since they are differently processed and thus represent an excellent window to explore how two languages are organized and interact with each other (see Comesaña et al., 2012, 2015, and Dijkstra, Miwa, Brummelhuis, Sappelli, & Baayen, 2010). Cognate words are translation equivalents which share orthographic and phonological form (e.g., *matriz* [matrix], in European Portuguese [EP] and English, respectively). In turn, noncognate words are also equivalent translations that only share meaning (e.g., *cavalo* [horse]).

Recent studies on cognate processing have identified a number of variables affecting cognate word representation and recognition which may explain, in part, the controversial results observed in literature regarding the direction of the cognate effect (i.e., facilitation or inhibition for cognate words in comparison with NCG words; see Comesaña et al., 2015, for overview). These variables are the degree of orthographic and phonological overlap (Comesaña et al., 2012, 2015; Mulder, Dijkstra, & Baayen, 2015; Peeters, Dijkstra, & Grainger, 2013), the type of cognate word – identical (e.g., banana in EP and English) and non-identical (e.g., *papel*-paper) – (Comesaña et al., 2015; Dijkstra et al., 2010; Lemhöfer & Dijkstra, 2004; Mulder et al., 2015; Peeters et al., 2013), the stimuli list composition (Brenders, van Hell, & Dijkstra, 2011; Comesaña et al., 2015), the requirements of the task (Dijkstra et al., 2010; Lemhöfer & Dijkstra, 2004; Mulder et al., 2015) and the position of the deviant letter (e.g., located at the end; e.g., *texte-texto*, or in the middle of the words; e.g., *usuel-usual*, Font, 2001). The deviant-letter refers to a given letter that is different in cognate words, e.g., on the English-EP cognate pair tiger-*tigre*, the deviant-letter is located at the end, since there's a migration of the position in one letter (from last position to the penultimate position).

Comesaña and colleagues (2012) developed an event-related potentials (ERP) silent reading experiment combined with the masked priming technique (see Forster & Davis, 1984) with EP-English bilinguals in an attempt to better understand the role of orthographic and phonological overlap in non-identical cognate processing. In this task, participants were asked to read isolated target words presented in English (their second language [L2]) as fast and accurately as possible. Target words were briefly presented by EP translation equivalents or by unrelated prime words. Participants were not aware of the presence of prime words. Contrary with what is typically observed in literature (e.g., Peeters et al., 2013; Sáchez-Casas, García-

Albea, & Davis, 1992), the authors observed a preferential processing for noncognates over cognate words (i.e., an inhibition effect for cognates). The inhibitory effect was stronger for those cognates with higher mismatches between orthography and phonology. Besides, priming effects (i.e., the difference between targets preceded by unrelated primes and those preceded by equivalent translations) were restricted to cognates with low orthographic overlap. The pattern of results regarding the direction of the cognate effect (i.e., a preferential processing for noncognates over cognates) were replicated in a recent behavioral study (a lexical decision task) with Catalan-Spanish bilinguals developed which aimed to assess the impact of stimuli list composition in cognate processing (Comesaña et al., 2015, Experiment 2). Interestingly, when the authors included identical cognate words in the list (Experiment 1), the pattern of results was reversed, that is, a facilitation effect for cognate words when compared with noncognates (see Dijkstra et al., 2010, Experiment 1, for similar results).

An interesting model well-fitted to the above findings is the Bilingual Interactive Activation Plus Model (BIA+; Dijkstra & van Heuven, 2002; Dijkstra et al., 2010) – see Figure 1. This is a computational model that proposes an integrated lexicon with a non-selective access for the two languages, i.e., words in L1 and L2 are stored in the same lexicon and, when, for example, reading a word, lexical candidates in the two languages are activated and compete for selection. According to this model, cognate processing is affected by linguistic variables such as the degree of orthographic and phonological overlap and cognate word-type (Dijkstra et al., 2010; Bultena, Dijkstra, & van Hell, 2014; De Bruin, Roelofs, Dijkstra, & FitzPatrick, 2014; Peeters et al., 2013) but also by non-linguistic variables such as the stimuli list composition (Brenders et al., 2011; Comesaña et al., 2015) and task requirements (Dijkstra et al., 2010). The models' capability to explain modulations on cognate processing as a function of linguistic and non-linguistic factors is due to the incorporation of two different systems: an identification system (context-free) and a task-decision component. The task-decision system takes into consideration variables like task requirements, the instructions given to the participants to perform the task, and the stimuli list composition. Importantly, this system receives continuously input from the word identification system.

In the identification system different levels of processing (feature, letter, whole-word, language nodes) come into operation after the presentation of a given target word to reach its recognition. The language in which the perceived word is represented is marked by the language nodes. Then, the activated information is used by the task-decision component to carry out the remainder of the required task.

During the recognition process, in addition to the activation of targets candidates in both languages (activation in the figure is represented by arrows), there is an inhibition system that takes place between lexical representations (in the model is not represented). This process, called lateral inhibition, reduces the activation of neighbor candidates, that is, words in both languages that share orthographic (and also phonological) features with the target (see Dijkstra and van Heuven, 2002, for more detail).

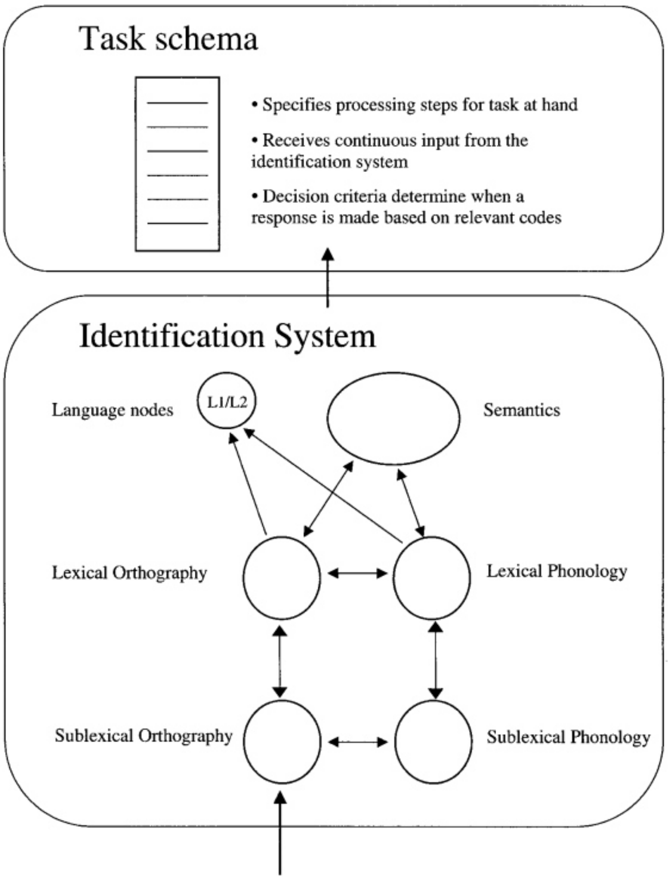

Figure 1. The BIA+ model for bilingual word recognition (Dijkstra & van Heuven, 2002; Dijkstra et al., 2010).

Although being interesting, this model presents a weakness regarding the way in which letter positions of words are encoded, since it assumes by simplicity's sake that positions are perfectly encoded. In other words, it does not assign a special role to any letter position. Thus, if true, English-EP cognate words like koala-*coala* and paper-*papel,* ceteris pabirus, would be processed in the same way because both pairs differ in just one letter while maintaining the same degree of orthographic overlap. However, from left-to-right processing effects observed in literature with monolinguals, we know that when the degree of orthographic similarity between prime and target is kept constant the quality of information, and the priming effect, vary according to letters' position (Grainger, Granier, Farioli, Van Assche, & van Heuven, 2006; Humphreys, Evett, & Quinlan, 1990; McCuster, Gough, & Bias, 1981; Peressotti & Grainger, 1999). Remarkably, across several experimental paradigms, the literature has a well-sustained finding: there is a superior performance for the first letter of a given string (e.g., Averbach & Coriell, 1961; Butler & Merikle, 1973; Haber & Standing, 1969; Hammond & Green, 1982; Ktori & Pitchford, 2008; Mason & Katz, 1976; Mewhort & Campbell, 1978; Pitchford, Ledgeway, & Masterson, 2008; Tydgat & Grainger, 2009; Wolford & Hollingsworth, 1974; Ziegler, Pech-Georgel, Dufau, & Grainger, 2010).

These findings on letter position encoding prompt to question the postulates regarding location-specific letter coding of computational models developed so far (Interactive Activation [IA] model, McClelland & Rumelhart, 1981; Rumelhart & McClelland, 1982; Dual-Route Cascaded [DRC] model, Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Multiple Readout Model [MROM], Grainger & Jacobs, 1996) and, as a consequence, lead to the development of more flexible orthographic codification schemes (e.g., Overlap Model, Gomez, Ratcliff, & Perea, 2008; Sequential Encoding Regulated by Inputs to Oscillating Letter units [SERIOL] model, Whitney, 2001; the open-bigram model, Grainger & van Heuven, 2003; Self-Organizing Lexical Acquisition and Recognition [SOLAR] model, Davis, 2010).

For instance, the Overlap Model developed by Gomez, Ratcliff and Perea in 2008 holds that, in a string, letters' identity follows a normal distribution over position. As an illustration, in the word *house,* the letter "u" will be associated with Position 3 but also, in a lesser extent, with Position 2 and 4 (according to this model, each letter localization encloses a specific standard deviation). Interestingly, this model postulates that, when strings are presented unmasked and for an unlimited amount of time, position codification happens accurately. Yet, when strings are presented very briefly and masked, there are distributions over letter position. This means that uncertainty about position is reduced over time and that distributions over positions only occur during the initial encoding process. It is important to mentation that a highly valuable technique to explore these issues is the masked priming technique (Forster & Davis, 1984) because it taps into the very earliest stages of lexical access.

Extending these assumptions to the bilingual domain, since the IA model and the BIA+ model assume the same input codification scheme, the latter doesn't seem capable to account for effects regarding deviant-letter position if they also appeared, as it is reasonable to assume, during bilingual visual word recognition.

To the best of our knowledge, there is just one unpublished bilingual study on letter-position encoding developed so far by Font in 2001. The author asked French-Spanish bilinguals to perform a masked priming lexical decision task in their L2 (i.e., participants were asked to decide if a chain of letters where or not a real L2 word as fast and accurately as possible) with the aim to explore the effect of deviant-letter position on cognate processing. L2 target words were briefly preceded by L1 translation equivalents or L1 unrelated words. The results revealed faster reaction times for cognate target words which deviant-letter position was at the end (e.g., *texte-texto*) when comparing with cognates which deviant-letter position was in the middle of the word (*usuel-usual*). However, leaving aside the fact that the work was not published, the materials were not available and thus we do not know if the experimental conditions were matched in the abovementioned variables that affect cognate processing such as the degree of orthographic and phonological overlap.

Therefore, the main aim of the present research was to further explore letter position coding in cognate processing by manipulating the position of the deviant-letter while maintaining constant the degree of orthographic and phonological overlap between cognate words as well as other variables that affect lexical processing (e.g., word frequency in both languages, length, size of neighborhood). For that purpose, two experimental conditions were created according to the location of the deviant-letter: (a) at the end (*matriz*-MATRIX in EP and English respectively); and (b) at the beginning (*coala*-KOALA). One more condition with higher levels of O and P overlap was created as a control to assess modulations on cognate processing as a function of cross-linguistic similarities, as the BIA+ model sustains and as previous studies have showed (Dijkstra et al., 2010; Bultena et al., 2014; De Bruin et al., 2014; Peeters et al., 2013). Of note that the deviant-letter position in this last condition was located both at the beginning and at the end of the words (*escala*-SCALE). Hence, if the postulates of the BIA+ model regarding the encoding of letter position and the effect of cross-language similarities (i.e., the degree of orthographic and phonological overlap) are right, no differences would be expected between cognates as a function of deviant-letter position when the degree of orthographic and phonological similarity is matched. Conversely, if processing is guided by left-to-right principles, we expect to observe a preferential processing for cognates whose deviant-letter position is at the end (a greater size of priming effect) than for cognates whose deviant-letter position is at the beginning.

To do so, a masked priming lexical decision task was employed for being the most used task in previous studies focused on cognate processing and on the codification of letter identity and letter position.

Method

Participants

Twenty-eight college students (13 of which were females) from the University of Minho (M_{age} = 22.61; *SD* = 3.31) participated in the experiment. All of them received course credit for enrolling on the research. They were recruited from different courses and they were all proficient bilinguals of EP (L1) - English (L2). To access their linguistic background, participants were asked to fill the Language History Questionnaire (Li, Zhang, Tsai, & Puls, 2013). This questionnaire accesses information regarding age of L2 acquisition as well as their estimated L2 proficiency on several languages skills (listening, speaking, reading and writing). On average, participants acquired their L2 at the age of 8.57 (*SD* = 2.091) on average. Furthermore, their estimated English proficiency, on average, was 5.54 (*SD* = 0.805) (in a 7-point Likert scale ranging from 0 ["very poor"] to 7 ["native like"]).

Materials

One-hundred and forty-four EP-English translation equivalents were selected (half were cognates and the other half were noncognate). Targets were presented in English and primes in EP. Cognate words (the critical words) were assigned to three experimental conditions according to deviant-letter position: 24 words were set in the first condition which vary at the end of the target word in one or two letters (e.g., *matriz*-MATRIX, *risco*-RISK*)*; 24 words in the second condition which vary at the beginning of the target word in one or two letters (e.g., *escala*-SCALE, *foto*-PHOTO); and 24 words in the third condition which vary at the beginning and at the end of the target word (e.g., *escala*-SCALE; *quilograma*-KILOGRAM). The total set of words per condition is presented in the Appendix A. Values for English target words were obtained from N-WATCH database (Davis, 2005) and they were matched in logarithmic frequency per million, length (number of letters), summed logarithmic bigram frequency (SLBF), mean logarithmic bigram frequency (MLBF), phonological and also orthographic neighbors (all p_s > .148; see Appendix B). Likewise, EP primes were also matched in logarithmic frequency per million, length (number of letters), SLBF, MLBF, phonological and also orthographic neighbors (all p_s > .148; see Appendix B) and the values for these characteristics were taken from the P-PAL database (Soares et al., 2014).

The degree of orthographic similarity of cognate words was calculated by the NIM database (Guasch, Boada, Ferré, & Sánchez-Casas, 201319). NIM computes the index of van Orden (van Orden, 1987), which ranges from 0 (not similar at all) to 1 (exactly the same). As expected, condition 1 and 2 did not differ in this variable (see Table 1). This allowed us to assess the role of deviant-letter position in cognate word processing when controlling for orthographic overlap. However, conditions 1 and 2 differed from condition 3 in orthographic overlap (both $p_s < .001$; see Table 1). This enabled us to assess if the processing observed in previous studies on cognate processing is replicated here (i.e., if cognate word processing vary as a function of the degree of orthographic overlap). Cognate words' phonological similarity was calculated by an expert on phonetics. The phonological overlap between the two languages was rated according to the following criteria: (i) common syllables' number amongst the two words; (ii) position of the stressed syllable; (iii) stressed syllable vowel quality; and (iv) stressed syllable phonological context (preceding and following). The algorithm used to assess phonological similarity varied from 0 to 1. Conditions 1 and 2 were matched on this variable (see Table 1), but they differed from condition 3 (both $p_s < .05$; see Table 1), allowing us to control possible outcomes that could arise from differences at the phonological level. Regarding the words' grammatical category of stimuli, only nouns (approximately 73%) and adjectives (around 27%) were selected and distributed homogeneously per condition. Moreover, words with hyphens and accents were not incorporated in the experimental list. Noncognate words were introduced as fillers as they do not vary neither in deviant-letter position nor in the degree of orthographic overlap.

Table 1.
Targets' and primes' mean, standard deviation and multiple comparisons of orthographic and phonological similarities

Characteristic	Condition	Mean	Std. Deviation	Multiple Comparisons	*p* values
Orthographic similarity	1 (End)	0.690	0.080	2 (Beginning)	1
				3 (Beginning + End)	.000*
	2 (Beginning)	0.720	0.160	1 (End)	1
				3 (Beginning + End)	.000*
	3 (Beginning + End)	0.470	0.150	1 (End)	.000*
				2 (Beginning)	.000*
Phonological similarity	1 (End)	0.466	0.201	2 (Beginning)	1
				3 (Beginning + End)	.058*
	2 (Beginning)	0.524	0.261	1 (End)	1
				3 (Beginning + End)	.005*
	3 (Beginning + End)	0.307	0.226	1 (End)	.058*
				2 (Beginning)	.005*

*** $p < .05$**

Target words were preceded either by translation equivalents (e.g., *matriz*-MATRIX) or by unrelated words (e.g., *prosa* [prose]-MATRIX). Equivalent Translation (ET) and Unrelated Translation primes (UT) were matched across conditions in logarithmic frequency per million, length in number of letters, phonological and orthographic neighbors, SLBF and MLBF (all p_s > .219; see Table 2).

Table 2.
Primes' (EP) mean values and standard deviations of the lexical characteristics by type of prime

Characteristic	Type of prime	Mean	Std. Deviation	*p* values
Logarithmic frequency per million	Equivalent Translation	.86	.61	.813
	Unrelated Translation	.83	.49	
SLBF	Equivalent Translation	15.08	5.12	.974
	Unrelated Translation	15.12	5.33	
MLBF	Equivalent Translation	2.57	0.42	.509
	Unrelated Translation	2.62	0.37	
Length	Equivalent Translation	6.94	2.08	.798
	Unrelated Translation	6.83	2.18	
Orthographic neighbours	Equivalent Translation	3.1	5.06	.384
	Unrelated Translation	4.	5.07	
Phonological neighbours	Equivalent Translation	2.93	4.56	.219
	Unrelated Translation	4.14	5.22	
***p < .005**				

It is also important to note that target and prime words did not differ in logarithmic frequency per million, length in number of letters, SLBF, MLBF, phonological and also orthographic neighbors (all p_s > .013; see Table 3). See the entire set of materials in the Appendix A.

Table 3.
Targets' and primes' mean values and standard deviations

Characteristic	Stimuli type	Mean	Std. Deviation	*p* values
Logarithmic frequency	Targets	.90	.60	.532
	Primes	.85	.57	
SLBF	Targets	13.59	5.00	.055
	Primes	15.09	5.16	
MLBF	Targets	2.48	.41	.09
	Primes	2.59	.40	
Length	Targets	6.53	1.9	.22
	Primes	6.91	2.11	
Orthographic neighbours	Targets	1.69	3.46	.013
	Primes	3.4	5.05	
Phonological neighbours	Targets	5.06	7.67	.069
	Primes	3.33	4.8	
***p < .005**				

Two lists were created to counterbalance prime-target pairs, that is, to guarantee that the same target was preceded by its translation and by an unrelated word in different lists. No subject saw any prime or target more than once. Participants were randomly assigned to these lists.

Due to the nature of the lexical decision task, 144 pseudowords were created. For their creation we selected a set of words with similar characteristics as the targets and then, with the Wuggy software (Keuleers & Brysbaert, 2010), the pseudowords were generated (e.g., the word "grenade" was transformed in the pseudoword "BLENIDE"). These pseudowords were either preceded by the translation of the word used to the pseudoword creation (e.g., *granada*-BLENIDE) or by an unrelated word (e.g., *profeta* [prophet]-BLENIDE).

Procedure

The experimental procedure was approved and followed the ethical guidelines of the University of Minho. Participants signed a consent form, based on the Declaration of Helsinki (World Medical Association, 2013). After that, they were engaged in a short interview in L2 and filled out the Language History Questionnaire (Li et al., 2013) in order to ensure a homogeneous sample.

Then, participants were individually tested in a sound-proof booth to perform the lexical decision task in L2 (English). In this task, participants were asked to decide whether a given string was or not an English word. Stimuli presentation and recording of the response times (RTs) and error rate (%E) were done through the use of the DMDX software (Forster & Forster, 2003). Each trial of the experiment was performed with the following structure: presentation of a forward mask (#####), for during 500 ms, following the presentation of the prime word in lowercase, for 50 ms, and then by the target word in upper case. Target word remained in the screen until the participants' response or 2,500 ms have elapsed. Stimuli presentation was randomized by participant.

Results

Data was collected from 63 participants. Participants who presented a linguistic background distinct, i.e. age of L2 acquisition and self-rating skills distant from the majority, were excluded from the data analysis (n = 25). Likewise, data from participants with an error response rate above 20% were also excluded (n= 10). Thus, the final sample was constituted by 28 participants (M_{age} = 22.61; *SD* = 3.31). Incorrect responses and RTs less than 200 ms or greater than 2000 ms were removed from the latency analysis. Furthermore, RTs falling more than 2 standard deviations (SDs) from the mean for a given participant in all conditions were removed.

Table 4 shows the mean RT data for correct responses as well as the percentage of errors (%E) for the three experimental conditions as a function of prime type (Equivalent Translation primes and unrelated translation primes). The size of priming effects by RTs and by errors in each priming condition is also presented.

Table 4.
Mean, standard deviation and size of priming effects by RTs and %E

	End		Beginning		Beginning + End	
Primetype	RTs	%Error	RTs	%Error	RTs	%Error
Equivalent Translation	762 (21.9)	8.04 (1.9)	775 (23.2)	9.23 (1.5)	805 (25.9)	16.90 (2.4)
Unrelated Translation	816 (21.4)	11.01 (1.7)	808 (22.3)	12.8 (1.8)	830 (26.1)	17.26 (2.0)
Priming effect	54 ms (*p* = .002)	2.97 (*p* = .047)	33 ms (*p* = .039)	3.57 (*p* = .054)	25 ms (*p* = .097)	0.36 (*p* = .88)

Data analysis was conducted with the IMB® SPSS® (version 20) software. Separate ANOVAs by participants (F1) and by items (F2) were conducted for RT data and on the %E data based on a 3 (Deviant-letter position: Condition 1 [End], Condition 2 [Beginning], and Condition 3 [Beginning + End]) x 2 (prime type: Prime-related vs Prime-unrelated) x 2 List (List A vs List B) design. In participants' analysis, "List" was a between-subjects factor whereas "Deviant-letter position" and "Prime-type" were within-subjects factors. In the analysis by items, "List" and "Deviant-letter position" were between-subjects factors whereas "Prime-type" was a within-subjects factors.

The ANOVA results on the RT data showed that words preceded by an equivalent translation were answered faster than words preceded by an unrelated word (781 ms and 818 ms, respectively), showing a main priming effect regardless conditions, $F_1(1, 26) = 19.99$, $MSE = 2870.46$, $p = .000$, $\eta^2_p = .44$,; $F_2(1, 66) = 4.94$, $MSE = 13387.71$, $p = .03$, $\eta^2_p = .07$. Regarding the three experimental conditions, no statistical differences were found between Condition 1 (End) and Condition 2 (Beginning). However the difference between Condition 1 (End) and Condition 3 (Beginning + End) approached significance ($p = .056$) as well as Condition 2 (Beginning) and Condition 3 (Beginning + End) ($p = .096$), $F_1(2, 52) = 4.87$, $MSE = 2798.66$, $p = .012$, $\eta^2_p = .16$; $F_2(2, 66) = 2.23$, $MSE = 15696.512$, $p = .11$, $\eta^2_p = .06$. The interaction between prime and conditions was non-significant for both subjects and items analysis.

The ANOVA results on the %E only showed significant statistical differences for subjects which indicated that participants committed more errors when words were preceded by an unrelated translation than when they were preceded by their equivalent translation (13.7% and 11.41%, respectively), $F_1(1, 26) = 5.24$, $MSE = 41.75$, $p = .030$, $\eta^2_p = .17$; $F_2(1, 66) = 1.41$, $MSE = 260.28$, $p = .39$, $\eta^2_p = .01$. Concerning the experimental conditions no differences were found between Condition 1 (End) and Condition 2 (Beginning), yet Condition 3 (Beginning + End) differed from Condition 1 (End) ($p = .006$) and from Condition 2 (Beginning) ($p < .001$), $F_1(2, 52) = 11.05$, $MSE = 81.97$, $p = .000$, $\eta^2_p = .30$; $F_2(2, 66) = 1.88$, $MSE = 414.13$, $p = .16$, $\eta^2_p = .05$. The interaction between prime and conditions was non-significant for both subjects and items analysis.

Overall, even though response latencies to words from the third condition (the condition with lower levels of orthographic similarity) were slower than response latencies to words from the other two conditions (those with equivalent degree of orthographic similarity), there were no signs of priming effects' modulations as a function of deviant-letter position. However, as only the first two conditions were matched in the degree of orthographic and phonological overlap, we decided to conduct a planned comparison between these two conditions (the critical issue at stake) to further explore modulations of masked priming effect as a function of deviant-letter position (note that the size of priming in the Condition 1, 54 ms, was two-thirds higher than that observed in the Condition 2, 33 ms). The factor List (list 1, list 2) was included again as a dummy factor in the analyses. Again, the results on the RTs failed to show modulations on the size of priming as a function of deviant-letter position.

Discussion

The present masked priming lexical decision experiment aimed to explore the role of the deviant-letter position in visual cognate word recognition. The literature on the bilingual domain has explored several times the differences between the processing of cognate and noncognate words. Nonetheless, the number of studies that investigated how the perceptual features (e.g., deviant-letter position) of these words modulate their processing is scarce. The present research aimed to directly answer to this matter, using cognate words characterized by the position of the deviant-letter. For that purpose, two different conditions were created in function of deviant-letter position (at the end [Condition 1] – e.g., matri**z**-MATRI**X** – vs. at the beginning [Condition 2] – e.g., **c**oala-**K**OALA) by maintaining constant the degree of O overlap of cognate words. One third condition (Condition 3) – e.g., **e**scal**a**-**S**CAL**E** – with lower levels of O overlap was included as a control (deviant-letter position was at the beginning and at the end) to further explore the role of cross-language similarities in cognate word processing. The overall findings of this study, conducted with proficient EP-English bilinguals, were clear-cut and showed no modulations on cognate words' recognition in function of the position of the deviant-letter. First, when the degree of orthographic similarity was matched, both Conditions 1 and 2 produced a similar magnitude of effects (both for RTs and %E). Second, even when responses were faster to cognates with higher degree of orthographic overlap (Conditions 1 and 2) in comparison with cognates with lower degree of orthographic similarity (Condition 3), masked priming effects were not modulated by deviant-letter position.

The results of our study did not confirm our hypothesis. We expected to observe modulations on the results as a function of the deviant-letter position, observing a higher cost (i.e., bigger RTs and more errors) for cognate words which deviant-letter was located at the end, since: (i) a preferential processing for initial letters is systematically reported in the literature (e.g., Chanceaux, & Grainger, 2012; Tydgat & Grainger, 2009); (ii) initial letters are often the most informative with respect to word identity (e.g., Dandurand, Grainger, Duñabeitia, & Granier, 2011); and (iii) an accurate generation of words' phonological codes depends critically on an efficient identification of the first letter (e.g., Grainger & Ferrand, 1996; Schiller, 2004). Interestingly, the findings reported in the current research seem to be incongruent with the results of Fonts' work (2001) on deviant-letter position of French-Spanish cognate words. Specifically, the author found a preferential processing for cognates whose deviant-letter was located at the end (e.g., *texte-texto*) when compared with cognates whose deviant-letter was in the middle of the word (e.g., *usuel-usual*).

Although our results seem to be, a priori, consistent with the predictions of the BIA+ model (Dijkstra & van Heuven, 2002; Dijkstra et al., 2010) regarding orthographic encoding, before reaching a firm conclusion it should be considered which other variables could be explaining our results. For example, in Fonts' study (2001), the author observed that words' frequency played a role on the processing of cognates' deviant-letter position: when cognates were of low frequency in both languages, the facilitation effects regarding deviant-letter for the latter group (i.e., deviant-letter located in the middle of the words) disappeared and tended towards inhibition. Matter of fact, previous studies have reported that frequency seems to be a critical variable for cognate word processing: higher values of frequency seem to boost words' activation, resulting in faster RT to target words (e.g., Baayen, Feldman, & Schreuder, 2006; Balota, Cortese, Sergent-Marshall, Spieler, & Yap, 2004; Duyck, Vanderelst, Desmet, & Hartsuiker, 2008; Peeters et al., 2013; Strijkers, Costa, & Thierry, 2009; Yap & Balota, 2009).

Unfortunately, materials in Font's study (2001) are not available and we do not know the range-frequency values of cognate words used by the author. In our study, words' logarithmic frequency per million had a wide range (the values oscillate between 0.00 and 2.49). However, it was not possible to run post-analyses to explore modulations on the pattern of results between low frequency words and high frequency words as a function of deviant-letter position. This was due to low number of items per condition that was matched in frequency and other important variables (specifically in length, MLBF, MLBF, phonological neighbors, orthographic neighbors, orthographic similarity and phonological similarity). Therefore, further research on the effects of frequency on deviant-letters' position is necessary to help clarify this issue.

As it was aforementioned, the results of our study seem to be in line with the postulates of the input coding scheme proposed by the BIA+ model (Dijkstra & van Heuven, 2002; Dijkstra et al., 2010). When the degree of cross-language similarities was matched, our results revealed no differential processing according to deviant-letter position and, accordingly to the claims model, such differentiation should not be expected since letters' position are perfectly encoded, i.e., no special role is assigned to letter position. Furthermore, since the critical variable for cognate word processing is the degree of cross-language overlap (Dijkstra & van Heuven, 2002), and Conditions 1 and 2 were matched on this variable, the deviant-letter position seems to be only assumed as visual noise during cognate processing, i.e., regardless of the position of letters' mismatch, the high degree of cross-language overlap seems to be the most significant variable affecting cognate word processing.

The literature on the monolingual domain seems to provide some data that support the findings stated on the current research which systematically reported that letters that occupy external positions (i.e., strings' first and last positions) seem to be computed (in terms of identity and position) in the same way (e.g., Grainger & Jacobs, 1993; Humphreys et al., 1990; Jordan, Patching, & Thomas, 2003; Tydgat & Grainger, 2009). Matter of fact, the literature reports that an accurate identification of letters' position follows a W-shaped function (e.g., Averbach & Coriell, 1961; Haber & Standing, 1969; Schwantes, 1978; Stevens & Grainger, 2003; Tydgat & Grainger, 2009; Ziegler et al., 2010), meaning that the positions' computation seems to be maximal for first and last positions on the string and also at the center of the word (the fixated point). This variation on the position accuracy appears to be explained by two factors: visual acuity and a crowing effect. The visual acuity takes into account a decreasing on the performance from the fixation point to more peripheral locations, whereas the crowding effect for outward letters is one of the explanations why letters that occupy external positions in the string are processed in such an efficient way (Chanceaux & Grainger, 2012; Tydgat & Grainger, 2009). Regarding the latter, it seems that the advantage for outward letters arises due to their reduced crowing effect, i.e., since these letters are flanked by only one letter they seem to suffer from less interference from adjacent letters (e.g., Bouma, 1970, 1973; Chanceaux & Grainger, 2012; Grainger, Tydgat, & Isselé, 2010; Tydgat & Grainger, 2009). The aforementioned findings regarding the computation of outer letters' positions enables a better understanding of our results: the failure on the observation of modulations in function of deviant-letter might be precisely due to manipulation of two equally critical positions to word recognition. Moreover, Fonts' results (2001) might also be explained by this preferential processing reported on the monolingual field.

In sum, the results reported in this study seem to be in line with the front-end codification scheme proposed in the BIA+ model, granting more empirical support and confirming the robustness to the model. However, this study presents a limitation that is important to discuss: the stimuli selection was a difficult assignment to accomplish and it was only possible to assign 24 words per condition. The main difficulty arose on the selection of cognate words which deviant-letter was located at the beginning, since there was a scarce number of cognate pairs which varied on this variable and, at the same time, were matched on the controlled variables previously mentioned on the method section.

Future research should be conducted in order to explore and better understand the issue underlying the role of the deviant-letter position in the cognate word processing. Firstly, a control group of English monolinguals should be tested, to assess if the pattern of results is reproduced within this population. If so, the results could not be entirely explained by the words' frequency in both languages. Secondly, different pattern of results might be found if the selected stimuli are, for instance, false friends, considering that there is only a shared form for these type of words. The effects of deviant-letter position should also be tested with different alphabetical languages in order to allow an enlargement of the number of stimuli selected per condition. At last, this issue should be explored with other techniques and paradigms, since different tasks can produce distinct effects on cognate word recognition (e.g., Dijkstra et al., 2010). For instance, "sandwich masked priming" (Lupker & Davis, 2009) presents itself as a good alternative to further explore the issue underlying deviant-letter position, since it allows to produce priming due to orthographic overlap when the conventional masked priming paradigm is not able to.

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Appendix

Appendix A.

Stimuli (target, equivalent translation primes and unrelated translation primes) used in the experiment

Condition	Target	Equivalent Translation	Unrelated Translation
1 (End)	abrupt	abrupto	faceta
	agent	agente	rampa
	risk	risco	cela
	consequent	consequente	protestante
	duet	dueto	latim
	idiom	idioma	cadete
	tiger	tigre	signo
	sociology	sociologia	peste
	latrine	latrina	divino
	tent	tenda	prosa
	paradigm	paradigma	religião
	prism	prisma	planta
	antecedent	antecedente	faceta
	sale	saldo	cela
	senate	senado	divino
	lapse	lapso	rampa
	soup	sopa	latim
	subtle	subtil	cadete
	matrix	matriz	prosa
	imperative	imperativo	protestante
	tomato	tomate	signo
	variant	variante	religião
	vicious	vicioso	planta
	zinc	zinco	peste
2 (Beginning)	charisma	carisma	espectacular
	ellipse	elipse	bilingue
	equal	igual	duna
	illegal	ilegal	pupila
	immaterial	imaterial	divergente
	immoral	imoral	evolutivo
	immortal	imortal	disciplina
	splendor	esplendor	disputa
	kerosene	querosene	humorista
	kilo	quilo	anual
	koala	coala	passe
	name	nome	teste
	phalange	falange	anual
	phase	fase	teste
	phenomenal	fenomenal	pupila
	photo	foto	espectacular
	phrase	frase	divergente
	quota	cota	evolutivo
	spacial	espacial	duna
	special	especial	disputa
	spectral	espectral	bilingue
	spiral	espiral	disciplina
	spiritual	espiritual	passe
	immune	imune	humorista
3 (Beginning + End)	chapel	capela	cometa
	herb	erva	anjo

	immature	imaturo	dentista
	immense	imenso	sincero
	immigrant	imigrante	infinitivo
	imminent	iminente	oeste
	speleology	espeleologia	imediato
	kilogram	quilograma	nicotina
	kiosk	quiosque	prefixo
	master	mestre	puro
	phoneme	fonema	criticismo
	scale	escala	selecta
	spasm	espasmo	cometa
	specialist	especialista	prefixo
	spectre	espectro	dentista
	speculative	especulativo	sincero
	cost	custo	puro
	sperm	esperma	oeste
	spinach	espinafre	infinitivo
	sponge	esponja	nicotina
	spore	esporo	imediato
	strange	estranho	selecta
	unjust	injusto	criticismo
	yard	jarda	anjo

Appendix B.

Targets' (English) and primes' (EP) mean values and standard deviations of the lexical characteristics by condition

		Targets				Primes			
Characteristic	Condition	Mean	Std. Deviation	F	*p* values	Mean	Std. Deviation	F	*p* values
Logarithmic frequency per million	1 (End)	0.910	0.480			0.91	0.48		
	2 (Beginning)	0.860	0.700			0.86	0.70		
	3 (Beginning + End)	0.940	0.640			0.94	0.64		
	Total	0.900	0.600	.090	.913	0.90	0.60	.091	.913
SLBF	1 (End)	12.830	5.080			12.83	5.08		
	2 (Beginning)	13.560	4.120			13.56	4.12		
	3 (Beginning + End)	14.390	5.760			14.39	5.76		
	Total	13.590	5.000	1.960	.564	13.59	5.00	.578	.564
MLBF	1 (End)	2.520	0.410			2.52	0.41		
	2 (Beginning)	2.350	0.330			2.35	0.33		
	3 (Beginning + End)	2.570	0.450			2.57	0.45		
	Total	2.480	0.410	0.830	.148	2.48	0.41	1.962	.148
Length	1 (End)	6.130	2.010			6.13	2.01		
	2 (Beginning)	6.790	1.720			6.79	1.72		
	3 (Beginning + End)	6.670	1.970			6.67	1.97		
	Total	6.530	1.900	1.240	.439	6.53	1.90	.832	.439
Orthographic neighbours	1 (End)	2.210	4.570			2.21	4.57		
	2 (Beginning)	0.790	1.980			0.79	1.98		
	3 (Beginning + End)	2.080	3.310			2.08	3.31		
	Total	1.690	3.460	0.470	.296	1.69	3.46	1.240	.296
Phonological neighbours	1 (End)	6.210	8.910			6.21	8.91		
	2 (Beginning)	4.000	8.060			4.00	8.06		
	3 (Beginning + End)	4.810	5.670			4.81	5.67		
	Total	5.060	7.670	23.290	.625	5.06	7.67	.473	.625

***p < .005**