Do bilinguals inhibit one language to speak another?

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Abstract:

How do bilinguals control which language they use when they speak? D. Green's inhibitory control (IC) model (1998a; 1998b) is the most studied account of bilingual language management, and proposes that though both a bilingual's languages are active when speaking, one of them becomes inhibited. In this chapter, I provide an overview of a selection of empirical studies designed to investigate this claim, focussing particularly on evidence relating to competition for selection between languages, asymmetrical language switching, and bilingual advantages in non-linguistic inhibition. I conclude that although inhibition alone has been found unlikely to account for all aspects of bilingual language control (E. Runnqvist, K. Strijkers & A. Costa 2014), recent constraints applied to the model which posit that bilinguals interacting in different socio-linguistic contexts may vary in their experience with inhibition (D. Green & J. Abutalebi 2013) should lead to an enhanced understanding of what role, if any, inhibition may play.

1. Introduction

Despite the apparent ease with which we speak in our everyday lives, the process of producing even a single word incorporates multiple stages (A. Caramazza 1997; W. Levelt, A. Roelofs & A. Meyer 1999). Specifically, our 'preverbal message' must collect syntactic, semantic and phonological information before producing speech. For bilinguals, this process is yet more complicated. Bilinguals need to monitor for changes in their environment that might necessitate a switch in language, and they need to ensure that that language is output successfully (J. Abutalebi & D. Green 2007). A failure in either of these requirements would lead to a failure to communicate at all in the majority of cases. Despite these additional considerations, it has been shown that bilinguals rarely making errors in language choice (e.g. T. Gollan, T. Sandoval & D. Salmon 2011; T. Sandoval, T. Gollan, Ferreira & D. Salmon 2010).

There is by now fairly clear evidence that some discrete process is involved in controlling language selection in bilinguals. Bilinguals are slower to produce a word when they need to switch languages to do so compared to when they do not, whether externally cued to do so (e.g. R. Meuter & A. Allport 1999; G. Jackson, R. Swainson, R. Cunnington & S. Jackson 2001), or when the switch is at a time of the bilingual's own choosing (e.g. T. Gollan & V. Ferreira 2009). Studies of patients presenting pathological language switching following lesions have also strongly suggested that the ability to switch languages is external to the knowledge of the two languages themselves (J. Abutalebi, A. Miozzo & S. Cappa 2000; S. Aglioti, A. Beltramello, F. Girardi & F. Fabbro 1996; F. Fabbro, M. Skrap & S. Aglioti 2000). A fundamental question then is: what is the process by which bilinguals can select between languages?

The aim of the present chapter is to describe and discuss a limited (and necessarily subjective) selection of the empirical evidence for and against the dominant theory of bilingual language production, namely the notion that the deselected language becomes activated but is reactively *inhibited* (D. Green, 1998a, 1998b; 2011; D. Green & J. Abutalebi 2013). I will argue that inhibition alone is unlikely to be the sole mechanism for bilingual language control (e.g. E. Bialystok, F. Craik, D. Green & T. Gollan 2009; T. Gollan, R. Montoya, C. Cera & T. Sandoval 2008; I. Koch, M. Gade, S. Shuch & A. Philipp 2010; E. Runnqvist, K. Strijkers & A. Costa 2014), but that recent refinements of the original hypothesis (D. Green & J. Abutalebi 2013; H. Blumenfeld & V. Marian 2014) might yet provide a more stable platform from which to make future predictions about its possible role.

2. The Inhibitory Control account of bilingual language production

D. Green's Inhibitory Control (IC) model (1998a; 1998b) proposes that language production is an action, and like any other action is controlled through top-down processes. Basing his theory on D. Norman and T. Shallice's (1986) framework of control of actions, D. Green proposed that first there is a Goal, such as to speak the word 'dog' in English and not its translation equivalent in Spanish, 'perro'. Initially, a Conceptualiser generates the relevant concept ('DOG') and feeds this information into the bilingual's lexico-semantic system. A Supervisory Attentional System (SAS) acts as an executive that mediates language actions or *schemas* (i.e. speak in *English*), which in turn mediates between the two responses offered by the Conceptualiser ('dog' and 'perro'). The SAS enforces the Goal by altering the activation levels of the 'English' schema relative to the 'Spanish' schema. D. Green proposes that words in both languages (e.g. 'dog' and 'perro') initially compete for selection before the non-target language's activation is suppressed. This inhibition is proposed to occur at the lemma level, where syntactic and semantic information is retrieved but before phonological information accessed (W. Levelt et al. 1999).

The IC model makes three predictions. Firstly, both languages must be active when a bilingual speaks, and hence relevant words in both languages (e.g. 'dog' and 'perro') compete for selection. If this were not the case, then there would be no requirement to inhibit a competitor word. Second, the more dominant the potential response, the more inhibition needs to be applied. For example, 'perro' would require more inhibition than 'dog' in an unbalanced Spanish-English bilingual. Third, the IC model posits that the inhibitory control required forms part of a domain-general executive which also serves to control other, non-linguistic actions. In other words, language control is handled outside of the domain of language itself.

In the following section I discuss some of the evidence for these three predictions. First I briefly review the evidence that both a bilingual's languages are available for selection in spoken word production. Secondly, I discuss the case for stronger inhibition of the more dominant response. Thirdly, I present a selection of research which contends that bilingual language control enhances performance on non-linguistic tasks that also require inhibition – hence suggesting mutual and domain-general processing.

3. Evidence for and against a role of inhibition in bilingual language control

3.1 Do words in both languages compete for selection?

In a seminal study, A. Costa and A. Caramazza (1999; see also A. Costa, A. Miozzo & A. Caramazza 1999) gave bilinguals a picture word interference task in which they were instructed to name a picture and ignore a distractor word superimposed upon it. When the distractor word was semantically related to the target picture name, the time to name the picture was slower compared to when the distractor was unrelated. For example, when seeing a picture of a table, participants were slower to name the picture when the superimposed word was 'chair' than when it was 'finger'. Crucially, this was found to be the case even when the distractor word (e.g. 'chair') was printed in the non-target language (e.g. 'silla'), and regardless of which language (L1 or L2) participants were instructed to name in. The authors interpreted this result as evidence that both languages are active when naming pictures. However, contrary to the IC model, they did not interpret this finding as evidence of *competition* between languages. Instead, they argue that the distractor word in the non-target language ('silla') activates its translation equivalent in the target language ('chair'), and this word competes for selection with the target word at a within-language level only. Lexical selection is therefore language-specific. A. Costa and colleagues point out that they consistently found that superimposing the translation equivalent of the target name upon the picture ('table' – 'mesa') actually facilitated naming responses. This, they argue, is not line with the notion that words in both languages compete for selection, since the translation equivalent of the target word should be the fiercest competitor. They propose that instead the target name receives additional activation from the semantic properties elicited by the translation equivalent, and that since translation equivalents translate into the target word, no within-language competition would be expected to interfere with naming speed.

In response, M. Finkbeiner, T. Gollan and A. Caramazza (2006) suggest that this language-specific selection account does not explain A. Costa et al.'s finding that *unrelated* distractor words caused more interference if they were in the target language than if they were in the non-target language. They reasoned that if lexical access is language-specific, no effect of language choice itself should be found. However, M. Finkbeiner and colleagues also do not accept that languages compete for selection (see below).

Cognates are words that share phonological and semantic features across two languages, such as 'guitar in English and 'guitarra' in Spanish, and can provide an insight into the activation patterns of a bilingual's two languages (A. Costa, A. Caramazza & N. Sebastián-Gallés 2000). I. Christoffels, C. Firk and N. Schiller (2007) found that German-Dutch bilinguals named pictures faster if the target name was a cognate than if it was a non-cognate (see also A. Costa et al. 2000), in both mixed-language and blocked naming, suggesting both languages were active throughout the task. Again, however, these results are not interpreted as supporting the IC model. If inhibition occurred at this stage, they argue, then the processing of the picture's name in the deselected language should not go so far as the retrieval of phonological information - something which cognate facilitation effects strongly suggest.

In short, although there is a great deal of support for the idea that both of a bilingual's languages are active when speaking, the arguments for cross-language competition for selection and inhibition as a means of resolving this competition remain in doubt.

3.2 Do more dominant languages receive more inhibition?

In a seminal study, R. Meuter and D. Allport (1999) found that unbalanced bilinguals were slower to name numerals when they were required to switch languages from one trial to the next compared to when they were not. Crucially, they also found that it took longer for bilinguals to name the numerals when switching into their dominant language than their weaker one. The authors argued that the L1 was inhibited when naming in L2, and that this inhibition persisted, creating a 'paradoxical' asymmetry by which it becomes harder to re-activate L1 on a switch trial. This finding supports the arguments of IC model that asymmetrical switch costs constitute evidence of an inhibitory control mechanism that regulates bilingual language management.

What about balanced bilinguals, for whom there is perhaps no clear 'dominant' language? J. Abutalebi and D. Green (2007) add that highly proficient bilinguals may not show strong asymmetry effects, a hypothesis supported by studies with highly proficient bilinguals (e.g. M. Calabria, M. Hernández, F. Branzi & A. Costa 2011). However, the IC model does not appear to explain the evidence of symmetrical switch costs in *unbalanced* bilinguals (e.g. T. Gollan & V. Ferreira 2009; K. Verhoef, A. Roelofs & D. Chwilla 2010). For example, T. Gollan and V. Ferreira (2009) found symmetrical switch costs in both balanced and unbalanced Spanish-English bilinguals in mixed-language blocks in a picture-naming task. However, in support of a role of inhibition, they also found a 'reversed language dominance', such that bilinguals actually named pictures faster in their nondominant language compared to their dominant language under these same conditions. The researchers propose that since participants knew that they needed to switch languages in the task and they may have maintained a degree of inhibition on their L1 throughout the block as a result.

M. Finkbeiner, J. Almeida, N. Jansen and A. Caramazza (2006) have argued that asymmetrical switch costs, which they call the 'signature' evidence of inhibition, need not be evidence of language inhibition per se (see also W. La Heij's (2005) discussion of R. Meuter & A. Allport's results for a similar argument from a different angle). Replicating the findings of R. Meuter and A. Allport (1999), they found that bilingual participants showed an asymmetrical switch cost when switching between languages while naming Arabic numerals, such that naming on switch trials in L1 took longer than naming on switch trials in L2, but failed to find the same asymmetry when participants switched from numerals in L2 to pictures, which were named only in L1. M. Finkbeiner et al. concluded that the inhibitory control account does not predict the finding that switching from numerals in L2 to pictures in L1 incurs no additional cost, and argue instead that bivalency of the task stimuli (naming the same stimulus in both languages instead of one) and the speed of response availability are candidates for such findings. Explaining the latter notion, they suggest that easier responses (such as responses in L1) become 'suspiciously' easy on switch trials and hence might be initially rejected before then requiring regeneration. In support of this argument, M. Finkbeiner and colleagues found that there was a greater switch cost in producing 'fast' (easily accessible) words (e.g. 'dog') than 'slow' words (e.g. 'puppy'), even when the entire experiment was conducted in L1 English. They also observed that the faster an item was named in a non-switch trial, the slower it was named on a switch trial (see I. Koch et al. 2010, for a review of the role of inhibition in task switching more generally). M. Finkbeiner and colleagues therefore argue that inhibition is not required to explain asymmetrical switch costs.

An important point in M. Finkbeiner and colleagues' argument is that there is more than one theoretical framework that can explain the results of language switching studies, inhibition being just one of them. Intriguingly, a recent study has suggested the converse problem - that the behavioural results of language switching studies might not be informative about inhibition. A. de Bruin and colleagues (2014) conducted a picture naming task with unbalanced Dutch-English-German trilinguals and found no evidence of asymmetrical switch costs in mixed-language blocks. A number of further results of interest were obtained. Firstly, the cost of naming in mixed blocks versus single-language blocks was largest for L1 (see also T. Gollan and V. Ferreira 2009). Secondly, a measure of inhibition from a non-linguistic task (the Simon task – see next section) predicted switch costs in all three languages, but this relationship was negative only for switches to L1. A. de Bruin and colleagues interpreted this relationship as evidence that the poorest inhibitors incurred smaller switch costs into L1 since they applied less inhibition to it in the first place. Finally, brain activation in the right inferior frontal gyrus and the pre SMA, both implicated in domain-general inhibition, were found when participants were engaged in switching away from L1 relative to when they repeated an L1 response. The researchers concluded therefore that behavioural data alone may not reflect the use of inhibitory control, and hence that switch costs "cannot be taken as a reliable measure of inhibition." (A. de Bruin et al. 2014: 355).

Measures of switching have not been the only means of exploring a potential link between inhibition and dominant languages. For example, T. Gollan and colleagues (2008) investigated the hypothesis by analysing Tip-of-the-tongue (TOT) states in bilinguals and monolinguals. TOTs are characterised by the sense of the imminent retrieval of a word that is as yet inaccessible. Low-frequency words (e.g. 'goblet') have been found to elicit more TOT states than high-frequency words (e.g. 'cup') (Brown 1991). T. Gollan and colleagues (2008) found that TOT-related slowing was larger for the low frequency words in the bilinguals than monolinguals. The researchers point out that it is unclear how the IC model, which posits that more dominant responses compete more strongly for selection, can account for this interaction. T. Gollan et al. propose instead that word frequency effects can account for such results, since bilinguals have less experience with individual words than monolingual owing to their use of two languages (the 'weaker links' hypothesis; see also T. Gollan, R. Montoya, C. Fennema-Notestine & S. Morris 2005).

In sum, empirical evidence for the IC model through switch cost asymmetry appears inconsistent, and alternative explanations for empirical findings equally if not more plausible in some cases.

3.3 Is there a bilingual advantage over monolinguals in inhibition on non-linguistic tasks?

One of the arguments against alternative accounts to the IC model is that, for example, the weaker links hypothesis (e.g. T. Gollan et al. 2008) cannot explain why bilinguals seemingly display performance advantages over monolinguals in non-linguistic tasks that require domain-general executive control (J. Abutalebi & D. Green 2007; J. Kroll et al. 2008). It has been reported that bilinguals show enhanced performance on a number of non-linguistic tasks in either inhibition, conflict monitoring (adapting to changing tasks), or both skills (see J. Kroll & E. Bialystok, 2013 for a review). One such non-linguistic paradigm is the Simon task, in which participants are instructed to respond to the colour of a presented square with a left or right button press while simultaneously ignoring its location on the left or right of the screen. The cost of responding to an incongruent trial (where the stimulus and response occur on the same side) compared to an incongruent trial is known as the Simon Effect, and is a measure of non-linguistic inhibition. Studies such as that by E. Bialystok, F. Craik, R. Klein and M. Viswanathan have reported smaller Simon Effect measures in bilingual adults, which they interpret as evidence of enhanced inhibitory control. Results such as these appear to offer evidence, albeit indirect, of the IC model's claim that inhibition is implicated in bilingual language control and that this inhibition stems from domain-general source (e.g. E. Bialystok & F. Craik 2010).

M. Calabria and colleagues (2011) set out to test the relationship between linguistic and non-linguistic task switching by asking participants to perform a picture naming task and also a non-linguistic task in which participants had to match items according to either their shape or colour. In both tasks, participants were required to switch their response type on cue, such that they had to switch between languages (L1, L2 or L3) in the naming task, or between a colour or shape response in the non-linguistic task. They found that highly proficient Spanish-English bilinguals and unbalanced Catalan-Spanish-English trilinguals showed symmetrical switch costs on the linguistic tasks but asymmetrical switch costs in the non-linguistic task. They also found a time-course effect: the cost of switching into L1 decreased in the second half of the experiment, while the cost of switching into L2 and L3 remained constant. No matching time-course effect was found for switch costs in the non-linguistic task. M. Calabria and colleagues interpret the evidence not supporting generalizability from the bilingual language control system to domain-general executive function.

Recently, a number of attempts to replicate and findings of a bilingual advantage to other tasks requiring inhibition have failed (see K. Paap, H. Johnson & O. Sawi in press, for a review), as have attempts to extend findings to tasks that investigate non-linguistic switching in a communicative context, such as in perspective taking tasks (e.g. R. Ryskin, S. Brown-Schmidt, E. Canseco-Gonzalez, L. Yiu & E. Nguyen 2014; S. Samuel, K. Roehr-Brackin & D. Roberson 2015). Such tasks should presumably reflect better the role that executive control plays in a bilingual's day-to-day experience. In sum, the case for a bilingual advantage is yet to be clearly made (e.g. K. Paap et al. in press), and the ability of non-linguistic task performance to speak to the role of inhibition at the linguistic level appears yet to be proven.

4. Recent refinements to the IC model

Recently, D. Green and J. Abutalebi (2013; see also D. Green 2011) have revisited the IC model, imposed new constraints and making more specific predictions. Specifically, they propose that bilinguals recruit different processes to different degrees according to the interactive context in which they most frequently communicate. They define three such contexts. In a single language context language use is typically defined by one's environment, such that one might speak one language only at work and the other at home and/or the wider community. In a dual language context code switching is common, though not within utterances. In the dense code switching context, on the other hand, code switching is common within utterances. D. Green and J. Abutalebi propose that while interference suppression (suppressing conflicting information) is common in both single- and dual-language contexts, response inhibition (suppressing an unwanted response) is characteristic of dual language contexts only. Further, they argue that in dense code switching contexts the bilingual's two languages co-operate rather than compete, and as such inhibitory processes are only minimally required relative to the other scenarios. In sum, the fundamental contribution of this standpoint to the role of inhibition in bilingual language control is the prediction that dual-language context bilingualism leads to the greatest requirement for and practice with inhibition and conflict monitoring skills, dense code-switching the least, with single language context bilingualism lying between. In a shift on the original proposal, D. Green (2011) also proposes that inhibition may occur at later stages in lexical processing in dual-language contexts.

This refinement of the original model introduces individual differences into a field that had traditionally compared bilinguals to monolinguals rather than to other bilinguals, though there have been exceptions. For example, J. Festman, A. Rodriguez-Fornells and T. Münte (2010) divided a sample of Russian-German bilinguals into switchers and non-switchers based on cross-language interference errors in a language switching task. Those who committed the most such errors were classified as switchers, with the remaining participants classified as non-switchers. They found that the switchers were slower and/or less accurate on a battery of tasks designed to test their executive function, including inhibition and monitoring skills. From these findings J. Festman and colleague suggest that bilingual language control is not simply a matter of inhibition alone, but executive function more generally. Note however that the participants in this study were not asked whether they switched languages frequently – they were judged according to their experimental performance alone, which may or may not accurately reflect their actual language use habits.

Enhanced monitoring skills have been linked to the practice of frequent language switching, and are associated with faster response speeds on non-linguistic tasks (e.g. A. Costa, M. Hernández, J. Costa-Faidella & N. Sebastián-Gallés 2009). Ongoing research by S. Samuel, K. Roehr-Brackin, M. Schmid and D. Roberson (2015) has found preliminary evidence of a relationship between self-reported language habits and global speed on a standard Simon task, but in an unexpected direction. They found a *negative* correlation between self-reported code switching frequency (whether measured as within or between utterances) and response speeds across every trial type, including control trials in which the stimulus squares were presented centrally. However, no consistent performance difference was found between bilinguals and monolinguals on the Simon Effect measure of inhibitory control. Following from D. Green and

J. Abutalebi's (2013) suggestion that code-switching bilinguals might perform more poorly when they were restricted to cued rather than voluntary switching, Samuel and colleagues speculate that being able to speak interchangeably in two languages might mean that word-finding difficulties and issues with accuracy of expression in one language can be easily circumvented by switching to the alternative language (a suggestion made by T. Gollan & V. Ferreira 2009), and hence frequent code-switchers might be less practiced at cued switching even on non-linguistic tasks. Regardless of the precise cause of the effect, this study supports a link between language habits and non-linguistic performance in the absence of a clear role of inhibition.

5. Conclusion

It is important to note that the argument for an inhibition account is not fatally undermined i) if the source of inhibition is not shown to be domain-general but a language-specific (or partially specific) mechanism, ii) if bilinguals do not show a performance-related advantage over monolinguals on non-linguistic tasks, iii) switch costs symmetry patterns are not shown to follow the 'more inhibition for more activation' rule (since activation could in theory be of parallel strength in both languages and still require inhibition to suppress the non-target system). However, as pointed out by M. Finkbeiner et al. (2006), accounts of bilingual language control that do not give a central role to inhibition are also viable candidates. A. Philipp, M. Gade & I. Koch (2007) have suggested that asymmetrical switch costs could indicate the need to overcome an activation *boost* for the weaker language.

In addition to the plausibility of alternative accounts, and despite the argument that behavioural data may not be sufficient to pass final judgment on whether or not inhibition is at play on a task (e.g. A. de Bruin et al. 2014; see also E. Bialystok et al. 2005), or what type of inhibition is involved (J. Abutalebi & D. Green 2007), there are also difficulties drawing firm conclusions from the alternative - namely neurological evidence, alone (M. Chee, C. Soon & Ling H. Lee 2003; K. Paap et al. in press).

In potential support of an inhibition account, however, it is also plausible that the problem is not in the model but in the measures. It has been argued that the heterogeneity of language switching experiments complicate their comparisons (e.g. S. Bobb & Z. Wodniecka 2013; M. Declerck, I. Koch & A. Philipp 2012), and relatively unstudied (and uncontrolled) factors such as response-to-stimulus intervals may influence results (M. Declerck et al. 2012). As such, individual paradigms such as the picture-word interference task and language switching task may prove too vulnerable to numerous task-, stimuli-, and proficiency-related factors to be decisive enough in the search for an answer (E. Runnqvist et al. 2014). To illustrate, the outcomes of tasks such as those described above have been shown to be influenced by factors including language proficiency (e.g. I. Christoffels et al. 2007; M. Calabria et al., 2011; T. Gollan & V. Ferreira 2009), language of experimental context (e.g. K. Elston-Güttler., T. Gunter & S. Kotz 2005), language of response (e.g. A. Costa et al. 1999; D. Hermans et al. 1998), sentence context (M. Declerck & A. Philipp, 2015), changing effects over the course of the experiment (M. Calabria et al., 2011), the cognate status of target words (I. Christoffels et al., 2007), voluntary, quasi-voluntary or cued switching (T. Gollan & V. Ferreira 2009), whether stimuli are named in both languages or only one (M. Finkbeiner et al. 2006), whether stimuli are Arabic numerals or pictures (M. Declerck et al. 2012), cue-to-stimulus preparation time (K. Verhoef, A. Roelofs & D. Chwilla 2009), and stimulus-onset asynchrony (D. Hermans et al. 1998).

To conclude, constraints on the underlying theory are likely to prove essential to further research into bilingual language control. In this context, the refinements proposed by D. Green and J. Abutalebi (2013) are very welcome. Describing the type (or types) of of inhibition required (e.g. H. Blumenfeld & V. Marian 2014; E. Van Assche, W. Duyck & T. Gollan 2013), at which stages of lexical processing it is applied (e.g. C. Reverberi et al. 2015), and how long it takes to decay, are also likely to be fruitful avenues of research.

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