Bilingualism: Language and Cognition 9 (2), 2006, 189–201 © 2006 Cambridge University Press doi:10.1017/S1366728906002537

Language control in bilinguals: Monolingual tasks and simultaneous interpreting

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The typical speech of (fluent) bilinguals in monolingual settings contains few switches into the non-target language. Apparently, bilinguals can control what language they output. This article discusses views on how bilinguals exert control over their two languages in monolingual tasks, where participants only have to implicate one of their languages in performing the task, and in translation and, especially, simultaneous interpreting, tasks that can only be performed if both languages are addressed. A distinction is made between "global" control, where control involves the activation and/or inhibition of complete language systems, and "local" control, where control impacts on a restricted set of memory representations. A number of studies suggest that bilingual control is a special case of the control of action in general. This insight suggests an opportunity to incorporate relevant work in the field of translation studies in the study of bilingual control, embedding it in the same theoretical framework.

During the past 25 years the study of bilingualism from a cognitive point of view has drawn the attention of an increasingly larger number of researchers. One of the reasons for this increased interest is a growing awareness that bilinguals may process language differently from monolinguals. The canonical models of language processing have been based on the study of monolingual language users or on studying bilingual or multilingual language users from a monolingual point of view. In the latter type of studies the fact that the participants have a command over more than one language is simply ignored. The models of language processing that emerged from these research efforts may be incomplete or, worse, flawed. The study of bilingualism helps to identify such caveats and flaws, thus contributing to a fuller understanding of human language processing.

A common approach in studying bilingualism is testing the bilingual participants in monolingual tasks, that is, in tasks in which the participants, IN THEORY, only have to tap into one of their two language systems, such as picture naming in their L1 or lexical decision in their L2. According to this definition, studies that use tasks in which the participants speak in one language while to-be-ignored distractors in the other language are presented may also be regarded monolingual tasks. Stretching the definition of a monolingual task somewhat further, even language-switching tasks, where participants have to produce a response in L1 on some trials and in L2 on other trials, might be regarded monolingual tasks: responding ON EVERY INDIVIDUAL TRIAL only requires the involvement of one of the two language systems. An interesting question is whether and when the other language system is nevertheless implicated while performing these tasks. Many of these monolingual-task studies have shown that, indeed, the non-target language is also involved in task performance. Another approach is to use bilingual tasks pur sang, that is, tasks that can only be performed if (on every single trial) both language systems are addressed somehow. One such task is translating between the languages involved, where the term TRANSLATING covers all forms of language use, written and oral, where a message expressed in one language (the SOURCE language) is rephrased into another language (the TARGET language).

The involvement of both of a bilingual's languages in both monolingual- and bilingual-task studies gives rise to the question how exactly bilinguals control the two languages in these tasks, more specifically, how they ultimately select the target language in the monolingual-task studies and balance the continuous involvement of the two language systems in bilingual tasks such as translation. The main purpose of this article is to contribute to answering this question, ultimately focusing on bilingual control in translation, and especially in simultaneous interpreting. Simultaneous interpreting is a form of oral translation where the translator (interpreter) must listen to and comprehend the speaker's speech and produce its translation at the same time, dividing attention between comprehension and production (and other task components; see below). The task poses a formidable challenge to even very experienced professional interpreters and requires subtle control operations that are likely to inform and qualify models of language control based on monolingual-task studies.

In the next section we start our discussion presenting Green's (e.g. 1986, 1998) interpretation of an intriguing

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https://doi.org/10.1017/S1366728906002537 Published online by Cambridge University Press

case of bilingual aphasia in terms of control failure. This case – and other forms of bilingual aphasia – illustrates the important role of control processes and mental resources in both monolingual language production and translation. Green's explanation of the associated symptoms has contributed importantly to the growing awareness that in order to understand bilingualism the pertinent models cannot do without a system that controls the workings of the language system proper. The way bilinguals exert control over their output is likely to depend on the structure of and information in the underlying language base. Therefore, a third section of this article presents some of the relevant views on structure. A fourth section discusses the various views on the way control is exerted in monolingual tasks. A fifth section extends the ideas presented in this section to the special case of language control in translating and interpreting. A different perspective on control in simultaneous interpreting is presented in the final section.

A control account of flawed language use

Paradis, Goldblum and Abidi (1982) presented a seemingly rather puzzling recovery pattern of two bilingual aphasics (one an Arabic–French bilingual and the second a French–English bilingual; see also Fabbro and Paradis, 1995, for a similar case). The recovery pattern was characterized by two salient phenomena that the authors dubbed ALTERNATE (or ALTERNATING; Paradis, 2004) ANTAGONISM and PARADOXICAL TRANSLATION. Alternate antagonism involved the alternating availability of either one of the two languages known before the aphasia. On one particular day the patient would be relatively fluent in producing one of the languages spontaneously and the other would be unavailable for spontaneous production, whereas on another day the opposite pattern would occur; on both days comprehension was good in both languages. In both patients, this switch pattern repeated itself several times. Particularly the combination of this phenomenon with the second phenomenon, paradoxical translation, was puzzling: on the days that, say, French, was available for spontaneous production in the Arabic–French bilingual, she could translate from French into Arabic but not from Arabic into French. Conversely, when Arabic was available for spontaneous production, she was successful in translating from Arabic into French but not from French into Arabic. The authors concluded, among others, that translation is a cognitive task totally dissociable from understanding and speaking two languages, and that the aphasia cannot have resulted from a loss of language competence, because the interval between failure to use a language spontaneously and subsequent successful usage was too short for relearning to have occurred between failure and subsequent successful use. Importantly, more cases of alternate antagonism have been identified (see Fabbro, 1999 for an overview), but unaccompanied by paradoxical translation.

Paradis et al. (1982) assumed the existence of two translation strategies: decoding of the source language input until a meaning is abstracted, followed by encoding in the target language, or going from an item in the source language directly to its equivalent in the target language (Paradis et al., 1982; see also Paradis, 1994, and the sub-section "Horizontal translation and translation systems" below). The authors proposed an explanation of successful translation into one language, combined with a failure to use that language spontaneously, in terms of this two-strategies model, by assuming a direct link between translation equivalents in the absence of a link from the conceptual representation to the phonological representation of the concerned word. At the same time they acknowledged that this explanation fails to account for why this link was not available in the opposite direction of translation. Furthermore, this explanation does not fit comfortably with the observation that links that are functional on a given day fail to work properly on the next, and vice versa.

Green (1986) took a different approach in explaining Paradis et al.'s (1982) data. He focused on the control requirement in using language, a focus that also materialized in much of his later work (Green, 1998; Price, Green and Von Studnitz, 1999; Green and Price, 2001; Green, 2005). According to Green (and others, e.g. Fabbro, 1999), non-pathological language use not only requires intact language (sub)systems and intact connections between them but also the means to activate and inhibit these systems and to inhibit inappropriate outputs of the systems. He furthermore assumed that both activation and inhibition require resources, energy, to operate and that these resources need to be replenished constantly. If the subsystems are intact but the resources to activate or inhibit them or to inhibit their outputs are insufficient, performance failure may result. Green assumed that the two bilingual aphasic patients of Paradis et al. (1982) – and aphasics of other types to be discussed later – had intact language systems, with separate subsystems for comprehension and production, but that their aphasia had affected (at least temporarily) the availability of sufficient resources for inhibition.

Green (1986) envisioned a bilingual language system that contains two word-input systems, one for each language L1 and L2; two word-output systems, again one for each language; one conceptual system shared between the languages; one system for phonological assembly that operates on the output of both word-output systems; one specifier, that specifies how the system must be controlled in order to speak the one or the other language (or to perform another task such as translating between the two languages); and, finally, a resource generator, that provides the system with the energy to operate. For

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each language, two processes of suppression (inhibitory control) may be operative, one external and one internal. Internal suppression involves the suppression of the output of a word-output system so that this output will not be fed into the phonological assembly system. External suppression suppresses activation at the assembly stage. Exactly which of the suppression mechanisms is operative at any moment in time and on what subsystem depends on the particular demands of the task to be performed (e.g. speaking L1; speaking L2; translating from L1 into L2; translating from L2 into L1). But, in general, Green (1986) assumed (without clearly substantiating this position) that the spontaneous language use in one particular language involves the external suppression of the words from the other language, whereas translation performance implicates the mechanism of internal suppression. So, for instance, if a bilingual intends to speak L1, L2 words are externally suppressed, and if this same bilingual intends to translate from L1 to L2, L1 words are internally suppressed, given that the available resources required for suppression suffice in both cases.

Given this theoretical framework, Green (1986) attributed the pattern of alternation in Paradis et al.'s (1982) two patients to too slow a rate of generation of the resources required for the specific type of suppression involved. For instance, if the resources that suppress L2 internally (thereby enabling translation from L2 into L1) gradually decrease, at some point the (L2) output from the L2 word-output system will no longer be adequately suppressed. From this point in time translation from L2 to L1 will be impeded. In the mean time, the resources required for suppressing L1 internally may have been built up sufficiently, enabling translation from L1 to L2.

The attraction of a control account of failures in language use is the wide scope of such failures it can explain. First, failures in control provide a means to explain other cases of pathological language behavior than alternate antagonism combined with paradoxical translation, such as the inability to avoid switching between the two languages (BLENDING, as observed by, for instance, Fabbro, Skrap and Aglioti, 2000) and SELECTIVE RECOVERY, where there are lasting aphasic symptoms in one language. In the case of blending, the problem may be caused by the control mechanism failing to let the target language maintain dominance over the other language as long as the communicative setting demands it to do so. In Paradis' (2004) terms, the problem is due to loss of inhibition. On the other hand, in selective recovery the specific problem may be that the control mechanism cannot stop one language from dominating the other ('permanent inhibition'; Paradis, 2004). SEQUENTIAL RECOVERY (where one language only begins to reappear after the other one has been restored) and DIFFERENTIAL RECOVERY (where recovery of the one language is accompanied by recovery of the other language but the two languages do not progress equally) may be caused by temporary inhibition and greater inhibition of one language, respectively (Paradis, 2004).

Assuming an important role for a control mechanism in language use, a mechanism that needs constant fueling at a sufficient rate to operate flawlessly, provides the insight that imperfect control may also underlie performance failures in the language use by non-aphasics: external circumstances that compete with language processing for the limited resources, such as stress-inducing circumstances, anxiety, jet lag and fatigue, may affect language performance in non-aphasics. The fact that the speech errors produced by non-aphasics are similar to the errors produced in language pathology, supports the view that problems of control may underlie both (see e.g. Dornic, 1978).

Green (1998) widened the scope of his control approach to pathological and non-pathological language use even further by embedding (a different version of) his theory (now called the "Inhibitory Control Model") in a general theory of action (Norman and Shallice, 1986), departing from the assumption that the control of language processes and the control of action have much in common. In so doing, he adopted from this general theory the notion of schemas (memory networks that specify action sequences) and of a Supervisory Attentional System (SAS), which constructs and modifies existing schemas and monitors whether performance meets the goals set by the task to be performed. Applied to the language domain, Green proposed that so called language task schemas regulate the outputs from the lexico-semantic system by altering the activation levels of representations within that system and by inhibiting outputs from the system (Green, 1998, p. 69). For instance, when a bilingual's task is to name pictures in L2, the relevant schema is activated and enables task performance by increasing the activation level of L2 items in the lexico-semantic system, decreasing the activation of L1 items in that system, and inhibiting the L1 outputs that, despite the differential activation of L2 and L1 items in the system, might nevertheless seep through. If, instead, the task is naming pictures in L1, the opposite pattern of control is established by the SAS. Translation from L1 to L2 or from L2 to L1 requires yet different, more complex, forms of regulation. For instance, when the task is to translate from L1 to L2, a schema for FORWARD (L1 to L2) translation is installed by the SAS. This schema specifies L1 as the input and activates a schema for producing L2 as the output; it, furthermore, inhibits the schema for naming the input in L1 (Price et al., 1999). Note that, as in Green (1986), two loci of control are assumed, one acting proactively, by adapting the levels of activation of the elements in L1 and L2 to the requirements of the task, and a second operating reactively, suppressing non-target language output that inadvertently pops out of the system. It is not clear whether or not these two loci of control map

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onto the two loci of control (internal and external control) assumed in the earlier model.

Green's (e.g. 1986, 1998, 2005) views on resource limitations and language control have played, and continue to play, a crucial role in current theories of bilingualism. Much of the earlier work on bilingualism was – partly because of the different questions it posed – only concerned with language representation, ignoring language control. More recent models acknowledge the importance of control in bilingual language processing and try to incorporate it, sometimes by adopting Green's notion of task schema's (e.g. the most recent version of the Bilingual Activation Model, Dijkstra and Van Heuven, 2002). As pointed out earlier, the way control is exerted depends on the structure of and information in the underlying language base. In our next section we will present some views on this, thus laying a foundation for the fourth section, which deals with control in monolingual tasks.

Bilingual language structure

Many (if not all) models of bilingualism assume, explicitly or implicitly, the existence of separate language systems for the bilingual's two languages. For instance, Macnamara and Kushnir (1971) regarded the occurrence of a cost in processing when the input switched between the bilingual participant's two languages, as support for a switching device that directs the incoming information to the appropriate language system. They assumed that the other language system is not implicated in processing the input; in other words, the switch data were regarded support for language-selective access (but see, e.g. Grainger and Beauvillain, 1987). The point to make here is that, irrespective of the nature of the access process, Macnamara and Kushnir assumed separate language systems for the bilingual's two languages, because assuming a switch only makes sense when there are at least two systems to switch between.

A separation between language subsystems can also be identified in Dijkstra and Van Heuven's (1998, 2002) Bilingual Interactive Activation (BIA) model of bilingual language comprehension. (Yet, contrary to Macnamara and Kushnir, 1971, these authors adhere to the view that bilingual lexical access is language nonselective.) In addition to two layers of feature and letter nodes shared by the two languages and a word level where the words from both languages are fully connected, the BIA model contains a level with two language nodes, one for each language. In the 1998 version of the model a given language node receives activation from activated word representations from the corresponding language and sends back inhibitory excitation to the word representations of the other language. Such a process implies excitatory connections between each of the word-level elements of a language and the corresponding language node as well as inhibitory connections from this language node to the word-level elements of the other language. This setup, involving structural connections between representations, basically equals a separation between the two language subsystems, but at a more fine-grained level of analysis than explicated in Macnamara and Kushnir's account of switching. The later version of the BIA model (BIA+; Dijkstra and Van Heuven, 2002) no longer contains inhibitory connections from a language node to the word-level elements of the other language but has kept the excitatory connections from the word-level elements to the language node of the corresponding language; it thus has also kept the language-subsystems structure of the earlier version.

A number of authors (e.g. Poulisse and Bongaerts, 1994; Poulisse, 1997; Green, 1998; De Bot, 2000) assume that lexical representations or, more specifically, lemma's, contain a language tag, that is, the information that a particular element belongs to a particular language. In so doing, these models also distinguish between the two language subsystems of a bilingual: all elements with the one type of tag belong to one language; all elements with the other type of tag belong to the other language.

Finally, separate language subsystems can be identified within the bilingual language system because the elements representing the words of each language may be embedded in a separate network of strongly associated elements (Paradis, 1994; Grosjean, 1997a; De Bot, 2000). According to this account it is the unique position of the representation in a network of strongly associated elements that determines language membership. The associations themselves are formed just as all associations are formed, that is, by contiguity of the elements in the environment (and possibly by mental contiguity, that is, by the co-occurrence of words in thought). In other words, the representations of the words belonging to one particular language become strongly inter-connected in bilingual memory because they co-occur (in different combinations) in actual language use and are encountered as such by the language user. Some authors (e.g. Green, 1998; De Bot, 2000) assume the existence of both such subsets of strongly intertwined word representations in memory as well as a language tag for each individual word (lemma) representation. In a way such a set up specifies language membership twice for each word, once implicitly, in terms of the exact position and pattern of connections of the representation in the language network, and a second time explicitly, by the language tag.

Bilingual control in monolingual tasks

Given the different structural options described in the previous section, bilinguals may exert control over their two language subsystems by differentially activating

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and/or inhibiting their two language subsystems globally and/or locally, and they may do so proactively and/or reactively. Global activation and/or inhibition concerns the activation or deactivation/inhibition of a complete subsystem; in other words, all elements in the subsystem are simultaneously affected. In the case of local activation and/or inhibition not the complete subsystem but specific individual representations in it are affected. In theory, in one and the same model, these two types of activation/inhibition may both be assumed to operate, or a given model may rely on one of the two exclusively. In Green's (1998) Inhibitory Control Model control is exerted by, proactively, balancing the global activation levels of the two language systems and at the same time inhibiting, reactively and locally, inadvertent outputs of the non-targeted language system (a process that appears to implicate that the output of the complete non-target-subsystem is monitored). The language task schemas are responsible for both types of regulation. Lemmas in the lexico-semantic system are assumed to each contain a language tag. The selected schema exerts its activating and inhibiting effect through these language tags.

In the commentaries to Green (1998), both De Groot (1998) and Kroll and Michael (1998) stressed one particular problematic feature of Green's model of inhibitory control, namely, the fact that the language task schemas to be readied by the Supervisory Attentional System are not (always) structures that reside in memory permanently, but often have to be build up on the spot. As De Groot (p. 86) put it: "The task schemas appear to be the equivalent of an understanding of the task instructions in the subjects, of their mental representation of these instructions", and Kroll and Michael (p. 90) pointed out that "surely none of us arrived equipped with a lexical decision schema". It is hard to see how such temporary structures, with a content that varies with the specific demands posed by the current task (often a rather artificial task), could be equipped with detectors that can recognize the identity of the language tags. Such recognition seems a prerequisite for the constructed schema to perform one of its jobs: suppressing the lemmas from the non-targeted language. Recognition is part and parcel of the realm of well-established memory structures; it is hard to imagine how ad hoc structures in working memory could perform that job.

Another feature of Green's (1998) model that has been questioned is the notion of (local) reactive inhibitory control. In a series of picture-naming studies that, among others, tried to resolve the question whether speech production proceeds in a discrete, serial way or, instead, cascaded, Costa and colleagues (Costa, Miozzo and Caramazza, 1999; Costa, Caramazza and Sebastián-Gallés, 2000; see also Costa, 2005) developed a model of bilingual language production that encompasses two critical stages: a stage of language-nonspecific activation of the bilingual system followed by a stage of language-specific lexical selection, where only words of the target language compete for selection. The data of both Costa et al. (1999; picture naming with distractor words) and Costa et al. (2000; picture naming without distractors) strongly suggested that the non-target language is activated during picture naming. Furthermore, the results suggested that activation of the non-target language is not confined to the lexical-level representations (see also Hermans, Bongaerts, De Bot and Schreuder, 1998), but proceeds to the sublexical phonological representations, a finding that supports cascaded production models. Especially crucial in the present context was the finding (Costa et al., 1999) that distractor words that were translations of the intended response (e.g. a picture of a table, requiring the Catalan response *taula*, presented with *mesa*, the Spanish word for table; participants were Catalan–Spanish bilinguals) FACILITATED responding as compared to a condition with unrelated distractors. Costa et al. (1999; see also Costa, 2005) argued that the language-nonspecific model of lexical selection predicts the opposite result, that is, SLOWER responding with translation distractors, and concluded that during lexical selection elements of the non-target language are not involved in the competition process. If true, no process of (local) reactive inhibition, as assumed by Green (1998), has to be assumed (see also Roelofs, 1998, who arrives at the same conclusion on the basis of other arguments).

Meuter and Allport's (1999) views on bilingual control appear to involve the notion of global inhibition of either the L1 or the L2 language subsystem. Similar to Green (1998), these authors embedded their study in a more general theory of control that was developed to explain cognitive control in a variety of tasks, linguistic as well as non-linguistic. In fact, when applied to the language domain, the act of task switching in this more general theory appears to equal the installment of a new language schema in Green's Inhibitory Control Model (see also Costa and Santesteban, 2004). Meuter and Allport focused on "paradoxical" asymmetries that are observed when participants have to switch between an easy, behaviorally relatively dominant task (e.g. word reading, a task well practiced in adult, literate, readers) and a more difficult, behaviorally weaker task (e.g. color naming). The cost that accompanies a switch between tasks is typically larger when the participant has to switch from the weaker (color naming) to the more dominant (easier, more practiced) task than with a switch in the reverse direction, from dominant into weak. This counterintuitive effect is explained in terms of differences in the required level of suppression of the non-target task, in combination with a phenomenon called "Task Set Inertia": to enable task performance, the non-target task must be actively suppressed and the target task must be activated. The stronger the non-target task, the more it has

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to be suppressed in order not to interfere with target-task performance. Task Set Inertia is the phenomenon that the task set of the previous trial carries over into the current trial. In other words, with a switch from color naming to word reading, the relatively strong suppression of the (dominant) word-reading task on the previous trial causes a relatively large delay in producing the word reading response now required (Allport, Styles and Hsieh, 1994).

Meuter and Allport (1999) used this switching methodology testing a group of unbalanced bilinguals who during the course of the experiment switched unpredictably between numeral naming in L1 and L2. As predicted, switch trials were slower than non-switch trials, and the switch cost was larger with a switch from the weaker L2 to the stronger L1 than with a switch from L1 to L2. The latter result replicated the "paradoxical" asymmetry observed in the earlier (not bilingual) studies and can readily be accounted for in terms of the more general theory on the control of task performance advanced by Allport et al. (1994). These results strongly suggest that bilingual language production requires the suppression of the non-target language and the activation of the target language, and that the degree of suppression of the non-target language depends on language strength: the stronger the non-target language, the more it needs to be suppressed in order not to interfere with the current target language.

The fact that the results mimicked those of earlier studies on task control in other domains supports the contention of Green (1998) and Meuter and Allport (1999) that language switching is a special case of task switching in general. Hernandez, Martinez and Kohnert (2000) provide additional support for this view. These authors searched for neural correlates of language switching (in a picture-naming task) in an fMRI study, and observed that the dorsolateral prefrontal cortex was involved. From the fact that this area is likely to be involved in other task switching behavior as well, they inferred that there is no area exclusively involved in language switching, in other words, that no such thing as a language switch is likely to exist.

The theoretical framework of Meuter and Allport (1999) predicts equally large switch costs in both switching directions in the case of balanced bilinguals, equally proficient in both languages (because in that case the baseline activation levels of the two language subsystems are the same and, therefore, no differential suppression is required), a finding that was indeed obtained in an earlier (category-naming) study by Meuter (1994). In a series of five experiments, Costa and Santesteban (2004) extended and qualified Meuter and Allport's results, focusing on the effect of bilinguals' relative proficiency in their two languages and using a picture-naming task instead of a numeral-naming task. With this setup, when testing unbalanced bilinguals (Spanish native speakers learning Catalan and Korean learners of Spanish), Costa and Santesteban replicated the asymmetrical switching costs observed by Meuter and Allport (1999). However, the asymmetry disappeared when balanced (Spanish–Catalan) bilinguals were tested. Interestingly, balanced (Spanish–Catalan) bilinguals who were in the process of learning a third language (English), which was still much weaker than their L1 and L2, demonstrated this same pattern (no asymmetry in the switch costs) when they switched between Spanish and their (weak) L3, English. To explain this unexpected result the authors suggested that switching behavior in these tasks changes qualitatively rather than quantitatively during the learning of a new language, L2, and that, when yet a further language, L3, is being learned, the switching behavior applied to the, by then, strong L2 is transferred to the L3.

Maybe the most appealing work suggesting that language switching shares (at least part of) its underlying mechanisms with tasks in other domains than the language domain, exploiting a more general mechanism of inhibitory control, is Bialystok's work on the relation between bilingualism and the effectiveness of mental control processes outside the language domain (e.g. Bialystok, Craik, Klein and Viswanathan, 2004; Bialystok, Craik, Grady, Chau, Ishii, Gunji and Pantev, 2005). Earlier studies had demonstrated that the decline in cognitive functioning with aging is to a large extent due to reduced effectiveness in inhibitory processes. Bialystok et al. (2004) took this observation as a starting point and predicted that bilinguals, due to the fact that their bilingualism has turned them into experts in inhibitory control, might be less susceptible to normal age-related decreases in inhibitory control than monolinguals. This is exactly what they found in a series of studies where middle-aged and older monolingual and (balanced) bilingual adults performed the "Simon task", a task that assesses the participants' ability to ignore irrelevant spatial information (see Bialystok et al., 2004, for further details). Not only did the bilinguals show a reliably smaller inhibitory effect of irrelevant spatial information than the monolinguals; they also showed a much smaller increase of the inhibitory effect with aging. Furthermore, bilingualism turned out to partly offset the negative effect of aging on working-memory capacity.

Bialystok et al. (2005), again using the Simon task, looked for neural correlates of this difference between monolinguals and (balanced) bilinguals using the magneto-encephalography technology. One of the analyses they performed on the brain images revealed differences between the brain-behavior relations in monolinguals and bilinguals. Specifically, faster responding in bilinguals was related to greater involvement of areas in the left prefrontal cortex and anterior cingulate cortex (cf. the translation and language switching study of Price et al., 1999). In contrast, fast responding in monolinguals was associated with greater activity in middle frontal

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regions. The authors suggested that the requirement of bilinguals (at least those who are active daily in their two languages) to continuously keep their languages apart has led to systematic changes in frontal cognitive functions. Importantly, prior experience in the language domain apparently leads to behavioral changes in a different domain (as addressed in the Simon task), suggesting the workings of a task-neutral control system. Given the occurrence of such changes, especially the neural changes, Costa and Santesteban's (2004) observation that near balanced bilingualism appeared to have caused a qualitative change in the switching behavior of bilinguals – a change that also appears to be operative when they switch between one of their two strong languages and a new language in an early stage of learning; see above – may seem less surprising than it appeared at first.

The models discussed so far in this section all assume that language selection involves the activation and/or inhibition of complete language subsystems – in other words, that control is global – and that the control mechanism involved not only regulates language behavior but other cognitive behavior as well. In some cases (e.g. Green, 1998), control involves a mixture of global proactive activation (of the target language) and global proactive inhibition (of the non-target language), augmented with a process in which elements of the non-target language that, despite the non-target language's global inhibition, nevertheless seep through, are filtered out reactively. They are recognized as elements of the non-target language because each individual lexical item is assumed to contain a language tag that specifies the item's language membership.

A number of other authors have also advanced the idea of global control, but without detailing a relation (if any is assumed at all) with a more general control system. As already pointed out above, according to Paradis (1994), Grosjean (1997a, b; 2001) and De Bot (2000), the two languages of a bilingual are stored in two separate language subsets/networks of strongly connected elements. The language subsets can be activated or inhibited independently of one another, and the pattern of interrelations between the elements within a subset determines language membership (so that language tags do not necessarily have to be postulated). According to Paradis (1994), when a bilingual intends to speak in one language only, the activation threshold of the non-selected language is raised sufficiently (inhibited) to prevent interference from that language during production. As mentioned, various forms of language pathology can be accounted for in terms of failures in setting, sustaining, or undoing the activation levels of the two language systems appropriately.

Grosjean (1997a, b; 2001) extended the view of global activation and inhibition by assuming that bilinguals respond to the specifics of the communicative setting by delicately balancing the activation levels of the two language systems such that they optimally meet the goals of this setting: depending upon such factors as the characteristics of the person spoken to, the conversational topic, the exact circumstances in which the conversation is held, and the goal of an interaction, a bilingual speaker "chooses" (but presumably unconsciously) a position on a LANGUAGE MODE CONTINUUM. On the one end of the continuum, the base language is maximally activated and the other language (the guest language) is deactivated as best as possible. In Grosjean's terminology, a bilingual operating in this state is in the MONOLINGUAL LANGUAGE MODE. This pattern of activation is associated with relatively few code switches. At the other end of the continuum, the two languages are about equally activated; the bilingual speaker is said to be in a BILINGUAL LANGUAGE MODE, a pattern of activation that gives rise to the occurrence of relatively many code switches.

La Heij (2005), extending earlier work by Poulisse and Bongaerts (1994) and Poulisse (1997), provided maybe the most parsimonious solution to the problem of language control presently available. In contrast to the views discussed above, his solution is one in terms of local control. In passing, he also provided a solution for the so called CONVERGENCE PROBLEM that has led to much debate in the monolingual language-production literature (see e.g. Levelt, 1989; Roelofs, 1992); this problem entails that the conceptual information in the preverbal message often does not uniquely specify one lexical item but matches more than one item instead. How then is the intended word, and not a competitor, output by the system? La Heij argued that this situation also holds for bilingual language production, where as a rule the L1 word and its L2 translation both express the same conceptual content. His solution is to assume a process of "complex access, simple selection", in which as part of the preverbal message it is specified, by means of a language cue, what language the bilingual wants to use. Lemmas are activated to different degrees, depending upon the amount of overlap between the information contained by the preverbal message and the information embedded in the lemmas, the latter including language tags. Because of the higher overlap, this process will typically result in the selection of a lemma in the target language. A similar solution can be applied to language production in monolinguals: according to La Heij, the preverbal message contains detailed information on the speaker's intention, such as whether slang, formal language, irony, or a euphemism should be used. Because the specifications in just one or very few lemmas will match this detailed set of information in the preverbal message, ultimately only one or very few lemmas will be selected (in the latter case, a production error may occur).

This section reviewed views on bilingual control in monolingual tasks, stressing the fact that a number of

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authors assume bilingual control is exerted by a control mechanism that also operates in other domains than language. The next section extends the views of global and local control to the bilingual tasks of translating and interpreting.

Bilingual control in translation and simultaneous interpreting

Paradis (1994) extended the view of differential activation of the two language systems of a bilingual to explain how translation and, more specifically, simultaneous interpreting, come about. Because in simultaneous interpreting comprehension of the source language and production of the target language take place simultaneously, at least most of the time (Chernov, 1994), in simultaneous interpreting (and in translation in general) both language systems must be activated simultaneously, although possibly not to the same extent. Paradis (1994) suggested that in simultaneous interpreting the threshold of all the elements in the source language is set higher than the threshold of the target-language elements. As a consequence of this setup, the interpreter will produce output in the target language (although occasionally a source language word may slip through).

Such differential global activation and inhibition (through threshold raising) of complete language subsets may guarantee that in most cases a word from the target language, not the source language, is spoken, but it does not yet explain why the INTENDED word, that expresses the conceptual information to be verbalized, is spoken rather than any other word from that same language. In order to account for this, the system will have to be augmented by a language production process where, in various steps, a specific conceptual content is expressed in a word that matches this particular content. One of the two translation strategies proposed by Paradis (1994; STRATEGY I, CONCEPTUALLY MEDIATED TRANSLATION, or VERTICAL TRANSLATION, De Groot, 1997; Macizo and Bajo, 2005; see also Paradis et al., 1982) indeed encompasses such a production process. According to this translation strategy the source language utterance is decoded until a non-linguistic meaning is abstracted, via phonological, morphological, syntactical and lexical semantic analysis. Subsequently, the abstracted non-linguistic meaning is encoded in the target language via lexical semantic, syntactical, morphological, and phonological processing steps. Conceptually mediated translation may thus exploit the same underlying system(s) as used in common, intra-lingual comprehension and production (although the fact that in translation comprehension and production operate in parallel presumably implies that they are modulated as compared to these processes operating in isolation).

One potentially problematic aspect of differential activation of the two language subsystems or, more specifically, of the relatively low level of activation of (or the high thresholds of the elements in) the source-language system, is that it may lead to sub-optimal comprehension. Under those circumstances simultaneous interpreting is likely to break down. The importance of good comprehension for simultaneous interpreting was demonstrated in a study by Barik (1975), who compared the interpreting performance of professional conference interpreters, student interpreters, and 'amateur' translators (fluent bilinguals without interpreting experience): the less proficient translators performed better when their dominant language was the source language and their weaker language was the target language than the other way around. Tommola, Laine, Sunnari and Rinne (2000/2001), obtained a similar result when testing professional interpreters with interpreting experience ranging from 5 to 20 years (accuracy scores concerned propositional accuracy). This result may seem surprising, given that, in general, language production (here, of the target language) is harder than language perception (of the source language; e.g. Snodgrass, 1993; Paradis, 1994) and that word translation has been argued to be harder from the stronger language to the weaker language than vice versa (e.g. Kroll and Stewart, 1994). In fact, a further finding of Tommola et al. (2000/2001; see also Rinne, Tommola, Laine, Krause, Schmidt, Kaasinen, Teräs, Sipilä and Sunnari, 2000) suggests that simultaneous interpreting is also harder from the stronger to the weaker language: employing the Positron emission tomography (PET) technique they observed more extensive activation when participants interpreted from their native language Finish into their non-native and weaker language English than vice versa. In other words, interpreting into the non-dominant language recruited more neural resources. Tommola et al.'s combined data thus suggest that, in terms of the number of errors, the participants are better at a task that is cognitively more demanding. This result, counterintuitive as it may seem, makes sense if one realizes how important good comprehension of the source language is for interpreting: with the dominant language as the source language, the comprehension processes are more effective, "enabling the interpreter to render more of the content, despite the fact that, qualitatively, the surface-level textual links between propositions, the lexical-syntactic formulation of output, and the fluency of delivery may not be at the same level as in SI into the dominant language" (Tommola et al., 2000/2001, p. 159). In other words, with the weaker language as the target language, all sorts of surface characteristics of the output may be more compromised than with the stronger language as the target language, but the rendering of the input messages' content may be better. Obviously, the correct rendering of meaning is of crucial importance in simultaneous interpreting, presumably generally more important than rendering polished output.

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The error data in the studies by Barik (1975) and Tommola et al. (2000/2001) show the importance of good comprehension in simultaneous interpreting. This requirement is hazarded in Paradis' proposal of differential activation of the source and target languages in translation and, specifically, in simultaneous interpreting. Activating the source-language system to the same extent as the target-language system provides no adequate solution to this problem, because under those circumstances the interpreting output would be mixed language. This is a situation the interpreter must avoid under all circumstances (and, indeed, motivated the assumption of a relatively low level of activation of the source-language system). Grosjean's (1997a; 2001) solution was to add input and output processing mechanisms to both language systems, that, just as the language systems proper, can be more or less strongly activated, or totally deactivated. Grosjean assumed equal levels of activation of the two language systems in simultaneous interpreting. In contrast, the input processing mechanism of the source language is activated (to allow for comprehension of the source language), but the output processing mechanism of the source language is inhibited (so that no source language elements emerge in the interpreter's output). Furthermore, both the input and output processing mechanisms of the target language are activated, albeit possibly to different degrees. The target language's output processing mechanism is activated for the obvious reason that output in this language is required. That the target language's input processing mechanism is activated as well is suggested by the fact that interpreters, as language users in a monolingual setting (Levelt, 1989), monitor their own speech (e.g. Gerver, 1976; Isham, 2000; Christoffels and De Groot, 2005).

An alternative, more parsimonious, solution appears to be to not distinguish between language systems on the one hand and input and output processing mechanisms on the other hand, as does Grosjean (1997a; 2001), but to REPLACE both the source and the target language system by an input part for comprehension and an output part for production, and to allow for different levels of activation of these four subcomponents of the bilingual language system. The requirements of simultaneous interpreting that (1) the source language input is comprehended, (2) source language output must be prevented, (3) target language output must be generated, and (4) target language output must be monitored, are met when the source language input system and the target language input and output systems are activated and the source language output system is deactivated or inhibited (see Christoffels and De Groot, 2005, Figure 22.2, Model b). As the account that assumes global activation or deactivation (inhibition) of whole language subsystems, but not divided in an input and an output component, this setup will also have to be augmented with a language production process that sees to it that the word that expresses the conceptual information to be verbalized is indeed output, and not ANY word from the target language (cf. the above discussion of Paradis, 1994).

Finally, it appears that La Heij's (2005) "complex access, simple selection" model of local control – the workings of which he illustrated with the case of bilinguals conversing in one of their two languages – could account for bilinguals' translation behavior circumventing the necessity of globally balancing the levels of activation of the language systems and/or input and output systems: the content of the preverbal message must be – by the very fact that it is preverbal (and thus non-verbal) – indifferent to the language of an input. As long as the preverbal message correctly specifies the target language, output in the intended language emerges, even if the rest of the content of the preverbal message is the result of decoding an input in the other language. In fact, this view specifies and complements the view of conceptually mediated translation (Strategy I translation; vertical translation) introduced above, by pointing at the language cue as one particularly crucial piece of information in the conceptual representations. The presence of the language cue guarantees that output in the target language – and not some source language paraphrase of the input – will be produced, just as it guarantees that in a monolingual conversational setting the targeted language will be output (see Christoffels and De Groot, 2005, Figure 22.2, Model c).

As pointed out above, La Heij's (2005; see also Poulisse, 1997) proposal of language control in bilinguals may be the most parsimonious of all. It does not require the basic assumption in most of the other models that bilinguals activate and deactivate whole language subsystems (cf. Costa, 2005) or, in simultaneous interpreting (and other forms of translation) subtly balance the activation levels of the two language subsystems. The occasional time that La Heij's "complex access, simple selection" process may come up with a word in the source language instead of its translation in the target language (and this source-language word is not picked up by the monitor internally, prior to articulation), a code switch in the output will result. In other words, La Heij's apparently simple setup seems to provide a plausible account of both bilinguals' monolingual and translation behavior. Yet, it cannot account for all data; more specifically, it cannot account for the data that suggest a role of HORIZONTAL TRANSLATION as well.

Horizontal translation and translation systems

As pointed out earlier, Paradis and his coworkers (Paradis et al., 1982; Paradis, 1994) assumed the occurrence of a second translation strategy (STRATEGY II), where an item in the source language is directly TRANSCODED into its

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(learned and rehearsed) equivalent in the target language. Translation via this STRUCTURAL route (HORIZONTAL TRANSLATION; De Groot, 1997; Macizo and Bajo, 2005) involves the literal transposition of words or multiword units into their equivalents in the target language. Transcoding may occur at all the various levels in the system (phonological, morphological, syntactical and at the level of lexical semantics). Translation experience and the amount of translation training determine which of the translation strategies, conceptually mediated translation or transcoding, is used most.

Importantly, whereas conceptually mediated translation may exploit the same underlying systems as used in common, intralingual comprehension and production, Paradis (1994) assumed the existence of two separate underlying translation systems in bilinguals, one for each direction of translation, that subserve transcoding. The existence of direct memory connections between translation equivalent words or multiword units is very plausible, given the fact that co-occurrence of language units in the environment leads to associations between the co-occurring elements in memory (cf. above, where language subset formation was attributed to co-occurrence of language elements): any translation act will become reflected in a memory trace that connects the two terms of the translation; the more often the same two terms (words or longer phrases) co-occur in a translation act, the stronger the memory connection between them will be. This presumably is the reason why Paradis (1994) assumed that especially skilled (well-practiced) translators exploit the structural route to translation relatively often. Note, however, that other authors hold exactly the opposite view, namely, that transcoding is a signature of non-skilled interpreting (e.g. Seleskovitch, 1976).

From the likely existence of direct connections between translation-equivalent terms in bilingual memory PER SE it does not follow that these connections are actually exploited in translation behavior. Yet, some support for the occurrence of transcoding exists. For instance, Isham (1994) and De Bot (2000) observed recency effects of source-language words and syntactic structures in the target language, and many studies (e.g. De Groot, 1992; Christoffels, De Groot and Waldorp, 2003; Macizo and Bajo, 2005) found cognate effects in translation. In conceptually mediated translation a completely deverbalized conceptual message is the final step in the comprehension process, from which the production process sets off. Such a process of deverbalization (as in La Heij, 2005) is incompatible with the observation that effects of the source language's forms and structures materialize in the output (as suggested by the recency and cognate effects). Therefore – in agreement with Paradis (1994) – Gile (1991) and Christoffels and De Groot (2005) concluded that both translation strategies occur. Whether horizontal translation exploits systems that are structurally different from the systems used by vertical, conceptually mediated translation – rather than simple memory connections between translation-equivalent structures – does not follow from the data discussed here. The translation systems assumed by Paradis (1994) might simply equal the complete sets of L1–L2 pairings (e.g. translation equivalent words and phrases), in two directions, stored in a bilingual's memory. If somehow these two sets serve as separate systems, the way control is exerted in translation tasks may require more complex models than those presented above, the reason being that the activation and inhibition processes involved would have to deal with a larger set of systems.

Control in simultaneous interpreting: A different perspective?

Gile (1995, 1997) took what at first sight appears to be a different perspective on control in translation, particularly in simultaneous interpreting. Instead of focusing on the issue of how the targeted language is output by the bilingual cognitive system, Gile focused on the fact that interpreting is essentially a divided-attention task, where at any moment in time attention has to be divided over more than one component process (see also MacWhinney, 2005). Similar to the above studies on bilingual control, also Gile acknowledges that a control process constitutes an essential part of language processing (in his case specifically in interpreting). Gile (1995, 1997) presented what he called EFFORT MODELS of various forms of conference interpreting, departing from the notion that conference interpreting, and especially simultaneous interpreting, are complex and demanding tasks that draw heavily on the interpreter's limited cognitive resources. The model for simultaneous interpreting contained four components (EFFORTS): a LISTENING AND ANALYSIS EFFORT (the comprehension component), a PRODUCTION EFFORT, a MEMORY EFFORT, and – especially important here – a COORDINATION EFFORT. No special component is reserved for the monitoring that takes place in simultaneous interpreting (see above). Instead, Gile considers monitoring part of the production effort (see also Petite, 2005). Gile (1997) assumed two sources of performance breakdown resulting from lack of cognitive resources (he acknowledged the existence of other sources of performance failures, such as when the interpreter does not know a term or concept in the source or target language, but ignored these in the context of this article). First, breakdowns will occur when the sum of the capacity required for the various components of the task is larger than the total amount of available capacity, a situation that Gile called SATURATION. Second, breakdowns will also occur when the total capacity is in fact not depleted yet, but the capacity available for one of the task's components is unavailable at the critical

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moment, a situation that he refers to as failure due to an INDIVIDUAL DEFICIT. Interestingly, saturation and individual-deficit capacity problems may not only lead to immediate failures, but also to failures 'upstream', at a distance from the problematic segment. In other words, the word or segment that is translated incorrectly or omitted may not be the problematic segment itself. This observation may be of relevance to error analysis of human performance in other research domains as well, for instance, to the analysis of speech errors in language production. Also there the source of an error may precede its actual locus in the speech output.

As discussed in De Groot (2000), Gile's (1995, 1997) treatment of the coordination effort as a separate component of simultaneous interpreting concurs with work on the acquisition of complex skills (e.g. Gopher, Weil and Siegel, 1989; Gopher, 1992), where the coordination or control component is referred to as "the control of attention" or "attention management". This work strongly suggests that this control component can be trained separately from training any other components of a complex skill and that such training has a beneficial effect on performing the "full task" (see De Groot, 2000, for details). Furthermore, it showed that the training of control in a particular task transfers to other tasks that have little in common physically with the training task. Gopher's work thus suggests that training the control of attention may be an advantageous component in a training program in simultaneous interpreting. This can, for instance, be effectuated by having the interpreting students perform the full task while varying the instructions as to what component to attend to primarily (e.g. comprehension, production, or memory). This way the students will be prepared for the fact that in simultaneous interpreting the amount of attention devoted to a particular task component has to be adjusted continuously, due to variations in the quality of the input, the density of the information it contains, and to variations in memory and production demands (De Groot, 2000).

Of course, training components that speed up and automatize comprehension and retrieval processes may be beneficial as well, because the more automatized these processes, the more capacity will be available at any moment in time and the fewer of the saturation and individual deficit problems discussed above will occur. A recent study by us (Christoffels et al., 2003), testing bilinguals without any previous experience in simultaneous interpreting, suggested the importance of fluent retrieval processes in interpreting. This study demonstrated a correlation between word translation and picture naming latencies on the one hand and interpreting performance on the other hand. Furthermore, it supported the existence of Gile's (1997) memory-effort component in interpreting, by showing a correlation between the participants' performance on various memory tasks and their interpreting performance (see also Padilla, Bajo, Cañas and Padilla, 1995). Another study (Christoffels, De Groot and Kroll, 2006) showed that professional interpreters possess a larger working memory capacity than bilinguals untrained in simultaneous interpreting, including bilinguals equally proficient in the L2 as the interpreters. This enhanced capacity will enable them to allocate a relatively large part of their limited resources to the remaining components of the task.

As a member of a different research community (of translation studies), Gile's (1995, 1997) terminology deviates in places from the standard terminology in psycholinguistic studies on bilingual control. Nevertheless, clear similarities between his approach of interpreting as a divided-attention task and part of the work discussed above – especially Green's (1998) embedding of his Inhibitory Control Model in a more general theory of action – can be detected. For instance, Gile's coordination effort (which was hypothesized above to equal the attention-management component in the literature on the acquisition of complex skills) is assigned much the same role as the Supervisory Attentional System (SAS) in Green (1998): Gile's control component (the coordination effort) takes care of dividing attention over the remaining task components in his model in much the same way as the SAS in Green (1998) and Norman and Shallice (1986) takes care of CONTENTION SCHEDULING, which, among others, negotiates "cooperative, shared use of common structures or operations" (Norman and Shallice, 1986, p. 5). Furthermore, that insufficient mental resources are a source of breakdown is a central concept in the psycholinguistic bilingual control literature as well as in Gile's views on simultaneous interpreting. In this article we devoted much attention to studies that have explicitly embedded the question of how bilinguals exert control over their two languages in a more general theory of control. It appears that such an approach also carries the promise that research on simultaneous interpreting can become more tightly integrated with the mainstream psycholinguistic work on bilingual control.

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Received March 14, 2005
Revision received September 4, 2005
Accepted September 30, 2005

https://doi.org/10.1017/S1366728906002537 Published online by Cambridge University Press