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The "code-switching issue": transition from (socio)linguistic to cognitive research

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Review Article

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Abstract

This review investigates the complex dynamics of code-switching (CS), the spontaneous alternation between languages within a conversation, particularly its implications for cognitive processes like executive functions (EFs). Analysing post-2015 studies, it critically assesses 23 experiments. Through stringent criteria and comprehensive search strategies, the review identifies factors influencing CS types and their impact on cognition, highlighting methodological inconsistencies and confounds. It highlights the evolving perspectives on CS, ranging from pragmatic approaches emphasizing communicative functions to structural analyses focusing on linguistic constraints. It underscores the importance of considering factors such as language competence, typological proximity and cognitive processes in understanding CS behaviour. It emphasizes the need for precise CS typology assessment to understand the complex link between CS behaviour and cognitive functioning, bridging linguistic and cognitive domains. This review contributes to clarifying inconsistencies in CS research methodology and findings, aiming to elucidate the factors influencing CS types and their implications for cognition.

Highlights

- CS has been reduced to quantitative properties in the transition from Linguistics to cognitive research.
- CS type was mostly determined by self-reports or self-assessment questionnaires.
- These methods do not capture decisive aspects relevant to cognitive processes.
- The investigated language processes should be in alignment with the tested EF skills.
- To postulate a causal relation between CS and EFs, a precise evaluation of CS is pivotal.

1. Introduction

Language contact results in various specific linguistic forms and verbal behaviours across all levels of verbal communication. Some phenomena remain stable over time, such as loanwords or transfer affecting different components of the linguistic system. Others are dynamic, created as temporary structures, like code-switching or translanguaging (use of both a foreign language and one's mother tongue in a classroom context). The use of terms which have been introduced in the literature to describe multilingual speech varies and lacks consistency across different studies. Since we are focusing on studies that consider code-switching (CS) as a specific form of multilingual speech we refer in the following to definitions that can be found in the relevant literature. CS is generally understood as the spontaneous use of two or more languages in the course of a conversation among speakers in multilingual societies. Switching points can occur within (1) or between (2) words and sentences (within: 3 and between: 4) as illustrated in examples from a conversation between German/Turkish bilinguals:

1. *Adamın* (The man **Turkish** + case marking Turkish) ***rechts-inde*** (on the right – **German + Turkish** *postpositional suffix*) *de bir tane başka kız yemek yiyor* (**Turkish**). (*The man on the right and another girl is eating.*)

2. *şey var* (There is – **Turkish**) ***Fieberthermometer*** (fever thermometer **– German**) *var* (there is – **Turkish**). (*There is something, thermometer, there is.*)

3. *Bir tane çocuk* (A child – **Turkish**) ***Pflanzen gießen*** (watering the plants – **German**) yapiyor (to do – Turkish) (a child plants water does – *a child is watering plants*)

4. *Dışarıda da yağmur yağıyor* (**Turkish**). *Man sieht eine Wolke* (**German**). (*Outside it is raining. One sees a cloud)*

In contrast to other forms of bilingual use such as lexical borrowing or translanguaging, CS requires an advanced level of language command in both languages (cf. Silva-Corvalan, 1983; Bullock & Toribio, 2009). There is no consensus with regard to the competence level, however. In some CS studies, only early bilinguals with native-like competence in both languages (acquisition of both languages before the age of three) are taken into consideration, in other studies also foreign language learners with unbalanced competence in both languages are included. This variation highlights the lack of agreement on the proficiency levels required for effective CS. A definition proposed by Bullock and Toribio (2009:1) attempts to be inclusive, suggesting that: 'CS is the ability on the part of bilinguals to alternate effortless between their two languages.'[1] However, this definition may not be as inclusive as it seems. Effortless alternation typically implies a high level of proficiency in both languages, aligning more closely with the initial statement that CS requires advanced language skills. Consequently, the proposed definition does not fully resolve the issue of varying competence levels highlighted earlier.

The history of research on CS has evolved through periods of different methodology and theoretical framing (for an overview see Myers-Scotton, 2017). Pragmatically oriented studies laid the foundation for linguistic approaches, which were then integrated into contemporary psycholinguistic and cognitive perspectives. Over time, the perspective on CS has changed significantly. One approach views CS as a communicative practice, an interactional phenomenon functional for conversation management. CS is seen as a form of language behaviour that can signal cultural identity, social inclusion or exclusion and serving as a means of organizing conversation and social interaction (Auer, 1998). The methods used in this framework are closely related to conversational analysis, keeping the empirical data as authentic as possible.

A second strand focuses on structural linguistic phenomena at the microlevel of language use, such as structural constraints on switching points in a sentence and across sentences (e.g., *free-morpheme constraint*, Poplack, 1980; *matrix-frame model*, Myers-Scotton, 1993; Pfaff, 1979) or on possible correspondences and confirmation of principles of Universal Grammar (Muysken, 2000). This approach also proceeds empirically, with CS corpora of different language pairs, that is authentic data, forming the basis. In contrast to sociolinguistic studies, the communicative context does not play a decisive role. In his seminal work on bilingualism, Muysken (1997, 2000) distinguishes between three types of CS, which have to be seen as located on a continuum of integration rather than as distinct categories: *Alternation* means that grammar and lexicon are switched, while the two languages are not integrated; *Insertion* means that one language provides the structural frame in which lexical items of the other language are integrated. Finally, *Congruent Lexicalization* describes the integration of the two languages within a clause. According to Muysken, the latter type can only occur if languages are typologically closely related allowing for a shared syntax and lexicon. These subcategories of bilingual language use have been taken up in many studies on CS until today (cf. the reviewed articles, Table 1). The *Matrix language frame* Model (Myers-Scotton, 1993), a widely received grammatical model of CS, claims that in the case of intra-sentential switching, there is an asymmetry between the two languages. One language provides the grammatical frame, which shows in the use of grammatical morphemes such as inflectional morphology, prepositions or conjunctions and the determination of word order. The other language is taken to be 'embedded', providing mainly content words (nouns, adjectives, verbs) to the CS utterance. Since then, numerous studies on many language pairs have put these claims on structural constraints to test with diverging results (cf. Deuchar, 2020).

This brief review highlights the diverse perspectives on CS. While the general definition of CS given above is widely shared, the different approaches lead to diverse operationalizations of CS: Level of competence in the two languages, language dominance (Birdsong, 2014, for a discussion), the degree of integration of the two linguistic systems with the possibility of a third CS system, structural properties of the code-switched linguistic units in relation to the typological proximity of the languages involved, social and situational contextual parameters – these are all factors that are taken into account and weighted differently in previous studies.

Nevertheless, it must be noted that there is also agreement on some points in the literature: CS generally entails fluency in the two languages, as suggested by Bullock and Toribio (2009). This implies that multilingual speech in early child language acquisition or in the early stages of foreign language acquisition should be considered a different object of investigation. The same consideration is often applied to cases of multilingualism involving language loss or language disorders. For these groups, specific factors have to be taken into account, such as potentially deficient language control mechanisms or deficits in domain-general cognitive control (Fyndanis and Lehtonen, 2021). Furthermore, there is agreement on the assumption that CS does not occur randomly, but according to principles rooted in language use (c.f. Bullock & Toribio, 2009). However, these principles are still poorly understood, and empirical data often present a heterogeneous, and sometimes contradictory picture. This unsatisfactory situation has led to a shift in perspective from focusing solely on linguistic products to examining processes, thereby expanding the view from linguistic phenomena to the inclusion of cognitive processes as a possible source of explanation for the observed variations.

In the last decade, significant progress has been made to unveil the mutual influence of bilingualism and cognitive abilities, particularly on executive functions (EFs). In this context, CS in particular is supposed to help gain more insight into the cognitive architecture and neural bases of bilingualism. The main question here is how different cognitive functions are affected when languages are alternated. That is to say, that CS does not only entail the activation of the language in use but also the suppression of the other language system(s) in the mind. Rather, the mutual interrelationship between bilingual language use and domain-general cognitive mechanisms is highly intricate. The increasing number of interdisciplinary studies also reveals the significance of a detailed investigation of aspects that have to be taken into account when trying to determine the processes of CS in more detail. However, it is a field of research, which cannot build on consolidated results as the results of different empirical studies are strikingly diverse and often contradictory (cf. the discussion in Jylkkä et al., 2020; Paap, 2019).

[1]We are aware of the fact that some researchers distinguish language alternation according to further, sometimes more fine-grained criteria. Hofweber et al. 2020, for instance, talk about *CS* in the context of natural language use, they use the term *language switching* for experimentally induced alternation. Others distinguish between *code mixing* (within a sentence) and *CS* (between sentences) (cf. Goldrick et al. 2016) or between code mixing (no conversational function) and CS (interactionally meaningful) (Auer 1998).

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Table 1. Overview of code-switching studies in relation to factors age, proficiency, code-switching and executive functions (or EF + switch costs)

Article	Participants (languages, *N*, age)	Proficiency assessment of languages involved	CStype	Assessment of CS type	Assessment of EF	Results and effects on EF
1. Hartanto, A., & Yang, H. (2016).	English & others, mainly Chinese (m.a. = 22)*N* = 58 in single language context, *N* = 75 in dual language context	Self-assessment questionnaire	Not specified	Self-assessment of language use in same or different contexts	Switch task (colour/shape)	Interrelation between group and EF performance, not between frequency as proxy measure
2. Hofweber, J., Treffers-Daller, J., & Marinis, T. (2016)	German–English (*N* = 22, m.a. 39)	Self-assessment questionnaire	Dense CS	Frequency judgement task ("rate how often you encounter each type of CS")	Flanker task	Dense CS frequency correlated positively with monitoring skills
3. Jylkkä et al. (2017)	Finnish–English (*N* = 51, m.a. = 29)	Self-assessment questionnaire	Not specified	Semantic categorization task	Flanker task, Simon task, Number-letter task	Significant symmetric language switch costs, and a mixing advantage in L2: faster reaction times in the mixed language block than in the single language block. Interactions with the general executive functions showed no consistent overall pattern
4. Jylkkä, J., Lehtonen, M., Kuusakoski, A., Lindholm, F., Hut, S. C., & Laine, M. (2018).	Finnish– English (*N* = 51, m.a = 29)	Self-estimation, L2 proficiency test	Not specified	Language switching in reception, cued naming task	Language general semantic categorization task, mixed and single language blocks, Flanker task, Simon task, number-letter task	Switch costs in both languages, mixing advantage in L2. Subjects with better monitoring capacity are better at keeping track of the activation levels of languages in a mixed-language context. Smaller interference effects from the non-target language
5. Ooi, S. H., Goh, W. D., Sorace, A., & Bak, T. H. (2018).	Monolingual English speakers, Bilingual speakers of English and various languages (*N* = 245, m.a = 22)	Self-report	Frequent CS	Self-reported switching tendency and frequency	ANT, TEA Elevator Task	Interactional context of bilinguals impacts attentional control differently
6. Wu, J., Kang, C., Ma, F., Gao, X., & Guo, T. (2018).	Chinese–English (*N* = 37, m.a = 22)	L2 acquired after 10, College English self-ratings of proficiency in reading, speaking, writing and listening in each language	Dual-language context	Not reported	Cued picture naming task	Bilinguals are more efficient at deploying reactive inhibition on the L1 with language-switching training. Effect lasted over 2 days Training induced different effects at the global and local levels. Language-switching training increased global inhibition on the dominant L1, reducing inhibition at the local, trial-by-trial level: Plasticity based on experience
7. Adler, R.M., Valdés Kroff, J. R., & Novick, J. M. (2020)	Spanish–English (*N* = 48, m.a. = 21)	Language history questionnaire for both languages, Boston naming test, grammar test	Alternation	CS self-assessment	Cross-task conflict adaptation paradigm, reading CS sentences, followed by Flanker, within-subject design	CS in comprehension recruits domain-general cognitive control procedures. Conflict adaptation strategies across tasks developed

(*Continued*)

Table 1. (*Continued*)

Article	Participants (languages, *N*, age)	Proficiency assessment of languages involved	CStype	Assessment of CS type	Assessment of EF	Results and effects on EF
8. Bosma & Blom (2019)	Frisian–Dutch (*N* = 105, m.a = 6)	(Parental) self-assessment questionnaire; vocabulary and morphology tests in both languages	Intra-sentential CS	(Parental) self-assessment questionnaire of code-switching frequency	Flanker task	Code-switching from majority language (Dutch) into minority language (Frisian) requires more cognitive control than vice versa
9. Hartanto & Yang (2019)	Chinese–English (*N* = 165), Malay–English (*N* = 7), Tamil–English (*N* = 3);(m. a = 22)	Self-assessment questionnaire	Single language context, dual language context, dense CS	Bilingual interactional context questionnaire; bilingual switching questionnaire	Modified arrow flanker task; modified Eriksen flanker task; modified colour flanker task; colour-shape switching task; magnitude-parity switching task; animacy-locomotion switching task; rotation span task; operation span task; symmetry span task	Bilinguals' dual-language context predicted task-switching, Dense CS predicted inhibitory control and goal maintenance
10. Hofweber, J., Marinis, T. and Treffers-Daller, J. (2019)	German–English (m.a. = 39) 1 – 1st generation German immigrants in the UK; exposure to English at 8 y.o., (*N* = 11) 2 – 5th generation German speakers in South Africa, exposure to English at 6 y.o., (*N* = 11)	Self-assessment	Dense CS,frequent CS	Frequency judgement of authentic stimuli, bilingual email production task = discourse completion task	Flanker task, short-term memory, long-term memory	Tasks revealed CS patterns that explain group differences observed in executive performance. Bilinguals engaging in frequent CS excelled in conflict monitoring
11. Gross, Lopez, Buac & Kaushanskaya (2019)	Spanish–English children (*N* = 90, m.a. = 9)	(Parental) self-assessment questionnaire	Not specified	(Parental) self-assessment questionnaire ("how frequently the child hears CS in various environments")	Dimensional change card sort	Processing costs of switches were modulated by cognitive control and language ability
12. Lai & O'Brien (2020)	English–Mandarin (*N* = 74, m.a. = 18)	Semantic verbal fluency task in English and Mandarin; language background questionnaire	Single language context, dual language context, dense CS	Word switching; sentential switching (2 tasks)	Verbal stroop task; non-verbal global–local task	Dual-language context positively related to cognitive engagement and disengagement on verbal tasks. Non-verbal goal maintenance and interference control related to uncued inter-sentential language switching
13. Hofweber, Marinis, & Treffers-Daller, (2020a)	German–English bilinguals (*N* = 29) and English monolinguals (*N* = 29)	1. Relative difference in proficiencies between the two languages was computed 2. Bilingual dominance scale	Alternation, insertion, dense CS	Self-assessment of frequency of alternation, insertion English into German, insertion German into English, dense code-switching	Flanker task	1. L1-dominant bilinguals performed better in the L2-single-language compared to the bilingual conditions 2. Frequency of dense code-switching was a negative predictor of performance in the condition activating alternational and monolingual control 3. The less L1-dominant and therefore more balanced bilinguals displayed better inhibitory performance in the bilingual conditions

(*Continued*)

Table 1. (*Continued*)

Article	Participants (languages, *N*, age)	Proficiency assessment of languages involved	CStype	Assessment of CS type	Assessment of EF	Results and effects on EF
14. Hofweber, Marinis, & Treffers-Daller (2020b)	German–English, recent immigrants to UK, late onset of L2, but active users (*N* = 43) Monolingual English speakers (*N* = 41)	Questionnaire, self-assessment judgement task – different CS patterns (four types) → frequency judgement	Alternation, insertion, dense CS	CS frequency judgement task	Manipulated flanker task: detailed modelling of control processes, proactive, reactive, go/no-go version of flanker	Different CS habits (proactive–reactive) lead to better performance compared to monolinguals in relevant aspects of the EF. Sociolinguistic variables are important Inhibition operates at different levels of the linguistic system: conceptual, articulatory. Overall selective inhibitory advantage for bilinguals in reactive monitoring condition
15. Treffers-Daller, Ongun, Hofweber & Korenar (2020)	Turkish–English;immigrants to the UK from Cyprus (*N* = 28) and from Turkey (*N* = 29) Monolingual English speakers (*N* = 30)(m.a. = 30)	Self-rating	Intra-sentential CS: insertion, alternation, lexicalization, back flagging	CS frequency judgement task, self-assessment questionnaire	Flanker task	Better EF performance in Cypriot bilinguals followed by mainland Turkish bilinguals, and monolinguals respectively. Better EF performance by persons with multicultural identity style
16. Kuzyk, O., Friend, M., Severdija, V., Zesiger, P., & Poulin-Dubois, D. (2020)	French–English toddlers (*N* = 29) Tested at 36 and 61 months	Both languages from birth, exposure to non-dominant language min 20%, parent interview, vocabulary tests	Inter- and intra-sentential CS	Frequency of CS audio recorded, intra−/inter-sentence switches, frequency words	Flanker task, card sort task: picture sequence memory, once after the session with the dominant language	Proficiency had no effect on EF. Correlation between Flanker outcome and inter-sentential frequency switching
17. Kheder & Kaan (2021)	Algerian Arabic–French (*N* = 134, m.a. = 22)	French proficiency and cloze test Self-reported knowledge in Algerian Arabic and French as part of a language history questionnaire	Daily dense CS	Assessment of code-switching experience survey	Simon task	Proficiency and language use are important factors. Highly proficient code-switching bilinguals are better at conflict adaptation. Switching behaviour impacts cognitive control
18. Jylkkä, J., Laine, M., & Lehtonen, M. (2021)	Finnish–English (*N* = 33, m.a. = 27) Late learners of English (AoA: 7.5)	Self-report	Dense CS,dual language context	Self-assessment of everyday language switching frequency Language switching performance on a cued bilingual naming task	Simon task Flanker task Number-letter task	Participants with lower monitoring capacity make more everyday language switches. Everyday language switching would facilitate EF. Associations between language switching and general EF are more complex than current models assume. More frequent everyday language switching, irrespective of type, was associated with worse performance in the cued naming task and the EF

(*Continued*)

Table 1. (*Continued*)

Article	Participants (languages, *N*, age)	Proficiency assessment of languages involved	CStype	Assessment of CS type	Assessment of EF	Results and effects on EF
19. Han, Li & Filippi (2022)	Mandarin–English (*N* = 31, m.a. = 28)	Self-assessment questionnaire and semantic verbal fluency test for language proficiency	Habitual CS	Self-assessment questionnaire, verbal picture naming task, and semantic verbal fluency test for switching proficiency	Nonverbal colour-shape switching task; go/no-go task	Frequent switchers showed higher efficiency in verbal switching and nonverbal cognitive shifting
20. Han, Wei, & Filippi (2023)	Chinese–English (*N* = 36, m.a. = 24)	Self-assessment; English proficiency test	Single language, dual language, dense CS	Self-assessment	Flanker task; baseline cognitive skills (forward–backward digit span test; Raven's advanced progressive matrices test)	Facilitations of bilinguals' CS experience on their conflict monitoring and response inhibition
21. Yahya, M., & Özkan Ceylan, A. (2022)	Turkish–English (*N* = 74, m.a. = 22)	Self-rating questionnaire about language experience and proficiency (LEAP)	Not specified	Language-switching paradigm (self-paced reading)	Combination of language-switching paradigm (self-paced reading) with the Stroop paradigm	Switch costs were larger on incongruent than congruent. Stroop effects were larger on language switch than repetition trials. Language control performance decreased while resolving conflict. Inhibitory control performance decreased during switching language. Ability to adjust performance by previous experience was disrupted during language switching
22. Jiang, Ma, & Chen (2023)	Chinese–English (N = 30, m.a. = 21)	Self-assessment questionnaire and Oxford placement test (for English)	Not specified	Self-assessment questionnaire	Flanker task	Larger switch cost asymmetry in alternation context than in dense CS context. Proactive monitoring in alternation versus reactive inhibition in dense CS
23. Hofweber & Marinis (2023)	German–English (*N* = 46, m.a. = 32)	Self-reports of their language proficiencies language history questionnaire LHQ	Alternation, insertion, and dense CS	Frequency judgement task	Flanker task Digit span task	Single-language sentences were repeated more accurately than sentences involving CS in L1. Bilinguals' performance in L2 single-language sentences was not better than their performance in mixed-language sentences. Bilinguals performed better in insertion and alternation compared to L2 single-language sentences. Most prominent predictors of repetition accuracy were working memory, age and education

As aforementioned, different types of CS are reported. Even though the definitions of these types of CS seem to be well established in the domain of (Socio)Linguistics, it turns out that, when transferring these to the study of cognition, discrepancies can be observed across the definition and interpretation of the CS types and the respective findings. Whereas in linguistic studies CS is mainly related to the languages and their structures, in cognitive studies the cognitive operation of switching per se is taken as a factor that influences the executive control system leaving aside the languages.

Hence, the aim of this critical review is to determine the inconsistencies in assessment and findings in the study of CS and its relation to cognitive mechanisms as well as to draw attention to potential confounds. We have focused on studies dealing with cognitive processes of CS after 2015 because we observed a significant shift from the research of bilingualism and its possible effects on EFs to the research of the interrelationship between EFs and CS.

To this end, we analysed 23 experimental studies that investigated the relation between CS and cognitive processes, in particular EFs, in order to identify and discuss the parameters modulating the CS types that might have caused incoherent findings across the studies. For our databases, we used the search engines "Science Direct" and "Google Scholar". Search dates were limited from 2015 to 2023. We used the following search terms: Code-Switching; Dense Code-Switching; Code-Switching & Executive Functions; Code-Switching & Cognitive Functions; Alternation; Insertion; Language Proficiency & Code-Switching; Language Typology & Code-Switching; Mental Lexicon & Bilingual; Language Acquisition & Code-Switching. Included were all experimental studies that investigated the mutual relationship between CS and Cognitive/Executive Functions. Exclusion criteria were reviews, position papers, commentaries and experimental studies that investigate processing cost in relation to CS without referring to the underlying cognitive mechanisms.

2. Why is "code-switching" not only "switching codes"? Modulating parameters

The main question in the study of the relation between CS and cognitive functions is whether or which executive control mechanisms are entailed in order to coordinate both languages and how these in turn are influenced by CS behaviour. A further question that is often investigated in this domain is related to processing/switch costs from Language 1 to Language 2 or vice versa.

As described above, Muysken (1997) categorized CS on the basis of bilingual corpora in three different patterns: Insertion, Alternation and Congruent Lexicalization. This classification builds on the structural properties of the languages involved during CS. Under the assumption that there has to be one underlying grammar in every act of language use, Muysken restricts the case of highly integrated bilingual speech to language pairs which are typologically very close. This linguistic view differs largely from a cognitively oriented perspective on CS. Green and Wei (2014), for instance, suggested a model, which relates different types of CS to different control modes. They also distinguished three patterns but used the term Dense CS as the third type besides Insertion and Alternation. It is defined as the rapid change of language within a clause during a conversational turn (Green & Wei, 2014), a definition which is not linked to grammatical convergence of the languages involved as in Muysken's categorization. Moreover, the views and findings regarding the effect of CS on cognitive control mechanisms are diverse. Van Hell et al. (2015) stated that "merging of two different languages into a coherent utterance not only reveals the flexibility of language processing, but also signifies a highly skilled cognitive control" (p.3). On the other hand, Green and Abutalebi (2013) stated that – according to their Adaptive Control Hypothesis (ACH), which relates control processes to different language contexts – in the single-language mode or in Dense CS contexts less inhibition is required compared to the dual-language mode. In contrast to this hypothesis, Hartanto and Yang (2019) found that dual-language context could predict better performance in task-switching, while Dense CS was associated with improved inhibitory control and goal maintenance. Jylkkä et al. (2017), however, reported that the interactions with the general EFs revealed no consistent overall pattern.

As can be seen very clearly the relevant literature is highly inconsistent concerning the relations between (everyday) CS and general EF task performance. CS is much more than switching back and forth between the languages in use. Language processing and executive control mechanisms are highly interwoven and react sensitively to the social context. Therefore, CS may influence domain-general cognitive mechanisms in various ways. For example, Kaan et al. (2020) found in their Event Related Brain Potentials (ERP) study that language control could be modulated by the co-presence of others. Depending on the language competence of a person present as monolingual or bilingual, a different ERP signal resulted when reading sentences with and without switches. They further suggested that their results are compatible with a dynamic control model (Control Process Model (CPM) of bilingual language comprehension proposed by Green and Wei (see Green and Wei, 2014; Green, 2018). The CPM suggests that language control can be pro-actively adapted to the linguistic and non-linguistic context and distinguishes between competitive and cooperative control. According to the CPM, in dual language situations in which languages are used in alternation, competitive control is implied, indicating that a narrow attentional state is involved. The focus of attention is on one language. Cooperative control, on the other hand, is implied in Dense CS and is associated with a broad attentional state. Kaan et al. (2020) concluded that their results are consistent with the CPM in which different language control processes are associated with different control mechanisms that can operate simultaneously on various scales.

The possible linkages between CS and EFs are still far from being understood. One possible reason is the task impurity problem in these studies, which is not new (for a recent review see Paap, 2019). However, the discrepancies of the findings, which are displayed in Table 1 made us assume that the unclear operationalization of CS and/or the imprecise assessment of CS might be a further reason for causing inconsistencies across the results.

Hence, in the following sections, we aim to delve deeper into some crucial issues in order to elucidate modulating parameters of CS types relevant for studying the interrelation between CS and cognition.

2.1. The frequency issue: quantity versus quality

Combining languages in one utterance can be motivated by different factors. It can help the speaker to fill lexical gaps, demonstrate group identity or manage bilingual interaction. But this is not what CS refers to in cognitive research. CS is regarded as a complex process having a pivotal impact on the executive control system. However, a common problem in the study of the relationship between CS and the executive system seems to be that the CS

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behaviour of the participants is underspecified. In the reviewed studies, we observed a broad and inconsistent labelling of CS types (e.g., Dense CS or Congruent Lexicalization or Opportunistic Planning for cases of rapid clause internal switching, Insertion, Alternation). However, due to the heterogeneous understanding of CS and, related thereto, the divergence of assessment of the CS types (if assessed), it is problematic to conjecture whether the CS types are comparable across the studies. Since the processing of any kind of linguistic input or the process of language production unfolds by coordinating multiple cognitive sources, (linked to distinct cognitive functions), the exact switch patterns, namely when, what and how individuals are switching, are critical. On the other hand, the switched utterances must be processed and comprehended by the interlocutor, inducing different processing mechanisms compared to those of the speaker (for a more detailed argumentation, see Section 2.3.).

In the reviewed studies, CS types are supposed to induce different aspects of cognitive control. One aspect of cognitive control is associated with the level of inhibition employed. The Inhibitory Control Continuum Hypothesis (Treffers-Daller et al., 2009) implies that the languages are supposed to be most separate in alternation and least separate in Dense CS. During inserting items from the other language both languages are supposed to be active (Treffers-Dalleret al., 2009). Treffers-Daller et al. (2009) further suggested that inhibition enables language separation and that in order to alternate between the languages the level of inhibition must be very high. Moreover, Insertion employs a lower level of inhibition compared to Alternation whereas Dense CS engages minimal levels of inhibition.

Hofweber et al. (2020b) investigated the effects of experimentally induced language modes (single language versus CS modes) on bilinguals' EF performance (Flanker task) and referred to the terms Coupled control code-switching (Green and Wei, 2014) and dual mechanism framework (see Braver, 2012). Green and Wei (2014) suggested that the CS types Insertion and Alternation can be realized by Coupled control under which the matrix language temporarily cedes control to the other language and allows for the intended Insertion or Alternation before control is returned back (see also Green, 2018). The dual mechanism framework, on the other hand, postulates that "proactive control reflects the sustained and anticipatory maintenance of goal-relevant information" and "reactive control reflects transient stimulus-driven goal reactivation" (p.106). Based on these assumptions, Hofweber et al. (2020b) stated that their results confirmed the predicted interactions between CS and EFs, namely that Coupled control code-switching (Alternation, Insertion) was predicted to train reactive control modes and Dense CS was predicted to train proactive control modes. They explained the proactive control mode in Dense CS by stating that "the prolonged linguistic co-activation in this CS type requires a constant readiness to use inhibition." (p.923). Moreover, Hofweber et al. translated the training effect of CS into bilingual advantages. On the contrary to these results, Jylkkä et al. (2021) reported that more frequent everyday language switching, irrespective of type, was associated with worse performance in a cued naming task and a Simon and Flanker task. The researchers argued that participants with lower executive functioning had the tendency to switch more often and concluded that the hypothesis that training language switching can train EFs is questionable since everyday language switching is an automatized process that does not require top-down control (Jylkkä et al., 2021; for a review see also Lehtonen et. al., 2023).

By referring to only a very few recent studies in the previous paragraph (details about other studies are displayed in Table 1) we wanted to emphasize how different the argumentation regarding the relation between CS and EFs (here inhibition) can be. Furthermore, it is not easy for the reader to disentangle the interdependence of the specific variables due to overgeneralized descriptions of bilingual language use. Hofweber et. al. (2020b) stated that, given their results, Alternation and Insertion train reactive control modes and Dense CS trains proactive control modes. The participants' CS behaviour was assessed according to how they judged themselves when "encountering" switched utterances. Therefore, it remains unclear whether these control modes are trained when encountering code-switches or when producing them. Similarly, it is not conceivable whether the constant readiness to use inhibition in the Dense CS type is valid when encountering or producing switches. A further important question that arises here is what is causing the "training" effect. Is it the Alternation between the languages per se or does the content of the switched elements make a difference. Hence, in the following we want to explain the importance of the content of switches in relation to EFs.

The results of the reviewed studies, which are displayed in Table 1, are showing that the CS type might play a decisive role in how cognitive processes are affected. However, in the reviewed literature, the CS type is mostly categorized based on the frequency of switches by applying a self-assessment questionnaire (see Table 1). If it comes to the methodology, it gets even more problematic. The frequency of switches is evaluated often only by a questionnaire where participants are told to rate the switches they produce or encounter in different situations (see de Bruin, 2019, for more details about assessment questionnaires on language use). Thus, a series of questions arise when self-assessed switch frequency is taken as the criterion for classifying CS behaviour.

- What is counted as a switch by the participant?
- Does the participant perceive switching in the same way as the experimenter?
- Is the participant able to make a distinction between borrowings or buzzwords and switches?
- How can the participant determine an average number of the switches produced per day?
- How is the participant able to rate how common it is for her/him to switch in specific contexts? (for a CS Assessment Questionnaire, see The Bilingual Code-Switching Profile – Olson, 2022; see also Section 2.3.)
- What about the switches at the level of (morpho-)syntax? How can these be counted? (for switches at the level of (morpho-) syntax, see examples 1–3 in the Introduction)
- How can the participant differentiate between intra-sentential (e.g., Insertion) and inter-sentential (e.g., Alternation) CS? This is important since different modes of language control might be involved (e.g., Green & Abutalebi, 2013; Green & Wei, 2014).

In comparison to a conceptualization of Dense CS as a frequent switch between the languages, Hofweber et al. (2020b) elucidated the term Dense CS in a more qualitative manner. They stated that "Dense code-switching describes cases of language mixing in which languages remain co-activated at both the grammatical and lexical levels. This means that speakers select lexical items and structural features based on their socio-pragmatic and structural appropriateness, not based on language membership. Switching takes place more frequently in Dense CS than in Alternation, but switch points are hard to identify. Contrary to Insertion, it is impossible to identify a Matrix language as speakers combine structural rules from both languages. Dense CS primarily occurs between closely related languages." (p. 910).

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Although this qualitative explanation of Dense CS is much more differentiated than in most of the other studies, we want to draw attention to a further point that seems to be neglected in most of the reviewed studies, namely the context where bilinguals might also switch between their languages in a very "dense" (in the sense of frequent) manner. Dense switching can also occur at schools/universities, where a foreign language is the medium of instruction. Other contexts where switching might be "dense" are international conferences and meetings as well as interpreting and translating. In a context where switching is very dense but challenging (e.g., interpreters, bilingual academic discussions, bilingual schools, etc.), the engagement of a high focus of attention would be expected in order to activate the specific item(s) which the speaker consciously selects as the most fitting ones in that specific utterance. On the other hand, no high focus of attention would be required when specific linguistic items are switched frequently in everyday communication, like communication between friends or family members, and are therefore mostly already active, if not to say, automatized. That means that even if the frequency (quantity) of the switched items is similar in two persons that are categorized as "Dense Code-Switcher", the switched elements and content (or "quality" as the counterpart of quantity) should also be considered.

Cognitive mechanisms during the course of conscious selection of the "to be switched element" or the conscious selection of the "most fitting expression" in the other language do entail different control mechanisms compared to the utterance of items that "come first" or "automatically". In other words, we put forward the assumption that the CS types Insertion and Alternation could both differ in terms of cognitive control related to the context and content they are used in. Both CS types are commonly produced in bilingual personal conversations as well as in bilingual professional contexts. We think that the main difference is that "automatically" produced switches in everyday communication do not tap into the EFs like monitoring, conflict resolution, attention and inhibition to the same extent as switches that are deliberately performed at a specific moment. Switches that are produced consciously do require a higher level of monitoring in order to find the most accurate equivalent in the other language. For instance, interpreters are required to densely alternate between the languages by using the most accurate expressions. In case more than one appropriate item in the mental lexicon is activated, the most fitting one has to be selected, which entails the resolution of a conflict as a cognitive function. All other closely related expressions have to be inhibited in a very rapid manner. It is conceivable that this intentional switching process requires a high focus of attention and monitoring. On the other hand, when switching in everyday communication, the need to focus attention to the switched elements and to monitor the utterance is supposed to be lower as in the first situation since the content and the time of the switch are not considered as inducing a conflict at that moment. That means that the most active items, irrespective of the language, can be straightforwardly uttered (this also applies to Dense CS). A further point, that we would like to underline, is that the CS type does not describe the type of how a bilingual is permanently using both languages. Rather we suppose that it is mostly the description of the momentary switching process. Hence, we concur with the assumption of Green and Abutalebi (2023) that the states of different executive control processes are adjusting to the CS type, the CS context and the languages per se, even within moments, depending on the needs of the bilingual speaker or listener.

In short, it can be said that Dense CS is far more than switching frequently between two languages and cannot be reduced to a quantitative phenomenon. The bilingual context and content (i.e., academic discussions versus everyday conversations) and, very importantly, the intention of the bilingual speaker (deliberate versus free switching) seem to be crucial factors regulating the underlying cognitive functions. These functions are also susceptive to the level of complexity of the content (for the adjustment of attentional states to changes in content and context, see Green and Abutalebi, 2023). In studies investigating the interrelationship between CS and cognitive functions, not only the "quantity" but also the "quality", as described above, should therefore be considered when assessing the CS type.

2.2. The "proficiency and organization of the mental lexicon" issue

In communities where two languages are used frequently, it is expected that in daily life switching between the languages is voluntary and free. One may say that, in conversations where switching is common and occurs naturally, this switching becomes a generalized ability facilitated by frequent use. Consequently, CS has often been considered fluent and smooth (Poplack, 1980) and described as the "most comfortable way" to speak (Dorleijn, 2017, p. 12). However, experimental studies measuring response times or switch costs during involuntary switches often report longer response times and larger switch costs (e.g., Burkholder, 2018; de Bruin et al., 2018; Jevtović et al., 2020; among many others) compared to voluntary switches. Moreover, Gross and Kaushanskaya (2015) found that voluntary language switching in children can be less costly even when naming items in the non-dominant language, depending on the frequency of use. This suggests that reaction time is influenced not only by whether a switch is voluntary or involuntary but also by language proficiency, which is a critical factor affecting cognitive costs during the switching process and should be evaluated in connection with the interactional context.

A further factor modulating EFs during lexical selection is the organization of languages in the mental lexicon. In the remainder of the section, we examine the effects of age of acquisition and language proficiency on CS, as these factors influence the organization of languages in the mental lexicon. To gain a broader perspective, we include relevant electrophysiological studies on the processing of code-switches.

In one of the first electrophysiological studies investigating neural responses to switched items during online sentence processing in proficient speakers and language learners, Moreno et al. (2002) found that CS can be less costly in the non-dominant language. They interpreted switching as an unexpected event processed similarly to low-cloze words, suggesting that the processing of a CS may be less costly than an unexpected within-language item. In contrast, van der Meij et al. (2011) suggested that proficiency modulates the processes triggered by language switches. Their EEG study indicated that higher L2 proficiency leads to greater involvement of L2 grammar in the processing of language switching in the group of more proficient learners compared to those with lower levels of L2 competence.

Contrary to these findings, Proverbio et al. (2004) did not relate the difference in L1/L2 switching to proficiency differences. According to the findings in their EEG study with simultaneous interpreters and monolingual controls during a semantic processing task, Proverbio et al. (2004) concluded that L2 neurofunctional organization depends on age of acquisition. They suggested that when L2 is learned later in life, it is more likely based on the translation of pre-existing lexical knowledge, whereas early

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acquisition results in overlapping semantic and conceptual systems. Similarly, Gosselin and Sabourin (2021) pointed out that CS can lead to processing costs for some but not for all bilinguals, likely due to differences in participants' experience (cf. Beatty-Martínez & Dussias, 2017; Beatty-Martínez et al., 2018). Verreyt et al. (2016) also suggested that language switching experience is crucial for executive control in adults and that language usage and proficiency differentially affect bilingual cognition.

In the first phases of child's language acquisition, input is not only restricted to the passively perceived language. The way how children use their language(s) has also an influence on how children process any new language (see Lieven et al., 2009). The acknowledgement of bilingual speakers' social and contextual environments is critical, since it determines the repeated use of specific languages and structures in different social contexts (Grosjean, 2015). Korenar et al. (2023) suggested that the repeated use of specific language forms and specific languages might be stored in memory as more salient in that context. To exemplify this supposition, Korenar et al. gave the example of a tourist guide who intensely uses English with the context of guided tours but rarely anywhere else. The authors argue that this guide will strongly associate English with specific vocabulary about architecture and history, and with talking to tourists. It can be inferred that interactional contexts and how the languages are used in these contexts (characteristic practices in bilingual communities) can therefore shape how and when children switch between the languages they know (for a review see Gaskins et al., 2022). Accordingly, it can be assumed that often recurring switched forms or structures, which the child encounters in her/his environment might be stored as a switch. To give an example here: a typical Turkish–German switch occurs in a structure $V_{infinitive}$ in German + V_{finite} in Turkish, such as in "malen yapıyorum" ("*to draw*/German *I am doing*/Turkish"). This form can be used with all verbs that express activities "doing sth." and is very common in the Turkish Community living in Europe (for a Turkish–German Code-Switching Corpus, see Çetinoğlu, 2016, p. 4216). We consider this kind of insertion as noteworthy, since a structure where two full verbs are combined with the finite verb following the non-finite verb does not exist as a construction in either of these two languages. In other words, the subsequent use of two verbs, namely the infinitive form of an action verb (i.e., *malen*/to draw – German) followed by the finite verb "to do" (*yapmak/etmek* – Turkish) is not possible in both languages albeit for different reasons. Therefore, the only explanation of the widespread usage of this structure can be that it is acquired and stored as a "switch-construction". Therefore, we assume that when uttering these kinds of frequently produced switches, only a low level of monitoring and attention is engaged. In their recent review Lehtonen et al. (2023), for instance, indicated that with increasing CS practice, bilingual language behaviours might become more automatic and less executively demanding since the cognitive system adapts through automatization. The authors further asserted that the engagement of domain-general executive resources diminishes over time, leading to an establishment of automatic task schemas in long-term memory that are not challenging EFs (Lehtonen et al., 2023).

Overall, it can be said that the interaction of age of onset of bilingual language acquisition, purpose of language use, linguistic structures, content and bilinguals' sociolinguistic context are all components constituting the intricate and interwoven linkages shaping the mental lexicon. Hence, we presume that the bilingual mental lexicon is not organized according to language proficiency and not according to the language systems, but rather according to how the languages are used and to what extent the switches are automatized. As aforementioned, the automatized production of frequently used switches might indicate that these are actually stored as a switch or a "switch template" (in the sense of the construction, like "malen yapıyorum" as explained above). In other words, we assume that often recurring switches in a bilingual community cannot be stored separately. This would overstrain cognitive resources. There is also the fact that most switches are individual. Hence, we hypothesize that often-used switches are stored as "switch templates" which can be modified according to the need of the bilingual speaker.

On the other hand, a bilingual's frequent and effortless switching abilities in daily communication might differ when this same person is involved in a bilingual context (same person, same languages) where the subject of conversation is not common for this person. A bilingual person might be very fluently switching when talking to family members or friends about common issues of daily activities, whereas when trying to explain a "special circumstance", CS would probably not be as effortless or automatic compared to "routine contents". Since accessing or activating less frequently used items takes longer compared to often used ones, it is not likely that a switch can be produced effortlessly and is therefore supposed to include conscious switching between the languages. The effortless/automatic production of frequently produced switches can be counted as a further argument that supports the idea that these are stored as "switch templates" in the mental lexicon. It should be noted that we do not suggest here that automatized code-switches are produced unconsciously. We think that, irrespective of containing a switch or not, each uttered lexical item is monitored before articulation which, of course, also requires attention. However, the level of the executive control functions is adapting to the degree of ease/difficulty of the lexical selection process.

In sum, future studies investigating the relation between CS, proficiency, processing costs and cognitive functions should also assess in detail to what extent the switched elements might be automatized, since these might be stored as such and would not tax EFs in the same level compared to intentionally produced switches.

2.3. The speaker–listener issue

Besides the issues mentioned above, CS must be regarded from the speaker's and listener's perspective. When planning an utterance, it is the speaker's individual choice how to make use of the available linguistic knowledge and accordingly when and which linguistic item(s) to switch. In other words, it is an individual planning process to accomplish a linguistic goal in the most expedient way. On the other hand, it is unclear up to now, in how far the listener is able to anticipate when a switch might occur, even in a context where switching is part of the way of communication. In current models of cognitive control, it is assumed that different CS types have different effects on aspects of the executive system. However, due to different language processes during production and comprehension, it is obvious that the effect on the executive system should also differ. Therefore, in studying the influence of CS on cognitive functions it is not sufficient to only consider the type of CS. These should further be subdivided according to whether a switch is being produced or encountered (see also Section 2.1). This crucial point has been mostly neglected so far. As can be seen in Table 1, in most of the studies, a self-assessment questionnaire is used in order to determine the switching type of the participants. These

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questionnaires are mainly based on determining the history of language switching, the use of language switching, the ease of language switching and the attitudes towards language switching (e.g., The Bilingual Code-Switching Profile, Olson (2022)). These kinds of surveys are mostly assessing CS production and do this in a very limited manner only. However, it is not evident whether the EF tasks used in the reviewed studies (Flanker, Stroop, Simon, ANT, etc., for the details see Table 1) tap into the associated cognitive constructs.

In Section 2.1, we suggested that the CS types could differ in terms of cognitive control related to the context and content. In this section, we aim to extend this assumption by exemplifying how the executive control processes might differ related to whether a switch is produced or perceived. When producing a switch, the intention and the speech planning process of the bilingual speaker are crucial. In other words, when the speaker in a bilingual context intends to make use of the other language, only when there is a need for it (Insertion or Alternation), it is likely that the activation threshold of the language in use is lower, and the other language has to be inhibited. As proposed by Green and Wei (2014), the matrix language temporarily cedes control to the other language and allows the intended Insertion or Alternation before control is returned back. In such a situation, it is probable that the EFs inhibition, conflict resolution, monitoring and attention are highly entailed in order to monitor where a switch is needed and how to switch appropriately. However, for the listener, the same EFs might at least not be engaged or not to the same extent. Moreover, we would suppose that the listener's cognitive flexibility functions should be more entailed since the listener does not know when and what type of switch to expect. The listener is therefore in a state where rapid adaptation is required. We, therefore, argue that the speaker's and listener's major EFs engaged in a specific situation might be different or at least not engaged to the same extent.

Hence, we suggest that the CS behaviour should be assessed in an ecologically valid manner, such as natural conversations, question and answer sessions, or descriptions, where production and comprehension of switches are clearly differentiated. Furthermore, future studies should consider the specific cognitive functions relevant to their study context to identify appropriate tasks for assessing each language modality (comprehension versus production). It is important to use EF tasks with robust psychometric properties to accurately assess domain-general cognitive abilities within the context of CS. This is crucial since otherwise the EFs tested in a study might not tap into the cognitive constructs of language production or comprehension, respectively.

2.4. The (socio)linguistic issue

In almost all reported studies, CS behaviour is taken to be a stable measurable factor across different contexts. The respective values are correlated with results from cognitive experiments. Given our knowledge from linguistic and sociolinguistic studies on CS, we see the need to capture linguistic behaviour in a far more differentiated way in order to allow for valid conclusions on the interrelation between CS and cognitive functioning.

We already touched on this briefly at the beginning. Previous linguistic studies looked at the patterns of mixed language under structural and functional aspects, resulting in a fine-grained description and explanation. The following insights are relevant.

2.4.1. Structural analysis of the switched sentences

Many studies looked into the linguistic structures of the involved languages under grammatical aspects (Poplack, 1980; Myers-Scotton, 1993; Muysken, 2000; among many others). A main distinction was made between two classes: content (nouns, verbs, adjectives) and function or system (prepositions, particles, auxiliaries, etc.) words. The general assumption at that time was that there are clear grammatical constraints with respect to possible switch points in relation to the class membership of the items involved. On these grounds, the question of language dominance was addressed. According to Myers-Scotton (1993), the dominant language is the one which provides grammatical function words (Matrix-frame model). To illustrate this by the *System Morpheme Principle* formulated by Myers-Scotton as an example: *all system morphemes which have grammatical relations external to their head constituent will come from the ML* (Myers-Scotton, 1993:83). The availability of more CS data across a whole range of languages showed that violations of the constraints could be observed. This led Muysken (2000) to assume a type of CS (congruent lexicalization) where neither language is dominant but both languages have the same status, and no structural constraints beyond those implied by the grammar of the languages have to be obeyed. According to Muysken, this is only possible if the languages involved overlap in their syntactic structures. Today we have empirical evidence for CS of the latter type and also for languages which do not share syntactic properties. Furthermore, the CS data available today show switches within word boundaries (lexical stem + grammatical morpheme), switches between function words and lexical elements (and so forth determinator + noun) and switches between languages with different word order (new function word construction to shift the position of the verb, for instance[2]). While the structural constraints as they were formulated in the early linguistic CS studies have proven to be untenable, we have learned from a large number of following studies that the level or degree of integration between the languages involved shows in the structural context in which switches occur. If switches occur within words (such as in Ex. 1) underlying processes of planning and activation have to be different from switches between function words and lexical items and again different from cases where switches appear between constituents or sentences (cf. an overview, Kroll & Gollan, 2014). A notion such as *Dense CS* which generalizes across all these types does not differentiate sufficiently for the analysis of underlying language processes.

2.4.2. Role of typological relatedness

The importance of the structural properties of switched sentences is related to the question of language typology (Comrie, 1989; Aikhenvald & Dixon, 2020). In the early phases of CS research, the assumption was that a high level of integration was only possible for structurally closely related languages (cf. the idea of congruent lexicalization, Muysken, 2000). However, we know by now that CS can be found at all levels of integration and also between languages which are typologically remote such as Chinese–English, or German–Turkish (Chan, 2009). The typological classification of the languages involved is nevertheless of great relevance, since the integration of two languages into one structure will require different cognitive processes. This is immediately obvious if we think of two languages such as Spanish and Italian, where syntactic planning can more or less follow the same principles in contrast to German and Turkish, where speakers have to come up with new ways of

[2]An example from our corpus of a Turkish/ German bilinguals would be: *die lässt es elinden kaçırıyor*. German places the finite verb in second position, here: die (she) lässt (lets) es (it), Turkish places the finite verb at the end, here: *elinden* (from her hand) *kaçırıyor* (escape), she lets it from her hand go.

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getting around structural incongruencies (e.g., new constructions altogether).

2.4.3. Language acquisition

An interesting source for the classification of CS type comes from the field of language acquisition. Data from children growing up bilingually from birth show what can be interpreted as CS from early on (Meisel, 1989; Müller & Cantone, 2009; Gardner, 2010). However, as Gardner (2010, p. 147) points out, in order to talk about switching there have to be two identifiable, separate systems. This is not the case in young children who are only developing their languages. This has led researchers to use the term language mixing for this stage of language use. How far bilingual children start with one system and gradually move into differentiating two systems (Volterra & Taeschner, 1978) or rather separate the systems from the beginning is still a matter of debate. Since there is a high level of interpersonal variation it might be the case that both pathways can be taken by children. Again, this personal factor is important to be taken into account, since it will affect cognitive processes in language use (Gardner, 2010:151) also at later developmental stages.

Further arguments which speak against a frequency measure for CS behaviour come from the field of sociolinguistics (Gumperz, 1982; Auer, 1998). Numerous studies have shown that the use of CS is dependent on a broad range of interactional factors as well as on factors related to questions of identity and attitude. This means that there is a high intrapersonal variation in CS use, which is related to a whole range of triggering factors, which can be calculative and conscious but also emotional and unconscious. In a study on CS in parent–child interactions, Willliams et al. (2020) found that negative arousal states, in particular, trigger CS. They assume that this emotional state restricts cognitive control and thus leads to the observed spontaneous CS (William et al. 2020; also Pavlenko, 2005, 2012). The different socio-psychological embeddings will be related to different cognitive processes in the sense of higher levels of automatization or control, respectively.

3. Conclusion

A shift from "pure linguistic" studies to interdisciplinary studies in the domain of CS is certainly to be welcomed. Nevertheless, what was truly remarkable was the fact that in the transition phase from Linguistics to cognitive research, the phenomenon of CS has been largely reduced to quantitative properties of multilingual language use. The differentiated results of linguistic studies on structural, semantic and pragmatic properties of mixed language have mostly been ignored and CS is merely perceived as the frequent switch between the languages. In the reviewed studies elucidating the reciprocal influence of CS and cognitive processes, in particular EFs, CS has been used in a broad and underspecified manner. Furthermore, we found that in most of the studies, frequently switching bilinguals have been referred to as "dense code-switchers", and in nearly all reviewed studies the CS type was determined by applying self-reports of CS or self-assessment questionnaires (some studies even have not reported any assessment). However, these methods are much too imprecise to differentiate between "quality" (content) and "quantity" (frequency) of the switched elements. The production of frequently switched elements, in which activation is automatized, might not tax EFs at the same level as the conscious selection of the most fitting expression in the other language. In most of the reviewed studies, the assessment of CS production and CS comprehension is not differentiated, so it is not clear whether they tap into the same cognitive constructs as those involved in the tested EF skills. Besides and very importantly, these assessment methods do not in any way capture aspects of the linguistic properties of the used languages, like typological relatedness, structure and their acquisition. Since all these are variables possibly inducing different cognitive processes, we suppose that inconsistencies in the findings might be due to the imprecise evaluation of CS. We conclude that switching between languages entails highly complex and interwoven cognitive processes that are not only sensitive to the frequency of code-switches but also to the aforementioned variables that we discussed in detail. We therefore suggest that in order to be able to postulate a causal relation between CS and the concurrent EFs that are tested, the evaluation of CS should be specified precisely. Furthermore, it is important to ensure that the specificity of the investigated language processes (production versus comprehension/processing) is in alignment with the cognitive processes that are measured with the EF tests. Otherwise, there is a risk that an interpretation of the connection between CS and the concurrent EFs is not meaningful.

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