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3

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Introduction

In this chapter, we use the term cognitive bilingualism to refer to a merge of two research traditions: i) the psycholinguistics of bilingualism (i.e., models and theories that try to describe in psycholinguistic thinking and terms how bilingualism works); and ii) work on the psychological aspects of language, in particular of bilingualism and specifically of effects and consequences of bilingualism on cognition (i.e., cognitive processes and development). The chapter provides an overview of the most prominent and empirically well-supported theories and models of cognitive bilingualism. In doing so, the cognitive control required for bilingual language processing in production and perception will be briefly reviewed as well as the impact of using two or more languages on cognitive development. Finally, the ongoing debate on the benefits of bilingualism on higher cognition will be outlined and discussed.

Cognitive Theories and Models to Solve Bilinguals' Unique Phenomena: Focus on Language Processing and Control

In bilingual research, theorizing has presumably been largely driven by a need for understanding several phenomena unique to bilinguals. Theories have attempted to answer the following related, fundamental questions:

> How can a bilingual speaker have access to two languages, but use only one at a time, without confusing them (i.e., unintentional cross-language interference), how can a bilingual use knowledge from one language when being involved with the other (i.e., transfer), how can a bilingual translate, and how can a bilingual use both languages for code-switching?

To date, there is no single theory of bilingualism that can account for all phenomena which have been observed and investigated so far and which are typical for bilingualism and the bilingual speaker. Nonetheless, there are many theories and models put forward to describe specific aspects of bilingualism. Most of them can be seen as extensions of earlier monolingual models, deal with language processing, and include the concept of control. Hence, we first look into the

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most prominent monolingual model for language production as point of departure for bilingual models. In the upcoming sections, we cover general mechanisms for language control (i.e., activation and inhibition), describe models that have attempted to capture the demands of co-activated languages (mainly production), and review those concerning perceptual processes. After these more overarching topics, we turn to models that are more specific: Those that describe typical bilingual phenomena such as transfer, translation, and code-switching. Then we put language processing into context and connect environmental demands to language processing and control. Finally, we discuss the more cognitive aspects of bilingual language processing and use on cognitive development.

Psycholinguistic models of monolingual language production (e.g., Levelt, 1989) suggest a number of discrete stages that occur during the preparation of speech production until a word or sound is uttered. Roughly speaking, an idea, message, or speaker intention has to pass through the stages of conceptualization, formulation, and finally production until a verbal utterance is produced and the initial speaker intention is expressed. Levelt also included the various types of knowledge structures, for example, the lexicon, the situational knowledge, encyclopedia etc., which are referred to in the separate stages.

The intention to express a specific message or thought launches a whole set of early processes in the conceptualizer: the required information is activated and selected from long-term memory (e.g., situational knowledge, i.e., about the interlocutor, the content of the ongoing conversation, as well as factual knowledge). This information is ordered to build an abstract speech plan, the preverbal message. All relevant information related to this preverbal message is available for further processes. The stage in the formulator receives this preverbal message as input for the next step: a translation of the abstract preverbal message into a linguistic structure. With access to the mental lexicon, lexical items are activated and selected in terms of their semantic as well as their grammatical (i.e., morphological) features, their syntactic specificities (i.e., how they need to be incorporated into sentence structures), and their phonological form. Meaning and syntactic information are represented in the lemma, whereas morphological and phonological information constitute the lexeme. A linguistic structure which represents the intended message and which is morphologically and grammatically adapted to fit the linguistic environment is transferred to the next stage: phonological encoding. For each lemma and the entire utterance, a phonological plan is created which is then articulated as phonetic plan.

Levelt included a speech-monitor with the help of which the produced utterance is compared to the intended message to control its fit. But even earlier in the production stages, right after building of the linguistic structure of the message, this information is compared to the intended message.

Although the first description of the model (Levelt, 1989) was strictly serial, i.e., one stage could only start after the preceding one has been completed, a later account included the likelihood of more parallel processing, but, more importantly, stressed the independence of the processing stages (Levelt et al., 1999, p. 36). Levelt's model is considered as one of the discrete two-stage processing models. Other monolingual language processing models take a more flexible approach when describing the flow of activation from conceptualization, formulation, and encoding to articulation (the so-called unidirectional cascade models, e.g., Peterson & Savoy, 1998), whereas interactive activation models (e.g., Dell, 1986) assume that activation flows back and forth between the stages.

These assumptions are crucial as they influenced the way bilingual theories have attempted to resolve the intriguing question of how much language information is activated (in terms of lexical units) and from how many languages. To put it differently: Whether access to the bilingual mental lexicon is non-selective (i.e., accessing lexical items in both languages) or selective (i.e., accessing lexical items belonging only to the target language) has been one of the prominent research questions in recent decades (see, e.g., Kroll et al., 2008). The view of selective access to the lexicon holds that, while words from the non-target language may become active, they are never considered actual candidates for selection by the attentional mechanism that ignores words from the non-target language (Costa et al., 1999). Non-selective access, in contrast, assumes that activation of lexical items in both languages is automatic and is not concerned with language classification of these items (see Bartolotti & Marian, 2012 for review). During lexical retrieval, candidates from both languages are activated in parallel and compete for selection. Parallel activation of a bilingual's two languages, i.e., the languages are both always active and can be used for processing, is the basis for the above-mentioned unique phenomena. Parallel activation has been demonstrated empirically in reading, listening to speech, and speaking, even when only one of the languages is currently in use or should be used (Dijkstra, 2005; Kroll et al., 2006; Kroll et al., 2012; Marian & Spivey, 2003; Thierry & Wu, 2007). The general agreement in the field that there is parallel activation of words from two languages requires a scientific explanation how a bilingual is nonetheless not helplessly confused by the two languages but rather able to use them appropriately in diverse contexts. Pertaining to the parallel activation view, situations of monolingual mode (i.e., using only one language as target language; for more detail, see Models to Capture Language in Context: Language Mode, Social Action, and Culture Adaptations) pose a specific condition for the language-processing system as possible constant cross-linguistic interference must be prevented.

Therefore, there have been suggestions regarding the ability for willful language choice, i.e., the speaker decides which language to use (often in accordance with the interlocutor), the ability to adapt to speech environment and certain speech codex in a certain society (e.g., frequency of code-switching), and to develop personal speech habits.

Hence, to ensure the selection of the target-language candidate, a suppression or inhibitory control mechanism is required (see IC model below). Finkbeiner et al. (2006) proposed an alternative model; they posited that it is not inhibition but increased activation of the target language candidates that solves the selection issue (see a follow-up on this idea in Blanco-Elorrieta & Caramazza, 2021). Given the empirical evidence today, it seems that bilingual language processing is in general more non-selective than originally thought.

The key consequences of bilingualism for theorizing language processing are that bilinguals have to deal with two languages that are in competition for selection (in particular at the formulation and articulation stages) due to parallel activation (Kroll et al., 2006), selection processes are particularly important when only one language (the so-called "target language", i.e., the appropriate language in the communicative situation or experimental setting) should be used (e.g., due to the communication partner's language knowledge), the non-target language needs to be inhibited (i.e., blocked) in order for the production system to focus on the current target language (following the IC-model by Green, 1998), which increases processing demands.

Consequently, enhanced costs for lexical retrieval are "normal" because selection processes are more demanding, thus retrieval is generally slower (a phenomenon addressed in the weaker links hypotheses by Gollan et al., 2005, 2021, in which each word in the bilingual lexicon is less often retrieved than in a monolingual lexicon and hence has weaker links; for an alternative competition-based account featuring inhibitory control, see Sullivan et al., 2018), and processing costs in bilingual performance are not a sign of low proficiency (Sorace, 2011) or deficient processing, but can be attributed to the fact that two languages are being activated simultaneously and therefore processing, as described, is more complex (Festman, 2013).

General Mechanisms for Bilingual Language Processing: Activation, Inhibition, and Language Control

Following the already outlined general idea about language production (i.e., for a word or sentence to be uttered, this word or utterance has to have passed a number of stages in the language processing system) and given a storage of specific information (e.g., on the conceptual, semantic, syntactic, and phonological level), the "best match" has to be selected from among a number of competitors. These fast "best-match" selection processes are thought to involve activation and inhibition, two mechanisms that are well known from psychology and which are counteracting forces. In the context of lexical selection, it is assumed that a number of relevant, appropriate lexical items receive activation to be more highly activated than the rest of the lexical items in the storage. In order to select one lexical item only, selection processes rely on the inhibition of competitors (i.e., a reduction of the earlier heightened activation). Only the most highly activated item that remains at the end of the selection process as the "best match" will be used for the next stages in the course of language processing.

Monolinguals experience competition for selection within a language—for example, between semantically similar lexical competitors (Levelt, 1989). Hence, monolinguals have to control for accuracy of content and form during language production stages (see Levelt's speech monitor). However, with two languages available for bilinguals, there is additional competition between the languages: Thus, bilingual speakers need to additionally control for accuracy of the target language (when only one language should be used for output). In bilinguals, not only semantically and phonologically similar lexical competitors are activated, but also candidates from the other language, for example, the respective translation equivalents. Consequently, a bilingual has to monitor content, form, and accuracy of the target language when selecting units for language production. The success in bilingual language processing relies on the development, refinement, and flexible, adaptive use of language control. Language control is understood as the ability to control the use of two languages to avoid interference and, if necessary, to select one or the other language depending on contextual demands. This implies that bilinguals need to strongly control their language output (in terms of content, form, and accuracy of target language). In contrast, when bilinguals can freely switch between languages (i.e., code-switch), they do not need to be concerned with controlling the accuracy of target language per se but rather the content and form of their utterances. For translation and during simultaneous interpreting, language control of both languages is necessary, which means one language is restricted to perception (visual or auditorily), the other to production (written or verbal), for the length of the translation/simultaneous interpretation.

Festman and Schwieter (2015) suggested two main processes constituting language control that are necessary to play out a bilingual's unique competences:

Language maintenance is the ability to restrict the language output only to the target language by inhibiting the non-target language as much as possible and to use each language as target language as long as necessary and intended, for example, in a conversation. The focus is on using one of the languages only for output.

Language switching is the ability to change target languages whenever necessary. This can be in terms of code-switching and for transfer. Both languages are involved and used. Consequently, also translation and interpreting rely on using both languages with the output language under language maintenance restrictions, as outlined above.

This means that language control refers to internal selection processes concerning the accurateness of the target language use (i.e., whether the selected lexical and phonological item belongs to the current target language) and, more broadly, to language use conditions (i.e., the flexible adjustment of the ever-changing target language to be used in context; see Models to Capture Language in Context: Language Mode, Social Action, and Culture Adaptations).

Models Addressing Language Co-activation

De Bot (1992; see also de Bot & Schreuder, 1993) extended Levelt's model (see above) to account for bilingual language processing. First, the "verbalizer", an addition to the conceptualizer, was thought to solve the problem of matching language-specific differences in the representation of a concept on the lexical level. As concepts can be lexicalized differently in a bilingual's two languages (for experimental studies, see, e.g., Thierry et al., 2009; Pavlenko, 2009), chunks are activated and then passed on to the next stage of lemma selection.

Second, the issue of language choice was suggested to be executed in the conceptualizer in terms of a language cue. Only at this stage in the bilingual language processing is knowledge available concerning the situation and respective specificities of speech habits and communicative codex.

De Bot put forward the idea of a language tag, i.e., each lemma is marked to which language it belongs. Assuming the functionality of language cues, activation can spread from early on in the processing stage to the target-language lemmas and push target-language lemmas to have a head-start for being selected. This would explain how monolingual language mode (i.e., the use of only one language, see Cognitive Theories and Models to Solve Bilinguals' Unique Phenomena: Focus on Language Processing and Control; for more detail, see Models to Capture Language in Context: Language Mode, Social Action, and Culture Adaptations) can be executed more easily. For bilingual language mode conditions (i.e., the use of both languages, e.g., during codeswitching), de Bot suggested that bilinguals generally can generate two speech plans (one per language) for each preverbal message. This way, bilinguals could code-switch effortlessly because all relevant information is already prepared in both languages.

In Green's inhibitory control (IC) model (1998), words stored in the bilingual lexico-semantic system are also language-tagged, i.e., a tag indicates to which language each lemma belongs. Driven by a communicative goal, its conceptual representation is created by the conceptualizer which is linked to control procedures and selection of language-tagged lemmas. Language selection is a result of cognitive control processes since language-task schemas are activated or inhibited by the SAS (supervisory attentional system, adopted from a prominent theory in psychology on control of behavior by Norman and Shallice, 1986). The SAS is a resource-limited, domain-general mechanism responsible for planning, regulating, and verifying task execution. This structure is assumed to reside in the prefrontal cortex and to control and supervise processes in order to prevent cross-language interference, slips etc. It intervenes when necessary, for example, by inhibiting (the language tag of) the currently irrelevant language. Language task schemas, in turn, can activate or inhibit these tags and thereby directly influence the activation processes at the lemma level. Adequate selection within the bilingual lexico-semantic system ultimately leads to output.

The SAS activates or inhibits specific task schemas (i.e., the components involved and stages to be executed for a given task such as reading aloud or picture naming). These task schemas have been either formed based on prior experiences as automatic, routine behavior or can be constructed on demand when necessary (e.g., when facing new task demands).

The conscious decision for use of a certain language (i.e., language choice) is assumed to lead to the preparation of the language system of the target language by activating the task schema *use Language x* (Lx). This task schema is executed by conceptual information in the conceptualizer according to an increase in activation of only those lemmas stored in the lexico-semantic system that are equipped with the language tag *Lx*. All lemmas tagged for another language are inhibited at this stage, so the availability of the non-target language is a priori reduced. This is called proactive control. In later processing stages, reactive control may come into action when several competitors are already activated and need to be selected for output. Reactive inhibition is necessary for contextually inappropriate lexical elements that might be activated erroneously due to limitations of resources. This means that cross-language interference can be detected and solved by means of reactive control.

In the IC Model, multiple levels of control support the language production system. The locus of control (i.e., global vs. local) refers to where in the language production/comprehension system control is exerted, either more on the language system itself or only on the output of the language system. Global control means that all the units of a target language are activated while all those of the non-target language are inhibited. Local control is more specific: only certain elements in a given language are inhibited. Evidence for the IC Model has been provided among others by studies based on paradigms for switching between L1 and L2 (for review, see De Groot, 2011) and studies investigating interlingual homographs (Macizo et al., 2010).

Green's early ideas about the role of inhibition and activation levels of words spelled out in his model have certainly had immense influence in the field of cognitive bilingualism. These ideas have been linked to cognitive control on the neural level. An efficient internal control mechanism is thought to be responsible which controls the flow of information as a domain-general process—that is, not restricted to the verbal domain (e.g., Green & Abutalebi, 2013). In neural terms, an entire network is responsible for controlling different aspects of language processing (Abutalebi & Green, 2007). The same network of prefrontal cortex, anterior cingulate cortex, basal ganglia, and inferior parietal lobule is involved in the control of actions and of languages and interacts dynamically depending on the type of task and its demands, i.e., requirements of the speech environment and speech codex. This goes beyond de Bot's earlier account of a language cue in the conceptualizer (see Models to Explain a Bilingual's Visual Word Recognition), which focused only on the control within the language system.

Models to Explain a Bilingual's Visual Word Recognition

Models that attempt to explain how words from the two languages known by a bilingual are recognized need to deal with the same very general question: Are the recognition processes language-specific or non-specific? If these processes were language-specific, i.e., if it were possible to fully deactivate the irrelevant language, then only orthographic competitors within the target language would become available for further processing. In contrast, in the non-specific view, orthographic competitors from both languages would become available and compete for selection.

Localist-connectionist accounts have attempted to model these processes for bilingual visual word recognition. Early accounts for such models are the Bilingual Interactive Activation (BIA) model (Dijkstra & Van Heuven, 1998; Van Heuven et al., 1998) and its extension BIA+ (Dijkstra & Van Heuven, 2002). Both models posit that when words are presented visually to bilingual individuals, several word candidates that resemble the target word or the input receive parallel bottom-up activation. In other words, these models assume 'language non-selective lexical access'. The orthographic representations then induce the activation of their semantic representations (Balota, 1994). At a later stage, language nodes come into play through which top-down inhibitory control mechanisms are drawn on to limit cross-language activation (i.e., inhibit the candidates from the language irrelevant for the given context). At the same time, lateral inhibition will also limit the activation of within-language competitors. Critically, the BIA+ also introduced linguistic context as a factor of influence in the processing of words. As words rarely appear in isolation and much more often in sentences, the syntactic and semantic processing involved in sentence reading may also affect word identification and processing (Van Hell & De Groot, 2008).

However, the BIA and BIA+ have some limitations such as that they make no predictions on how processes may change over time with growing L2 proficiency. To address this limitation, the Developmental Bilingual Interactive Activation Model (Grainger et al., 2010) added a developmental component to the model in that the relative strengths of the connections between each word form and its meaning as well as between translation equivalents across languages can change over time (as in the RHM, see below). With growing L2 proficiency, L2 word form-to-meaning links becomes stronger, and reliance on the L1 translation equivalent word becomes weaker. Inadvertently, inhibitory control is fine-tuned to allow for L2 word forms to inhibit orthographically similar words co-activated in the L1 and the L2. Finally, Multilink, a localist-connectionist model developed by Dijkstra and Rekké (2010) and Dijkstra et al. (2019), is a computational model that combines and extends the BIA+ and the RHM, and thus offers a unified account of bilingual word recognition, processing, and production. Multilink allows testing explicit assumptions about recognition and production of, for example, cognates vs. noncognates using word-processing simulations, which can subsequently be compared to real-life processing data. Model-to-model comparisons show that simulations based on Multilink resemble empirical data to a higher degree than what previous models such as BIA+ would predict. For more detailed descriptions of perception models, see the excellent description in Bartolotti and Marian (2012).

Models to Explain Transfer

There is evidence that the ability to discriminate between multiple languages in the environments can already be found in infants (e.g., Bosch & Sebastián-Gallés, 2001). To describe how such language discrimination is managed phonologically, Paradis (2001) put forth the Interactional Dual Systems Model of language representation in which the dual language input bilingual children are exposed to from birth is assumed to create two language systems that mutually influence one another. Critically, over time bilinguals acquire the capacity to draw on information from both languages and transfer information and skills from one language to the other for more efficient processing while at the same time retaining the separation between languages (Ramirez et al., 2013). This type of positive transfer at the initial stages of learning a new language is a strong receptive gain attributed to the learner's drawing on previous linguistic experiences (see Alonso & Rothman, 2017; Festman, 2021 for review).

One of the skills that has been assumed to transfer from one language to another is metalinguistic awareness, defined as the ability to reflect on language, manipulate and be flexible with language, and to switch between meaning and form. The Transfer Facilitation Model by Koda (2008), for example, predicts that metalinguistic awareness acquired in one language can be transferred to facilitate language development in another. More specifically, morphological awareness in the L1, which allows speakers to identify and manipulate morphemes such as affixes and roots, is assumed to transfer to reading skill development in the L2. Such facilitative transfer from L1 to L2 has also been explored for phonology (Branum-Martin et al., 2012) and syntax (Gottardo et al., 2018) in the domains of literacy and bilingualism research. Although bilinguals seem to be tuned to a cross-language comparative approach to reveal interlingual correspondences, positive transfer between languages is not necessarily exerted to the same extent, since in particular the size of the linguistic repertoire has been observed to influence multilinguals' actual abilities for direct positive transfer (for review, see Festman, 2021).

Models to Explain Translation

Early theoretical explanations suggested that L2 words are understood and produced by retrieving their L1 translation equivalent. Potter et al. (1984) put forth two opposing accounts for the structure of the bilingual memory or mental lexicon: the word association and concept mediation models. The word association model holds that L2 words are connected to their conceptual representation only by association with their translation equivalent in L1. The concept association mediation suggests that L2 and L1 words are both directly connected to their conceptual representation.

Subsequent explanations were more developmental in nature. For instance, Kroll and Stewart's (1994) Revised Hierarchical Model (RHM) demonstrates a developmental shift from lexical mediation to conceptual mediation. Specifically, the model posits that as L2 proficiency increases, L2 words no longer must be associated with their L1 translation equivalents to access the conceptual store. The RHM builds on these two earlier accounts and identifies L2 proficiency as a modulating factor of the strength of these lexical and conceptual links. At the beginning stages of L2 acquisition, learners are heavily reliant on existing links between their L1 words and their conceptual representations before developing the ability to mediate directly between L2 words and concepts. As L2 proficiency increases, and consequently L2 lexical-concept links strengthen, there is less need to associate L2 words with their L1 equivalents to access meaning. The model assumes weak and strong conceptual and lexical links. The strongest path for L2-to-L1 translation, for instance, is through association with the L1 word. Nevertheless, with increases in proficiency and bilingual competency, the L2-to-L1 translation path may be conceptually mediated due to the fact that L2 words increasingly become more strongly mapped onto concepts. In contrast, L1-to-L2 translation uses conceptual mediation for lexicalization. In a later paper, Kroll et al. (2010) note that in the RHM's original form, it was incorrectly assumed that the weak link between L2 words and the conceptual store was bidirectional but that the asymmetry is more critical for production versus recognition (see Kroll et al., 2002; Schwieter & Sunderman, 2009; Poarch et al., 2015).

There are a few shortcomings of the RHM that have drawn criticism from some researchers. Firstly, the model has difficulties accounting for translation equivalence and a shift in language dominance that is often observed in bilingualism, particularly in cases where individuals move to environments where their L2 is the majority language and thus must rely mostly on it for communication. Furthermore, it has been argued that the storage of L2 words may not necessarily be confined to the lexicon but rather may be represented as both lexical and conceptual entries if the words are acquired in an environment in which form and meaning are emphasized (La Heij et al., 1996). Brysbaert and Duyck's (2010) view of the bilingual memory and word processing aligns with connectionist approaches which we will discuss below. The authors argue that one path is not particularly faster than the other, but instead, there may be stronger connection weights that consequently influence the degree of activation. A final criticism of the RHM is that to consider word translation equivalents as having shared semantic qualities is problematic (Duyck and Brysbaert, 2004; see also the Distributed Features Model; Van Hell & De Groot,

1998) and, similarly, that to assume that during word retrieval the same conceptual representations are accessed from both languages can be potentially erroneous (Jared et al., 2013). Indeed, some concepts only exist in one language and, therefore, cannot be linked to a lexical item in another language (Pavlenko, 2009).

More recent theoretical accounts have begun to describe the architecture of the bilingual memory as a dynamic system involving lexical and conceptual processing as well as conceptual restructuring and overlapping. Pavlenko (2009), for example, put forth the Modified Hierarchical Model (MHM), a multimodal representation of the conceptual system consisting of categories that are argued to be either fully shared, partially overlapping, or entirely language-specific. According to the model, concepts are multimodal mental representations, i.e., they are inclusive of auditory, visual, kinesthetic, and perceptual information, and are stored in implicit memory. These representations dynamically change with language development and experiences and are sensitive to other individual differences.

Words have asymmetric links connecting them to the complex conceptual store (as in the RHM) as described above. Critically, and unique to the model, L2 development is not conceptualized as strengthening of direct links between L2 words and concepts, but rather as "conceptual restructuring and development of target-like linguistic categories" (p. 150).

Models to Explain Code-switching

Code-switching is a phenomenon in which bilingual speakers employ both their languages when producing utterances. Different types of code-switches have been identified: alternation, insertions, and dense code-switching (Muysken, 2000). Alternations are code-switches between stretches of words within an utterance, whereas insertions refer to instances of words from one language being inserted into a sentence of the other language, also described as the matrix language (Myers-Scotton & Jake, 2000), and dense code-switching is described as combining words or morphemes from both languages in structures that are largely shared between languages. Early approaches focused on whether specific words such as cognates (which share meaning and form across languages) could trigger code-switching (Clyne, 2003) and on the grammatical constraints of code-switched utterances by bilinguals (Poplack, 1980). In particular, it was of interest whether bilinguals differentially access lexical categories during code-switching (Myers-Scotton, 1997) and whether and to what extent the languages are differentially activated (Muysken, 2000). Testing such models has also led to the finding that lexical items in prior utterances can prime code-switching in following utterances (Kootstra et al., 2012; Fricke & Kootstra, 2016). Later approaches shifted attention to the involvement of cognitive mechanisms that feature in and allow for fluent code-switching. The Control Process Model of Codeswitching (Green & Wei, 2014), for example, describes how different types of code-switching and language contexts lead to different control requirements depending on whether: a) possible interference from the non-target language needs to be avoided because code-switching would be inappropriate; or b) both languages are strategically viable because code-switching is appropriate. Accordingly, in the Extended Control Process Model, Green (2018) distinguishes: a) two forms of cooperative control between the languages for the different types of code-switching, namely coupled control (for insertions and alternations) or open control (dense code-switching); and b) that the varying language contexts require either narrow or broad focus attentional states. A more detailed description of such language contexts and their corresponding cognitive control requirements can be found in the following section.

Models to Capture Language in Context: Language Mode, Social Action, and Culture Adaptations

After years of research, the current view is that bilinguals cannot entirely "switch off" one of their languages, even when they do not need it at a certain point in time. Bilingual language processing is genuinely including both languages being activated in parallel, at all levels of representation (cf. Desmet & Duyck, 2007, for review). However, not all speech output produced or input perceived by a bilingual speaker is necessarily bilingual. For a better understanding, we will turn to Grosjean's (2001) language mode hypothesis. He described each language (language-processing mechanisms included) having a certain activation level, and the more highly activated a language is the more it will be used for processing. The language mode theory is based on the idea of a very strong ability to choose which language to use and to control the outcome of this choice: "the bilingual has to decide, usually quite unconsciously, which language to use and how much of the other language is needed" (Grosjean, 2001, p. 2). He suggested that the relative activation level of bilinguals' languages varies along a continuum. At one end of this continuum is the monolingual mode, at the other end the bilingual mode. The relationship between a bilingual speaker and his/her environment (including interlocutors, situations, and their linguistic restrictions) have been taken into account in the following way: When a bilingual speaks to a monolingual or is in a situation when the use of only one language is appropriate or required, the bilingual would be in the monolingual mode, producing output only in the language both are able to use. The other language would be inactive, but never entirely deactivated. In contrast, in the bilingual mode, a bilingual produces output in both languages, usually when speaking with a bilingual who is knowledgeable of the same two languages; they frequently code-switch and draw on resources from both languages. Grosjean also incorporates the notion of individual differences: some bilinguals rarely code-switch while others do it all the time. Simultaneous interpreters are considered a special case as both languages are involved to the same extent: input is perceived in one language and output needs to be produced in the other. He used the idea of a continuum to remind us that: a) there are many positions in between the two ends: for example, a bilingual may use both languages, but one much more than the other; and b) a bilingual can slide along the continuum as s/he has the flexibility to change the degree of language activation of one or two languages any second. In a recent attempt to describe the resulting individual variation in bilingual language usage and processing, Tobar-Henríquez et al. (2020) introduced the lexical entrainment theory. They posit that bilingual adaptation to the context can also be modulated by the language used in dialogue in that there is a tendency to follow an interlocutor's lexical choices (see also Gries & Kootstra, 2017, for structural alignment in dialogue).

Thus, recent hypotheses in cognitive bilingualism not only theorize about the processing components and their functionality, but also include sociolinguistic aspects of language context. One such approach has been put forward by Green and Abutalebi (2013) as bilingual speakers use their languages in different ways depending on the interactional context in which they find themselves. Building on earlier ideas of the IC model (Green, 1998) and their multiple levels of control, language control mechanisms were the key candidate to be able to facilitate various patterns of language use and to realize the linguistic needs of a bilingual. Highly adaptive mechanisms of control were suggested to focus on one language (proactive control, global control), while other mechanisms assist in preventing cross-language interference (proactive, global and, if they are not sufficiently successful, reactive local control). The Adaptive Control Hypothesis (Green & Abutalebi, 2013) explains how the cognitive system orchestrates its processes to achieve highest efficiency in the ever-changing demands of current situations.

Different language contexts (single-language, dual-language, and dense code-switching) lead to distinct patterns of language selection. In *single-language contexts*, each of the languages is used separately (e.g., home vs. school), in *dual-language contexts*, the languages are both used but separately with different interlocutors, and in *dense code-switching contexts*, speakers switch freely between their languages with their multilingual interlocutors. These various situations have differential demands on the cognitive and neural processes for each language. The neural networks supporting bilingual speech production are hypothesized to adapt to use these processes as necessitated by the context. For example, a frequent code-switcher will utilize inhibitory control and attentional mechanisms in different ways than bilinguals who rarely switch between their languages.

Consequences of Bilingualism on Cognitive Development

The notion that bilingualism affects cognition has been investigated for almost a century, with early views reporting negative effects (see review by Darcy, 1953), while more recent studies have provided evidence of positive effects (see reviews by Adesope et al., 2010; Antoniou, 2019; Bialystok, 2017; Bialystok et al., 2012). The underlying assumption for such effects is that language processing in bilinguals induces repeated conflict due to language co-activation. The resolution of such conflict is necessary during language comprehension (Marian & Spivey, 2003; Thierry & Wu, 2007) and language production (Poarch & Van Hell, 2012a; Sullivan et al., 2018) and is dependent on a language control mechanism that is assumed to be provided by the domain-general executive function (EF) network (Abutalebi & Green, 2008). This EF network includes subcomponents such as inhibition (response suppression), monitoring (updating information in working memory), and shifting (task switching) (Diamond, 2013; Miyake & Friedman, 2012). Drawing on such a control mechanism allows bilingual speakers to choose the correct language for a given context and enables them to switch between languages. Critically, bilinguals draw on language control repeatedly in daily life, and language control processes and the executive function network have been found to be related (Festman et al., 2010) and to involve overlapping brain areas (Calabria et al., 2018; Coderre et al., 2016). Hence, the bilingual experience using domain-specific cognitive control may over time modify the neural mechanisms underlying these cognitive processes and thus transfer to domain-general cognitive control (DeLuca et al., 2019; Luk et al., 2020; Olguin et al., 2019). Some bilinguals use their language skills professionally, and research on simultaneous interpreters has shown substantial short-term training on working memory and shifting, and long-term effects yielding a neuroanatomical and neurofunctional profile (for review, see Ferreira et al., 2020).

Evidence for differences between monolinguals and bilinguals in the efficacy of the executive function network has been found across the lifespan. Kovács and Mehler (2009), for example, conducted an eye-tracking study with 7-month-old monolingual and bilingual infants and reported that the bilingual infants were better at suppressing a previously learned response pattern in order to use a newly learned pattern than the monolingual infants (see also Crivello et al., 2016; Filippi et al., 2019). There is also evidence for bilingual children outperforming monolingual children in tasks tapping executive function processes (Blom et al., 2017; Poarch & Van Hell, 2012b; Poarch & Bialystok, 2015), for such differences in young adults (Blumenfeld & Marian, 2014; Coderre et al., 2013; Costa et al., 2008), and in older adults (Bialystok et al., 2014; Pot et al., 2019; Salvatierra & Rosselli, 2011).

However, there are studies that have reported no behavioral differences in executive function between groups of monolingual and bilingual infants and children (Antón et al., 2014; D'Souza et al., 2020) and adults (de Bruin et al., 2015; Kousaie & Phillips, 2012; Paap &

Greenberg, 2013), which has sparked a debate about how to explain such diverging findings and on how to move forward in the field of research (Bialystok, 2021; Blanco-Elorrieta & Pylkänen, 2018; Filippi et al., 2019; Poarch & Krott, 2019). Note that even when no behavioral performance differences across groups are found particularly in research with young adults, bilinguals have been shown to be more efficient in resolving the conflict induced in executive function tasks compared to monolinguals (Botezatu et al., 2021; Incera & McLennan, 2016; see also Grundy, 2020).

Various issues have been identified that may help explain previous mixed findings. For one, designating individuals as monolingual and bilingual follows a dichotomous view that is becoming increasingly difficult to maintain, given the varied language experience within bilingual populations (Anderson et al. 2020; De Bruin, 2019) and the influence of linguistically divers contexts even on monolinguals (Bice & Kroll, 2019). Hence, when bilingualism is operationalized as a continuous construct or a gradient measure (Sulpizio et al., 2020), the degree of bilingualism has been found to be positively related to executive function task performance (Chung-Fat-Yim et al., 2020). Given the varied cognitive demands induced by differences in bilinguals' language exposure and experience, Gullifer and Titone (2020) have recently introduced the construct of language entropy to better capture such individual differences. Evidence that cognitive task performance is modulated by language context has been provided by, for example, Beatty-Martinez et al. (2020), Chung-Fat-Yim et al. (2021), Ooi et al. (2018), and Pot et al. (2018). Additionally, differences in language exposure have also been linked to variation in neural restructuring (De Luca et al., 2019). Furthermore, the tasks generally used to tap executive function have not been used in a standardized manner across studies (Poarch & Krott, 2019), show little convergent validity across tasks measuring executive function (Czapka & Festman, 2021; Poarch & Van Hell, 2019), the data collected through such tasks is subsequently not uniformly processed (Zhou & Krott, 2016), and statistical analyses performed on the remaining data are not standardized (Poarch et al., 2019). Finally, the complexity of bilingualism and executive function also calls for an adequate treatment in research designs and participant selection, including moderating factors (see Festman et al., 2022).

Conclusion

As will have become clear, bilingualism is a very complex phenomenon influenced by various factors that are individually tuned and modulated by the diverse interactional contexts bilingual individuals find themselves in. These contexts can require various levels of adaptation in response to the cognitive control that needs to be exerted by speakers to navigate them. Hence, there is a need for a very flexible cognitive system. However, theories in cognitive bilingualism can only capture specific aspects of the complexity of bilingualism that pertain to neurobiological speaker-internal factors and the social and linguistic restrictions imposed by the speech environment. Thus, cognitive bilingualism remains a mosaic in which psychological approaches and linguistic realities are pieced together (see Gullifer & Titone's language entropy, 2020, and Green & Abutalebi's adaptive control, 2013). The picture that presents itself as yet lacks full coherence due to an absence of a clear description of all influential and decisive factors, which may modulate or even cancel out each other (e.g., proficiency vs. AoA in Perani et al. 1998) and influence distinct brain networks (Nichols & Joanisse, 2016). Nevertheless, there is evidence that bilingual experience can reshape brain structure and change brain connectivity (DeLuca et al., 2020; Pliatsikas et al., 2017). In conclusion, while there is ample evidence that bilingualism can affect cognition, the theories available to explain such effects will need more refinement in order to make clearer predictions for how and under which circumstances bilingualism does indeed affect an individual's cognition.

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