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Lexical access in spoken word production by bilinguals: evidence from the semantic competitor priming paradigm*

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The competitive nature of the lexical selection process during spoken word production is well established in monolinguals. In this paper we explore the implication of this process for spoken word production in bilinguals. A cross-language semantic competitor priming effect was demonstrated, which shows that cross-language lexical competition is a feature of the word production system of the unbalanced English–French bilinguals who participated in the experiment. Experimental evidence was also found which suggests that a selected language bias effected through inhibition of the unwanted language plays an important role in resolving the cross-language lexical competition during bilingual word production in a selected language. The data further suggest that the dominance of the unwanted language relative to the selected language determines the presencelabsence or ''strength'' of inhibition through which the selected language bias is effected. These findings are also interpreted in terms of a recent language-specific lexical selection account of bilingual lexical access.

It is now widely accepted that lexical access in language production involves a competitive process of lemma retrieval: a to-be-expressed concept activates multiple lemmas to varying degrees and these compete with each other for selection (e.g., Vitkovitch and Humphreys, 1991; Wheeldon and Monsell, 1994). Given the idea of a competitive process of lemma retrieval, the classic question in psychological research on bilingualism of how bilinguals manage to keep their two languages separate can be reformulated as follows: When a bilingual has a clear intention to lexicalize a concept in a certain language, is there still cross-language lexical competition during lemma retrieval? In other words, do semantically related words of the unwanted language enter the competition process during lemma retrieval? If they do, what processing mechanism ensures that none of them wins out? If they don't, what processing mechanism allows the considerable match between their meanings and the to-be-expressed concept to be ignored by the word production system? This paper will first review empirical evidence for (and against) cross-language lexical competition during bilingual word production. One main experiment and two sub-experiments will then be reported which address the issue using the semantic competitor priming paradigm.

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Spoken word production by bilinguals

Several lines of work can be brought to bear on the question of whether words of the unwanted language are activated at all in the lexical selection process when a bilingual decides to express a concept in a certain language.

Word-finding errors of normal and brain-damaged bilingual speakers

Poulisse and Bongaerts (1994) collected and analyzed the (cross-language) tongue slips made by Dutch–English bilinguals in their spontaneous speech in L2 English. They found cross-language equivalents of

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blend and semantic substitution in their corpus. Byng, Coltheart, Masterson, Prior, and Riddoch (1984) tested a deep dyslexic Nepalese–English bilingual on, among other things, picture naming in his two languages. In the test in L1 Nepalese, one-fifth of the naming responses were "correct" names in L2 English even though the patient was frequently reminded of what language was required for naming. The errors made by normal and brain-damaged bilingual speakers can reasonably be taken as suggesting that in normal bilinguals, both languages are activated even when only one is intended to be in use.

Bilingual deficit in picture-naming latency

Mägiste (1979) reported a study of picture naming in both German and Swedish by young German immigrants in Sweden. Irrespective of their relative proficiency in German and Swedish, the bilingual participants named pictures more slowly in either language than a control group of young Swedish monolinguals. This bilingual deficit could be taken as evidence that more words are activated in the word production process in bilinguals than in monolinguals, even when bilinguals are clearly instructed to use only one language (indeed, their dominant language). This line of evidence is, however, inconclusive because Mägiste (1979) herself offered another explanation: bilinguals use each language less frequently than the respective monolingual speakers, so the bilingual deficit could be a reflection in a bilingual context of the basic word frequency effect on picture naming (see e.g., Wheeldon and Monsell, 1992).

Picture-word interference studies

Hermans, Bongaerts, de Bot, and Schreuder (1998) reported cross-language Stroop-like picture–word interference effects in picture naming by Dutch–English bilinguals: target picture naming in L2 English (e.g., *mountain*) was slower when a semantically related distractor word in L1 Dutch (e.g., *dal* "valley") was presented auditorily 150 ms prior to picture onset. It was also slower when a distractor L1 Dutch word (e.g., *berm* "verge") which was phonologically similar to the Dutch translation equivalent (e.g., *berg* "mountain") of the target English word, was presented auditorily between 0 and 300 ms prior to picture onset. (Both comparisons were made against a control condition where an auditorily presented unrelated distractor word in L1 Dutch (e.g., *kaars* "candle") was tested at the same word–picture onset asynchrony.) These effects can be interpreted as evidence for cross-language lexical competition during L2 word production by unbalanced bilinguals.

On the other hand, using the same picture–word interference paradigm with Catalan–Spanish, Spanish–English, and English–Spanish bilinguals, Costa and Caramazza (1999) and Costa, Miozzo, and Caramazza (1999) found that target picture naming in one language was not only not inhibited, but actually facilitated, by a visually presented distractor word which was the target word's (non-cognate) translation equivalent in the unwanted language. This finding means that translation equivalents of a bilingual's two languages do not compete during word production in a selected language, and constitutes evidence against the existence of cross-language lexical competition during word production in either language by balanced and unbalanced bilinguals. Specifically, Costa and his colleagues interpreted their finding as follows: the semantic representation(s) of the picture and the distractor word activate lexical entries of both the wanted and unwanted languages; the lack of any cross-language lexical competition is due to the existence of a lexical selection mechanism that considers only the activated lexical entries of the wanted language.

Notice that with Costa and his colleagues' processing assumption, the cross-language effect reported by Hermans et al. (1998) can be argued to be a within-language effect in disguise: what underlay the apparent cross-language competition between *mountain* and *dal* "valley" may have been a within-language competition between *mountain* and *valley*. Nevertheless, Costa and Caramazza (1999) have also suggested that the contrasting results obtained by themselves and Hermans et al. (1998) might be explained by a difference between the two studies in the participants' L2 proficiency or in important procedural details (for example, in the modality in which the distractors were presented).

Language switching

The few available studies of wilful language switching in production all employed a methodology which, in rationale, was not different from that used by other experimental psychologists to study non-linguistic task switching (see e.g., Allport and Wylie, 1999 for discussion), i.e., comparing participants' performance in a "task-switching" condition with that in a "no-task-switching" condition. Macnamara, Krauthammer, and Bolgar (1968) asked French–English bilinguals to name digits in both the language-switching and no-language-switching conditions. It was found that wilful language switching took an observable amount of time and that a

predictable switch took less time than an unpredictable switch. More recent work on language switching has questioned the relative invariance of the time for wilful language switching previously assumed by some researchers (e.g., Macnamara and Kushnir, 1971). For example, Meuter and Allport (1999) highlighted the importance of considering the direction of a language switch: their bilingual participants took less time to switch into L2 than into L1 in a digit naming task. On the whole, there appears to be experimental evidence for the psychological mechanism that controls wilful language switching in bilinguals.

In this line of work, the assumption was made that bilinguals manage to use each language on its own because they have two sets of language-specific information processors. This necessitates the existence of a language switching mechanism that controls which language is "on" at any one time. If the turning-on of one language entails the shutting-out of the other, then as far as bilingual word production is concerned, speakers' conscious choice of one language implies that words of the other language are not active during the lexical selection process. In other words, evidence for the working of the mechanism that controls wilful language switching in bilinguals can be taken as indirect evidence that words of the unwanted language are not activated during bilingual word production.

Pulling together the four lines of work just reviewed, we see some suggestive evidence that words of the unwanted language are activated in the lexical selection process during bilingual word production. But the opposite can be argued for on the basis of one reasonable interpretation of the language switching data. Recent work that employed the picture–word interference paradigm has also produced both evidence for, and evidence against, the existence of cross-language lexical competition in bilingual word production.

One way of reconciling the contrasting results is to assume that the mechanism which controls wilful language switching does not always deterministically select one language to the exclusion of the other. This means that it remains possible that words of the unwanted language enter the lexical competition process during bilingual word production in a selected language, but that their activation is maintained at a low level relative to words in the wanted language such that they rarely win out over words of the selected language. One way of integrating the notion of a "language switch" into a model of lexical selection is to include a "language-to-use" attribute as part of the multi-attribute input pattern which serves as input to the word production system (see also de Bot, 1992; Green, 1998; Monsell, Matthews, and Miller, 1992; Poulisse and Bongaerts, 1994, for similar ideas under various labels). With the assumption that the language-to-use attribute is just another attribute which is on a par with other conceptual attributes in the input pattern, it is reasonable to hypothesize that a word of a certain language (e.g., *fox* in English) which is in the cohort of competitors for the production of a target word in the same language (e.g., *dog* in English) will also be in the cohort of competitors for the production of the translation equivalent of the target word (i.e., *chien* "dog" in French, assuming the other language involved to be French). This means that, with an appropriately sensitive methodology, cross-language competition (i.e., between *fox* and *chien* "dog"), like within-language competition (i.e., between *fox* and *dog*), ought to be detectable in successful word production by normal bilinguals.

Obviously the very existence of the "language switch" ought to be called into question if its working does not result in one language being reasonably strongly biased, if not deterministically selected, over the other in the lexical selection process. During bilingual word production in a selected language, there must be a "selected language bias" whereby more (but not necessarily all) weight is given to the words of the selected language than to those of the unwanted language. Seen from a different angle, the "selected language bias" is logically necessary because if both languages are activated during production in a selected language, a mechanism must be in place to ensure that words of the selected language eventually are chosen. One reasonable hypothesis for how the selected language bias is effected is that during word production in a selected language, the unwanted language as a whole is inhibited (cf. Green, 1998; Paradis, 1987; but see Roelofs, 1998 for a counter-proposal). Again, with an appropriately sensitive methodology, the inhibitory nature of the selected language bias ought to be detectable in successful word production by normal bilinguals.

In the following, we present a study which we shall argue demonstrates (i) within- and cross-language lexical competition in *successful* target word production by bilinguals, and (ii) the inhibitory nature of the selected language bias in the lexical competition process during word production in a selected language. Our study exploited the subtle inhibitory semantic competitor priming effect demonstrated by Wheeldon and Monsell (1994) in English monolingual speakers. Their experimental paradigm provides a viable alternative to the picture–word interference methodology for the study of successful spoken word production.

Experiment

In Wheeldon and Monsell's (1994) experiments, the participant alternated, from trial to trial, between responding to a written definition and naming a pictured object. The time to name a picture (e.g., *shark*) was longer when a semantic competitor of the target word had been produced in response to a definition three trials ago (e.g., *whale*, in response to "The largest creature that swims in the sea"), relative to when a semantically unrelated word had been produced in response to a definition three trials ago. A semantic competitor of a target is a word that is thought to be semantically close enough to the target to be very likely to compete with the target during production of the target as a picture-naming response. It was reasoned that given the rate at which people choose words from their mental lexicon to express themselves in normal speech, parallel matching must be involved in the underlying process whereby the right lemma is selected to express a concept. ("Lemma" is the technical term used to refer to the semantic, syntactic, and pragmatic specifications for appropriate use of a word.) An inevitable consequence of parallel matching is that in the lexicalization of a to-be-expressed concept, multiple lemmas are activated to the degree that they match the to-be-expressed concept, and semantically related lemmas have to compete with each other for selection until one of them wins out. The competition between lemmas takes time to resolve and the winning out of a lemma will take longer than normal to complete if one of its competing lemmas is given a head start in the competition. The inhibitory semantic competitor priming effect was explained by assuming that prior production of a semantic competitor results in its lemma being given a head start in the lemma competition that takes place during the lexicalization of the concept denoted by the corresponding target word.

Wheeldon and Monsell (1994) located the inhibitory semantic competitor priming effect, not at the stage of conceptual activation, but at the lexicalization process (see also Vitkovitch and Humphreys, 1991), in particular the lemma selection process. They found that the inhibitory priming effect was larger when two unrelated trials intervened between the competitor and target trials than when no trial intervened. The larger effect in the two-intervening-trial case was purely the inhibitory effect due to the head start that the competitor enjoyed in the lexical competition that took place on the target trial. The smaller effect in the no-intervening-trial case was shown to be the net result of the relatively long-lasting inhibitory effect seen in the two-intervening-trial case *and* a transient facilitatory effect due to the spread of activation among related concepts. Consideration of the different time courses of the two effects involved in the no-intervening-trial case led Wheeldon and Monsell (1994) to locate the transient facilitatory effect at the stage of conceptual activation and the longer-lasting inhibitory effect at the process of mapping from concepts to lexical items (i.e., the lexicalization process). They further located the inhibitory effect at the stage of lemma selection because it has a different time course from the even more long-lasting facilitatory repetition priming effect (Wheeldon and Monsell, 1992), which they located at the phonological retrieval stage.

We followed Wheeldon and Monsell (1994) in assuming that the inhibitory semantic competition priming effect seen in the two-intervening-trial case had its locus in the lemma selection process. We reasoned that any finding of inhibitory semantic competitor priming across languages can be taken as evidence for cross-language lemma competition during word production in a selected language. The purpose of the main experiment was therefore to establish whether inhibitory semantic competitor priming of spoken word production occurs across languages, i.e., whether picture naming in one language can be inhibited by prior production of semantically related words in another language in response to definition stimuli.

In this study, English–French bilingual participants alternated between responding to a trio of definition stimuli and naming two pictures in a row. The definitions were always presented and responded to in English. The two pictures in a row could both be named in English, or both in French, or one in English followed by one in French, or one in French followed by one in English – each combination had an equal probability of occurrence. The response language for each picture was cued with a national flag (i.e., Union Jack for English, Tricolour for French), which appeared shortly before a picture came on. Some pictures were designated as target pictures which were always presented as the second picture in a row of two pictures and could be named in either English or French (e.g., *dog* or *chien* "dog"). For each participant, half the target picture trials in each language were "primed" in the sense that an English semantic competitor (e.g., *fox*) of the required response to a target picture (e.g., *dog* or *chien* "dog") was produced in response to a definition three trials before the target picture trial, and half were "unprimed" in the sense that an unrelated English word (e.g., *snow*, in the case of *dog*/*chien*) was produced in response to a definition three trials before the target picture trial. (The definition of a

semantic competitor, when present, always occupied the middle position in a trio of definition stimuli.) It was reasoned that inhibitory semantic competitor priming across languages would be indexed by target picture naming in French being inhibited by prior production of a semantic competitor in English in response to a definition, i.e., primed production of a French word being slower than unprimed production of the same word.

We also manipulated, orthogonally to the factors of target language and competitor priming, what will hereafter be referred to as the "preceding" language, i.e., the response language (English or French) required on the "filler" picture trial immediately preceding a target picture trial. This manipulation was included to test for the hypothesized inhibitory nature of the selected language bias. The basic idea is as follows: if the selected language bias is effected through inhibition of the unwanted language as a whole, any semantic competitor priming effect which spans more than one trial can be modulated by whether the competitor language is inhibited through the use of another language between competitor and target productions. Using the same language as the competitor language between competitor and target productions will "keep alive" the activation of the competitor language and hence "sustain" the head start that the competitor can have in its competition with the target during the production of the target (in either language), whereas using a different language from the competitor language between competitor and target productions will inhibit the competitor language and hence "erode" the head start that the competitor can have in its competition with the target during the production of the target (in either language). The semantic competitor priming effect should be larger when the head start that the competitor can have has been "sustained" than when it has been "eroded'. Therefore, the inhibitory nature of the selected language bias should be indexed by greater inhibitory semantic competitor priming (within or across languages) when English was the preceding language than when French was the preceding language.

The four possible combinations of English and French as preceding and target languages can be conceptualized as being formed by crossing the target language and preceding language factors. But equally validly, one can take the target naming trial as a focal point, and conceptualize the four combinations as being formed by crossing the target language and language change factors. The language change factor concerns the presence/absence of a change in response language from a preceding trial to a target trial. In our study, the target language/language change conceptualization (rather than the target language/preceding language one) was adopted for the purpose of design and analysis. On this conceptualization, the hypothesized inhibitory nature of the selected language bias should manifest itself as a three-way interaction of the language change, target language, and competitor priming factors.

Criticisms could be made that the requirement of frequently changing response language throws into doubt the claim that bilingual language production in a selected language would be tapped in the present study. It could be argued that frequent response language changes would make the participant unsure of what language to use on a particular target picture trial, and hence artefactually induce cross-language competition. To minimize the participant's uncertainty of what language to use, each picture naming trial started with the presentation of a language cue for 1300 ms, thereby allowing a (hopefully) sufficient amount of time for the preparation of the required language. It could also be argued that frequent response language changes would encourage participants to adopt a word-form level translation strategy in producing L2 words (see e.g., Chen and Leung, 1989), which in turn means that any cross-language effect would probably be a mere within(-first)-language effect in disguise. To address this possibility, a direct test of whether L2 word production involved word-form level translation was incorporated into the present study: Following Monsell et al. (1992), we reasoned that if word-form level translation were occurring, the L1 English response to a definition should prime naming a picture of the *same* concept at a later point in the experiment, even if that response is made in L2 French. Long-lag repetition priming within languages is well established, and if participants are naming pictures in L2 by translating from the appropriate response in L1, then the repetition priming effect should also be obtained across languages, except that the apparent cross-language effect would be a within-language effect in disguise. In the present study, two sub-experiments were embedded within the main experiment to test for within- and cross-language long-lag repetition priming effects on target picture naming. They each made use of a different set of materials from the main experiment. Any cross-language long-lag "repetition" priming would be taken as diagnostic of word-form level translation during L2 word production.

Method

Materials. The experimental vocabulary consisted of 36 semantically related word pairs for the main experiment, 16 English words for the sub-experiment

on within-language long-lag repetition priming and 16 French words for the sub-experiment on cross-language long-lag "repetition" priming. The three pools of words did not overlap with each other. (See Appendices 1 to 3 for listings of the items.)

(i) Main experiment on within- and cross-language semantic competitor priming. For each word pair, a target picture was available which could readily be named in English and French (e.g., *rain*/*pluie*) and a definition in English was written to which participants could readily respond with the semantic competitor (e.g., *snow*: "It falls in white fluffy flakes from the sky."). The same 36 word pairs and associated pictorial and definition stimuli were used in Lee and Williams's (1997: Experiment 3) study where a within-English semantic competitor priming effect was replicated in a slightly different paradigm, so the "competitiveness" of the selected materials should not be in doubt. The 36 word pairs were divided into four subsets of nine, matched for the French words' frequency count in Juilland, Brodin, and Davidovitch (1970). In addition, for each word pair, two unrelated English fillers and an unrelated translation equivalent filler pair were chosen for use on the definition and filler picture trials preceding a target picture trial.

(ii) Sub-experiment on within-language long-lag repetition priming. For each of the 16 English words, a picture was available and a definition was written both of which could readily be responded to with the target word (e.g., *stool*: "Seat for one, having no back or arms"). The 16 words were divided into two subsets of eight, matched for the pictures' baseline naming latency – pre-testing of the pictures was done by Wheeldon and Monsell (1992, 1994). In addition, for each word, three unrelated English fillers and an unrelated translation equivalent filler pair were chosen for use on the definition and filler picture trials preceding a target picture trial.

(iii) Sub-experiment on cross-language long-lag "repetition" priming. For each of the 16 French words, a picture was available which could readily be named in French (e.g., *coeur* "heart") and a definition was written which could readily be responded to with the English translation equivalent of the target French word (e.g., in the case of *coeur*, *heart*: "Organ for pumping blood"). The 16 words were divided into two sub-sets of eight, matched for the French words' frequency count in Juilland et al. (1970). In addition, for each word, three unrelated English fillers and an unrelated translation equivalent filler pair were chosen for use on the definition and filler picture trials preceding a target picture trial.

In addition to the experimental vocabulary, a large number of English and French words were used as practice or filler items. Each of the chosen words could be elicited with either a picture or a definition (in English).

Procedure. Participants were tested individually. They were seated next to the experimenter and in front of a microphone and a computer screen. The experiment was made up of runs of trials arranged into blocks. Each run of trials consisted of three "self-paced" definition trials in English followed by two picture-naming trials. Each run of trials began when the experimenter pressed the space bar once and the task cue "___ ___ ___" appeared for 800 ms. Half a second after the offset of the task cue, a beep, which the participants could not hear, was sent from the computer on which the experiment was run, to a tape recorder connected with the computer, and at the same time, a trio of definitions appeared simultaneously on the screen. The three definitions in a trio were placed on three widely separated lines from top to bottom, and participants had been instructed to give single-word responses (or say "don't know") to all of them in the order they were placed on the screen. After participants had started responding to the last definition in a trio, the experimenter pressed the space bar once to clear the screen, and a fixation sign in the form of "*******" immediately appeared at the centre of the screen. The fixation sign remained on the screen for 2 s. After the offset of the fixation sign, the screen remained blank for 400 ms. Then the first picture naming trial began with the presentation of one of the two language cues for 800 ms. Half a second after the offset of the language cue, a picture was presented and at the same time, a beep (inaudible to participants) was sent from the computer to the tape recorder. Participants had been instructed to name the picture as quickly and as accurately as possible with the most obvious word in the cued language, or to respond to it by saying "don't know" or "sais pas" (depending on the cued language). On hearing a response, the experimenter pressed the space bar once to clear the picture from the screen. One second after the offset of the picture, the second picture naming trial began with the presentation for 800 ms of another language cue, which could be the same as, or different from, the one presented before the last picture. The same sequence of events was repeated as for the first picture naming trial. One second after the offset of the second picture, the next run of trials began with, as stated above, the presentation of the definition task cue.

The experiment consisted of one practice block of eight runs of trials followed by five experimental blocks of 16 runs of trials, with breaks of 30 s between experimental blocks. In addition, each experimental block included two extra picture

Table 1. *A sequence of expected responses in an example run of trials for each of the eight experimental conditions of the main experiment*

Condition*	English filler elicited with a definition	English *competitor* or filler elicited with a definition	English filler elicited with a definition	English or French "filler" elicited with a picture	English or French **target** elicited with a picture
EEP	liar	*snow*	cinema	roof	**rain**
EEU	liar	heart	cinema	roof	**rain**
FFP	liar	*snow*	cinema	toit	**pluie**
FFU	liar	heart	cinema	toit	**pluie**
FEP	liar	*snow*	cinema	toit	**rain**
FEU	liar	heart	cinema	toit	**rain**
EFP	liar	*snow*	cinema	roof	**pluie**
EFU	liar	heart	cinema	roof	**pluie**

* Because the language change factor was manipulated between participants, each participant received either the EEP, EEU, FFP, and FFU conditions or the FEP, FEU, EFP, and EFU conditions.

naming trials before, and three extra definition trials after, the 16 runs of trials. The extra trials, as well as the presentation of a fixation sign for 2 s in the middle of each run of trials, were employed to invite the participants to develop a different notion of a run of trials from that described above, thereby camouflaging the semantic relationship between the second definition response and the second picture naming response on some runs of trials. Care was taken to make the language to be used on a picture trial probabilistically unpredictable before the appearance of the language cue.

The whole experimental session was audio-recorded. From the recordings, tallies were made of accuracies in naming the preceding pictures (with respect to language only) and of accuracies in naming the target pictures (with respect to both the language and the naming response expected). Latencies of naming the target pictures (i.e., time intervals from the onset of the beep that accompanied picture onset to the onset of naming response) were measured manually on a speech editor (cf. Morrison and Ellis, 1995) to the nearest millisecond.

Design. (i) Main experiment on within- and cross-language semantic competitor priming. A target picture could be named in one of the eight conditions formed by factorially crossing three two-level factors: target language (manipulated within participants and within items), language change (manipulated between participants and within items), and semantic competitor priming (manipulated within participants and within items). The factor of target language concerned whether a target picture was named in English or French. The factor of language change concerned whether, on a target picture trial, there was a language change from the immediately preceding filler picture trial. It was manipulated between participants because there were not enough items for a three-factor fully within-participants design. The semantic competitor priming manipulation concerned whether production of a target word as the second picture naming response in a certain run of trials was preceded by prior production of a semantic competitor ("primed") or an unrelated filler ("unprimed") as the second definition response in the same run of trials. The eight conditions will hereafter be referred to by the abbreviations: EEP, EEU, FFP, FFU, FEP, FEU, EFP, and EFU. The first, second, and third letter indicate, respectively, the preceding language (English or French), target language (English or French) and semantic competitor priming (Primed or Unprimed). Table 1 gives a sequence of expected responses in an example run of trials for each of the eight experimental conditions.

(ii & iii) Sub-experiments on within- and cross-language long-lag repetition priming. A target picture could be named in one of the four conditions formed by factorially crossing two two-level factors: language change (manipulated between participants and within items) and within-/cross-language long-lag repetition priming (manipulated within participants and within items). The factor of language change was as in the main experiment. The within-language long-lag repetition priming manipulation concerned whether production of a target word as the second picture naming response in a certain run of trials in a certain block was ("primed") or was not ("unprimed") preceded by prior production of the same word as the second definition response in a certain run of trials in the immediately preceding block (i.e., at least 62 trials plus a break of 30 s

earlier). The cross-language long-lag "repetition" priming manipulation concerned whether production of a target French word as the second picture naming response in a certain run of trials in a certain block was ("primed") or was not ("unprimed") preceded by prior production of the translation equivalent of the target French word as the second definition response in a certain run of trials in the immediately preceding block (i.e., at least, as it turned out, 57 trials plus a break of 30 s earlier). The four conditions of the within-language sub-experiment will hereafter be referred to by the abbreviations: E . . . EEP, E . . . EEU, E . . . FEP and E . . . FEU, and those of the cross-language sub-experiment: E . . . FFP, E . . . FFU, E . . . EFP and E . . . EFU. The second letter after the three dots indicates target language, which was always English in the within-language case and French in the cross-language case. The first and third letter after the three dots indicate, respectively, preceding language (English or French) and within-/cross-language long-lag repetition priming (Primed or Unprimed). Tables 2 and 3 show a sequence of expected responses in an example priming event, where applicable, and an example run of trials for each of the four conditions of each sub-experiment.

Runs of trials for the main experiment were interspersed among those for the two sub-experiments. Subsets of materials for the main experiment and the two sub-experiments were rotated around the respective experimental conditions to create eight counterbalanced lists of pseudo-randomly ordered runs of trials. Each list was given to an equal number of participants. Throughout an experimental session, the probabilities that any definition, and any middle definition in a trio of definitions, would be followed by a semantically related picture (in either language) in the same run of trials were .07 and .21 respectively; the probabilities that any English word said in response to a definition, and to the middle definition in a trio of definitions, would be repeated after some time (or followed after some time by its French translation equivalent) were .03 and .09 respectively.

Participants. The 48 paid participants were all native speakers of English and had experience of living and/or travelling in French-speaking countries in Europe or Africa. At the time of testing, they all were students reading for an honours degree in modern languages at the University of Cambridge and had studied French as a second language for at least five years (M=8.79; SD=2.18). They scored a mean of 2.83 (SD=0.41) out of 4 on an adapted version of a published self-assessment scale designed and validated by language testing specialists (Bachman and Palmer, 1989). The participants were randomly divided into two cohorts of 24. One cohort was assigned to the no-language-change conditions of the main experiment and the language-change conditions of the sub-experiments; their mean number of years of French study was 9.21 (SD=2.43) and mean self-assessment score 2.79 (SD=0.36). The other cohort was assigned to the language-change conditions of the main experiment and the no-language-change conditions of the sub-experiments; their mean number of years of French study was 8.38 (SD=1.80) and mean self-assessment score 2.89 (SD=0.45). T-tests showed that the two cohorts did not differ in years of study or self-assessment score (ps>.18, two-tailed).

Results and discussion

The main experiment and the two sub-experiments were subjected to the same data analysis procedure.

Table 2. *A sequence of expected responses in an example priming event (where applicable) and run of trials for each of the four experimental conditions of the sub-experiment on within-language long-lag repetition priming*

Condition*	English *target* or filler elicited with a definition	Long lag**	English filler elicited with a definition	English filler elicited with a definition	English filler elicited with a definition	English or French "filler" elicited with a picture	English **target** elicited with a picture
E . . . EEP	*stool*	. . .	hedge	truant	printer	bee	**stool**
E . . . EEU	sun	. . .	hedge	truant	printer	bee	**stool**
E . . . FEP	*stool*	. . .	hedge	truant	printer	abeille	**stool**
E . . . FEU	sun	. . .	hedge	truant	printer	abeille	**stool**

* Participants who received the EEP, EEU, FFP, and FFU conditions in the main experiment received the E . . . FEP and E . . . FEU conditions while those who received the FEP, FEU, EFP, and EFU conditions in the main experiment received the E . . . EEP and E . . . EEU conditions.

** More than 60 intervening definition and picture trials in English and French.

Table 3. *A sequence of expected responses in an example priming event (where applicable) and run of trials for each of the four experimental conditions of the sub-experiment on cross-language long-lag "repetition" priming*

Condition*	English *target* or filler elicited with a definition	Long lag**	English filler elicited with a definition	English filler elicited with a definition	English filler elicited with a definition	English or French "filler" elicited with a picture	French **target** elicited with a picture
E . . . FFP	*heart*	. . .	dryer	Madrid	calculator	cochon	**coeur**
E . . . FFU	snow	. . .	dryer	Madrid	calculator	cochon	**coeur**
E . . . EFP	*heart*	. . .	dryer	Madrid	calculator	pig	**coeur**
E . . . EFU	snow	. . .	dryer	Madrid	calculator	pig	**coeur**

* Participants who received the EEP, EEU, FFP, and FFU conditions in the main experiment received the E . . . EFP and E . . . EFU conditions while those who received the FEP, FEU, EFP, and EFU conditions in the main experiment received the E . . . FFP and E . . . FFU conditions.

** More than 55 intervening definition and picture trials in English and French.

Target picture naming data that fell into any of the following five categories were first excluded from consideration: (i) data from trials on which a target picture was not named within 3 s after the onset of the beep that accompanied picture onset; (ii) data from trials on which the required language was not used in naming or in saying "don't know" (or the like); (iii) data from trials on which the required language was used in saying "don't know" (or the like), or in saying a word that was not the expected target word; (iv) data from trials on the preceding filler trials of which the required language was not used in naming or in saying "don't know" (or the like); and (v) data from "primed" trials for which the competitors had not been successfully elicited as definition responses. After these exclusions, items that had more than one-third of the data points missing in at least one of the experimental conditions were identified and data (in all conditions) on these identified items were discarded from further analysis. (The discarded items are marked with asterisks in the respective appendices.) Mean target picture naming latency, percentage of data points lost in each of the above five categories, and total percentage of lost data were calculated from the remaining data for each condition. (Details of the amount of data lost to each category in each condition are given in Appendix 4.) By-participants analyses of variance were performed of mean naming latency, arcsine-transformed percentage of data lost in each of categories (i) to (iv), and arcsine-transformed total percentage of lost data when criterion (v) for data exclusion was suspended (i.e., when data from misprimed but otherwise correct target picture trials were reinstated – this was to take account of the fact that criterion (v) for data exclusion could never apply to the unprimed conditions). Notice that by-items analyses will not be reported because, as pointed out by Raaijmakers, Schrijnemakers, and Gremmen (1999), separate by-participants and by-items analyses are not necessary when, as in the present experiment, item variability is controlled by counterbalancing. Also, the various "lost data" analyses will be reported only when they might impinge on the interpretation of the latency data.

Within- and cross-language semantic competitor priming. Nine items were lost. By-participants analyses were carried out with target language and competitor priming as within-participants factors, language change as a between-participants factor, and item set assignment as a (four-level) between-participants factor. Mean naming latency and total percentage of lost data, in each critical condition (i.e., collapsed across levels of the "item set assignment" factor) are presented in Table 4.

Pictures were named about 300 ms more slowly in L2 French than in L1 English. This was confirmed by a highly significant main effect of target language, $F1(1,40)=233.46$, $MSe=17968.71$, $p<.001$.

The three-way interaction of language change, target language, and competitor priming was significant, $F1(1,40)=4.54$, $MSe=21580.68$, $p<.04$. In the absence of a main effect of competitor priming ($p>.1$), the three-way interaction means that cross- and within-language semantic competitor priming did not occur without the use of English (i.e., the competitor's language) as the preceding language, or, in other words, that cross- and within-language competitor priming could be eliminated completely by the use of French, a language other than the competitor language, as the preceding language. This was confirmed by t-tests showing significantly longer naming latency in the EEP and EFP conditions than

Table 4. *Results of the main experiment: mean target picture naming latency (and standard deviation) (in ms). (In square brackets is the mean total percentage of lost data.)*

		Language of the target picture					
		English (L1)			*French (L2)*		
		Primed	Unprimed	Priming effect	Primed	Unprimed	Priming effect
Language of the preceding picture	*English (L1)*	1000 (183) [6.3]	932 (113) [1.2]	68	1355 (241) [10.6]	1270 (189) [8.2]	85
	French (L2)	1051 (147) [8.4]	1062 (195) [3.6]	−11	1293 (171) [11.8]	1309 (179) [9.9]	−16

in the EEU and EFU conditions respectively (ps<.05, one-tailed), but no reliable difference between the FFP and FEP conditions and the FFU and FEU conditions respectively (ps>.3, one-tailed). One might wonder whether the elimination of the priming effects was really due to the use per se of French on the preceding trial, or was simply because of a longer time lag between the productions of a competitor and its corresponding target (in either language) when the preceding trial was in French. It is almost certain that such confounding existed (although the preceding picture naming latencies have not been measured). Nevertheless, one should not lose sight of the magnitude of the difference between L1 and L2 naming speeds found in the present study or of the persistence of the demonstrated effects: when they were both in English, the two unrelated intervening trials between a competitor trial and its corresponding target trial lasted not less than 10 s; irrespective of what language the second of them (i.e., the preceding trial) was in, they were always separated by the presentation of a fixation sign for 2 s. It seems extremely unlikely that within- and cross-language priming effects that had a persistence of not less than 10 s would have been completely obliterated by the extra few hundred ms required when the preceding trials were in French.

The main effect of language change was not significant (p>.19), but the two-way interaction between language change and target language was, $F1$(1,40)=4.20, MSe=17968.71, p<.05; the same interaction was also found in an analysis of the unprimed responses alone, $F1$(1,40)=12.82, MSe=13477.52, p<.002. In line with Meuter and Allport's (1999) counter-intuitive finding, language change adversely affected target picture naming in English, the stronger language, but not in French, the weaker language: t-tests revealed that the difference of 130 ms in naming latency between the EEU and FEU conditions was significant (p<.01, two-tailed), but the difference (in the opposite direction) of 39 ms between the FFU and EFU conditions was not (p>.46, two-tailed). The lack of any language change effect when French was the target language, did not reflect a mere ceiling effect because neither the FFU nor the EFU condition had the longest naming latency, which means that given suitable manipulations (of which language change appeared not to be one), there was room for intrinsically long French responses to be systematically prolonged even further.

Analyses of the mean percentages of data lost to the use of a wrong language in naming a preceding/target picture revealed that participants were far more likely to use the wrong language on a preceding/target picture trial in French than on one in English. To assess stringently how frequently such errors occurred, a separate measure was set up which counted the "correct" responses to target pictures that were made in the wrong language (e.g., *rain*/*pluie* when *pluie*/*rain* was required respectively) (see the values in parentheses in the %TL column in Appendix 4). On this measure, a main effect of target language was still found, $F1$(1,40)=12.11, MSe=.039, p<.01. This clearly shows that "wrong language" errors occurred more often in naming in French than English. It should, nevertheless, be noted that, on the whole, errors of this type were infrequent (no more than 5% in the worst affected condition), so it would appear that the cueing of language with a national flag was very effective and that despite the requirement of frequently changing response language, participants were indeed engaged in spoken word production in a selected language when naming pictures.

Analysis of mean percentage of data lost to the 3 s cut-off showed that more trials had been discarded in the French-as-target-language conditions, so one might wonder whether the results reported above are an artefact of using a common cut-off point for English and French responses. In an attempt to address this potential problem, a different cut-off (2.7 s, which took account of the difference between L1 and L2 naming speeds) was set for the English responses, and the mean naming latency and various "lost data" measures were recalculated. Reanalysis of mean naming latency yielded a highly similar pattern of results to that reported above, including the most important three-way interaction of target language, language change, and competitor priming. Also, even with different cut-off points for English and French responses, mean percentage of data lost to cut-offs still revealed a significant main effect of target language. All this lends support to the contention that the pattern of results reported above did not depend on a common cut-off for both target languages.

For our present purpose, the important findings of the main experiment are that some cross-language semantic competitor priming was clearly present (under unexpectedly restricted circumstances), and that a three-way interaction of the language change, target language, and competitor priming factors was found, which, as explained earlier, is indicative of the inhibitory nature of the selected language bias during bilingual word production in a selected language. It is now necessary to establish that the cross-language effect was not just a within-language effect in disguise, the issue addressed by the two sub-experiments.

Within-language long-lag repetition priming. Three items were lost. By-participants analyses were run with repetition priming as a within-participants factor, and language change and item set assignment as two (two-level) between-participants factors. The results are presented in Table 5.

Mean naming latency yielded a significant main effect of repetition priming, $F1(1,44)=4.08$, $MSe=11939.63$, $p<.05$. Target picture naming in English could be facilitated to the order of, on average, 45 ms by prior production of the same word in response to a definition at least 62 trials earlier. No other main or interaction effect was found.[1]

Table 5. *Results of the sub-experiment on within-language long-lag repetition priming: mean target picture naming latency (and standard deviation) (in ms). (In square brackets is the mean total percentage of lost data.)*

		Primed	Unprimed	Priming effect
Language of the preceding picture	*English (L1)*	1013 (246) [12.1]	1068 (227) [2.5]	−55
	French (L2)	1060 (156) [9.1]	1094 (202) [3.2]	−34

Table 6. *Results of the sub-experiment on cross-language long-lag "repetition" priming: mean target picture naming latency (and standard deviation) (in ms). (In square brackets is the mean total percentage of lost data.)*

		Primed	Unprimed	Priming effect
Language of the preceding picture	*English (L1)*	1185 (160) [10.8]	1179 (166) [3.3]	6
	French (L2)	1191 (235) [8.1]	1191 (243) [7.1]	0

Cross-language long-lag "repetition" priming. Three items were lost. By-participants analyses were run with "repetition" priming as a within-participants factor, and language change and item set assignment as two (two-level) between-participants factors. The results are presented in Table 6.

Mean naming latency yielded no main or interaction effect (all Fs<1), indicating that target picture naming in French could not be reliably facilitated by prior production of the English translation equiva-

[1] Wheeldon and Monsell (1992, 1994) established that competitor priming occurs at a lag of two trials, but unlike repetition priming, it does not occur at a lag of several minutes. Because of the difference in time course between the two effects, they located competitor priming at the lemma selection stage and repetition priming the phonological retrieval stage. Our data provide further evidence for their argument: when only the English-as-target-language conditions in the main experiment and the sub-experiment are examined, it appears that language switching affected only competitor priming but not long-lag repetition priming. This contrast is likely to be a reflection of the different loci of the two types of priming. It also suggests that language switching, which has itself been independently established as a short-lived effect (see Allport and Wylie, 1999), does not seem to affect the phonological retrieval stage.

lent of the target French word as a definition response at least 57 trials earlier. (It may be noted that French responses seemed faster in the sub-experiment than in the main experiment. However, this difference may not be very meaningful because the main experiment and the sub-experiment made use of different sets of items.)

According to the argument advanced by Monsell et al. (1992), the presence of a within-language long-lag repetition priming effect *and* the lack of a cross-language long-lag "repetition" priming effect in the same bilingual participants jointly count against the suggestion that participants relied on translation at the word-form level in producing L2 words.[2] If French word production was not mediated by English in the sub-experiments, it could not be so in the main experiment either, because the main experiment and the sub-experiments ran in parallel and it was extremely unlikely that participants had been aware of whether a target trial belonged to the main experiment or to either sub-experiment. The combined results of the two sub-experiments also make it impossible to argue that because participants could have covertly translated every definition response into French, any cross-language effect could be a within-French effect in disguise. The present data do not suggest that covert translation or translation at the word-form level is never possible. They indicate only that participants did not engage in this sort of translation activity during L2 (and L1) word production in the two sub-experiments or, by implication, in the main experiment. Following on this, a case can be made that the cross-language effect found in the main experiment was genuinely cross-language, and was not a within-language effect in disguise.

General discussion

Wheeldon and Monsell (1994) reported a semantic competitor priming effect on picture naming, which provides clear evidence for lexical competition in the normal word production process in monolinguals. In the present study of unbalanced English–French bilinguals, a within-language semantic competitor priming effect in English and a cross-language semantic competitor priming effect from English to French were found. Both effects spanned two trials on which unrelated words were said. Steps had been taken to rule out the interpretation of the cross-language effect as a mere within-language effect in disguise. This therefore provides a new line of evidence for cross-language lexical competition during bilingual word production in a selected language.

It was also found that the use or non-use of English, the competitor's language, on the unrelated intervening trials, could influence both the within- and the cross-language semantic competitor priming effects. Departing from pre-experiment expectation, the use of French, a language other than the competitor's language, on the preceding filler trial, did not just attenuate the priming effects, but completely eliminated them. This suggests that the use of French on the second of the two intervening trials involved a selected language bias towards French during word production on that trial. The selected language bias was effected through such a high level of inhibition of all English words that the head start that the English competitor could have enjoyed in the lexical competition during target production on the subsequent trial, was completely wiped out.

Strictly speaking, the present study only showed that bilinguals' L2 word production involves lexical competition with, and strong inhibition of, L1 words; lexical competition with, and/or inhibition of, L2 words during L1 word production remains to be demonstrated. Some relevant information can, however, be gleaned from another finding in the present study. Recall the significant interaction between target language and language change, which was found even when unprimed target picture naming latencies of the main experiment were analyzed alone: a target trial was adversely affected by the requirement of a change of language from a preceding trial only when the target trial was in English, not when it was in French. This finding is similar to the paradoxical interaction reported by Meuter and Allport (1999) between target language and language change in bilingual digit naming.[3] Both Meuter and Allport's and the present findings are counter-intuitive in that one would have expected the demand of a language change to affect naming in the weaker language, and not in the stronger language, but in reality the reverse was found. Although this

[2] Our failure to find a long-lag "repetition" priming effect from L1 definition naming to L2 picture naming seems inconsistent with Sholl, Sankaranarayanan, and Kroll's (1995) finding of such an effect from L1 picture naming to (conceptually mediated) L1-to-L2 translating. We acknowledge the inconsistency but shall not attempt a resolution here other than noting that our finding replicates that of Monsell et al. (1992).

[3] Several differences should be noted between Meuter and Allport's (1999) study and the present study: their digit naming task is less "open-ended" than the picture naming task; they used simultaneous presentations of a language cue and a to-be-named digit; their language change effect in the weaker language was unambiguously inhibitory, whereas in the present study it did not remotely approach even the .10 level of significance and was, if anything, facilitatory; there was no sign in the present data of the dramatic cross-over found on the language-change trials in their study.

counter-intuitive interaction involved the factor of language change, the mechanism ostensibly responsible for the intentional component of the control of wilful language switching was unlikely to be the locus of the interaction: with the cueing of response language with a national flag, the participants were allowed up to 1.3 s to prepare for a language change before a to-be-named picture was presented. It is puzzling that the (intentional component of the) mechanism would work in such a way that a change is more difficult from a weaker to a stronger language than from a stronger to a weaker language. It is therefore opportune to attribute the interaction to the lexical selection process which takes place (in a functional sense) after conceptual activation.

An account of the paradoxical interaction between target language and language change in terms of cross-language lexical competition and the selected language bias might run as follows. Arguably the strongest cross-language lexical competition during unprimed target word production in a selected language is that between a target and its translation equivalent in the unwanted language. Any inhibitory language change effect on unprimed target production by bilinguals can be seen as reflecting an intensification of this particular cross-language lexical competition – the target word takes longer to win over its translation equivalent in the unwanted language. Such intensification occurs when a target trial involves a language change from the immediately preceding trial, because the target, together with other words of the same language, has been inhibited, through the selected language bias, on the preceding trial where the language to which the target belongs is the unwanted language.

Furthermore, the size of any inhibitory language change effect can be taken to indicate how strongly the target language as a whole has been inhibited on the preceding trial where it is the unwanted language. The main experiment revealed a strong inhibitory language change effect on naming in English and no such effect on naming in French. This suggests that, for the present participants, producing French words involved a selected language bias towards French which was effected through massive inhibition of all English words. Producing English words, on the other hand, involved either no selected language bias towards English (which entailed no inhibition of any French word), or a much weaker selected language bias towards English which entailed only mild inhibition of all French words.

This interpretation of the counter-intuitive interaction between target language and language change in the main experiment is consistent with the finding elsewhere in the present study that bilinguals' L2 word production involves lexical competition with, and strong inhibition of, words of the unwanted L1, and suggests that L1 word production also involves lexical competition with, but entails only slight or no inhibition of, words of the unwanted L2.

Finally, we want to consider our data in the light of Costa and his colleagues' suggestion of a language-specific lexical selection mechanism. Recall from the first section that Costa and his colleagues argued that both their balanced Catalan/Spanish and unbalanced English–Spanish and Spanish–English bilingual participants possess a flexible language-specific lexical selection mechanism which allows only the words of the wanted language to compete with each other during word production (cf. Roelofs, 1998; see also Grosjean and Miller, 1994, for a similar idea on a flexible language-specific selection mechanism that controls phonetic realization of phonemes during production of mixed-language sentences). Costa and Caramazza (1999) implied that "genuine" cross-language lexical competition could occur when the flexible language-specific lexical selection mechanism is not completely functional (as in, they claimed, Hermans et al.'s (1998) Dutch–English bilinguals), and/or when participants have to switch back and forth between two languages.

The boundary condition on the cross-language semantic competitor priming effect in our data tells us something about the flexibility of the lexical selection mechanism in our unbalanced English–French bilinguals. It does not seem to be the case that the selection mechanism is not completely functional in our participants because the absence of cross-language competitor priming in the FF condition shows that the selection mechanism could be put into the French mode. The priming effect found in the EF condition (which we argued above was a genuine cross-language semantic competitor priming effect) therefore reflects the inflexibility of a fully functional language-specific lexical selection mechanism in our participants. The selection mechanism could not be automatically put into the French mode when the participants decided to speak French, as evidenced by the presence of cross-language lexical competition even when they were given 1.3 s to prepare to switch from English to French. This is in contrast to the balanced Catalan/Spanish bilinguals who showed no cross-language lexical competition even when given only 300 ms to prepare for a language change in the "mixed naming" condition of Costa et al.'s (1999) Experiment 2.

Costa and his colleagues were unspecific on how the language-specific lexical selection mechanism is to be implemented (but see Roelofs, 1998), but they seem very much against the idea that inhibition of the

unwanted language is involved. However, our data strongly suggest that language-specific selection is achieved through massive inhibition of the unwanted language: it is difficult to see how target picture naming in L1 English could be inhibited by the use of L2 French on a preceding trial, or how the within-English semantic competitor priming effect could be eliminated by the use of L2 French on the trial preceding a target trial in L1 English, if there was not at least inhibition of L1 English during production of L2 French.

In summary, the present study experimentally demonstrated that cross-language lexical competition is a feature of the word production system in the bilinguals who participated in the present study, and that the selected language bias, which is effected through inhibition of the unwanted language, plays an important role in resolving the lexical competition involved in bilingual word production in a selected language. Our data could be interpreted in terms of Costa and his colleagues' suggestion of a language-specific lexical selection mechanism, but they also place constraints on how the mechanism is to be implemented.

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Appendix 1

Materials for the main experiment on within- and cross-language semantic competitor priming: the definition of a semantic competitor is followed by, in parentheses, the semantic competitor itself and its corresponding target word in English/French.

Edam is a kind of Dutch ___. (cheese, butter/beurre)
The Queen lives at Buckingham ___. (palace, castle/château)
Animal that travellers ride on in the desert (camel, horse/cheval)
Four and twenty blackbirds baked in a ___. (pie, cake/gâteau)
You cut the wool off a sheep with a pair of ___. (shears, scissors/ciseaux)
A child often sucks its ___. (thumb, finger/doigt)
Ticking time piece that stands on a cupboard (clock, watch/montre)
*Adult male of domestic cattle (bull, cow/vache)
Small dwelling in rural area with thatched roof (cottage, house/maison)
Cunning animal with a bushy tail, hunted by the gentry (fox, dog/chien)
It rises in the east and sets in the west (sun, star/étoile)
Small soft fruit with a stone, whose skin can be yellow or purple (plum, strawberry/fraise)
In the race the tortoise beat the ___. (hare, rabbit/lapin)
*Heavy footwear for walkers (boot, shoe/chaussure)
*Delicious, hard, brown food made from cocoa beans (chocolate, sweet/bonbon)
Piece of clothing worn by woman which covers her body and part of her legs (dress, skirt/jupe)
An ___ a day keeps the doctor away. (apple, pear/poire)
*Form of air transport used in mountain rescue (helicopter, aeroplane/avion)
Pair of straps that men use to hold up trousers (braces, belt/ceinture)
Public place where children are educated (school, church/église)
*A man who lives in a monastery (monk, nun/nonne)
Long strip of material worn round neck for warmth (scarf, tie/cravate)
*Small portable mechanical device used for igniting cigarettes (lighter, match/allumette)
Cinderella had a ___ Godmother. (fairy, angel/ange)
*Piece of plastic with pointed teeth, used for combing your hair (comb, brush/brosse)
Sensory organ for hearing (ear, eye/oeil)
You switch it on to watch programmes (television, radio/radio)
*Spherical representation of surface features of the Earth (globe, map/carte)
It falls in white fluffy flakes from the sky. (snow, rain/pluie)
Part of skeleton, corresponding to the head (skull, bone/os)
Transparent utensil from which you drink liquid (glass, cup/tasse)
*They were given a twenty-one ___ salute. (gun, cannon/canon)
Wooden implement for smoking tobacco (pipe, cigarette/cigarette)
She waited for the double decker ___ for half an hour. (bus, train/train)
Warm covering you wear on your hand (glove, sock/chausette)
You put food into your ___ when you eat. (mouth, nose/nez)

Appendix 2

Materials for the sub-experiment on within-language long-lag repetition priming: the definition of a target word is followed by the target word itself in parentheses.

Powerful carnivorous animal with shaggy mane (lion)
Seat for one, having no back or arms (stool)
You hold one under your chin and play it with a bow (violin)
Regular block used for building walls (brick)
*Fabric case filled with soft material, which you put on a seat (cushion)
Large musical instrument with a row of black and white keys (piano)
*Garden tool used for loosening earth (rake)
Man's outfit which consists of a jacket and trousers, all made from the same fabric (suit)
Tool used for cleaning the floor, which has a sponge and a long handle (mop)
Everest is the highest ___ in the world. (mountain)
Piece of furniture with a flat top, used for putting things on (table)
*Water bird with short legs, short neck and large flat back (duck)
Very small bag that people use to keep their coins in (purse)
Snack made of two slices of bread and a filling (sandwich)
Enormous fish that has sharp teeth and attacks people (shark)
Container with a lid, used for making and serving tea (teapot)

Appendix 3

Materials for the sub-experiment on cross-language long-lag ''repetition'' priming: the definition of the translation equivalent of a target word is followed by the target word itself in parentheses.

Animal that lives in the sea and is caught with a hook (poisson "fish")
Organ for pumping blood (coeur "heart")
You can borrow one from a library (livre "book")
*Fruit which grows in a vineyard and is used for making wine (raisins "grapes")
*In autumn the ground is covered with fallen ___. (feuilles "leaves")
Four-wheeled personal transport (voiture "car")
Outdoor head covering, often with brim (chapeau "hat")
Vertical surface made of bricks (mur "wall")
You cut steak with it (couteau "knife")
Part of body you use to hold things or pick things up (main "hand")
You attach them to letters, postcards, etc. (timbres "stamps")
Small vessel for travelling on water (bateau "boat")
*"Please open the ___, not the door, to let some fresh air in." (fenêtre "window")
Piece of furniture you sleep on at night (lit "bed")
Structure for spanning a river (pont "bridge")
Large plant with a woody trunk, branches, etc. (arbre "tree")

Appendix 4

Breakdown of data lost in each category in the various conditions of the main experiment and the sub-experiments

	Condition[a]	%TT[b]	%CF[c]	%TL[d]	%WG[e]	%PL[f]	%MP[g]
Main	EEP	6.3 (2.6)	0.0	0.0 (0.0)	1.2	1.4	3.7
experiment	EEU	1.2	0.0	0.0 (0.0)	0.0	1.2	n.a.
	FFP	11.8 (10.5)	2.1	2.3 (1.8)	3.8	2.3	1.3
	FFU	9.9	1.4	3.5 (3.5)	4.5	0.6	n.a.
	FEP	8.4 (5.9)	0.0	1.9 (1.9)	1.4	2.6	3.1
	FEU	3.6	0.5	0.5 (0.5)	0.0	2.5	n.a.
	EFP	10.6 (7.8)	1.7	4.1 (2.4)	1.3	0.7	3.5
	EFU	8.2	0.7	4.9 (2.3)	2.6	0.0	n.a.
Within-language	E . . . EEP	12.1 (2.4)	0.0	0.0 (0.0)	2.4	0.0	10.3
sub-experiment	E . . . EEU	2.5	0.0	0.0 (0.0)	2.5	0.0	n.a.
	E . . . FEP	9.1 (1.3)	0.0	0.0 (0.0)	0.6	0.7	7.8
	E . . . FEU	3.2	0.0	0.0 (0.0)	0.6	2.6	n.a.
Cross-language	E . . . FFP	8.1 (5.2)	0.6	1.8 (1.2)	0.0	2.8	3.0
sub-experiment	E . . . FFU	7.1	1.2	1.9 (1.2)	2.0	2.1	n.a.
	E . . . EFP	10.8 (5.1)	0.0	0.6 (0.6)	3.8	0.7	5.6
	E . . . EFU	3.3	1.4	1.2 (0.6)	0.7	0.0	n.a.

[a] Experimental condition (cf. Tables 1 to 3).

[b] Mean total percentage of lost data. %TT may be less than the sum of the corresponding %CF, %TL, %WG, %PL, and %MP because some data points were lost for more than one reason, but they were counted only once in the calculation of mean total percentage of lost data. (In parentheses is the mean total percentage of lost data obtained when misprimed but otherwise correct naming responses had been reinstated.)

[c] Mean percentage of data lost to the 3 s cut-off.

[d] Mean percentage of data lost to the use of an incorrect language in naming a target picture. (In parentheses is the mean percentage of "correct" response in the wrong language.)

[e] Mean percentage of data lost to wrong responses (but in the right language) in naming a target picture.

[f] Mean percentage of data lost to the use of an incorrect language in naming an immediately preceding filler picture.

[g] Mean percentage of data lost to mispriming.