

The Impact of Code-Switching on Bilinguals' Executive Control Functions

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This literature review provides an overview of research into bilingualism and executive control focusing on code-switching as a variable. Bilinguals have been reported to outperform monolinguals at executive control tasks testing inhibitory control and task-switching. Inhibitory advantages are attributed to the fact that bilinguals constantly draw upon related skills to suppress momentarily unintended co-activated languages. Inhibition of non-target varieties is only required when in monolingual modes, though. During bilingual code-switching modes languages are mixed, which potentially requires less inhibitory control. This raises the question to which extent regular code-switchers display inhibitory control advantages. The flipside of not inhibiting languages may be enhanced practice at task-switching, as code-switching involves juggling several varieties at the same time. Answers to these questions may depend on the type of code-switching bilinguals regularly engage in. My PhD project at Reading University is therefore investigating: (1) the impact of code-switching on task-switching performance, (2) the impact of code-switching on inhibitory control performance, (3) modulation of impact by code-switching type. There are no results yet, but a literature review and predictions derived from two code-switching control process models are presented in this paper.

1. Literature review

This literature review starts off with a definition of the term executive control. After that, models of control processes involved in code-switching are presented. This is followed by an overview of language and cognition research into bilingualism and executive control with a focus on code-switching. Finally, an attempt to derive hypotheses regarding the impact of code-switching on executive control is made by combining insights from linguistic models with findings from language and cognition studies.

1.1. The notion of executive control

In terms of a working definition, executive control refers to mechanisms guiding goal-oriented behaviour. Inhibitory control is akin to what everyday language refers to as concentration skills, i.e. the ability to ignore distracting information to focus on the relevant. Task-switching could be described as what is generally referred to as multi-tasking, i.e. managing simultaneously activated task schemata. In terms of a precise neurological definition research still “lacks a compelling theory” (Miyake et al. 2000: 50) outlining the nature of executive control. From a connectionist perspective the brain is a complex system in which goal-oriented behaviour is orchestrated by the cooperation of a combination of networks. In that spirit Miyake et al. (2000) explore the ‘unity and diversity’ of executive control identifying three separable functions: task shifting or monitoring, working memory and inhibitory control. These functions partially overlap because they all involve inhibitory control to varying degrees underlining its crucial role in executive processes (Miyake et al. 2000), which explains why experimental psychology has prioritized the study of inhibition since the early 19th century (Stroop 1935). Posner and Petersen’s (1990) approach to executive control (cited in Costa et al. 2008) is more general, focusing on attentional

processes taking place in three networks: orienting, alerting and executive networks. It is noteworthy that the concept of executive control is not embraced by all scholars with some deconstructing the term as “hypothetical” and rooted in a discourse of “identification of mind with a unitary soul” (Paradis 2002: 146). Paradis (2002) argues against the existence of one central brain region representing willpower using evidence from split brain patients. Individuals whose hemispheres have been disconnected for medical reasons occasionally perform antagonistic acts simultaneously. However, this observation could equally indicate that the corpus callosum plays a crucial role in coordinating the operation of executive networks and that its suspension disrupts their operation. To summarize, scholars agree upon the fact that behavioural control is not exerted by a centralised ‘control tower’, but results from the cooperation of several attention-channelling networks possibly located in the prefrontal, inferior parietal and anterior cingulate cortex and influenced by excitatory and inhibitory neurochemical processes in the basal ganglia (Green & Abutalebi 2007). Injury to prefrontal regions indeed often leads to deficits at behavioural control (Baddeley 1997).

1.2. Code-switching typology and control continuum

The following sections describe code-switching models directly relevant for the predictions made by this project, i.e. Muysken’s (2000) typology, Treffers-Daller’s (2009) control continuum and Green and Li’s (2014) control process model. A detailed overview of code-switching research is beyond the scope of this paper. Comprehensive summaries of the field can be consulted in Muysken (2000), Gardner-Chloros (2009) and Clyne (2003). Initial code-switching research focused on the identification of universal constraints; however, most suggested constraints have been questioned by counter-examples (Muysken 2000; Gardner-Chloros 2009). As a consequence, it is more appropriate to speak of preferred structures occurring with greater frequency rather than of absolute constraints (Muysken 2000; Clyne 2003; Backus, forth.). A popular framework used by many code-switching researchers is Myers-Scotton’s (2006) Matrix Language model that regularly gets refined and updated based on newly emerging insights. According to this model, one language always provides the grammatical framework of the utterance. Items from the embedded language are slotted into that matrix. However, the principle may not account for all varieties of code-switching because when analysing authentic data it often proves challenging to assign a matrix language to every utterance (Muysken 2000; Gardner-Chloros 2009).

The attractiveness of Muysken’s (2000) typology consists in the fact that it draws conclusions from a wide range of empirical data collected by different researchers in varying sociolinguistic settings. Thus it pulls together different approaches under one umbrella by explaining diverging code-switching patterns on the basis of differences in the respective speech communities. Muysken classifies what he calls *code-mixing* into three types.

Alternation. Syntactically independent phrases from different languages juxtaposed within same conversation: “und no laes ich ung’faehr a halb Stund und nochhaer [...] APRES CA J’ESSAYE DE M’ENDORMIR”; “and then I read for about half an hour and then [...] AFTER THAT I TRY TO FALL ASLEEP” (French-Alsatian, from Gardner-Chloros 2013: 170).

Insertion. Individual phrases from one language embedded within grammatical structure of the other: “CHAY-TA las dos de la noche TA CHAYA-MU-KU”; “THERE at two in the morning WE ARRIVE” (Spanish-Quechua, from Muysken 2000: 63).

Congruent lexicalisation. Renamed ‘dense CS’ in Green & Li (2014). The lexicon and grammar of both languages converge, often creating novel linguistic blends: “C’ETAIT QU’IL stinkt”; “IT (the problem) WAS THAT IT stinks” (French-Alsatian, from Gardner-Chloros 2013: 169).

Insertion is akin to the Matrix Language framework and occurs predominantly in early immigrant environments in which concepts associated with the second language environment are integrated into the structure of a more dominant first language. As language proficiency becomes more balanced speakers gradually move to alternational switching patterns. Finally, dense code-switching is characteristic of established bilingual communities with a high degree of linguacultural convergence (Agar 1994, cited in Clyne 2003). Assessing what constitutes a speech community is a huge challenge for any code-switching research given the fluid nature of social networks (Milroy 1987; Wardhaugh 2010) increasingly characterized by communities of practice (Wenger 1998) displaying a great extent of inter and intra-individual variation in code-switching patterns (Dewaele & Li 2014; Backus, *forth.*).

Although primarily sociolinguistic in nature, Muysken's (2000) work hypothesizes that code-switching types differ psycholinguistically regarding level of activation of each language and degree of integration of linguistic systems. During alternation languages are mixed within the same conversation but kept fairly separate structurally, whilst during insertion the language system becomes partially permeable but only on a lexical level. In dense code-switching the walls of separation are almost completely torn down suspending inhibition so that grammatical and lexical structures from co-activated varieties converge to construct the utterance. Assuming that the degree of language separation is directly proportional to amount of required inhibitory control, Muysken's code-switching types can be located along a "continuum of control process involvement" (Treffers-Daller 2009: 68), according to which alternation requires the maximum, insertion a medium and congruent lexicalisation the minimum amount of bilingual language control.

Control processes are seen as transfer suppression with code-switching being viewed as a form of overt linguistic transfer. The proposed continuum is in line with Backus (*forth.*) suggesting that overt lexical transfer, e.g. insertion, requires greater cognitive control than covert transfer phenomena, e.g. calque translations, which could be grouped with the convergence phenomena of dense code-switching. The hypothesized continuum, however, still needs to be "corroborated with experimental evidence" (Treffers-Daller 2009: 68). Examining code-switchers' executive control functions is a way of providing at least indirect evidence of its validity. The continuum predicts that dense code-switching practises inhibitory control least, whilst alternation enhances inhibitory skills most. If these predictions hold true, findings would be in support of the code-switching control continuum theory.

1.3. The Control Process model

Whilst previously the lack of psycho- and sociolinguistic interdisciplinary dialogue represented a barrier to creating a holistic model of code-switching (Myers-Scotton 2006; Gardner-Chloros 2009), the recently proposed control process (hereafter CP) model of code-switching (Green & Li 2014) considers the complexity of sociolinguistic reality by incorporating Muysken's (2000) typology. Language is seen as a domain-general phenomenon akin to other human behaviour controlled by task schemata. Different interactional contexts trigger 'language modes' (Grosjean 1989) in which language schemata either compete or cooperate. In diglossic communities languages are kept separate, e.g. language A spoken at home and language B at work. Hence schema competition leads to global suppression (De Groot & Christoffels 2006) of varieties in discourse settings they are conventionally not associated with. In dual language contexts cooperative control modes enable speakers to exploit code-switching for socio-pragmatic purposes. Insertion, alternation and dense code-switching correlate cognitively with two subtypes of cooperative control modes. Insertion and alternation call for coupled control modes enabling frequent schema-switching through local suppression. The open control mode of dense code-switching involves least inhibition as processing does not discriminate by language. By grouping alternation and insertion under the heading of coupled control mode the authors imply a

dichotomous relationship between alternation and insertion versus dense code-switching. This is in contrast to the scalar relationship between alternation, insertion and dense code-switching postulated by Muysken (2000) and adopted by Treffers-Daller (2009).

According to the single network hypothesis (Green & Abutalebi 2007) lemmata tagged for language membership are simultaneously activated and get selected based on their socio-pragmatic appropriateness, for which language choice is one of many criteria. Tagging depends on bilinguals' metalinguistic awareness. In the diachronic process of borrowing lemmata may even 'lose their language tags' (Treffers-Daller 1998). Frequent code-switches in the neighbourhood of cognates (Bultena 2013) are testimony to potentially ambiguous tagging. Despite of initial parallel activation, lemmata are eventually uttered in serial order. A planning layer prioritizes items according to degree of activation. The competitive choice layer fulfils the role of inhibiting less active linguistic items thus passing the most active one on for phonological assembly.

The CP model represents a parsimonious theory of code-switching taking into account the complexity of sociolinguistic reality and the fluidity of neural processes. Nevertheless questions regarding language structure remain unanswered. According to Muysken (2000: 35), one of the greatest potentials of code-switching research is to shed light on the "division of labour between grammar and lexicon". The CP model touches upon this issue only in a few places using the terms 'serial order' and 'adaptation', possibly referring to 'word order' and 'morphology'. According to Green & Li (2014: 3), "competitive queuing system [...] solve the serial order problem". However, they fail to account for the interaction of serial order with adaptation, which is crucial for understanding code-switching amongst typologically distant varieties. In synthetic languages adaptations such as case endings mark functions encoded by word order in analytical languages. Mixing of synthetic and analytic varieties inevitably creates instances in which adaptation versus serial order as expressions of identical functional categories compete for selection (cf. Clyne 2003, for Hungarian-English examples). How this conflict is resolved is not explained in the CP model. Given the model's emphasis on socio-pragmatic factors, serial order could be conceived to sequence discourse elements such as theme, topic and focus (Halliday 2004), but this is not explicitly discussed. Generally speaking, a clearer definition of the terms serial order and adaptation would have decreased the ambiguity surrounding this terminology and increased the model's potential to account for the resolution of structural cross-linguistic transfer.

Most relevant for this paper are predictions made regarding the impact of code-switching on executive control functions. Whilst diglossia trains inhibitory control most, dense code-switching is predicted to have the least positive impact. A great advantage of the CP model is that it emphasizes the importance of language schemata thus allowing for predictions regarding task-switching. Dense code-switchers may display greatest advantages at mixing cost because they constantly manage both lexical and grammatical schema co-activation. Insertional code-switchers practise monitoring skills moderately as they manage co-activated lexical schemata only. Alternational code-switchers, on the other hand, should show the least task-switching advantages as they keep linguistic task-schemata comparatively separate.

1.4. The impact of bilingualism on executive control

Language and cognition studies explore cross-fertilisation effects between language and thought. Evidence for the interdependence of non-verbal and verbal representations comes from experiments showing that the degree of linguistic lexicalisation and grammaticalisation of concepts shapes individuals' non-verbal perception (Athanasopoulos 2008, 2011) and processing (Pavlenko 2011; Boutonnet et al. 2012). Having certain colour terms in your language for instance shapes your visual perception of them (Athanasopoulos et al. 2010). The experience of speaking several languages has been shown to train creativity (Hill 2009; Kharkhurin & Li 2014) and executive skills (Bialystok 2009).

The connection between executive control and language production was first remarked in aphasia research suggesting that many speech disorders do not stem from damage to language-specific brain regions, but from domain-general processing issues (Astell & Harley 1998). Although lexical control deficits are often symptomatic of damage to the left inferior frontal gyrus, a region overlapping with Broca's area (Scott & Wilshire, 2010), some forms of semantic aphasia resulting from lesions in the prefrontal cortex do not stem from deletion of semantic representations but from general executive control deficits (Jefferies & Lambon 2006). It was by applying the insights derived from aphasia cases to the study of bilingualism that Green (1986, 1998) created his influential model of bilingual language production postulating inhibitory control to regulate language selection.

Any type of language production requires speakers to pick linguistic items from competing options according to socio-pragmatic appropriateness. During this process bilinguals manage the additional criterion of language selection thus practising inhibitory skills. Indeed neuroimaging data reveals overlaps in brain regions activated during conflict resolution and language control (Green & Abutalebi 2007). Eventually bilingualism may alter processing to such an extent that conflict is resolved in different neural regions altogether, as suggested in Bialystok et al.'s (2005) MEG study. Refined experimental blocking techniques suggest that bilingual advantages stem not only from inhibitory control, but also from task-switching possibly trained by code-switching (Costa et al. 2009; Soveri et al. 2011). Whilst the bilingual-monolingual dichotomy dominated most initial studies comparing balanced bilinguals to monolinguals in between-subjects designs, a trend towards within-subjects designs exploring the various facets of bilingualism whilst reducing cross-subject variation is taking shape. Most lately, Wu and Thierry (2013) added intra-individual variation to the discussion showing that executive control performance is modulated by temporary language modes. In terms of executive control definitions some researchers use Miyake et al.'s (2000) paradigm (Bialystok 2009), whilst others investigate attentional systems (Colzato et al. 2008; Costa et al. 2008, 2009). The following sections discuss various approaches in greater detail, focusing first on inhibitory control and then on task-switching. Variables potentially altering the impact of bilingualism on executive control are subsequently discussed.

1.4.1. Bilinguals' inhibitory control advantages

Inhibitory control is divided into two cognitive processes, interference suppression and response inhibition (Bunge et al. 2002, cited in Bialystok 2008). This disassociation is supported by an fMRI study revealing differential activation patterns, i.e. prefrontal cortex during response inhibition and anterior cingulate cortex during conflict resolution (Cabeza & Nyberg 1997, cited in Bialystok 2009). Response inhibition refers to the ability to suppress an already generated behavioural response. The term interference suppression stands for the ability to ignore distracting information to focus on the relevant. It is classically measured in tasks presenting conflicting stimuli, e.g. Simon, Stroop or flanker task. In the flanker task participants are presented with a row of arrows and instructed to indicate whether the central arrow faces leftwards or rightwards. In the congruent condition all arrows face the same way ($\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow$). The incongruent condition creates a conflict because surrounding arrows face in the direction opposite to that of the to-be-named arrow ($\rightarrow\rightarrow\leftarrow\rightarrow\rightarrow$). The so-called conflict effect is calculated from error rate and/or reaction time (hereafter RT) differences between congruent and incongruent conditions. A smaller conflict effect indicates greater interference suppression skills.

When it comes to identifying the cognitive processes underlying the behaviourally observed bilingual advantages, most studies report significant differences between monolinguals and bilinguals for interference suppression but not for response inhibition (Bialystok 2006; Colzato et al. 2008; Blumenfeld & Marian 2014). Behavioural findings are backed up physiologically by an fMRI study (Luk et al. 2010) in which bilinguals' activation patterns diverge from those of monolinguals for interference suppression but are identical for

response inhibition. Blumenfeld and Marian (2014) test two bilingual groups in interference suppression and response inhibition tasks confirming greater advantages at the former. The authors draw upon code-switching to explain differences between bilingual participants' results post-hoc. Whilst all bilinguals display greater advantage at interference suppression than response inhibition, bilinguals assumed to engage in code-switching based on regular practices in their speech community performed less strikingly well in the interference task than those living in supposedly diglossic communities. Interference suppression advantages may be mitigated by code-switching as it allows uninhibited co-activation of languages. This reasoning is in line with Green and Li's (2014) prediction that diglossia practises suppression processes more than code-switching settings. Interestingly, Blumenfeld and Marian (2014) mention Linck et al.'s (2012) experiment showing a positive correlation between language switching and response inhibition performance, possibly suggesting that during code-switching items from either language reach articulatory stages of processing, i.e. they are response-inhibited just before being uttered rather than being suppressed at an earlier stage.

Whilst the role of inhibitory control in language production is widely accepted in the research community, some authors subscribe to bilingual language production models based on a combination of excitatory and inhibitory processes assuming that behaviour results from the "summation of positive and negative impulses generated by [...] local executives [...] analogous to the firing of neurons as a result of the computation of positive and inhibitory impulses" (Paradis 2002: 147). Colzato et al. (2008) express scepticism towards Green's (1998) inhibitory control model based on active inhibition. Instead they present an alternative framework assuming inter-target lateral mechanisms of 'reactive inhibition' (Logan 1994, cited in Colzato et al. 2008). Task goals are assumed to facilitate target lexeme selection through priming in such a way that local competitors become reactively inhibited. This view is compatible with La Heij's (2005, cited in Colzato et al. 2008) 'complex access, simple selection' model and does away with a central executive. Colzato et al.'s (2008) research question is whether active or reactive inhibitory processes underlie language selection. As an indicator of reactive inhibition the attentional blink paradigm (Luck et al. 1996; Hommel et al. 2005) is used. Bilinguals are predicted to exercise stronger reactive inhibition than monolinguals resulting in them performing worse at the task. Results confirmed this prediction. Hence the possibility of a combination of excitatory and inhibitory processes facilitating bilingual language selection cannot be discarded, although the fact that Heidlmayr et al. (2014) find bilingual advantages for the Stroop inhibition rather than facilitation effect supports the inhibitory account.

A number of studies investigate bilingualism's impact on attentional processes. Costa et al. (2008) acknowledge Green's model, but distance themselves from such concrete propositions stating more generally that bilingual language production requires "some kind of attentional control mechanism" in the sense of Posner and Petersen (1990, cited in Costa et al. 2008). The attentional network task (hereafter ANT) uses flanker tasks to test functioning of alerting, orienting and executive networks by manipulating cues. Bilinguals responded significantly faster than monolinguals across all tasks. Regarding the executive network, bilinguals displayed a significantly smaller magnitude of conflict effect. Moreover, they benefited from alerting cues more than monolinguals. Orienting cues on the other hand did not affect language groups differentially. This is at odds with Colzato et al. (2008), who found the mean effect of orienting cues to be negative for bilinguals and positive for monolinguals. From this differential cueing cost pattern they deduce that bilinguals create shorter representational windows so that they benefit less from preceding spatial cues. Intrigued by these findings Hernandez et al. (2010) repeated Colzato et al.'s (2008) experiment. Failing to replicate differential results, they confirmed Costa et al.'s (2008) results suggesting an interaction of bilingualism with executive and alerting, but not with orienting networks.

Wu & Thierry (2013) explore intra-individual variation at executive control functioning by exposing identical bilingual participants to different language modes in a within-subjects experimental design. Welsh-English bilinguals were presented with two blocks of flanker tasks priming them with single versus mixed linguistic cues. Participants performed better and showed reduced P300 amplitudes in the mixed compared to the single language block. This finding is counterintuitive assuming inhibitory resources are consumed by the mixed language mode leaving less energy to resolve non-verbal tasks. However, executive control has been shown to have a positive priming effect on simultaneously performed tasks testing similar functions (Gratton et al. 1992, cited in Wu & Thierry 2013). Heightened levels of inhibition triggered by the mixed language mode thus transfer to non-verbal executive control. Green and Li (2014) mention Wu & Thierry's (2013) experiment suggesting that following this logic participants must have been coupled control code-switchers. Had they been dense code-switchers, mixed language modes would have induced low inhibitory involvement resulting in opposite results.

However, there is an alternative explanation accounting for the possibility that participants could have been dense code-switchers. If performance at executive control is not due to Gratton's transfer effect, but indeed depends on how much inhibitory control is "used up" by the language mode, then dense code-switchers should not require much inhibition for the linguistic side of things so that they retain more inhibitory energy to devote to the resolution of the non-verbal executive task. Most importantly, the experiment demonstrates language mode induced performance variation brought about by "fast modulation", i.e. the flexibility of neurons' dendrites to adapt to situational requirements within minutes, which is a major source of neural plasticity (Rosenzeig et al. 2004). This raises the question to which extent executive functioning is permanently entrenched or constantly in flux. Highly fluid neural processes of this type may well be the cause of the described difficulty to capture code-switching in rigid frameworks (Gardner-Chloros & Edwards 2004). The adaptive qualities of fast-modulation could also be hypothesized to facilitate code-switching's accommodation functions (McEwan & Coupland 2000). Finally, fast-modulation might mean that any bilingual is theoretically capable of processing any type of code-switching, as postulated by Green and Li (2014). If this was the case any code-switching mode could be elicited in any bilingual for experimental purposes.

1.4.2. Bilinguals' task-switching advantages

Task-switching or monitoring skills are measured by comparing trial blocks containing only one task type to blocks requiring task-switching. From these blocked experiments two types of costs representing different types of cognitive effort can be calculated. Mixing cost is caused by increased processing demands on "top-down management processes controlling competing task sets" (Soveri et al. 2011: 6) and measures monitoring skills, i.e. what is commonly referred to as multi-tasking. It is expressed in the overall error rate and/or RT difference between the single-task versus the mixed-task blocks. Switching cost is defined as error rate and/or RT differences between trials preceded by identical versus different tasks and is symptomatic of short-term switching.

Initially bilinguals' advantage at incongruent task conditions was attributed to enhanced inhibition skills. However, 12 of the 25 research projects listed in Costa et al.'s (2009) article found bilinguals to outperform monolinguals in both congruent and incongruent tasks. At the same time, the bilingual advantage was reported to be more obvious in experiments requiring frequent task-switching (Bialystok 2006, cited in Costa et al. 2009). Using ANT flanker tasks Costa et al. (2009) thus explore monitoring skills in detail by presenting participants with trial blocks that vary according to degree of congruent-incongruent task-switching required (50%-50%, 75%-25%, 92%-8%). Overall bilinguals responded faster than monolinguals, the difference being greatest in the 50%-50% block posing the greatest burden on monitoring efforts, thus confirming the hypothesis that bilingual practices train neural networks

supporting task-mixing. In line with Kutas et al.'s (2009: 303) claim that "training in switching languages seems to generalize to other cognitive domains", Costa et al. (2009) hypothesize that it is code-switching that trains monitoring processes. Indeed managing co-activated task-schemata mirrors the bilingual experience of code-switching. Therefore, "bilingual speakers in diglossic sociolinguistic environments [...] may not show advantages in monitoring processes." (Costa et al. 2009: 145). The CP model suggests that in turn diglossic environments enhance inhibitory skills. Hence, there may be a trade-off between advantages at inhibition and monitoring skills.

Several studies have since investigated the code-switching variable. Soveri et al. (2011) assess the effect of Swedish-Finnish bilinguals' self-reported code-switching behaviour and language background variables on their executive functions using Rodriguez-Fornells et al.'s (2012) Bilingual Switching Questionnaire BSWQ. A reduced conflict effect was strongly associated with age of onset of L2 acquisition, but not with code-switching. BSWQ variables, in particular code-switching frequency, significantly predicted a reduced mixing cost, but did not impact switching cost. This suggests that language mixing does not involve continuous switching, but is a process during which simultaneously activated idioms are monitored in a 'mixed language mode'. Authentic code-switching behaviour does not always overlap with self-reported values with under-reporting being more common than over-reporting due to social stigmata (Dewaele & Li 2014).

Yim & Bialystok (2012) increase the validity of the code-switching variable by collecting authentic data from English-Cantonese bilinguals who also completed verbal and non-verbal switching tasks. To elicit code-switching instances, participants were instructed to use language A to discuss topics culturally connected to language B and vice versa, e.g. converse about Chinese New Year in English. Arguably, this experimental design creates a bias towards insertional code-mixing with participants slotting language A cultural terms into the conversation's prescribed base language B, but this is not problematized in the article. In the article's introduction Yim & Bialystok (2012) promise to analyse code-switching according to frequency and type. For the qualitative analysis, Muysken's (2000) typology differentiating between alternation and insertion is adopted. Why dense code-switching is not given consideration remains unclear. In fact results of the qualitative analysis are not discussed at all in the article, leaving some research questions unanswered. Code-switching frequency scores were found to be negatively correlated with language switch cost, but not with non-verbal task-switching. Yim & Bialystok (2012) conclude that their findings suggest that language-specific mechanisms controlling code-switching correlate with verbal, but not non-verbal task-switching implying a partial dissociation of those mechanisms. There was no monolingual control group to assess whether bilinguals displayed an overall task-switching advantage.

Several recent studies imply a partial dissociation of task and language switching on the basis of differential impacts of ageing on bilinguals' verbal and non-verbal switching functions (Weissberger et al. 2012; Calabria et al. 2014; Goral et al. 2014). These studies are based on artificially induced language switching, which has been argued to poorly imitate authentic code-switching (Gardner-Chloros 2009). The fact that Yim and Bialystok's (2012) study based on semi-authentic code-switching finds a similar dissociation is a stronger argument for language-specific switching mechanisms. Other studies (Soveri et al. 2011) do find code-switching to predict monitoring skills, though. Moreover, Abutalebi and Green (2008) make an argument for overlapping neural correlates of language and task-switching on the basis of a range of behavioural and neuroimaging studies. It is thus still feasible that code-switching impacts task-switching, especially when controlling for code-switching type.

1.4.3. Variables impacting bilinguals' executive control performance

Although bilingual advantages at executive control appear to be independent of socio-economic background (Calvo & Bialystok 2012), they are highly sensitive to developmental

factors (Bialystok et al. 2008). Bilinguals develop inhibitory control skills earlier during childhood (Bialystok 2001; Bialystok & Martin 2004; Bialystok & Senman 2004; Martin-Rhee & Bialystok 2008; Meltzoff & Carlson 2008). Similarly, in old age their cognitive control declines less rapidly than that of monolinguals (Bialystok et al. 2006) – an advantage shown to be greater for dominant than for balanced bilinguals (Goral et al. 2014). Bilingual benefits are most debated for young adults with findings painting a complex picture. In flanker tasks administered to young bilinguals Costa et al. (2008) found a reduced conflict effect with the reservation that monolinguals catch up with bilinguals throughout the experiment due to practice effects. Young monolinguals' ability to make up for any potential disadvantages is also demonstrated in Bialystok et al.'s (2006) study revealing practice at computer games as a stronger predictor of inhibitory control than bilingualism. Age and other inhibitory control enhancing activities thus need to be considered as confounding variables in projects exploring code-switching and inhibitory control.

Further important variables are language proficiency and dominance. Costa et al. (2008) explore the interaction of language proficiency and task-switching. Their rationale is derived from the observation that highly proficient bilinguals switch languages with comparative ease, whilst low proficiency bilinguals display asymmetrical switching cost taking more time returning to the more strongly inhibited L1 (Costa & Santesteban 2004). This phenomenon appears to transfer from language to general thought, because the balanced bilinguals of Costa et al.'s (2008) study display reduced switching cost when switching from the harder incongruent task back to the more intuitive and more strongly inhibited congruent condition. Goral et al. (2014) hypothesized that balanced bilinguals assumed to regularly switch languages practise inhibition most. Contrary to predictions, balanced bilinguals performed less well than dominant bilinguals, possibly because asymmetrical language switching trains inhibition more. This may also be due to the type of code-switching balanced bilinguals engage in. For Muysken (2000), balanced bilinguals tend to code-switch densely employing minimal inhibitory control, which could provide an alternative explanation of the absence of inhibitory advantages amongst Goral et al.'s (2014) balanced bilinguals. Executive performance also depends on the extent to which language practices are internalized. Successive bilinguals have been proven to display greater inhibitory advantages after shorter rather than longer periods of L2 immersion suggesting that when transfer suppression processes become automatized inhibition is no longer practised (Heidlmayr et al. 2014).

2. Hypotheses derived from existing models and research

Green & Li (2014) explicitly elaborate on the implications of their model for language and cognition research, i.e. the impact of code-switching on executive control skills. Demands to inhibitory processes should be greatest in diglossic contexts, followed by the coupled control mode. The open control mode of dense code-switching requires the least inhibitory control involvement. This is largely in line with the extreme ends of Treffers-Daller's (2009) control continuum, but Green & Li (2014) group alternation and insertion together rather than locating them along a scale. Whilst Treffers-Daller's (2009) continuum only refers to inhibitory control involvement in code-switching contexts, the CP model also makes predictions for diglossic environments. Moreover, they incorporate schema switching into their model, so predictions regarding the impact of code-switching on task-switching can be derived. This PhD project adopts Treffers-Daller's (2009) scalar approach in combination with Green & Li's (2014) predictions for diglossic speech communities and task-switching. Inhibitory control involvement increases along a scale being lowest in the cooperative open control mode and highest in the competitive control mode. For task-switching the opposite pattern is predicted. The overlapping character of the Venn diagram highlights the existence of grey areas in empirical code-switching data (Fig. 1).

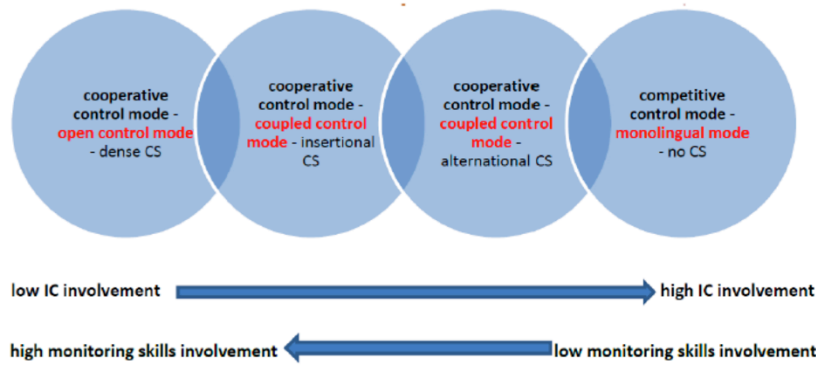


Figure 1. Inhibitory control and monitoring skills according to code-switching mode (author’s PhD project).

My PhD project at Reading University employs a mixed experimental design to explore the hypotheses illustrated in Fig. 1. Bilingual participants’ regular code-switching practices are assessed using Muysken’s (2000) typology. Then they are tested in flanker tasks measuring task-switching and inhibitory control, as well as in a Flanker-Stroop task (Kanske & Kotz 2011) inducing fast-modulated code-switching modes. Assuming that linguistic and non-linguistic executive control processes draw upon shared neural mechanisms the following hypotheses are derived:

Impact of code-switching on inhibitory control performance. Bilinguals’ inhibitory control performance may increase in line with the degree of IC involvement associated with individuals’ regular code-switching habits, as illustrated by the hypothetical graph in Fig. 2.

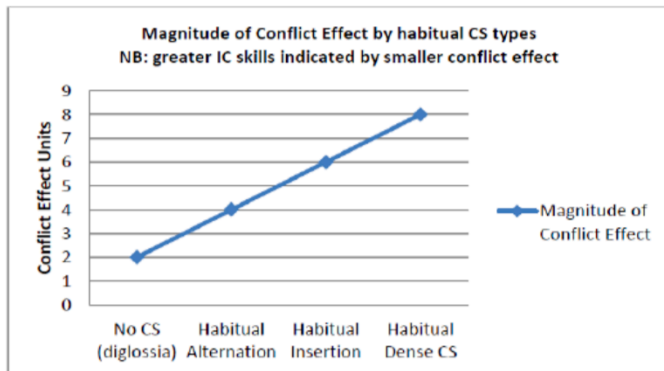


Figure 2. Inhibitory control performance across groups of code-switchers (author’s PhD project hypothesis).

Impact of code-switching on task-switching performance. Bilinguals’ monitoring skills may increase in line with the degree of task-switching associated with individuals’ regular code-switching habits, as illustrated by the hypothetical graph in Fig. 3.

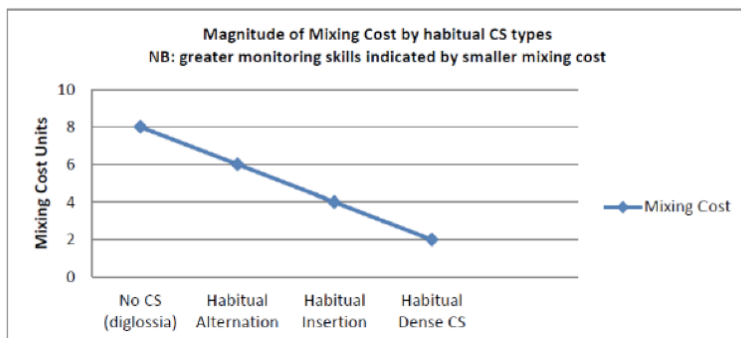


Figure 3. Prediction of monitoring skill performance in different groups of code-switchers (author’s PhD project).

Fast-modulated modes. Inhibitory control transfer from code-switching mode to executive functioning should increase along the scale of inhibitory control involvement implied by the induced mode. The interaction of the variables code-switching habits, fast-modulated code-switching mode and executive control is an exploratory question.

The predicted linear relationships are of a hypothetical nature and will almost certainly turn out to be more complex or different during result analysis. Considering a potential dissociation of language and task-switching (Yim & Bialystok 2012), it is possible that code-switching has little impact on monitoring skills for instance. Inhibitory control might equally be unrelated to code-switching behaviour given Soveri et al. (2011) did not find code-switching to predict conflict effect performance. In terms of the predicted differences for language modes, it is noteworthy that Gardner-Chloros & McEntee-Atalianis (2012) found no differences in pausing between monolingual and code-switching mode within identical subjects, suggesting that code-switching is not more effortful than monolingual speech. Assuming that pausing is an indicator of processing effort, monolingual and bilingual modes might not train cognition differentially at all, although we do not know the nature of the processes taking place during pausing and it is possible that combinations of more and less effortful processes cancel each other out (Gardner-Chloros & McEntee-Atalianis 2012). In light of the multiplicity of possible results this project therefore maintains an open mind when it comes to interpreting results in accordance with empirical findings. Aside from the difficulty of defining what constitutes a speech community, the greatest challenge to this project is potentially individual variation between the make-up of bilinguals' linguistic representations and connections, which means that any generalizations will have to be met with caution.

3. Conclusion

So far the precise nature of the control processes taking place during language mixing is poorly understood. Therefore the extent to which code-switching modulates related non-verbal skills also remains unknown. Investigating the impact of code-switching on executive control skills has the potential to reveal information about the origin of bilingual advantages at cognitive control, i.e. whether they arise from task-switching or inhibitory control. This in turn may also increase our understanding of language control processes themselves thus contributing to solving the puzzle of bilingual language control. The above-described predictions are currently being investigated in my PhD project at Reading University. Whilst previous studies considered code-switching as one variable, this project investigates the phenomenon in greater detail hypothesizing that various code-switching types impact executive control functions differentially.

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