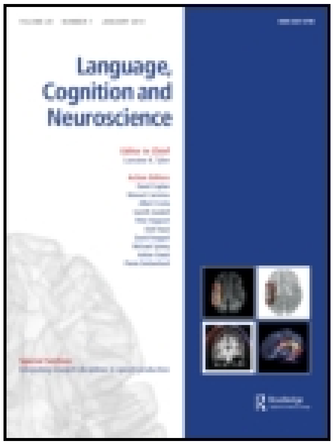

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Switch cost modulations in bilingual sentence processing: evidence from shadowing

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In bilingual processing, cognates are associated with facilitatory processing, while switching between languages is associated with a processing cost. This study investigates whether co-activation of cognates affects the magnitude of switch costs in sentence context. A shadowing task was conducted to examine whether verb cognates reduce switch costs in sentences that switched between participants' L1 and L2. In addition, we considered whether these effects were influenced by L2 proficiency, switching direction and cross-linguistic overlap in syntactic structure. Bilinguals were presented with L1 and L2 sentences that contained a language switch preceded by a cognate. Shadowing latencies showed that switching to L2 was more costly than switching to L1. Switch costs in both directions were not modulated by the presence of a verb cognate, and this effect was not affected by syntactic structure or L2 proficiency. The results are informative for the field of bilingual processing and the lexical trigger hypothesis.

Keywords: language switching; cognates; sentence processing; L2 proficiency; shadowing

Bilinguals who speak more than one language fluently are quite able to switch between their languages. Yet, such switching between languages in production or comprehension is associated with a measurable cognitive cost (e.g., Meuter & Allport, 1999). This is the case even though numerous studies have shown that bilinguals access lexical representations from both languages in parallel from an integrated lexicon even during processing in a monolingual context (e.g., Dijkstra & Van Heuven, 2002; Duyck, Van Assche, Drieghe, & Hartsuiker, 2007; Schwartz & Kroll, 2006; Van Hell & De Groot, 2008). The occurrence of bilingual activation in lexical processing raises the question whether such language non-specific processing can influence language-related switch costs. In the present study, we examined the relation between switch costs and cross-linguistic lexical and syntactic overlap in sentence context. Using a shadowing task, we studied how language switching in sentences with a cross-linguistically similar or different syntactic structure is influenced by the presence of cognates, such as the English word 'to drink', which shares its meaning and, to a large extent, also its form with the Dutch verb 'drinken'. To set the stage for this study, we will first discuss switch costs and cognate effects in sentence processing and then consider studies that investigate how cognates influence language switching.

Language switching

A typical finding in studies examining task switching is that it incurs a cognitive cost. In behavioural tasks, switch trials elicit longer reaction times and more errors than non-switch trials (Monsell, 2003) because switching between tasks increases the cognitive load involved in processing. A similar cost is observed in language switching: When bilinguals are using one of their languages, a switch to their other language is costly. Switch costs are prominent in studies involving word processing in sentence context regardless of the modality of the language user: They are found in mixed-language sentence reading (e.g., Altarriba, Kroll, Sholl, & Rayner, 1996; Moreno, Federmeier, & Kutas, 2002; Proverbio, Leoni, & Zani, 2004; Van Der Meij, Cuetos, Carreiras, & Barber, 2011) and in experiments involving auditory presentation of sentences (FitzPatrick, 2011; Ruigendijk, Zeller, & Hentschel, 2009). Similar switch costs have been observed in speech production (e.g., Christoffels, Firk, & Schiller, 2007; Costa & Santesteban, 2004; Kroll, Bobb, & Wodniecka, 2006; Meuter & Allport, 1999; Philipp, Gade, & Koch, 2007; see Meuter, 2009 for a review), although the majority of these studies has been conducted using a picture naming paradigm involving single words instead of sentences. The cost associated with switching is very robust and can be observed in both switching directions.

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The robustness is also underlined by the finding of switch costs in voluntary switching when participants were free to switch on any experimental trial of their choice (Gollan & Ferreira, 2009). Even when language users can control their own speech output and a word in another language is more readily available, language switching is costly.

The magnitude of switch costs in forward (L1–L2) and backward (L2–L1) direction is subject to an asymmetry that appears to be task-dependent. Picture and number naming studies often report that switching from L2 to L1 is more costly for unbalanced bilinguals than vice versa (e.g., Meuter & Allport, 1999). In contrast, evidence from sentence comprehension points to an asymmetry in the opposite direction. While comprehending words in sentence context, switching to the dominant L1 is easier than switching to the less dominant L2 (see Van Hell & Witteman, 2009, for a review). An electrophysiological study by Proverbio et al. (2004) showed a larger N400 effect for switches from L1 to L2 than for switches from L2 to L1, indicating that switching to L2 leads to more problems of semantic integration. Although processing non-switch sentences in L2 was not harder than in L1 for the professional translators tested by Proverbio et al., the observed asymmetry can normally be accounted for in terms of differences in language proficiency. Switching to the non-dominant L2 is harder than switching to the dominant L1 and it seems dependent on how quickly representations in a language can be activated (see Litcofsky, 2013, for similar results). This suggests that proficiency in the L2 can influence the switch cost asymmetry (see Costa & Santesteban, 2004) and possibly also the size of switch costs (see Bultena, Dijkstra, & Van Hell, 2014b).

The origin of switch costs is a much debated issue. The debate revolves around the question whether language switch costs are similar to general task switch costs that are incurred outside the lexicon (e.g., Green, 1998; Thomas & Allport, 2000; Von Studnitz & Green, 2002) or stem, in part, from language-specific processes within the lexicon (e.g., Della Rosa, 2011). The Inhibitory Control Model (Green, 1998) supposes language non-specific activation of lexical items and therefore requires a mechanism to select the lexical candidate in the target language; it assumes that lexical selection for production involves suppression of the non-target language. The model includes task schemas that not only control language output but also control cognitive processing in general, implying that switch costs related to language switching are not different from general task switch costs (see also Moreno et al., 2002). Yet, most studies suggest that such switch costs are at least to some degree specific to language switching (e.g., Della Rosa, 2011), implying that costs in language comprehension stem in part from inside the lexicon. Although very few studies have explicitly adressed whether lexical factors influence switch costs (e.g., Van Heuven, Conklin, Coderre, Guo, & Dijkstra, 2011), recent findings from electrophysiological studies on switch costs in comprehension showed different early neural correlates that are assumed to reflect language-specific processes, related to both semantic (Proverbio et al., 2004; see also FitzPatrick, 2011) and lexical levels (e.g., Orfanidou & Sumner, 2005; Van Der Meij et al., 2011). The presence of a switch cost in the absence of executive control in masked priming paradigms supports the claim that costs are incurred at the lexical level (Chauncey, Grainger, & Holcomb, 2008; see also Duñabeitia, Dimitropoulou, Uribe-Etxebarria, Laka, & Carreiras, 2010, for earlier switch cost effects in the Evoked Related Potential signal). The assumption that switch costs have a lexical basis is further supported by evidence showing that switch costs can be influenced by ongoing lexical processing in a sentence, such as cross-linguistic activation, as is observed for cognates.

Cognate effects

When bilinguals process cognates, such as the English-Dutch word 'film', they have been shown to activate representations in both their languages (e.g., Dijkstra, Grainger, & Van Heuven, 1999). Cognates are activated faster than translation equivalents that lack form overlap, which is known as the cognate (facilitation) effect. There is by now quite some evidence for noun cognate effects in visual word recognition in language neutral contexts, where cognates were presented in isolation, relative to one-language control words (e.g., Brenders, Van Hell, & Dijkstra, 2011; De Groot, Borgwaldt, Bos, & Van den Eijnden, 2002; Dijkstra, Miwa, Brummelhuis, Sappelli, & Baayen, 2010; Lemhöfer et al., 2008; Peeters, Dijkstra, & Grainger, 2013; Van Hell & Dijkstra, 2002; Yudes, Macizo, & Bajo, 2010) and for cognates embedded in L2 and L1 sentence contexts (see Van Assche, Duyck, & Hartsuiker, 2012, for a review). Similar findings of facilitatory processing for cognates have been observed in speech production using picture naming tasks (e.g., Costa, Caramazza, & Sebastián-Gallés, 2000; Hoshino & Kroll, 2008; Poarch & Van Hell, 2012).

Cognate facilitation is an indication of co-activation of the target and non-target languages. Because representations for overlapping word forms in both of the bilingual's language subsets are automatically activated, they together can activate a common semantic representation (e.g., Dijkstra & Van Heuven, 2002), resulting in faster activation compared to non-cognate words. The degree of non-target activation for cognates is assumed to depend on a bilingual's relative proficiency in the target and non-target language (Dijkstra & Van Hell, 2003). More proficiency in a language yields more activation of that language. This means that for an unbalanced bilingual who is dominant in L1, non-target activation of L1 during L2 processing will be stronger than non-target activation of L2 during L1 processing. Because word forms in the more dominant L1 have been more frequently processed, they more easily generate non-target activation than L2 word forms, leading to stronger cognate facilitation in L2 processing (e.g., Christoffels et al., 2007). Co-activation depends on the strength of the representation, which is, in turn, dependent on L2 proficiency. Therefore, it is assumed that for unbalanced bilinguals, there is more non-target activation of L1 during L2 processing than vice versa, causing larger cognate facilitation in L2 processing (see also Bultena, Dijkstra, & Van Hell, 2014a). Co-activation furthermore depends on stimulus characteristics, such as cross-linguistic orthographic overlap (Dijkstra et al., 2010; Duyck et al., 2007) and may also depend on the sentence context. Using a reading task, Gullifer, Kroll, and Dussias (2011) examined processing of Spanish-English cognates in sentences with language-specific and language non-specific syntactic structures, and showed that the most proficient and fastest Spanish-English bilinguals produced a decreased cognate facilitation effect in sentences with a language-specific syntax. This points to a constraining syntactic influence on lexical effects.

The studies discussed so far show that sentence processing is affected by language switching, which slows down lexical processing, and by co-activation for cognates, which speeds up lexical processing. An emerging question is how co-activation of cognates influences language switching in sentence context. If both switch costs and co-activation reside in the lexicon, then language non-selective activation for cognates may affect processing of language switches.

Interactions between cross-linguistic activation and switching

Bilingual effects in language processing often concern facilitation of reaction times due to cross-linguistic similarities or switch costs resulting from cross-linguistic differences. One study that investigated these two aspects of bilingual processing jointly is that by Ibáñez, Macizo, and Bajo (2010). These authors asked bilinguals and professional translators to read sentences that contained a cognate. The language of the sentence changed between trials. After reading, sentences were to be repeated out loud. In this 'reading for repetition' task, reading times of bilinguals showed a switch cost, but no cognate facilitation, while professional translators showed cognate facilitation in reading, but no switch cost. This suggests that the bilinguals did not co-activate their L1 and L2 when they had to inhibit one language, while translators were able to activate both languages, which made switch costs disappear. When similar groups of participants were asked to only read the sentences, without repeating them afterwards, the results changed: In the read-only task, both groups of participants showed cognate effects and no switch costs. This finding shows that effects of co-activation and switch inhibition can be dissociated, suggesting that co-activation can influence the occurrence of switch costs. Other studies examined more directly how processing of cognates can influence code-switching.

The proposal that language switches can be influenced by the presence of cognates is based on natural language data. On the basis of corpora containing code-switches, Clyne (2003) argued that language use of habitual code-switchers is determined by lexical availability, which means that language users use the first word that is available to them. This word can be from any language that is suitable in that context. Based on the assumption of lexical availability, Clyne predicted that switching would be easier and therefore more frequent after the processing of cognates, due to their similarity in form and meaning between two languages. These word forms are available in two languages and therefore make representations from another language system more accessible.

Empirical evidence does indeed suggest that code-switches can be triggered by lexical items. In an analysis of bilingual speech samples from interviews with immigrants, switches occurred more often in the neighbourhood of cognates (Broersma & De Bot, 2006). This pattern has been found for bilingual speakers of different language backgrounds (Broersma, Isurin, Bultena, & De Bot, 2009) and for cognates of different grammatical categories, including those that are less cross-linguistically similar (Broersma, 2009). The interpretation of lexical triggering is based on the reasoning that a cognate co-activates representations in two languages because it is language ambiguous (see Tracy & Lattey, 2010), and so is able to pre-activate lexical candidates from the non-target language, which then facilitates switching to that language. Although recent studies also indicate cross-language activation for non-cognate items (see Dimitropoulou, Duñabeitia, & Carreiras, 2011), cognates in particular are a likely candidate for trigger effects, given that the amount of co-activation increases with more cross-linguistic overlap (see e.g., Duñabeitia, Perea, & Carreiras, 2010, for larger priming effects with cognates).

Recent studies have looked at lexical triggering in an experimental setting. Kootstra (2011) examined whether the presence of a cognate can enhance switching in bilingual speech. In a dialogue setting involving a confederate, a participant was asked to describe pictures. The pictures contained items that were manipulated for cognate status; a colour cue instructed whether one or two languages should be used to describe the picture for each trial. Switches were always in the L1–L2 direction. When the confederate had switched in the previous trial, participants more often switched when describing a picture that depicted a cognate compared to when it depicted a non-cognate. This showed that cognates increase the likelihood of switching in relatively free language production (see Kootstra, Van Hell, & Dijkstra, 2012, for related results with syntactic priming).

Apart from enhancing the frequency of switching, cognates might affect the magnitude of the processing cost associated with language switching, i.e., they could reduce the switch cost due to their co-activation. This is, for example, suggested by evidence from a cued naming task examining the influence of stimulus type on switch costs (Declerck, Koch, & Philipp, 2012). Switching between German and English items yielded smaller costs when the items concerned picture of cognates or when they were numbers (which included many cognates) compared to switching between non-cognate pictures. Declerck et al. argued that phonological co-activation associated with cognates reduced language switch costs. In the present study, we examined whether a modulation of switch costs would also occur when the switch was preceded by a cognate. If cognates can enhance the likelihood of switching, as indicated by the evidence for triggering, then they might also influence the cost associated with that switch.

The present study

In our study, we investigated if and how switch costs are modulated by the presence of cognates prior to the switch. We looked at switches in sentence context preceded by cognates in a controlled experimental setting, using scripted output, which allowed us to examine a modulation of switch costs. We presented sentences in L1 and in L2 that contained a cognate or a non-cognate control verb and included a switch to the other language or not. English-Dutch verb pairs like 'to start – starten' and 'to respect – respecteren' are cognates by definition, given that they overlap in both meaning and form and for that reason may be identified as similar by bilinguals and linked in the mental lexicon (Carroll, 1992). However, the experimental approach so far has mainly focused on noun cognate effects. Cognate effects for verbs have received far less attention in the literature, although some studies indicate facilitation for verb and noun cognates alike (Bultena, Dijkstra, & Van Hell, 2013; Van Hell & De Groot, 1998). In order to gain more insight in the processing of verb cognates, we manipulated the sentence main verb in the present study. This is a prime candidate for examining the interaction between words and sentence context because it is relevant at the word level and at the same time carries the sentence structure.

In addition to the language, cognate status and switch manipulations, we manipulated the syntactic structure of the sentences. Syntax is relevant for both our verb cognate manipulation and the switching paradigm. Cross-language syntactic priming effects provide evidence that syntax is shared between languages for overlapping structures (Bernolet, Hartsuiker, & Pickering, 2007; Hartsuiker, Pickering, & Veltkamp, 2004; Loebell & Bock, 2003; Schoonbaert, Hartsuiker, & Pickering, 2007). They also indicate that cross-linguistic overlap in syntax, like overlap on a lexical level, may be beneficial to bilingual processing. A language-specific syntactic structure may function as a contextual constraint affecting the degree of cross-linguistic lexical processing of words in the sentence (see Schwartz & Van Hell, 2012). Cognate facilitation may be reduced in case of a language-specific syntactic structure. Although evidence for this effect so far is limited, the sentence's main verb in particular may be prone to influences of syntactic processing. Furthermore, cross-language syntactic activation can also influence language switching patterns, evidenced by the observation that a shared word order is preferred for language switching (Kootstra, Van Hell, & Dijkstra, 2010; Poplack, 1980). In other words, an overlapping sentence structure between languages makes it easier to switch and may increase co-activation for lexical items. We therefore also manipulated syntactic structure and presented sentences with a Subject-Verb-Object (SVO) structure that occurs both in English and Dutch, as well as a language-specific Adjunct-Verb-Subject-Object (XVSO) structure that is only possible in Dutch. By comparing two sentence structures, we tested for an effect of language-specific syntax on cross-linguistic activation of the verb cognate and switch costs.

Because the triggering hypothesis was originally based on studies in the production domain and has been linked to an explanation in terms of phonology (Broersma, 2011; see also Declerck et al., 2012), we opted for a task that involves spoken language. The shadowing task (e.g., Marslen-Wilson, 1973, 1975, 1985; Marslen-Wilson & Welsh, 1978) was selected to test language switching in a controlled experimental setting that is reminiscent of speech. Shadowing involves the instantaneous reproduction of an incoming signal; participants are presented with an auditory recording of a word or sentence, which they are asked to repeat as quickly and as accurately as possible. It offers the possibility to measure the delay between word onset of the original recording and the participant's reproduction of it, which reflects the time course of processing. The shadowing task has been shown to be sensitive to lexical effects, such as neighbourhood density (Ziegler, Muneaux, & Grainger, 2003), lexical frequency (Radeau & Morais, 1990) and word length (Marslen-Wilson, 1985), indicating that lexical access takes place during language processing in such a task. The task is also sensitive to proficiency, as Treisman (1965) found that bilinguals showed better performance in L1 than in L2. Furthermore, shadowing has been shown to involve parallel activation of two languages in bilinguals in spite of language-specific phonetic cues that can help in identifying the switch (Li, 1996). The original shadowing studies indicated substantial variability in shadowing performance: Close shadowers, who had an onset around 200 ms were therefore analysed separately from distant shadowers (Marslen-Wilson, 1985). However, both close and distant shadowers showed full lexical processing.

We hypothesised that we would find a language dominance effect in the processing of lexical items during shadowing: Because the bilinguals tested in this study were highly proficient L2 learners, who were L1 dominant, we expected that processing in their L2 would be more demanding than in L1. Furthermore, we predicted that switching would incur a cost, which should be reflected in the processing time measured locally at word positions (WPs) in the sentence following the switch. Based on the few sentence comprehension studies that studied intra-sentential language switching in both directions (Litcofsky, 2013; Proverbio et al., 2004), we expected that switching would be more costly in forward direction (from L1 into L2) than in backward direction (from L2 into L1) because L2 is not as easily activated as the dominant L1. Although shadowing is a form of language production, the source of the message to be communicated comes from auditory input rather than a concept to be named or a thought to be formulated. Due to the processing of the auditory input, switch costs in the shadowing task may therefore be more similar to switch costs observed for visual comprehension.

If lexical accessibility plays a role in switching (Clyne, 2003; Gollan & Ferreira, 2009), access to a switched constituent should be easier after having processed a lexical item that co-activates representations in two languages. We therefore hypothesised that the presence of a cognate should lead to a reduction in switch costs, provided that this co-activation is strong enough and yields a cognate facilitation effect in sentence context. Given that L1 activation in an L2 context is stronger than L2 activation in an L1 context (e.g., Dijkstra & Van Hell, 2003), a facilitatory effect of cross-linguistic activation on switch costs might occur particularly in sentences starting in L2 where the cognate effect is more prominent. Lastly, we examined whether we could find an effect of syntactic structure: If cognates have an influence on switch costs, the effect may be more likely to occur for cognates embedded in a sentence structure that is similar between two languages (SVO) than in a structure that is language-specific for Dutch (XVSO). Because both cognate facilitation and switch costs have previously been shown to be modulated by proficiency in the L2, we decided to consider L2 proficiency as a between-subject variable. Given the number of manipulations in this design, higher order interactions with syntactic structure and proficiency were more exploratory in nature.

Method

Participants

Fifty Dutch-English bilinguals (40 females), all students from the Radboud University Nijmegen, between 18 and 41 years of age (*M* = 23, *SD* = 4) took part in the experiment. All participants were native speakers of Dutch and had learned English at school as an L2 starting around the age of 11. Their mean score on the English version of the XLex vocabulary knowledge test (Meara, 2006) was 85.18% (*SD* = 9.14), indicating that they were highly proficient learners of English. Being university students, they all regularly used English text books; some of them were students of English or were enrolled in another English programme. Several others also indicated to have friends with whom they communicated in English or had spoken much English while studying abroad. None of them reported any hearing problems. Participants were paid a small amount of money or received course credit for their participation.

Stimulus materials

Forty different sentences were created. All 40 sentences were declarative main clauses with the syntactic structure SVO (24 items) or XVSO (16 items). The SVO construction is possible in both English and Dutch; a VSO word order is required in Dutch when another constituent (labelled 'X'), such as an adjunct of time or place, is added at sentence initial position. The experiment involved a 2 (English, Dutch) × 2 (cognate, non-cognate) × 2 (switch, non-switch) factorial design, yielding eight possible versions for each of 24 SVO sentences. Dutch and English sentences were exact translations. Because English does not allow the XVSO construction, the language manipulation was discarded in this condition, yielding four different versions of each of 16 XVSO sentences, which could only contain an L1–L2 switch. Each of the SVO and XVSO sentences was constructed in a similar way: The verb, presented in its infinitival form, was manipulated for cognate status and was directly followed by a language switch (Tables 1 and 2). Unlike previous sentence studies based on single-word insertions in another language (e.g., Moreno et al., 2002), the sentences in the present study involved a full switch to the other language. Sixty filler sentences were added, which could start in Dutch or English, and had an SVO (80%) or XVSO (20%) construction. Half the filler sentences contained a switch, which could be located at different positions in the sentence (before the verb, at the verb or at a prepositional phrase following the object). Unlike the target sentences, the filler sentences contained inflected past tense verbs (50%) or passive constructions (50%).

Table 1. Example SVO sentence in which the onsets of measured word positions (WPs) are indicated; the last WP indicates the offset of the sentence final word.

WP1			WP2	WP3		WP4			WP5
det	*adj*	*noun*	*Cognate/control* ***verb***	*det*	***noun***	*prep*	*det*	***noun***	**.**
The	disguised	knights	bring/carry	the	victim	to	the	city wall	.
De	vermomde	ridders	brengen/dragen	het	slachtoffer	naar	de	stadsmuur	.

Table 2. Example XVSO sentence in which the onsets of measured word positions (WPs) are indicated; the last WP indicates the offset of the sentence final word.

WP1	WP2	WP3		WP4		WP5			WP6
X	*cognate/control* ***verb***	*det*	***noun***	*det*	***noun***	*prep*	*det*	***noun***	**.**
Na hun fietstocht,	drinken/schenken	the	boys	the	juice	from	the	bottle	.
Na hun fietstocht,	drinken/schenken	de	jongens	het	sap	uit	de	fles	.

Note: Sentences of this type always started in Dutch. The Dutch sentence onset reads "After their bicycle ride [the boys] drink/pour".

For each cognate verb, a control verb was selected that fitted in the same sentence context as the cognate verb (see Appendix). Cognates had been rated in terms of phonological overlap on a scale of 1 (no overlap) to 7 (perfect overlap) by 18 Dutch-English bilinguals; the mean rating for cognates in the SVO condition was 5.28 (SD = 0.90) and the mean rating for cognates in the XVSO condition was 5.06 (SD = 0.80). The mean ratings for non-cognates were 1.31 (SD = 0.25) in the SVO condition and 1.31 (SD = 0.39) in the XVSO condition. Ratings for cognates and non-cognates were significantly different for both sentence types (ps < .001), while cognates across the two sentence types did not differ (ts < 1). Orthographic overlap was measured in terms of Levenshtein distance, which showed a similar pattern with a smaller distance between translation equivalents for cognates in the SVO (M = 3.42, SD = 1.06) and XVSO (M = 3.31, SD = .87) conditions, and substantially more character changes for controls in the SVO (M = 6.29, SD = 1.52) and XVSO (M = 6.56, SD = 1.71) sentences. Target verbs were matched both within languages (cognates vs. controls) and between languages (Dutch vs. English), with respect to word length in syllables (although Dutch verbs were always at least one syllable longer due to a fixed –en suffix) and frequency (Baayen, Piepenbrock, & Gullikers, 1995; note that items were matched on general lemma frequency rather than spoken frequency, as the latter is not available for Dutch in CELEX). Independent samples t-tests indicated that cognate and control verbs in both the Dutch and English conditions did not differ from each other with respect to word frequency and word length (all ps > .10). A plausibility rating conducted after the experiment verified that cognates and non-cognates in both languages were considered to fit the sentence context equally well. A total of 32 Dutch-English bilinguals from the same participant pool were asked to rate the plausibility of either the cognate or the control word in the sentence context, such that each word received 16 ratings. A one-way analysis of variance (ANOVA) with four levels showed no difference between Dutch cognates (M = 5.28, SD = .64), Dutch controls (M = 4.98, SD = .67), English cognates (M = 4.93, SD = .59) and English controls (M = 4.86, SD = .83), $F_1(1, 60) = 1.14$, p = .339, $F_2(3, 124) < 1$.

All content words in the sentences other than the manipulated verbs were non-cognates; loan words were excluded too. Furthermore, noun translation equivalents in the Dutch and English sentences following the verb were matched across languages on word form frequency (all ps > .10). All target verbs as well as nouns immediately following the verb started with a plosive or fricative (/b, d, f, g, k, p, s, t, v, z/) in both English and Dutch in order to avoid problems due to co-articulation and acoustic reduction, so that their word onsets could easily be distinguished in the acoustic signal.

Conditions were counterbalanced across groups according to a Latin square design. Eight different lists were constructed, such that all combinations of cognate, switch and language manipulations appeared equally often across the lists. Each experimental list contained one version of each sentence.

For the recordings of the stimulus materials, a balanced Dutch-English bilingual male speaker who grew up with the two languages read the Dutch and English sentences aloud at an easy pace and in a well-articulated manner. All sentences were recorded multiple times in a soundproof studio with a Bruël & Kjaer 4006 Omnidirectional microphone, using a MOTU 828mk2 audio interface sampling monaurally with a 44.1 kHz frequency at 16 bit. The different versions of one sentence were recorded successively to ensure that pitch intonation patterns were as similar as possible. Native speakers of Dutch (N = 9) and English (N = 9) were asked to rate the accent of the speaker based on excised recordings of the Dutch and English cognate verbs on a scale of 1 (native, no foreign accent) to 10 (non-native, clear foreign accent). Dutch natives rated the Dutch productions as native-like (M = 2.00, SD = .71) and English natives likewise rated the English productions to be native-like (M = 1.78, SD = .83). An independent t-test showed no differences between the ratings in the two languages ($t < 1$).

After the recordings, all sentences were segmented and cross-spliced to form different versions of each sentence in accordance with our manipulations. For each sentence, eight SVO or four XVSO versions were created by splicing the initial part of a sentence (sentence onset up to the verb) with a verb and a continuation (from the verb to the sentence end). The silence between the offset of the constituent preceding the verb and the onset of the verb was kept constant at 160 ms for all sentences. Sentence parts were cut-off at and concatenated at zero crossings (amplitude 0 dB) to eliminate click sounds at the splicing position, which ensured that the sentences did not have any acoustic characteristics that rendered them detectable as manipulated speech. Similarly, silences were cut-off at the beginning and the end of the recording at zero crossings. Cross-spliced filler sentences were created by concatenating two different recordings of a filler sentence to avoid any audible differences between experimental and filler sentences.

Procedure

All participants were tested individually on a Windows XP Intel® Pentium® 4CPU computer. The experiment was run with Presentation software (www.neurobs.com). Participants were seated in a soundproof booth fitted with a DM-5000 LN Stage line microphone and a computer screen on which instructions were given. Stimuli were presented to the participant binaurally over Sennheiser HD 280 headphones. Outside the booth, the researcher monitored participants' performance and the recording volume over headphones. Audio recordings of the shadower's output were made on a separate computer using Cool-Edit Pro.

Prior to testing, participants were instructed that they would hear sentences that could contain a language switch from English to Dutch or vice versa. Participants were asked to start shadowing as soon as the first syllables of the sentence had been uttered. The instructions stressed that correct repetition of the auditorily presented sentence was important and that participants should not talk in chunks. At the beginning of the experiment, participants completed a 20-trial practice block, half of which contained a language switch, to familiarise themselves with the procedure. Subsequently, the 100 items were presented in five blocks that were separated by pauses.

Sentences were presented to the participant one by one, preceded by a high tone and a 1000 ms interval. Sentences were separated by a 5-s silence to allow shadowers to finish their sentence before the next one began. In between trials, participants were presented with an English ('Now repeat the next sentence') or Dutch ('Herhaal nu de volgende zin') fragment that cued the starting language of the subsequent trial, so as to eliminate possible switch costs between trials. Participants were instructed not to shadow this cue. The order of presentation of trials was pseudorandomised differently for each participant.

After completing the shadowing task, participants performed the Simon task (Simon & Rudell, 1967) and the Operation Span task (Turner & Engle, 1989) to measure their cognitive control skills. Participants were also tested on an English proficiency task, XLex (Meara, 2006). A complete session lasted approximately 60 minutes.

Results

Prior to analysing the data, shadowing performance was assessed. Data from four participants were removed from the data-set: One participant had to be discarded due to technical problems during recording, one participant failed to fully articulate words and two participants had latencies that were more than 2 z-scores above the participants' means. For the remaining 46 participants, shadowing latencies and accuracy were analysed.

In order to obtain shadowing latencies, participants' recordings were compared to the original speaker recordings, which was possible because signals had been recorded as two different audio tracks. We measured the delay of the shadowers' performance in comparison to the speaker's signal at the different WPs in the sentences identified in the acoustic signal (see Tables 1 and 2). For each WP, participant latencies were determined relative to the shadower's word onset by subtraction (e.g., Radeau & Morais, 1990; see also Schmidgen, 2005); for example, in order to determine the latency of the shadower's verb, the delay between the shadower's verb onset and the speaker's verb onset was measured. Prior to latency analyses, the onsets of the verb (WP2) and subsequent nouns (WP3, WP4; and for XVSO, WP5) were coded, as well as the sentence onset (WP1) and the offset of the sentence-final word (for SVO, WP5; for XVSO, WP6). Coding was done by the first author, based on auditory and visual inspection of the acoustic signal using PRAAT software (www.praat.org). About half of the data-set (22 participants) was also coded by a second coder. Inter-coder reliability turned out to be very high, evidenced by an average correlation of r = .98 over all data points (p <. 001).

Accuracy was evaluated based on speech errors, omissions and long pauses in sentence production. All sentences that were marked for one or more of these accuracy measures were discarded from the RT analyses as a whole because all latencies in a sentence were assumed to be interdependent. The SVO data yielded 13% incorrectly shadowed sentences overall, while the XVSO data generated 12% incorrectly shadowed sentences. Latencies above 2000 ms were considered outliers and removed from the data-set before analysis (2% of the SVO data-set and 1% of the XVSO data).

SVO and XVSO data were treated separately. A 2 × 2 × 2 ANOVA was performed on the response latencies and accuracy data with language (L1/L2), cognate status (yes/no) and language switch (yes/no) as within-subject factors for the participant analyses (F_1), and as between-subject factors in the item analyses (F_2) for the SVO data. Furthermore, we added L2 proficiency as a between-subject factor to all analyses. Participants were classified as either more or less proficient in L2 based on a median split of the XLex scores. More proficient English speakers (M = 4631, SD = 154) performed significantly better on the XLex task than the less proficient speakers (M = 3843, SD = 313), F(1, 44) = 120.15, p < .001. There were no differences between the more and less proficient groups in terms of cognitive control as measured by the Operation Span and Simon tasks (Fs < 1).

The SVO sentences' data-set contained five dependent variables for the RT data, which were latencies at different WPs in the sentence. Similar analyses, but without the factor language (as this was not manipulated) were performed on the XVSO data. For the latter sentence type, there were six dependent variables of response latency. We first tested for effects of language and switching, and then examined whether these effects were modulated by the presence of a cognate. Multivariate analyses (see Table 3) were conducted to test for effects of the language, cognate status and switching manipulations

Table 3. Multivariate tests on shadowing latencies.

		*F*1				*F*2				
Effect	Measure	df	*F*	*p*	η_p^2	df	*F*	*p*	η_p^2	Significance
SVO sentences										
Proficiency (Between subject)	WP1-5	5, 37	3.07	.021	.29	5, 357	35.78	.000	.33	**
Language	WP1-2	2, 40	16.23	.000	.45	2, 372	6.66	.001	.04	**
Proficiency × Language	WP 1-2	2, 40	<1			2, 372	<1			NS
Cognate	WP2	1, 41	<1			1, 369	<1			NS
Language × Cognate	WP2	1, 41	<1			1, 369	1.12	.291	.00	NS
Proficiency × Cognate	WP2	1, 41	2.54	.118	.06	1, 369	<1			NS
Language × Cognate × Proficiency	WP2	1, 41	2.20	.146	.05	1, 369	<1			NS
Switch	WP3-5	3, 39	9.13	.000	.42	3, 367	4.70	.003	.04	**
Language × Switch	WP3-5	3, 39	10.56	.000	.45	3, 367	6.58	.000	.05	**
Proficiency × Switch	WP3-5	3, 39	1.10	.375	.08	3, 367	<1			NS
Language × Switch × Proficiency	WP3-5	3, 39	<1			3, 367	<1			NS
Cognate × Switch	WP2-5	4, 38	<1			4, 358	<1			NS
Cognate × Switch × Proficiency	WP2-5	4, 38	<1			4, 358	<1			NS
Language × Cognate × Switch	WP2-5	4, 38	2.77	.041	.23	4, 358	1.29	.276	.01	*
Language × Cognate × Switch × Proficiency	WP2-5	4, 38	2.29	.077	.19	4, 358	<1			NS
Alternative switch calculation										
Switch (L1)	WP3-5	3, 41	21.04	.000	.61	3, 178	8.08	.000	.12	**
Switch × Proficiency	WP3-5	3, 41	<1			3, 178	1.60	.192	.03	NS
Switch (L2)	WP3-5	3, 40	<1			3, 179	<1			NS
Switch × Proficiency	WP3-5	3, 40	<1			3, 179	<1			NS
XVSO sentences										
Proficiency (between subject)	WP1-6	6, 39	2.35	.049	.27	6, 115	12.32	.000	.99	**
Cognate	WP2	1, 44	<1			1, 124	<1			NS
Cognate × Proficiency	WP2	1, 44	1.93	.172	.04	1, 124	<1			NS
Switch	WP3-6	4, 41	32.54	.000	.76	4, 121	12.33	.000	.29	**
Switch × Proficiency	WP3-6	4, 41	2.51	.056	.20	4, 121	<1			*
Cognate × Switch	WP2-6	5, 40	1.06	.400	.12	5, 116	<1			NS
Cognate × Switch × Proficiency	WP2-6	5, 40	1.22	.318	.13	5, 116	<1			NS

*Indicates trends towards significance; **indicates significance in both F1 and F2; NS stands for 'not significant'.

over WPs for which we had expectations about a certain effect, as well as interactions among those and interactions with the between-subject factor L2 proficiency. Based on significant effects in the multivariate tests, univariate ANOVAs for separate WPs were conducted using Bonferroni adjusted alpha levels per comparison (corrected p =.05/number of tests). Accuracy of shadowing performance, based on error-free sentence completions, was analysed for both types of sentence structure using univariate analyses. Outcomes for the analyses are reported in the text later; univariate statistics are presented in Tables 4 and 5.

SVO sentences

L2 proficiency

Multivariate analyses showed a main effect of the between-subject variable proficiency. Further univariate analyses over all WPs indicated that this effect was only significant at speech onset, with shorter latencies for more proficient speakers (M = 727, SE = 45) compared to less proficient speakers (M = 885, SE = 46) at WP1. The L2 proficiency factor did not show any significant interactions with the other manipulated factors in the latency data. A main effect of L2 proficiency was observed only in the item analysis over the accuracy data, with better performance for the more proficient speakers (M = 88%, SE = 1) compared to the less proficient speakers (M = 86%, SE = 2).

Language effects

A language effect was expected to occur in the first two WPs (WP1 and WP2), before the occurrence of the switch. Following a significant main effect of language in the multivariate analyses (see Table 3), univariate analyses revealed a significant effect of language only at WP2, indicating that sentences starting in L2 (M = 824, SE = 35) were shadowed slower than sentences starting in L1 (M = 764, SE = 34). There was no significant difference between shadowing in L1 and L2 at sentence onset at WP1 (see Figure 1 and Table 4). The language effect was paralleled by the accuracy data, which showed better performance for sentences starting in L1 (M = 90%, SE = 1) compared to those starting in L2 (M = 84%, SE = 2; see Table 5). The effect of language did not interact with proficiency in either the latency or the accuracy data.

Switch effects

An effect of language switching was observed in analyses over the last three WPs from the onset of the switch (WP3) until the sentence end (WP5; see Table 3). Shadowing latencies at WP3 showed slower processing for sentences containing a switch (M = 892, SE = 34) than those without a switch (M = 823, SE = 33). WP4 similarly showed significantly longer latencies for switched constituents (M = 919, SE = 34) compared to constituents that continued in the same language (M = 874, SE = 33). A significant difference between sentences containing a switch (M = 969, SE = 37) and those without a switch (M = 927, SE = 35) was also present at WP5 (see Table 4).

Furthermore, analyses yielded an interaction between language and switching after the first switched word, at WP4 and WP5. Follow-up analyses on WP4 and WP5 indicated that a significant effect of switching was present only for sentences starting in L1. Shadowing latencies revealed a cost for switches to L2 (M = 910, SE = 34) compared to non-switches (M = 819, SE = 33) at WP4. A similar significant difference was observed between switches in the L1–L2 direction (M = 961, SE = 36) and non-switches (M = 869, SE = 36) at WP5. For the sentences starting in L2, there was no significant difference in latencies between switches to L1 (M = 928, SE = 37) and non-switches (M = 928, SE = 37) at WP4 and for latencies of switches (M = 977, SE = 40) and non-switches (M = 985, SE = 38) at WP5 (see Figure 1 and Table 4). Note that the present analysis reflects a comparison based on a similar sentence onset (i.e., the WPs in the switch and non-switch conditions follow a sentence onset that overlapped between the conditions). Based on the four conditions shown in Figure 1, an alternative comparison can be made too. A comparison based on the same response language following the switch (i.e., shadowing in L1 in the non-switch condition compared to shadowing in L1 following a switch from L2 to L1) yields larger costs in L1 (difference WP3: 146 ms, WP4: 114 ms, WP5: 115 ms) compared to L2 (difference WP3: –5 ms, WP4: –17 ms, WP5: –23 ms). Analyses for the L1 comparison showed significant switch costs for WP3, WP4 and WP5, whereas the L2 comparison showed no effect of switch cost (see Tables 3 and 4). Similar to the other switch cost calculation, there were interaction effects with L2 proficiency.

The accuracy data yielded a marginally significant effect of switching in the participant analysis (see Table 5), which indicated better performance on sentences without a switch (M = 90%, SE = 2) than on sentences containing a switch (M = 86%, SE = 2). This effect was not significant in the item analysis. There was no language by switching interaction in the accuracy data (see Table 5). The switch effects in the latency and accuracy data were also not modulated by proficiency.

Cognate effects

Shadowing latencies showed no cognate effect at the WP manipulated for cognate status: Mean latencies at WP2 were not different for cognates (M = 793, SE = 34) and non-cognates (M = 796, SE = 35) and there was no interaction with language (see Table 3). The accuracy data

Table 4. Univariate tests on shadowing latencies.

		F_1					F_2						
Effect	Measure	df	*MSE*	*F*	*p*	η_p^2	df	*MSE*	*F*	*p*	η_p^2	corr. *p*	Significance
SVO sentences													
Proficiency	WP1	1, 41	356,747.54	6.00	.019	.13	1, 361	36,144.53	126.29	.000	.26	.010	*
	WP2	1, 41		<1			1, 361	43,049.04	29.38	.000	.08	.010	*
	WP3	1, 41		<1			1, 361	45,469.30	6.70	.010	.02	.010	*
	WP4	1, 41		<1			1, 361	51,027.83	<1			.010	NS
	WP5	1, 41		<1			1, 361	55,469.08	<1			.010	NS
Language	WP1	1, 41	15,681.55	1.13	.293	.03	1, 373		<1			.025	NS
	WP2	1, 41	17,895.00	17.37	.000	.30	1, 373	42,655.41	6.39	.012	.02	.025	**
Switch	WP3	1, 41	15,825.79	25.83	.000	.39	1, 369	45,121.65	12.99	.000	.03	.017	**
	WP4	1, 41	16,337.37	10.88	.002	.21	1, 369	50,333.79	8.21	.004	.02	.017	**
	WP5	1, 41	16,285.23	9.53	.004	.19	1, 369	54,895.51	6.53	.011	.02	.017	**
Language × Switch	WP3	1, 41		<1			1, 369		<1			.017	NS
	WP4	1, 41	18,923.13	9.55	.004	.19	1, 369	50,333.79	2.18	.141	.01	.017	*
	WP5	1, 41	19,457.76	11.15	.002	.21	1, 369	54,895.51	2.97	.086	.01	.017	*
Language × Cognate × Switch	WP2	1, 41	10,113.31	9.05	.004	.18	1, 361	43,049.04	4.20	.041	.02	.013	*
	WP3	1, 41	12,693.12	3.78	.059	.08	1, 361	45,469.30	2.23	.136	.01	.013	NS
	WP4	1, 41	18,823.00	1.23	.274	.03	1, 361	51,027.83	1.44	.230	.00	.013	NS
	WP5	1, 41	16,732.66	2.23	.143	.05	1, 361	55,469.08	1.69	.195	.01	.013	NS
Language × Cognate × Switch × Proficiency	WP2	1, 41		<1			1, 361		<1			.013	NS
	WP3	1, 41		<1			1, 361		<1			.013	NS
	WP4	1, 41		<1			1, 361		<1			.013	NS
	WP5	1, 41	16,732.66	1.30	.260	.03	1, 361		<1			.013	NS
Alternative switch cost calculation													
Switch (to L1)	WP3	1, 43	14,928.23	64.26	.000	.60	1, 180	46,351.88	21.98	.000	.11	.017	**
	WP4	1, 43	12,765.76	45.48	.000	.51	1, 180	51,700.22	15.09	.000	.08	.017	**
	WP5	1, 43	13,271.41	44.76	.000	.51	1, 180	58,013.59	11.86	.000	.06	.017	**
SVO follow-up analyses to examine interaction effects													
L2: Switch	WP4	1, 44		<1			1, 183		<1			.025	NS
	WP5	1, 44		<1			1, 183		<1			.025	NS
L1: Switch	WP4	1, 44	13,390.98	31.53	.000	.42	1, 186	42,418.20	11.28	.001	.06	.025	**
	WP5	1, 44	13,600.31	32.49	.000	.43	1, 186	45,627.98	11.10	.001	.06	.025	**
L2: Cognate × Switch	WP2	1, 41	9747.24	2.16	.150	.05	1, 179	46,064.83	1.21	.272	.01	.050	NS
L1: Cognate × Switch	WP2	1, 44	15,966.89	7.55	.009	.15	1, 182	40,082.97	3.34	.069	.02	.050	*
L1 Cognates: Switch	WP2	1, 44	8821.58	7.36	.009	.14	1, 91	35,413.06	3.29	.073	.04	.050	**
L1 Non-cognates: Switch	WP2	1, 44	14,288.37	2.57	.116	.06	1, 91		<1			.050	NS
XVSO sentences													
Proficiency	WP1	1, 44	170,849.86	4.28	.045	.09	1, 124	14,052.37	39.15	.000	.24	.008	*
	WP2	1, 44		<1			1, 124	14,175.07	6.73	.011	.05	.008	NS
	WP3	1, 44		<1			1, 124		<1			.008	NS
	WP4	1, 44		<1			1, 124	18,878.54	1.44	.233	.01	.008	NS
	WP5	1, 44	202,116.82	1.60	.213	.04	1, 124	19,768.65	6.26	.014	.05	.008	NS
	WP6	1, 44	235,429.98	1.76	.192	.04	1, 124	25,084.36	8.30	.005	.06	.008	*

Table 4 (*Continued*)

Effect	Measure	F_1					F_2						
		df	*MSE*	*F*	*p*	η_p^2	df	*MSE*	*F*	*p*	η_p^2	corr. *p*	Significance
Switch	WP3	1, 44		<1			1, 124		<1			.013	NS
	WP4	1, 44	11,785.77	13.54	.001	.24	1, 124	18,878.54	9.18	.003	.07	.013	**
	WP5	1, 44	19,066.87	12.87	.001	.23	1, 124	19,768.65	11.53	.000	.09	.013	**
	WP6	1, 44	19,746.60	34.57	.000	.44	1, 124	25,084.36	25.57	.000	.17	.013	**
Switch × Proficiency	WP3	1, 44	9009.56	2.99	.091	.06	1, 124		<1				
	WP4	1, 44	11,785.77	1.07	.306	.02	1, 124		<1				
	WP5	1, 44	19,066.87	1.55	.220	.03	1, 124		<1				
	WP6	1, 44	19,746.60	3.24	.079	.07	1, 124		<1				

Note: L1 and L2 indicate the language spoken at the start of the sentence.
*Indicates trends towards significance; **indicates significance in both F1 and F2; NS stands for 'not significant'. Significance is determined by Bonferroni corrections (0.05/number of tests) given in the column corrected *p*.

Table 5. Univariate tests on accuracy.

Effect	Dataset	F_1					F_2					
		df	*MSE*	*F*	*p*	η_p^2	df	*MSE*	*F*	*p*	η_p^2	Significance
SVO												
Proficiency	ACC	1, 44	422.24	1.36	.250	.03	1, 361	270.57	5.15	.024	.01	*
Language	ACC	1, 44	434.03	8.81	.005	.17	1, 361	270.57	6.60	.011	.02	**
Language × Proficiency	ACC	1, 44		<1			1, 361	270.57	2.44	.119	.00	NS
Cognate	ACC	1, 44		<1			1, 361		<1			NS
Language × Cognate	ACC	1, 44		<1			1, 361		<1			NS
Proficiency × Cognate	ACC	1, 44		<1			1, 361	270.57	4.05	.045	.01	*
Language × Cognate × Proficiency	ACC	1, 44	460.57	1.15	.290	.03	1, 361		<1			NS
Switch	ACC	1, 44	426.87	3.91	.054	.08	1, 361	270.57	1.24	.267	.00	*
Cognate × Switch	ACC	1, 44		<1			1, 361		<1			NS
Switch × Cognate × Proficiency	ACC	1, 44		<1			1, 361		<1			NS
Switch × Proficiency	ACC	1, 44		<1			1, 361		<1			NS
Language × Switch	ACC	1, 44	434.50	1.83	.183	.04	1, 361		<1			NS
Language × Switch × Proficiency	ACC	1, 44		<1			1, 361		<1			NS
Language × Cognate × Switch	ACC	1, 44		<1			1, 361		<1			NS
Language × Cognate × Switch × Proficiency	ACC	1, 44	307.11	1.07	.306	.02	1, 361		<1			NS
SVO follow-up analyses to examine interaction effects												
More proficient: Switch	ACC	1, 23		<1			1, 185	217.63	1.42	.234	.01	NS
Less proficient: Switch	ACC	1, 21		<1			1, 188	324.96	2.71	.102	.01	NS
XVSO												
Proficiency	ACC	1, 44		<1			1, 120		<1			NS
Cognate	ACC	1, 44		<1			1, 120		<1			NS
Cognate × Proficiency	ACC	1, 44		<1			1, 120					NS
Switch	ACC	1, 44	319.29	2.31	.136	.05	1, 120	217.45	1.48	.226	.01	NS
Switch × Proficiency	ACC	1, 44		<1			1, 120		<1			NS
Cognate × Switch	ACC	1, 44		<1			1, 120		<1			NS
Cognate × Switch × Proficiency	ACC	1, 44		<1			1, 120		<1			NS

*Indicates trends towards significance; **indicates significance in both F1 and F2; NS stands for 'not significant'.

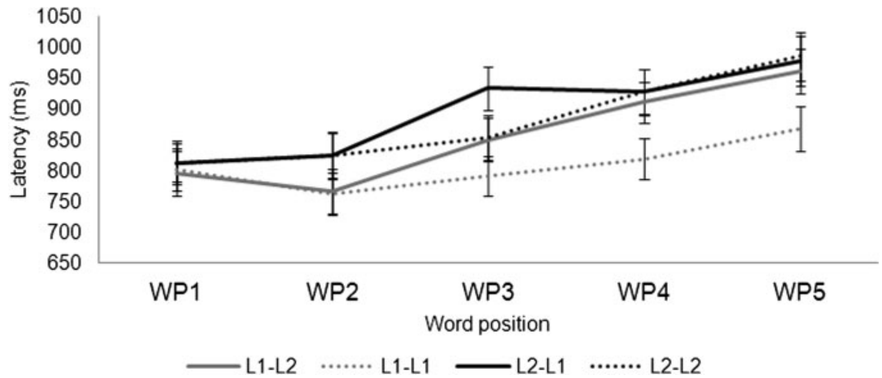

Figure 1. Mean latencies of switched and non-switched SVO sentences in L1 and L2 (+*SE*); switches occurred at WP3.

showed an interaction between cognate status and proficiency, which was only significant in the analysis over items. Follow-up analyses showed that the cognate effect was neither significant for the more proficient nor for the less proficient L2 speakers. No other effects of the presence of a cognate were observed in the accuracy data (see Table 5). Neither the latency nor the accuracy data showed an interaction between cognate status and proficiency or language.

We also examined effects of cognate status on shadowing latencies on WPs from the cognate (WP2) onwards till the end of the sentence (WP5). Multivariate tests for the shadowing latencies showed a three-way interaction between cognate, language and switch in the analysis over participants (see Table 3). The four-way interaction including the proficiency factor was not significant. Univariate tests indicated that the three-way interaction was significant in the participant analysis for WP2. After applying the Bonferroni correction, this interaction was no longer significant in the item analysis. The three-way interaction was not significant at later positions in the sentence. Follow-up analyses on WP2 indicated that the cognate by switching interaction was significant for the sentences that started in L1 in the analysis over participants, and marginally significant in the analysis over items. The two-way interaction was not significant for sentences that had started in L2. Further examination of the cognate by switch interaction in the L1 sentences showed that L1 sentences containing a cognate yielded a switch cost (47 ms), while L1 sentences with a non-cognate showed a non-significant effect in the other direction (−40 ms; see Figure 2A). Concerning this switch cost following L1 cognates (in comparison to non-cognates), it must be noted that a difference in that direction was already present from the start (see Figure 2A). *T*-tests on WP1 in the L1–L2 condition confirmed that the difference between cognate and non-cognate sentences in the switch condition was present at sentence onset [$t(45) = 2.57$, $p < .05$]. An additional analysis showed that once speech latencies were corrected for differences at WP1, by subtracting the value of WP1 from all other latencies, the cognate modulation disappeared. Corrected values showed no difference between cognate and non-cognate conditions for either switch and non-switch sentences, while the effect of language switching remained. This implies that the interaction effect found at WP2 is probably a carryover effect from the difference at WP1. The three-way interaction was not present in the accuracy data nor was the four-way interaction (see Table 5).

XVSO sentences

Proficiency effects

Multivariate analyses indicated a significant main effect of the between-subject variable L2 proficiency. Univariate analyses over all WPs showed this effect to be significant only at speech onset, with shorter latencies at WP1 for more proficient speakers ($M = 726$, $SE = 42$) than less proficient speakers ($M = 852$, $SE = 44$). There was no effect of proficiency on the accuracy data.

Switch effects

Switch costs were predicted for WP3–WP6. The latency analyses first indicated an effect of language switching at WP4, the second word after the switch onset (see Figure 2C), with longer latencies for switches ($M = 869$, $SE = 29$) compared to non-switches ($M = 810$, $SE = 33$). A similar difference between switches ($M = 921$, $SE = 31$) and non-switches ($M = 848$, $SE = 38$) was present at WP5 and WP6 likewise showed a difference between switches ($M = 990$, $SE = 33$) and non-switches ($M = 868$, $SE = 41$; see Table 4). A numeric switch effect was also present in the accuracy data, with better performance on the non-switch sentences ($M = 90\%$, $SE = 2$) than the switch sentences ($M = 86\%$, $SE = 2$), but this was not significant (see Table 5). The switch effect showed an interaction with proficiency that was marginally significant in the multivariate participant analysis over latencies. Subsequent univariate analyses, however, did not show significant interaction effects at any of the WPs. There

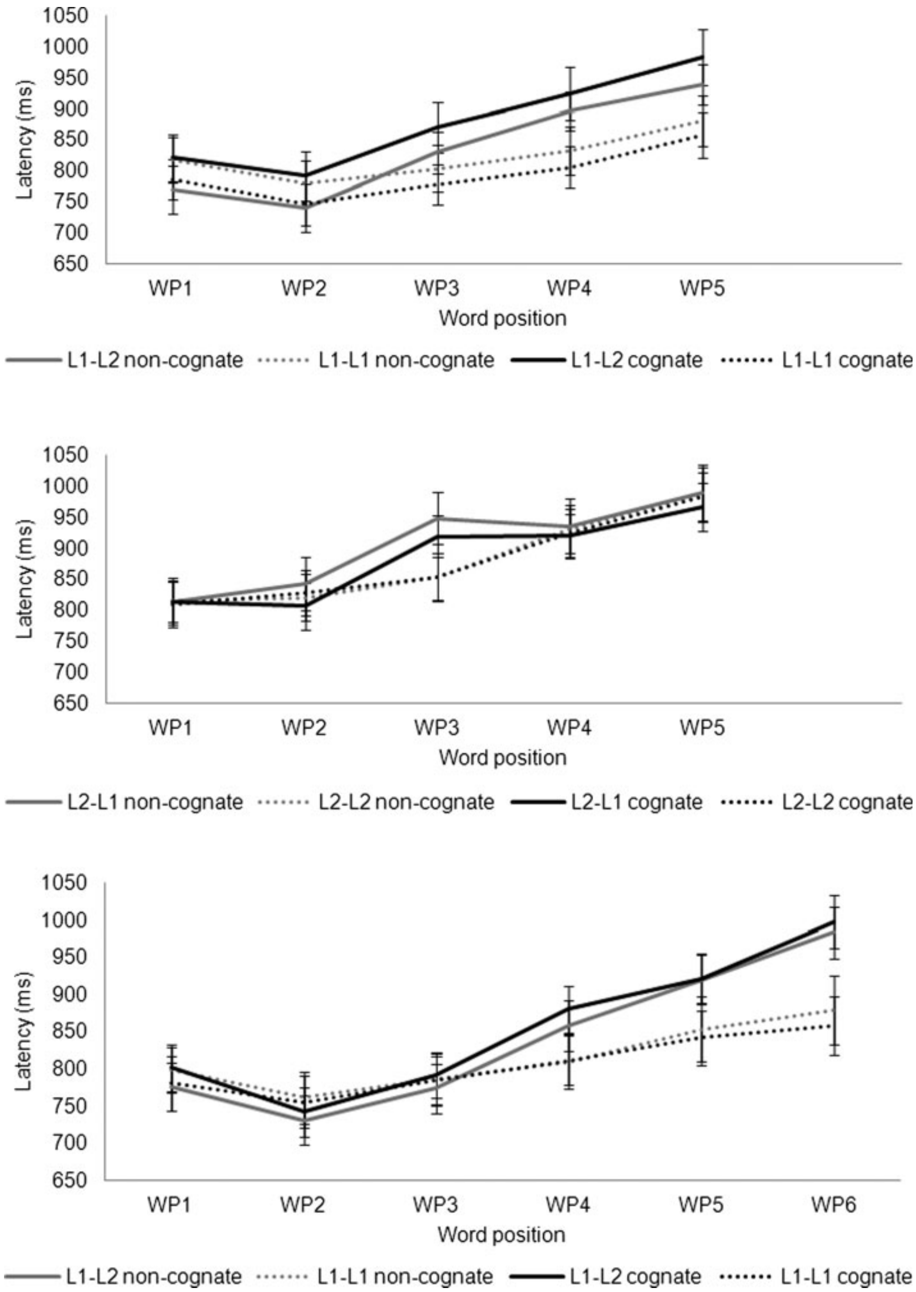

Figure 2. Mean latencies of switched and non-switched sentences containing a cognate or control verb (+*SE*); WP2 was manipulated for cognate status and switches occurred at WP3. Panel A reflects SVO sentences starting in L1, panel B shows SVO sentences starting in L2, and panel C displays XVSO sentences starting in L1.

was also no significant interaction effect in the accuracy data.

Cognate effects

Shadowing latencies showed no effects of cognate status in the data at any position in the sentence in the multivariate analyses, neither as a main effect nor in interaction with language switching (see Table 3). There were also no effects of cognate status in the accuracy data (see Table 5).

Discussion

Using a shadowing task, we examined whether verb cognates influence processing of subsequent language switches in sentence context, and if these effects are influenced by switching direction and cross-linguistic overlap in syntactic structure. We hypothesised that, because a cognate activates representations in two languages, a subsequent switch to the co-activated language should be facilitated compared to a language switch preceded by a non-cognate control.

The speech latencies of language non-specific SVO sentences showed a cost in both switching directions, albeit different in magnitude; switches from L1 to L2 were more costly than those from L2 to L1. Accuracy data also indicated a switch cost, which was similar in both switching directions. The latencies for SVO sentences showed an effect of language: Shadowing in L2 was slower and more often subject to errors than shadowing in L1, suggesting that lexical processing in L2 is more taxing than in L1. The difference between non-switched L1 and L2 sentences numerically increased in the course of the sentence, which could suggest that the language effect is in part due to integrative processes that are also more demanding in L2. There were no effects of the presence of a verb cognate in L1 and L2 sentences, irrespective of the presence of a language switch in the sentence. Similar to the SVO sentences, language-specific XSVO sentences showed a cost for switches in L1–L2 direction, which was not modulated by the presence of a cognate. Hence, switch cost were not shown to be affected by the syntactic structure of the sentence. Finally, overall, the shadowers' L2 proficiency affected the latencies at speech onset but did not influence the processing of cognates and switches.

Asymmetric switch costs depending on language dominance

Corresponding to previous findings on languages switching in sentence context (Proverbio et al., 2004), the latencies in our study revealed asymmetric switch costs associated with language switching for SVO sentences. Switch costs from L2 to L1 in the overlapping syntactic construction were short-lived, only showing an effect at the first switched WP; in the remainder of the sentence, shadowing latencies were just as fast as sentences that had continued in L2. In contrast, L1–L2 switches for language non-specific as well as language-specific syntactic structures showed a long-lasting slowing of responses, which persisted throughout the sentence. It is not clear why the onset of the switch cost occurred only after the first switched WP for XVSO sentences.

The asymmetry seemed to indicate an effect of language dominance, given that costs of switching to the non-dominant L2 were bigger than costs for switches to the dominant L1. This is consistent with the finding of a language dominance effect indicated by latencies at WP2 in the SVO sentences. When participants shadowed lexical items in their first language, they were consistently faster than when they shadowed items in their second language (see also Treisman, 1965). The language effect and the continued slowdown in latencies for L1–L2 switches after the initial switch both showed that processing in L1 was easier than processing in L2 for these unbalanced bilinguals. Similar results were recently obtained in a comparable self-paced reading studies that tested for effects of switch costs in both language directions (Bultena et al., 2014b; see also Van Hell, Litcofksy, & Ting, in press; Van Hell & Witteman, 2009).

An alternative approach to calculating switch costs based on the response language (see Figure 1) showed that switching to L1 yielded a cost compared to continuing in L1, whereas switching to L2 did not differ from continuing in L2. Note that this way of calculating switch costs is similar to the approach used in picture naming, where switch trials are compared to non-switch trials in the same language (e.g., Meuter & Allport, 1999). This alternative analysis is in contrast to the findings reported earlier, but need not give the best reflection of the effect that language switching has in sentences because of differences in baselines prior to the switch. Given that subsequent latencies are interdependent, a non-overlapping sentence structure can give a distorted picture of the data. This means that the L1 switch cost is much larger because non-switch sentences in L1 are shadowed much faster from the beginning and the L2 switch cost disappears because non-switch sentences in L2 are slower at the beginning of the sentence (even slower than the switch condition). We therefore think that the analysis based on comparable sentence onsets is a more appropriate approach to sentence data.

Cognates affecting switch costs

The shadowing latencies indicated no effect of the presence of a verb cognate on processing of language switches in sentences, neither in L1 nor L2. The numeric effect for L2–L1 switches concerning an interaction between cognate processing and switch costs (as suggested in Figure 2) was not borne out in the reported analyses. The absence of a modulating effect of cognate processing on switch costs co-occurred with a lack of main effects of cognate facilitation at the position of the verb in both L1 and L2; this may well explain why switch costs were not attenuated by the presence of verb cognates. Studies examining cognate processing typically use nouns as their stimulus materials, and cognate facilitation is generally observed for such nouns in L2 comprehension (see Dijkstra, 2005), as well as L2 production (e.g., Costa et al., 2000). The present study, however, showed no sign of cognate effect for verbs, but this null effect for verb cognates is in line with several recent studies that examined verb cognate effects in sentence context (Bultena et al., 2014a, 2014b; Van Assche, Duyck, & Brysbaert, 2013). These studies also showed limited cognate facilitation effects for verbs when embedded in a sentence, a finding that has been related to the reduced cross-linguistic overlap for verb cognates in comparison to noun cognates. Alternatively, it could be argued that the power of the present study was low given the number of manipulations and too low to detect a verb cognate effect regarding the size of the switch cost. However, post-hoc power analyses on WP2 and WP3 for the cognate vs. control conditions in the L2–L1 switching direction showed that adding more participants would not yield a significant difference between the cognate and control conditions.

Contrary to our predictions, L1 cognates in language non-specific sentences in the present study seemed to yield larger switch costs than in the non-cognate condition. Yet, the difference in latencies prior to the occurrence of the cognate can explain the effect found at later positions. This renders the modulating effect in the L1–L2 sentences likely to be spurious. What caused the difference at sentence onset is unclear. Because the participants generally started shadowing before the speaker pronounced the verb, it seems unlikely that the presence of a cognate in a sentence influenced their speech onset time (i.e., their latency at WP1).The absence of a cognate effect in L1 can be related to a growing body of evidence showing that cognate effects in L1 processing are generally much smaller than in L2 processing (see Brenders et al., 2011; Christoffels et al., 2007; Costa et al., 2000; Poarch & Van Hell, 2012; Van Assche, Duyck, Hartsuiker, & Diependaele, 2009; Van Hell & Dijkstra, 2002). The cognate effects in L1 may simply not be strong enough to affect switch costs.

There were no differences regarding the cognate effect for sentences with overlapping syntactic structures and non-overlapping structures, indicating that a shared word order did not influence cross-linguistic activation in the present study (but see Gullifer et al., 2011, for different findings). Overall, the pattern of results thus leads to the conclusion that verb cognates do not modulate switch costs in either switching direction.

To some extent, the lack of a cognate effect also seems to be in line with findings reported by Ibáñez et al. (2010), who showed that co-activation and language switch costs did not occur simultaneously in visual comprehension of sentences. In their study, the lack of a cognate effect can be attributed to the influence of the language control necessary to perform the task. Due to the occurrence of a language switch, participants could have inhibited the non-target language to such an extent that co-activation no longer emerged. Similarly, in our task it could be argued that shadowing of sentences containing language switches was highly demanding and requires precise language control. This could have had an influence on the amount of cross-linguistic effects. However, the non-switch sentences suggest that the lack of a cognate effect could also be interpreted otherwise. The null effect in non-switch sentences suggests that verb cognates may not have been strong enough to show any cognate facilitation, and hence did not affect processing of switches. Furthermore, relative to visual processing, the auditory context as well as the produced speech in our study could be argued to be more language-specific due to phonetics, which may also explain the absence of cognate effects.

The origin of language switch costs

So far we have seen that switch costs depend on the switching direction, which can be related to relative language proficiency, but are not reduced by the presence of a verb cognate. What does this tell us about the locus of language switch costs? In order to unravel the source of switch costs, it is important to consider the task and processing involved with it. The larger switch costs in the L1–L2 direction we observed in the present sentence paradigm differ from the larger switch costs observed in the L2–L1 direction in studies involving picture or number naming (e.g., Costa & Santesteban, 2004; Meuter & Allport, 1999). Therefore, an explanation for switch costs in terms of the inhibitory control mechanism, which is predominantly associated with cued naming, does not seem to apply to the shadowing data. Although shadowing involves speaking, the processing involved is different from that in naming and other forms of language production. Whereas picture naming indisputably requires lexical selection to the full, involving a top-down process starting from a concept all the way to the articulatory output (see also Chauncey et al., 2008), shadowing may bypass some of the stages of the production process. Given that a shadowing response could be considered to reflect lexical retrieval based on a mere repetition of the input signal, the stage of lexical selection on the basis of a concept does not seem necessary (see also Christoffels & De Groot, 2004 on the amount of semantic processing involved in shadowing). This implies that inhibition, assumed to be present during lexical selection, may not be required either.

Another difference between picture naming and shadowing pertains to the language specificity of the codes: The pictures in naming tasks contain an abstract cue that is not explicitly language-specific, whereas the acoustic signal in the shadowing task is language-specific in terms of its phonetics. The opposite asymmetry in shadowing can thus be explained by processing aspects that distinguish shadowing from naming, including the absence of having to choose amongst candidates of different languages and the available explicit language information. This results in activation that is to a large extent driven by the incoming stimulus. Therefore, switching to the weaker L2, of which the lexical form and phonetic codes are less often used, is more difficult than switching to the more frequently activated L1.

The pattern observed here in shadowing corresponds to comprehension studies examining switches embedded in meaningful sentences (see Van Hell & Witteman, 2009). These have previously been shown to generate larger switch costs in the L1–L2 direction due to differences in activation levels of lexical items in both languages (see also Bultena et al., 2014b). As argued in recent reviews (Van Hell, Kootstra, & Litcofsky, accepted; Van Hell et al., in press), the mechanisms underlying processing of language switched words in sentence context and switched items that are unrelated and presented in isolation are likely to differ, related to syntactic and semantic integration that only sentence processing requires. Given the resemblance of the pattern of results of the sentence shadowing task and other sentence reading tasks (Bultena et al., 2014b; see also Van Hell et al., in press) and the role of comprehension in the shadowing task, we propose that the cost observed in shadowing actually arose during the auditory comprehension phase.

Although cognates provide no evidence for a lexical origin of switch costs, the finding that the switch cost asymmetry reflects language effect does point in that direction. Lexical activation is easier in L1 than in L2, which can explain why switch costs are smaller in the L2–L1 direction. The present data therefore could suggest that switch costs originate, at least to some extent, from the lexicon (see Della Rosa, 2011; Van Der Meij et al., 2011). Further evidence that costs are language-specific pertains to aspects of articulation that play a role during language production in a bilingual sentence task. Aside from switching between lexical subsets, speakers also need to switch in terms of articulation. Therefore, the cost associated with language switching in language production need not stem from the word level alone. Switch costs in speech could in part be due to changing of language-specific phonetics and phonology in order to make an articulatory switch (see Philipp & Koch, 2011).

All in all, the shadowing latencies presented here provide no clear evidence that switch costs in sentences can be modulated at the word form level by the inclusion of verb cognates. The present results do indicate that for unbalanced bilinguals, switch costs in sentence context are dependent on language proficiency and may therefore originate in part from the lexical level.

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Appendix

SVO sentences (Sentence a in Dutch is a direct translation of sentence b in English)

1	a	De boze onderzoekers BELOVEN/PUBLICEREN een herziening van hun stuk.
	b	The angry scientists PROMISE/PUBLISH a revision of their piece.
2	a	De ervaren schilders TEKENEN/SCHETSEN de bloemen van een afstand.
	b	The skilled painters DRAW/SKETCH the flowers from a distance.
3	a	De eenzame jongens DELEN/BOEKEN een kamer tijdens hun vakantie.
	b	The lonely boys SHARE/BOOK a room during their holidays.
4	a	De gespierde bewakers VERNIELEN/TESTEN de bankjes buiten het gebouw.
	b	The muscular guards DESTROY/TEST the benches outside the building.
5	a	De kleine meisjes PASSEN/CREËREN een jurk van zwarte stof.
	b	The small girls FIT/CREATE the dress made of black fabric.
6	a	De slimme verkopers BESCHADIGEN/PARKEREN de auto op het plein.
	b	The clever salesmen DAMAGE/PARK the car on the square.
7	a	De bezorgde ouders TROOSTEN/KALMEREN de peuter na de botsing.
	b	The concerned parents COMFORT/CALM the toddler after the crash.
8	a	De gezonde arbeiders KAPPEN/PLANTEN de boom achter de boerderij.
	b	The healthy workers CUT/PLANT the tree behind the farm.
9	a	De trotse tandartsen BEWIJZEN/SIGNALEREN een fout in de behandeling.
	b	The proud dentists PROVE/SIGNAL a mistake in the treatment.
10	a	De beroemde schoonheden VERVELEN/MOTIVEREN hun klanten op het feest.
	b	The famous beauties BORE/MOTIVATE their customers at the party.
11	a	De snelle leerlingen FIETSEN/ZWEMMEN de afstand zonder pauze.
	b	The fast pupils CYCLE/SWIM the distance without a break.
12	a	De vermomde ridders DRAGEN/BRENGEN het slachtoffer naar de stadsmuur.
	b	The disguised knights CARRY/BRING the victim to the city wall.
13	a	De werkloze verkopers STEUNEN/STARTEN de jacht op de wasbeer.
	b	The unemployed salesmen SUPPORT/START the hunt for the raccoon.
14	a	De vermoeide zusters VERVANGEN/STELEN de kussens tijdens hun dienst.
	b	The tired nurses CHANGE/STEAL the pillows during their shift.
15	a	De vervelende reizigers PLAGEN/FILMEN de vrouwen met hun mobieltjes.
	b	The annoying travellers TEASE/FILM the women with their cell phones.
16	a	De huidige voorzitters TELLEN/VERWELKOMEN de vreemdelingen op de bijeenkomst.
	b	The current chairmen COUNT/WELCOME the strangers at the meeting.
17	a	De buurtbewoners BENADRUKKEN/TOLEREREN de overlast van de relschoppers.
	b	The local residents STRESS/TOLERATE the trouble caused by the troublemakers.
18	a	De dwaze brandweerlieden BELONEN/STIMULEREN het besluit van hun neven.
	b	The foolish fire fighters REWARD/STIMULATE the decision of their cousins.
19	a	De onzekere dames ZETTEN/BREKEN de spiegel op hun bureau.
	b	The insecure ladies PUT/BREAK the mirror on their desk.
20	a	De ongeruste tantes STUREN/DONEREN veel truien aan het weeshuis.
	b	The worried aunts SEND/DONATE many sweaters to the orphanage.
21	a	De zwangere vrouwen KRUIDEN/KOKEN de aardappelen met veel zout.
	b	The pregnant women SPICE/COOK the potatoes with a lot of salt.
22	a	De vermoeide spelers VERPESTEN/GEVEN hun voorstelling op het strand.
	b	The tired players SPOIL/GIVE their performance on the beach.
23	a	De drukke schrijvers VERZAMELEN/SORTEREN de gedichten zonder te klagen.
	b	The busy writers COLLECT/SORT the poems without complaining.
24	a	De eerlijke leden BEPALEN/FINANCIËREN the purchase of the fridge.
	b	The honest members PAY/FINANCE de aankoop van de koelkast.

XVSO sentences (Sentence a in Dutch is a direct translation of sentence b in English; in the experiment, the onset of sentence b was identical to that of sentence a)

1	a	Tijdens het eten, PRESENTEREN/VERKOPEN de kunstenaars hun schilderijen aan het publiek.
	b	[After dinner,] SELL/PRESENT the artists their paintings to the audience.
2	a	Kort na de stroomstoring, VERRASSEN/CONFRONTEREN de chirurgen hun vrouwen met hun beslissing.
	b	[Shortly after the power failure,] SURPRISE/CONFRONT the surgeons their wives with their decision.
3	a	Na hun fietstocht, SCHENKEN/DRINKEN de jongens het sap uit de fles.
	b	[After their bike trip,] POUR/DRINK the boys the juice from the bottle.
4	a	Tijdens de zitting, VEROORDELEN/CITEREN de rechters de aangeklaagde zonder medelijden.
	b	[During the hearing,] JUDGE/CITE the judges the accused without pity.
5	a	Tijdens de taalles, VERTALEN/FORMULEREN de meisjes een zin in het Duits.
	b	[During the language lesson,] TRANSLATE/FORMULATE the girls a sentence in German.
6	a	Bij zonsopgang, EINDIGEN/BEGINNEN deze mensen hun werkzaamheden op het platteland.
	b	[At sunrise,] FINISH/BEGIN these people their duties in the countryside.
7	a	Volgens hun vrouwen, BEWAREN/VERSPILLEN deze boeren hun voorraad voor het vee.
	b	[According to their wives,] SAVE/SPILL these farmers their supplies for the cattle.
8	a	Met veel moeite, KOPEN/BAKKEN de vrouwen een taart zonder eieren.
	b	[With a lot trouble,] BUY/BAKE the women a pie without any eggs.
9	a	Tijdens het afscheidsfeest, SPELEN/ZINGEN de docenten een lied uit de jaren negentig.
	b	[During the goodbye party,] PLAY/SING the teachers a song from the nineties.
10	a	Tijdens het uitje, VERLEIDEN/KUSSEN de bazen de schoonmakers in de kroeg.
	b	[During the outing,] SEDUCE/KISS the chiefs the cleaners in the pub.
11	a	Tijdens de vakantie, KRIJGEN/VINDEN de leerlingen een vogel met een grote snavel.
	b	[During the holidays,] GET/FIND the pupils a bird with a large beak.
12	a	Vlakbij het dorp, BELLEN/GROETEN de wandelaars de boer uit het dorp.
	b	[Close to the village,] CALL/GREET the hikers the farmer from the village.
13	a	Ondanks het vredesverdrag, BEZITTEN/PRODUCEREN deze burgers kogelvrije kleding van glasvezel.
	b	[Despite the peace treaty,] POSSESS/PRODUCE these citizens bulletproof clothes from fibreglass.
14	a	Tijdens hun reis, VERZINNEN/VERTELLEN de verkopers een verhaal over hun hond.
	b	[During their journey,] MAKE UP/TELL the salesmen a story about their dog.
15	a	Op het strand, TREKKEN/ZIEN de zeelui een paard met een kar.
	b	[At the beach,] PULL/SEE the sailors a horse with a wagon.
16	a	Na het optreden, STRAFFEN/SELECTEREN de leraren de leerlingen zonder duidelijke reden.
	b	[After the performance,] PUNISH/SELECT the teachers the pupils without a clear reason.