Short title: Cognate effect in spoken and written word production

Comparing the cognate effect in spoken and written second language word production

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Abstract

Cognates – words that share form and meaning between languages – are processed faster than control words. However, it is unclear whether this effect is merely lexical (i.e., central) in nature, or whether it cascades to phonological/orthographic (i.e., peripheral) processes. This study compared the cognate effect in spoken and typewritten production, which share central, but not peripheral processes. We inquired whether this effect is present in typewriting, and if so, whether its magnitude is similar to spoken production. Dutch-English bilinguals performed either a spoken or written picture naming task in English; picture names were either Dutch-English cognates or control words. Cognates were named faster than controls and there was no cognate-by-modality interaction. Additionally, there was a similar error pattern in both modalities. These results suggest that common underlying processes are responsible for the cognate effect in spoken and written language production, and thus a central locus of the cognate effect.

Keywords: bilingualism, word production, cognate effect, writing

Converging evidence suggests that bilinguals activate both their mother tongue (L1) and their second language (L2) simultaneously when processing linguistic information (e.g., Dijkstra & Van Heuven, 2002; Van Hell & Dijkstra, 2002). Also in a monolingual situation, when only one of both languages is relevant, the other language is active to some extent, and even influences processing in the relevant language. There is already much information available about bidirectional influences of L1 and L2 in the bilingual's reading, auditory perception, and speech production (e.g., Duyck & De Houwer, 2008; Green, 1998; Kroll & Stewart, 1994; Lagrou, Hartsuiker & Duyck, 2011; Van Heuven, Dijkstra & Grainger, 1998). In contrast, little is known about the cognitive processes underlying writing, especially in bilinguals. To illustrate this, according to the table of contents of *The Oxford Handbook of Language Production* (Goldrick, Ferreira & Miozzo, 2014), 19 chapters are dedicated to speech production and only 3 to writing. In their review on architectures, representations, and processes of language production, Alario, Costa, Ferreira and Pickering (2006) also pointed to the need for more research in the written domain. They argued that models of language production should entail both spoken and written production.

Despite the many similarities between spoken and written production, there are also some important differences between both modalities. For instance, writing requires phoneme-to-grapheme conversion on top of lexical and phonological selection that is present in speech production. Moreover, writing can be considered to be less automatic, because it is a relatively recent skill in humans. Thus, caution is needed when assuming that certain phenomena that occur in speech, such as parallel activation of both L1 and L2, also generalize to writing. The current study aims to gain more insight in whether and how bilinguals activate their L1 during L2 written production and how this relates to spoken production.

Several studies use cognates as a tool to investigate the interaction between languages

in the bilingual mind. Cognates are words that share a similar phonological form and meaning between languages, for instance 'apple' in English and 'appel' in Dutch. Van Hell and Dijkstra (2002) found that bilinguals had faster reaction times for cognates in comparison to control words during a lexical decision task. They argued that bilinguals are faster to recognize cognates, because these are represented in the lexicon of both languages and called this bilingual advantage the *cognate effect*. A similar advantage was also found in other tasks, such as translation tasks (e.g., de Groot & Nas, 1991), auditory lexical decision tasks (Woutersen, de Bot & Weltens, 1995), picture naming tasks (e.g., Costa, Caramazza & Sebastian-Galles, 2000), and sentence and text reading comprehension tasks (e.g., Duyck, Van Assche, Drieghe & Hartsuiker, 2007; Van Assche, Drieghe, Duyck, Welvaert & Hartsuiker, 2011; Van Assche, Duyck, Hartsuiker & Diependaele, 2009). Moreover, these reading comprehension studies showed that the semantic context, denoted by the surrounding sentences, cannot extinguish cross-lingual interactions. The language of the observed sentence can be seen as the context to select the target language, but this seems to be insufficient to deactivate the other language entirely.

To investigate the cognate effect in spoken word production, the most frequently used paradigm is the picture naming task, in which participants say aloud the name of the picture on the screen. In a Spanish experiment with this task, Costa, Caramazza and Sebastian-Galles (2000) found shorter naming latencies for cognates in comparison to control words in Catalan-Spanish bilinguals, but not in Spanish monolinguals, showing evidence for activation of non-selected lexical items. Moreover, the difference between naming latencies of cognates vs. non-cognates was larger in the non-dominant language. Cognate effects are also present in L1 in a monolingual context (Van Hell & Dijkstra, 2002), and can even be found in trilinguals, where the effects add up over the three languages (Lemhöfer, Dijkstra & Michel, 2004). In addition, proficiency seems to modulate the magnitude of the cognate effect

(Christoffels, de Groot & Kroll, 2006; Van Hell & Dijkstra, 2002). The cognate facilitation effect during picture naming is also reflected in ERP-components (Christoffels, Firk & Schiller, 2007; Strijkers, Costa & Thierry, 2010). In sum, converging evidence supports the hypothesis that bilinguals activate lexical representations of both languages when producing in one of them.

However, this hypothesis has recently been challenged by Costa, Pannunzi, Deco and Pickering (2017), who argued that many phenomena that are listed as evidence for parallel activation of both L1 and L2 – such as the cognate effect – can also be explained by another theory that does not require this parallel activation. They argue that the cognate effect could also be a result of the learning context in which bilinguals acquire new L2 vocabulary; because there are many resemblances between the translation equivalents in both languages, cognates might be picked up faster and earlier during learning than non-cognates, resulting in a strong memory trace for – and readily accessible representations of – cognates.

The locus of the cognate effect in word production

Despite the large number of studies investigating the cognate effect, researchers did not reach consensus yet about where this effect originates in the production process. In 2000, Costa and colleagues interpreted the cognate effect as evidence for a cascading model of word production: when a bilingual names a picture, lexical representations of both languages will become active and will each activate representations at the phoneme level. In the case of a cognate, this process will be facilitated because of the overlap in phonemes. According to this view, the cognate effect is situated in between central and peripheral levels, as the bilingual activation cascades from the lexical to the phonological level. Moreover, an ERP-study by Christoffels et al. (2007) shows a difference between cognates and non-cognates around 300

ms, indicating that the cognate effect indeed has a phonological origin given estimates of the time course of language production processes (Indefrey & Levelt, 2004).

In contrast, Strijkers, Costa and Thierry (2010) found an earlier time-window (i.e., 150-200 ms) for this effect and argued that lexical access rather than phonological retrieval seems to be the responsible mechanism. Because of the tight link between L1 and L2 phonology in cognates, translation equivalents become more often co-activated than in non-cognates (because the lexical item activates its phonology, which in turn activates words with similar phonology, including the translation equivalent), resulting in a strong connection between both lexical items that is no longer mediated by phonological access. In 2017, Costa and colleagues (2017) proposed that such a connection is formed during early stages of L2 acquisition – because cognates are picked up faster than non-cognates (see also Lotto & de Groot, 1998; de Groot & Keijzer, 2000) –, which suggests that the cognate effect has become strictly lexical in nature for more proficient bilinguals. In conclusion, it remains unclear whether the cognate effect is a purely lexical or – at least partly – phonological phenomenon. A possible way to gain more insight into this issue might be to compare the cognate effect in spoken and written production.

Spoken vs. written production

Most models of spoken production assume that there are three stages: a) selection of concepts, b) selection of lexical forms, and c) selection of phonological forms (e.g., Caramazza, 1997; Dell, 1986; Levelt, Roelofs & Meyer, 1999). It is often assumed that the central (i.e., conceptual and lexical) processes are shared between spoken and written modalities, whereas the peripheral, post-lexical processes, such as phonological and orthographic selection, and motor processes are different (e.g., Bonin, Chalard, Méot &

Fayol, 2002; Bonin, Méot, Lagarrigue & Roux, 2015; Hillis, Rapp, Romani & Caramazza, 1990; Perret & Laganaro, 2012; 2013). Evidence for shared central processes stems from studies that found similar results in spoken and written production for the semantic interference effect (Bonin & Fayol, 2000) and word frequency effect (Bonin & Fayol, 2002) – which are considered to have a central locus (Dell, 1986; Caramazza, 1997, but see Almeida, Knobel, Finkbeiner & Caramazza, 2007; Jescheniak & Levelt, 1994, for an alternative view). In addition, a neuro-imaging study comparing spoken and written picture naming found that lexical processes represented in the left fusiform gyrus (BA 37), were modality-independent (DeLeon et al., 2007).

Although there is a clear distinction between spoken and written production at the level of motor processes (e.g., mouth and tongue muscles in speech vs. hand and finger movements in writing), and in their building blocks (phonemes vs. graphemes), the role of phonology and orthography in both modalities is less intuitive. On the one hand, it seems that orthography does not necessarily play a role in speech, given that people who cannot read and write are nevertheless able to speak (see also Ferrand, Grainger & Segui, 1994, for a masked priming experiment showing that pre-activation of phonological, but not orthographic information facilitated spoken picture naming).

On the other hand, there is no consensus whether phonology plays a role in written language. Do people also activate phonological representations during reading and writing? In other words, does writing merely entail an additional stage, i.e., phoneme-grapheme conversion, on top of speech production processes or does the access of graphemic information not depend on phonological information? According to the *orthographic autonomy hypothesis* (Damian, Dorjee & Stadthagen-Gonzalez, 2011; Miceli, Benvegna, Capasso & Caramazza, 1997; Rapp, Benzing & Caramazza, 1997), orthographic information can be accessed without mediation of the phonological system, whereas the *obligatory*

phonological mediation hypothesis (Afonso & Álvarez, 2011; Bonin, Peereman & Fayol, 2001; Geschwind, 1969; Luria, 1970; Qu, Damian & Li, 2016) states that the phonological system is necessarily involved when processing orthographic information. Studies on this matter indicate that it is *possible* to by-pass phonology during writing, as shown in brain-damaged patients, who were able to write down picture names without being able to name them orally (e.g., Rapp & Caramazza, 1997; Shelton & Weinrich, 1997), and in languages with low phonology-orthography overlap, such as Chinese (Zhang & Wang, 2015; 2016). However, phonology seems to be activated for most of the time in healthy individuals during written production in alphabetic languages (Bonin et al., 2001).

In sum, the abovementioned studies indicate that written picture naming benefits from both phonological and orthographic activation, whereas spoken picture naming depends primarily on phonology. When taking this to a bilingual situation, the activation of words that have overlap in orthography and phonology between languages, such as cognates, cascades into both orthography and phonology in written production, but mainly into phonology in spoken production. Thus, if the locus of the cognate effect would be in the cascading between lexicon and phonological/orthographic form, a larger cognate effect should be observed in written as opposed to spoken production. In contrast, if the cognate effect is purely lexical, no differences should be observed between both modalities.

The aim of the current study was to compare the cognate effect in written and spoken word production by means of a picture naming paradigm. Dutch-English bilinguals produced the names of pictures in English by either naming them orally or typing the names on a computer keyboard as fast and accurately as possible. For spoken naming, reaction times were operationalized as voice onset time, and for writing, this was first keystroke latency (cf. Baus, Strijkers & Costa, 2003, who found frequency effects of the first keystroke latency, but not of whole word typing). The critical pictures represented a cognate word, like “bed” [bɛd]

(Dutch: “bed” [bet]), while control pictures were named with non-cognate words, for instance “dog” [dɔg] (Dutch: “hond” [hɔnt]). Because the cognate effect has been observed in spoken production, it can be hypothesized that this is also the case for written production. Moreover, if the cognate effect is purely lexically driven, participants should have faster reaction times and higher accuracy for cognates compared to control words to a similar extent in spoken and written picture naming, because central processes are shared between both modalities. In contrast, if the effect is (partly) peripherally located, larger cognate facilitation should be observed in written production, given that the lexical representation cascades to both phonological and orthographic representations during writing, resulting in stronger activation of the translation equivalent compared to spoken production, that relies mainly on phonology. Furthermore, if the cognate effect is a result of the activation of L1 during L2 processing, influences of L1 phonology, orthography or even lexicon should be observed into L2 production. In order to investigate this last hypothesis, an error analysis of the answers has been included.

Methods

Participants

In this study 80 psychology students (14 males and 66 females) received either credits or payment for participation, with ages ranging from 17 to 31 ($M = 19.9$, $SD = 3.20$). All of them were native Dutch speakers and had learned English as second language before the age of 14. Furthermore, they had normal or corrected-to-normal vision. In order to ensure sufficient vocabulary knowledge to name most of the pictures, only high proficient participants were selected based on their scores for the Dutch (L1) and English (L2)

LexTALE test (Lemhöfer & Broersma, 2012). Students that were interested to participate were sent an e-mail in which they were asked to complete the LexTALE tests online at www.lextale.com. The cut-off score was set at 70% for both languages.

The average LexTALE scores were 88.12% ($SD = 5.89\%$) for Dutch and 81.18% ($SD = 7.96\%$) for English. All scores ranged between 73.75% and 100% for the Dutch version, and between 70% and 98.75% for the English version. Furthermore, the majority of the participants had better scores for L1 than L2, showing the expected bilingual pattern (62 out of 80). This was also reflected in the self-ratings of proficiency (Dutch: $M = 6.00$, $SD = 0.58$; English: $M = 5.40$, $SD = 0.78$). The self-ratings for French show that French was the L3 ($M = 3.9$, $SD = 1.13$) in terms of dominance for most of the participants (only 2 rated French proficiency higher than English proficiency). Twenty-seven of the participants in the writing condition indicated that they had touch-typing skills. The others used on average 5.7 ($SD = 2.1$) fingers to type. The mean self-rated typing proficiency was 5.17 ($SD = 1.22$).

In order to exclude differences between participants in the spoken and written condition, both groups were compared on LexTALE scores, self-rating measures, and some other individual characteristics. An overview can be found in Table 1. One-way ANOVA tests showed that there were no significant differences between groups for any of the characteristics, except for the age of acquisition of English, which was significantly higher in the spoken group ($F(1, 78) = 9.21$, $p < .01$).

<Insert Table 1 about here>

Stimuli

Because most Flemish students also speak French, and earlier work has demonstrated effects

of cognates with L3 (Van Hell & Dijkstra, 2002), we selected only Dutch-English cognates that have a different form in French (e.g., 'computer'(NL)-'computer'(E)-'ordinateur'(F)). By doing so, we avoided the possibility that French variants would also have an influence on the processing of the cognates. For each of the 48 cognates, we selected a control, non-cognate word that was matched in length, frequency, bigram frequency, rank of first letter (i.e., ranking based on the frequency of a letter as first letter in a given language), and neighborhood for both L1 and L2, by means of WordGen (Duyck, Desmet, Verbeke & Brysbaert, 2004). Finally, 42 filler items were added. In total, 138 black and white drawings were taken from Severens, Van Lommel, Ratinckx and Hartsuiker (2005), of which 10 served as practice stimuli. A list of the words that were used and their features can be found in Appendix A. The programming and data collection of the experiment were done in E-Prime.

Procedure

First, participants signed an informed consent form after which they were seated in front of a computer screen on which the instructions of the experiment were presented. Trials started with a fixation cross presented during 500 ms, followed by a picture in the center of the screen. Half of the participants were instructed to type below the name of the picture in English as soon as possible using an AZERTY keyboard¹. If the target word was unknown, they could skip the trial and go on with the next. There were no time limits on responding. Correction was allowed within the trial by pressing <backspace> after which a {*} appeared and then the participant could type the whole word again. All typing was recorded, including mistakes that the participant corrected. When the word was written, the participant could press <enter> to get the following picture. The other half of the participants were instructed to name the pictures orally. They were also instructed to press <enter> to proceed to the next

picture.

No familiarization phase of the words and pictures was included, because we were also interested in errors, which might expose L1 influences. The first 10 trials were practice trials, which were not included in analysis. If something remained unclear the participant could ask questions before going on with the experiment. The experiment itself consisted of 128 trials and the order of picture presentation was randomized. Each picture was presented only once to the same participant. After every 32 trials, there was a break and after the last trial the student was asked to fill in a questionnaire, containing self-reporting measures of proficiency in Dutch, English, and French. The students were asked to estimate their reading, listening, speaking and writing skills in the three languages on a Likert scale (1-7). Furthermore, the questionnaire surveyed the age of acquisition of and frequency of exposure to English and French. Finally, participants in the written condition estimated their typewriting skills on a Likert scale.

Coding of responses

Responses on the picture naming task were scored as correct when the exact target word was produced. All other responses, including (near) synonyms were scored as errors. Errors were divided into eight categories: a) typing errors, as a result of pressing the wrong button (only for the typing condition), e.g., “beatr” instead of “bear”, b) disfluencies (only for the spoken condition)², e.g., “che... cherry”, c) L1 errors, e.g., “flyer” instead of “kite” (Dutch: “vlieger”, a noun derived from the verb “vliegen” [to fly]), d) orthographic errors, errors that reflect a wrong orthographic representation of the word form (only for the typing condition), e.g., “swann” instead of “swan”, e) phonological errors (only for the spoken condition), e.g., “hence” instead of “fence”, f) semantic errors, e.g., “glass” instead of “window”, g)

synonyms³, e.g., “ship” instead of “boat”, and h) no response, which means that participants continued to the next trial without writing/saying a word. Items in this final category were discarded from analysis. Responses could also be assigned to different error categories at the same time, e.g., when someone said “racket” instead of “rocket”, this was coded as a phonological error, but also as an L1 error (Dutch: “raket”).

Results

All data and analysis scripts are available on the Open Science Framework (link: https://osf.io/pkvnt/?view_only=3f9447fb9edc4e119f9873ca86962196).

Cognate effect

The number of valid responses (i.e., everything except no response) was 93.77% for the spoken condition and 96.09% for the written condition, whereas the accuracy of these responses was 85.67% in the spoken and 75.33% in the written condition. After exclusion of outlier reaction times (over 3*SD above the mean), two outlier words (in terms of accuracy or mean RT) were excluded from analysis: one because the accuracy was too low (i.e., ‘kite’) and one (i.e., ‘picture’) because the reaction times were too slow.

Reaction times. The mean reaction time (RT) for correct responses was 1168 ms (*SD* = 549) for cognates and 1305 ms (*SD* = 543) for controls in the spoken group and 2724 ms (*SD* = 1169) for cognates and 2954 ms (*SD* = 1220) for controls in the written group. There was a significant positive correlation between mean spoken and written reaction times aggregated per item (Pearson’s $r = .79$, $df = 92$, $p < .001$).

The cognate effect and its interaction with spoken and written condition was tested for

RTs using linear mixed effects models by means of the lme4 package in R (Bates, Maechler, Bolker & Walker, 2015). For the random part of the model, the maximal random effects structure (Barr, Levy, Scheepers & Tily, 2013) was included and then reduced until convergence (Matuschek, Kliegl, Vasishth, Baayen & Bates, 2017). This resulted in a random intercept for *word* and *subject*, an uncorrelated random slope for *modality* over words and a random slope for *cognate status* over subjects. The fixed part consisted of the *modality* * *cognate status* interaction. There was a significant main effect of *modality* ($\chi^2(1) = 291.55, p < .001$): spoken responses were faster than written responses. In addition, there was a significant main effect of *cognate status* ($\chi^2(1) = 4.88, p < .05$), in other words, there was a cognate facilitation effect. Post-hoc pairwise comparisons using the phia package (De Rosario-Martinez, 2015) showed that this effect was significant in the written modality ($\chi^2(1) = 5.95, p < .05$), but not in the spoken modality ($\chi^2(1) = 2.54, p = .11$). However, there was no significant interaction between *modality* and *cognate status* ($\chi^2(1) = 0.95, p > .1$), which indicates that the cognate effect is very similar in spoken and written production in terms of response latencies.

Accuracy. The mean accuracy was 0.86 ($SD = 0.35$) for cognates and 0.80 ($SD = 0.40$) for controls in the spoken condition, whereas in the written condition it was 0.75 ($SD = 0.43$) for cognates and 0.75 ($SD = 0.43$) for controls. There was a significant positive correlation between accuracy in the spoken and in the written condition for each item (Pearson's $r = .81, t(92) = 13.32, p < .001$).

A generalized linear mixed effects model with the logit link-function was fitted for *accuracy* (because it is a binomial outcome variable), using the same fixed and random effects structure as in the RT model. The output of this model revealed a significant *modality* * *cognate status* interaction ($\chi^2(1) = 8.47, p < .01$), indicating a difference in the cognate effect between both modalities. Pairwise contrasts showed that the cognate effect was

marginally significant in the spoken condition ($\chi^2(1) = 5.02, p = .0501$), but not in the written condition ($\chi^2(1) = 0.18, p > .1$).

Typewriting skills. Additional (generalized) linear mixed effects models with maximal random effects structure tested whether there was a difference in the written cognate effect for participants with and without touch typing skill. This was not the case (RT: $\chi^2(1) = 0.20, p > .1$; accuracy: ($\chi^2(1) = 0.00, p > .1$) and participants with touch typing skill were not faster in general ($\chi^2(1) = 0.00, p > .1$) or more accurate ($\chi^2(1) = 2.34, p > .1$) than participants without this skill.

Error Analysis

Beside the statistical tests and analyses, a qualitative assessment of the errors was conducted by means of the coding scheme (cf. supra). In total, 1902 errors were made (on a total of 10240 trials). The proportion of each error type for each condition can be found in Table 2. In addition, some errors (19 in total) even bore witness of L3 (French) influences. For instance, one of the participants wrote “cerish” instead of “cherry” and this resembles the French “cerise”.

A generalized linear mixed effects model tested the *cognate status * modality * error type* interaction on errors (binomial) with a random intercept for *word* and *subject*, and a random slope for *modality* over words and *cognate status* over subjects. The output of this model showed a significant *cognate status * modality * error type* interaction ($\chi^2(4) = 20.56, p < .001$). Pairwise contrasts revealed that for the written responses there were significantly more L1 errors ($\chi^2(1) = 16.80, p < .001$) and fewer semantic errors in cognates compared to controls ($\chi^2(1) = 19.98, p < .001$). For the spoken errors, there were more phonological errors in the cognates than in the controls ($\chi^2(1) = 8.79, p < .05$). When comparing the error pattern

in both modalities, the contrast between cognates and controls is similar for all error types, except for semantic errors ($\chi^2(1) = 14.24, p < .001$), in the sense that the contrast is larger in the written condition (i.e., it only reaches significance within the written condition).

<Insert Table 2 around here>

Discussion

The aim of the study was to compare the cognate effect in spoken and (type)written word production by means of an L2 picture naming task.

Overall, there was a clear cognate facilitation effect: the response latencies were shorter in cognates compared to control words. The difference between cognates and controls was about 140 ms for spoken and 230 ms for written production. In absolute terms, one could argue that the effect is larger in writing, but this is not surprising, given the longer response latencies overall. Moreover, statistical analyses failed to find a difference in the cognate effect between both modalities, which means that there is no evidence that the cognate effect has a (partly) peripheral locus. Indeed, the effect was very similar in relative terms (i.e., both were around 10% of the total RT), indicating that the cognate effect might be purely lexical in nature, hence centrally situated. However, it is still possible that the difference between spoken and written production is very small, making it very hard to detect with behavioral measures. In addition, the findings indicate that bilinguals largely rely on similar processes during L2 spoken and written production.

In contrast, no clear cognate facilitation was found in terms of accuracy. A possible reason for this might be that there is another mechanism into play underlying errors in both types of words. Indeed, the qualitative analysis of errors revealed that, despite the larger

number of synonyms and semantic errors in control words, cognates were more often influenced by their L1 equivalents and more prone to orthographic/phonological errors. Hence, it seems that the processing facilitation of cognates comes at the expense of an increased vulnerability to (or interference from) erroneous L1 influences. This finding is in line with the triggering hypothesis, which states that encountering a cognate word triggers activation of the non-target language in bilinguals (Broersma & De Bot, 2006; Clyne, 1967).

Other studies investigating the cognate effect in spoken picture naming yielded mixed results in the sense that they either found facilitation in terms of accuracy (Costa et al., 2000, Experiment 2), found no facilitation (Costa et al., 2000, Experiment 1; Starreveld, de Groot, Rossmark & Van Hell, 2014), or did not compare the errors between cognates and control words because the incidence was very low (Christoffels et al., 2006; 2007). However, none of the mentioned studies elaborated on this matter. One reason for this could be that most of the studies included a familiarization phase of the picture names, and hence decreased the chance of errors. Thus, the errors that occurred in these studies would probably be different in nature compared to studies without a familiarization phase. Still, spontaneous errors in L2 picture naming can provide important information about the realization of L2 words in bilinguals, and especially how their L1 affects this process. The current study brings insight into this subject by showing that the activation of L1 enhances and hinders L2 word production at the same time (see also Rogers, Webb & Nakata, 2015, who showed that cognates are easily learned but harder to use during L2 acquisition in comparison with non-cognates).

Moreover, the existence of phonological/orthographic interference from L1 in L2 cognate words (e.g., ‘shelp’ instead of ‘shell’ because of the Dutch ‘schelp’, an error that occurred in both spoken and written modality) indicates that bilinguals activate also phonological/orthographic features of the related L1 word. This finding is in line with the idea that both languages are activated in parallel, but challenges the idea that the cognate

effect is merely a learning artifact (Costa et al., 2017). Indeed, the activation of the connection between the L1 and L2 word-level representations seems to cascade further into the phonological and orthographic level. Amengual (2012) found that for speech production, this cascading even continues to the phonetic level. In contrast, when bilinguals produce cognates in their L1, the influence of L2 might be much smaller (e.g., Kroll & Stewart, 1994). For instance, Costa et al. (2000) found a larger cognate effect in the non-dominant language of Spanish-Catalan bilinguals compared to the dominant language.

L1 influences regarding errors were not limited to cognates, but appeared also in control words, for instance, “flyer” instead of *kite* (Dutch: *vlieger*, derived from the verb *vliegen* – to fly), “mailbus” instead of *mailbox* (Dutch: *brievenbus*), “fleermousse” instead of *bat* (Dutch: *vleermuis*), or “fabric” instead of *factory* (Dutch: *fabriek*). These examples indicate that the L1 word form is often used as retrieval cue for the L2 word, a strategy that is often used in L2 learners (de Groot & Keijzer, 2000). For cognates, this might be a successful strategy, but less so for words that have a different word form in the two languages.

In general, picture naming response latencies tended to be slower in typewriting. This was also the case in Bonin and Fayol’s (2002) and Baus et al.’s (2013) study, who argued that this slowing is unlikely due to differences in the access of conceptual information between both modalities, but rather to the lower degree of automaticity of the typewriting process in comparison with speech.

A limitation of the current study would be that the findings are solely based on VOTs and first keystroke latencies in picture naming. As such, the results can only provide insight in the access of the target words (Baus et al., 2013), but not in the online processing of the individual phonemes/graphemes during word production (see Bertram, Tønnessen, Strömquist, Hyönä & Niemi, 2015, for an example). Indeed, the letter-by-letter or sound-by-sound time registration could tell us whether bilinguals experience L1 interference in non-

identical cognates already at the onset of word production or whether this interference appears only at the position in the word where the L2 differs from the L1. In addition, our findings about writing are based on typewriting, but do not necessarily generalize to handwriting, which requires more in-depth processing of the graphemic forms (James & Engelhardt, 2012). Hence, it might be interesting to compare the cognate effect in hand- and typewriting. Another possible follow-up study could look into the individual contribution of orthographic and phonological representations in spoken and written production by comparing cognates that have both initial phoneme and grapheme overlap in L1 and L2 (e.g., heart-hart) with cognates that start with the same phoneme, but a different grapheme (e.g., cat-kat).

In sum, the current study shows that the cognate effect in bilingual word production is modality-independent, pointing in the direction of a central locus for cognate facilitation in bilinguals (e.g., Costa et al., 2000; 2017). Moreover, the analysis of the errors indicate that bilinguals activate both their L1 and L2 during L2 speech and writing.

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Footnotes

¹ For those participants who were more familiar with a QWERTY keyboard, a QWERTY version of the experiment was provided.

² Errors that were self-interrupted, such as “h... house”, were coded as disfluencies, and thus incorrect, to avoid distortion of reaction times.

³ Synonyms were scored as an error even though they were a correct description of the picture, because the target words were matched on several features, whereas the synonyms were not.

Table 1. *Group comparisons of participant characteristics.*

characteristic	<u>spoken</u>	<u>written</u>
	<i>M (SD)</i>	<i>M (SD)</i>
age	20.5 (3.36)	19.3 (2.96)
sex (N of females)	32	34
LexTALE Dutch	88.78 (5.79)	87.44 (5.98)
LexTALE English	81.63 (6.97)	80.74 (8.90)
self-ratings Dutch		
- speaking	6.1 (0.67)	6.1 (0.76)
- reading	6.3 (0.74)	6.1 (0.79)
- writing	6.1 (0.78)	5.8 (0.82)
- proficiency	6.0 (0.62)	6.0 (0.64)
self-ratings English		
- age of acquisition*	10.5 (2.44)	8.4 (3.82)
- speaking	5.3 (0.88)	5.6 (0.85)
- reading	5.7 (0.76)	5.8 (0.89)
- writing	4.9 (0.93)	5.0 (1.12)
- proficiency	5.3 (0.73)	5.5 (0.84)
self-ratings French		
- age of acquisition	10.0 (1.38)	9.3 (2.45)
- speaking	3.8 (1.04)	3.9 (1.25)
- reading	4.2 (1.19)	4.2 (1.44)
- writing	3.7 (0.99)	3.7 (1.45)
- proficiency	3.9 (0.91)	3.9 (1.33)

Note. * $p < .05$

Table 2. *Proportion of errors for each condition**.

error type	<u>spoken</u>		<u>written</u>	
	cognate	control	cognate	control
disfluency/typing error	0.04	0.03	0.24	0.23
L1 error	0.16	0.11	0.18	0.08
phonological/orthographic error	0.11	0.04	0.21	0.15
semantic error	0.57	0.51	0.28	0.43
synonym	0.26	0.38	0.22	0.23

*Some errors could belong to more than one category.

Appendix

Appendix A. List of words and their characteristics.

English	Dutch	Cognates			English	Dutch	Matched controls		
		log freq/ million	neighbours (N)	rank 1 st letter			log freq/ million	neighbours (N)	rank 1 st letter
<i>apple</i>	appel	1.51	2	6	<i>fence</i>	hek	1.52	1	10
<i>bear</i>	beer	2.11	19	4	<i>tear</i>	traan	2.11	16	5
<i>bed</i>	bed	2.46	14	4	<i>boy</i>	jongen	2.57	17	4
<i>bell</i>	bel	1.63	13	4	<i>tail</i>	staart	1.63	13	5
<i>boat</i>	boot	1.90	9	4	<i>coat</i>	jas	1.86	10	2
<i>book</i>	boek	2.63	12	4	<i>fire</i>	vuur	2.34	13	10
<i>bread</i>	brood	1.89	6	4	<i>nurse</i>	verpleegster	1.76	3	19
<i>bridge</i>	brug	1.84	2	4	<i>stairs</i>	trap	1.67	0	1
<i>clock</i>	klok	1.62	8	2	<i>witch</i>	heks	1.53	7	15
<i>cook</i>	kok	1.97	12	2	<i>lock</i>	slot	1.90	14	12
<i>cookie</i>	koek	0.70	3	2	<i>wallet</i>	portefeuille	0.90	3	15
<i>fish</i>	vis	2.31	4	10	<i>tree</i>	boom	2.31	5	5
<i>fist</i>	vuist	1.45	7	10	<i>whip</i>	zweep	1.45	9	15
<i>flag</i>	vlag	1.46	9	10	<i>belt</i>	riem	1.48	11	4
<i>foot</i>	voet	2.54	12	10	<i>wall</i>	muur	2.35	13	15
<i>glass</i>	glas	2.18	3	11	<i>dress</i>	kleed	2.25	5	7
<i>hair</i>	haar	2.32	5	13	<i>city</i>	stad	2.46	2	2
<i>hammer</i>	hamer	1.38	2	13	<i>bucket</i>	emmer	1.32	1	4
<i>hand</i>	hand	2.92	9	13	<i>road</i>	straat	2.40	9	8
<i>hat</i>	hoed	1.85	20	13	<i>bag</i>	zak	1.93	22	4
<i>heart</i>	hart	2.23	0	13	<i>chair</i>	stoel	2.17	2	2
<i>helmet</i>	helm	1.11	1	13	<i>knight</i>	ridder	1.11	0	22
<i>hook</i>	haak	1.76	11	13	<i>roof</i>	dak	1.78	8	8
<i>house</i>	huis	2.85	6	13	<i>watch</i>	uurwerk	2.48	8	15
<i>ladder</i>	ladder	1.20	2	12	<i>turkey</i>	kalkoen	1.18	0	5
<i>moon</i>	maan	1.79	11	9	<i>wing</i>	vleugel	1.80	10	15
<i>mouse</i>	muis	1.28	8	9	<i>shark</i>	haai	1.32	8	1
<i>nest</i>	nest	1.30	14	19	<i>duck</i>	eend	1.32	15	7
<i>net</i>	net	1.60	15	19	<i>pig</i>	varken	1.66	14	3
<i>owl</i>	uil	0.85	4	17	<i>bra</i>	beha	0.78	6	4
<i>pan</i>	pan	1.51	21	3	<i>bat</i>	vleermuis	1.34	22	4
<i>pumpkin</i>	pompoen	0.30	1	3	<i>mailbox</i>	brievenbus	0.30	0	9
<i>ring</i>	ring	2.18	10	8	<i>rock</i>	steen	2.14	12	8
<i>rocket</i>	raket	1.20	6	8	<i>waiter</i>	ober	1.36	4	15
<i>sheep</i>	schaap	1.62	7	1	<i>snake</i>	slang	1.43	5	1
<i>shell</i>	schelp	1.72	5	1	<i>skirt</i>	rok	1.54	4	1
<i>shoe</i>	schoen	1.92	6	1	<i>leaf</i>	blad	1.94	7	12
<i>shoulder</i>	schouder	2.15	0	1	<i>picture</i>	afbeelding	2.25	0	3
<i>sock</i>	sok	1.30	12	1	<i>deer</i>	hert	1.08	12	7

<i>star</i>	ster	2.05	8	1	<i>king</i>	koning	2.01	9	22
<i>step</i>	step	2.22	6	1	<i>bird</i>	vogel	2.03	4	4
<i>swan</i>	zwaan	0.90	7	1	<i>kite</i>	vlieger	0.70	6	22
<i>sword</i>	zwaard	1.26	2	1	<i>glove</i>	handschoen	1.32	3	11
<i>thumb</i>	duim	1.49	1	5	<i>queen</i>	koningin	1.72	3	23
<i>walnut</i>	walnoot	0.70	0	15	<i>napkin</i>	servet	0.85	0	19
<i>wheel</i>	wiel	1.73	0	15	<i>knife</i>	mes	1.69	0	22
<i>wolf</i>	wolf	1.11	3	15	<i>frog</i>	kikker	0.95	3	10
<i>worm</i>	worm	1.30	8	15	<i>doll</i>	pop	1.43	11	7
<i>MEAN</i>		1.69	7.21	7.83			1.66	7.29	9.25

		<u>Fillers</u>		
English	Dutch	log freq/ million	neighbours (N)	rank 1 st letter
<i>ant</i>	mier	1.08	7	6
<i>arrow</i>	pijl	1.15	0	6
<i>ax</i>	bijl	0.95	13	6
<i>boot</i>	laars	1.61	17	4
<i>box</i>	doos	2.03	13	4
<i>branch</i>	tak	2.00	2	4
<i>butcher</i>	slager	1.00	1	4
<i>button</i>	knoop	1.54	2	4
<i>cage</i>	kooi	1.28	12	2
<i>candle</i>	kaars	1.23	2	2
<i>car</i>	auto	2.55	19	2
<i>cheese</i>	kaas	1.51	0	2
<i>cherry</i>	kers	0.95	3	2
<i>chest</i>	borstkas	1.71	3	2
<i>chimney</i>	schoorsteen	1.04	0	2
<i>cloud</i>	wolk	1.81	2	2
<i>curtains</i>	gordijnen	0.00	0	2
<i>desk</i>	bureau	1.98	2	7
<i>dog</i>	hond	2.09	14	7
<i>donkey</i>	ezel	1.18	1	7
<i>eagle</i>	arend	1.00	0	14
<i>egg</i>	ei	1.94	5	14
<i>factory</i>	fabriek	1.77	0	10
<i>farm</i>	boerderij	1.99	7	10
<i>flower</i>	bloem	2.02	2	10
<i>girl</i>	meisje	2.66	3	11
<i>gun</i>	geweer	2.02	17	11
<i>key</i>	sleutel	1.96	6	22
<i>mirror</i>	spiegel	1.73	0	9
<i>monkey</i>	aap	1.28	1	9
<i>parrot</i>	papegaai	0.60	1	3
<i>peanut</i>	pinda	0.78	0	3
<i>pencil</i>	potlood	1.34	0	3
<i>rabbit</i>	konijn	1.30	0	8

<i>scarf</i>	sjaal	1.11	5	1
<i>scissors</i>	schaar	0.70	0	1
<i>smoke</i>	rook	1.98	3	1
<i>unicorn</i>	eenhoorn	0.00	0	18
<i>window</i>	raam	2.32	1	15
<i>woman</i>	vrouw	2.94	1	15
<i>MEAN</i>		1.50	4.13	6.63