Cognitive and emotional effects of bilingualism in adulthood

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Abstract

Knowing more than one language changes how individuals think about and interpret events in their environment. Using evidence from reaction time, eye-tracking, functional magnetic resonance imaging, and event-related potential research, we explore how language experience transforms cognitive control and emotion, two features that are central to human communication. We suggest that managing multiple languages not only impacts cognitive control and emotion independently, but also the way in which they interact with each other. Within cognitive control, we present research suggesting that bilinguals demonstrate benefits compared to monolinguals and discuss the potential sources of these benefits, including parallel language activation and language switching. We also explore the potential links between linguistic and non-linguistic cognitive processes. Within emotion, we discuss whether bilinguals process emotions similarly across their first and second languages and consider how linguistic context and one's cultural affiliation may impact memory (e.g., storage and retrieval) of emotional events. The evidence discussed in this chapter highlights the transformative effect that bilingual experience has on how human beings understand and interpret the world. (171 words)

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"The limits of my language mean the limits of my world."

(Ludwig Wittgenstein)

Language is a powerful human ability that shapes our thoughts and our perceptions of every day experiences. At a social level, many aspects of human communication are dependent on language; at a cognitive level, language helps us to understand events and experiences in our environment, and ascribe meaning to these events within our minds. For bilinguals, the ability to communicate, think, and understand the environment may be different from monolinguals due to the influence of managing multiple languages on the cognitive system. As a result, the ability to communicate in multiple languages may serve as a springboard for transforming higher order cognitive processes, ultimately impacting how we think about and interpret the world.

Consider, for instance, how language influences two highly interactive aspects of the cognitive system: cognitive control and emotion. These aspects of cognition are important to communication, as they affect our ability to understand and process language. When engaged in conversation with a friend in a crowded restaurant, we use cognitive control (e.g., inhibitory control, or the ability to suppress a response or irrelevant information) to ignore the other conversations and noise from the surrounding tables. Additionally, when asked to recall and describe an event (e.g., your fifth birthday party), the language we use to describe that memory (and the memory itself) is tightly bound to the emotions associated with this experience. These examples illustrate how cognitive control and emotion are connected, and how these aspects of cognition are filtered through and by language. Because language serves as a cornerstone for cognition, impacting human abilities like cognitive control, memory, and emotion, experience with two or more languages may change how we attend to the environment. In addition, how we think and feel about our experiences may be shaped by the additional linguistic channel(s) through which we perceive daily events.

Neurological research suggests a link between cognitive control and emotional processes in the brain. The regions involved in cognitive control (e.g., attention, self-regulation: prefrontal cortex (PFC) and anterior cingulate cortex (ACC)) and emotion (e.g., amygdala) become activated in concert when situations demand emotion regulation or control of emotional thoughts, such as in response to an aversive event (e.g., pain) (see Ochsner & Gross, 2005, for review). Interestingly, bilinguals simultaneously activate areas associated with cognitive control *and* emotion on language switching tasks, even when processing emotionally-neutral words (e.g., Hernandez, 2009), suggesting that cognitive control and emotion are highly interactive.

In order to further understand the interactivity of cognitive control and emotion in bilinguals, we discuss research on the impact of bilingual experience on these processes. Research on bilingualism has recently begun to explore the underlying mechanisms involved in the experience of managing two (or more) languages, as well as the cognitive changes incurred as a result of this experience. The evidence suggests that the bilingual mind may be organized differently than "single-language minds" (Kroll & Bialystok, 2013, pp. 497-498). Experience with multiple languages may also result in an enriched cultural identity that incorporates elements from both cultures, which may transform bilinguals' mental conceptual structure and the way they process their environment. These rich language and cultural experiences further impact cognition, resulting in enhanced cognitive control abilities, and shaping how emotional events are processed and retrieved from memory.

In the current chapter, we present evidence that highlights how and why bilingual experience impacts the human mind. Though the effects of bilingual experience on cognition are wide-ranging, we focus primarily on two aspects of cognition: cognitive control and emotion, as well as how these aspects interact. We draw on studies that examine different bilingual groups (e.g., simultaneous bilinguals, who learn both languages at the same time; sequential bilinguals, who learn one language prior to learning another; and adult second language (L2) learners), and discuss how bilinguals and monolinguals differ on cognitive control abilities and in emotional processing. Throughout this chapter, we explore how bilingual experience changes cognitive control and emotion, the underlying sources of change within each, and the links between cognitive control and emotion.

Bilingualism and Cognitive Control

Cognitive control can be thought of as the way individuals manage distraction or conflicting information in their daily lives, and is comprised of a constellation of skills that help individuals navigate their environment. One aspect of cognitive control is a process known as *conflict monitoring*, which is the ability to keep track of conflict or potential conflict in the environment (as measured by the Simon Task, see Figure 1A). Once aware of a potential conflict, individuals rely on another important feature of cognitive control known as *competition resolution*, or the ability to manage and resolve distractions while trying to focus on relevant information (as measured by the Stroop Task, see Figure 1B). Finally, cognitive control also includes skills like *interference suppression* and *response inhibition*, which involve ignoring distracting information or viable alternative responses when responding to a direction or question (as measured by the Flanker Task, see Figure 1C). Of central importance is the idea that cognitive control is domain-general. In other words, cognitive control is not limited to a single mental process, like language or vision, but extends into every aspect of perception and cognition.

---Insert Figure 1 Here---

Effects of Bilingualism on Inhibitory Control and Aging

The effects of bilingualism on cognitive control have been widely studied over the past 30 years and suggest that experience with multiple languages has a positive impact on cognitive control (e.g., Bialystok, Craik, & Luk, 2008; Kroll & Bialystok, 2013; Luk, De Sa, & Bialystok, 2011; Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004; but see Hilchey & Klein, 2011; Paap & Greenberg, 2013). For example, bilinguals have shown advantages over monolinguals across various aspects of cognitive control, including conflict monitoring (Bialystok, Martin, & Viswanathan, 2005; Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok et al., 2008; Martin-Rhee & Bialystok, 2008), competition resolution (Bialystok, et al., 2008; Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009; Costa, Hernández, & Sebastián-Gallés, 2008; Hernández, Costa, Fuentes, Vivas, & Sebastián-Gallés, 2010; Luk, et al., 2011), and interference suppression and response inhibition (Costa et al., 2008; Luk, Anderson, Craik, Grady, & Bialystok, 2010).

These bilingual advantages in cognitive control also translate to real-world benefits. For example, lifelong bilingualism increases *cognitive reserve*, a protective mechanism against dementia that arises as a result of sustained mental activity (e.g., Schweizer, Ware, Fischer, Craik, & Bialystok, 2011). Active bilingualism throughout the lifespan is associated with a delayed onset of symptoms of Alzheimer's Disease by four to five years (Alladi et al., 2013; Bialystok, Craik, & Freedman, 2007; Craik, Bialystok, & Freedman, 2010). Also within bilinguals, behavioral symptoms associated with Alzheimer's Disease are less severe than what would be expected from the amount of disease-related neurological breakdown (Schweizer et al., 2011). That is, when monolinguals and bilinguals are matched on neurological decline associated with Alzheimer's Disease, because bilingualism serves as a protective measure against age-related cognitive decline, bilinguals demonstrate fewer behavioral symptoms associated with Alzheimer's Disease. When Alzheimer's Disease is not present in older bilinguals, active bilingualism throughout the lifespan can lead to an advantage in the ability to remember events (Schroeder & Marian, 2012). Also in healthy older lifelong bilinguals, certain neurological tissues are better preserved in the brain relative to monolinguals, such as white matter (which is responsible for coordinating communication between brain areas) (Luk, Bialystok, Craik, & Grady, 2011) and grey matter (which involves specific processes such as executive control and muscle movement) (Abutalebi et al., 2014). Thus, as a result of sustained experience with managing two languages, the general cognitive system is enhanced, demonstrating cognitive control benefits as well as decreased cognitive and neurological decline relative to monolinguals. The lifelong effects of bilingualism are discussed in further detail in the chapter on aging (Phillips, this volume).

Effects of Bilingualism on Language Activation and Interaction

What aspects of bilingual experience give rise to cognitive enhancement? When engaged in a conversation, whether speaking or listening, bilinguals constantly activate both of their languages simultaneously. This parallel activation occurs across different linguistic contexts for bilinguals (see Kroll & Bialystok, 2013, for review), including in language production and comprehension (Bartolotti & Marian, 2012; Blumenfeld & Marian, 2007, 2011, 2013; Green, 1998; Kroll, Bobb, Misra, & Guo, 2008; Linck, Hoshino, & Kroll, 2008; Marian & Spivey, 2003a, 2003b; Martín, Macizo, & Bajo, 2010). Activating two languages in parallel increases a bilingual's overall cognitive load, as s/he has to manage the activation of an irrelevant language while trying to comprehend or produce speech in the target language. For example, as a monolingual hears a word unfold over time, s/he activates multiple competing candidate words (e.g., the target *plug* activates phonological competitors like *plum*; e.g., Blumenfeld & Marian, 2011). As a bilingual hears the same word, s/he experiences the same within-language activation, in addition to between-language competitor activation (e.g., *plug* activates *plancha*/iron for a Spanish-English bilingual; e.g., Blumenfeld & Marian, 2013). In order to manage this increased competition, bilinguals rely on inhibitory control (e.g., Green, 1998). Because similar inhibitory mechanisms underlie both linguistic (e.g., managing simultaneous activation of two languages) and non-linguistic control (e.g., competition resolution), an interdependent relationship likely exists between language and cognition in bilinguals (e.g., Blumenfeld & Marian, 2013). Thus, being a "mental juggler" of two languages (Kroll, 2009) increases cognitive control efficiency and transforms the cognitive system, allowing it to accommodate and manage multiple languages.

Evidence from language switching studies may also offer an explanation as to why inhibitory control is more efficient in bilinguals. Bilinguals who are less proficient in their L2 must inhibit their native language (L1) more strongly in order to avoid interference while using their L2 (e.g., Gollan & Ferreira, 2009; Meuter & Allport, 1999; Misra, Guo, Bobb, & Kroll, 2012). Functional Magnetic Resonance Imaging (fMRI) studies have suggested that the same cortical regions required to overcome L1 inhibition are also recruited in non-linguistic cognitive control tasks (e.g., interference suppression as measured by the Flanker task). Specifically, the dorsolateral prefrontal cortex (DLPFC) and the left inferior parietal gyrus (LIPG) were recruited when bilinguals switched from L2 blocked naming to L1 blocked naming (Guo, Liu, Misra, & Kroll, 2011). Studies exploring how listeners manage competition in language-free contexts (i.e., non-linguistic cognitive control) have demonstrated that the DLPFC is recruited during the Flanker task (e.g., Bunge, Dudukovic, Thomason, Vaidya, & Gabrieli, 2002; see Figure 1C for an example) and attentional control in bilinguals (Hernandez, Martinez, & Kohnert, 2000).

Together, these findings suggest that the DLPFC is involved in both linguistic and non-linguistic cognitive control.

Results from research on the simultaneous activation of languages and on language switching in bilinguals are consistent with the Inhibitory Control model (Green, 1998), which predicts that differences in switch costs between languages, which are asymmetrical depending on the direction of the language switch (i.e., L1 to L2 vs. L2 to L1), is a function of language dominance. For instance, research has found that as L2 proficiency increases, the asymmetry in cost between switching from L1-L2 versus L2-L1 diminishes (Costa & Santesteban, 2004). During language switching tasks, both languages in a bilingual are activated in parallel and compete for selection. Successful selection requires the inhibition of non-target language competitors. Green (1998) notes that overcoming suppression of the previously inhibited language is modulated by how strongly it was suppressed; for an unbalanced bilingual, it will take longer to switch into the dominant, more-suppressed language. For a balanced bilingual, both languages are activated and inhibited to a similar degree and the direction of the language switch does not affect the magnitude of the cost. That is, as proficiency with an L2 increases over time, so does the efficiency with which bilinguals manage parallel language activation and language switching. Thus, along with experience with parallel activation, language switching may serve as a potential mechanism for cognitive enhancement in bilinguals.

Effects of Bilingualism on the Interaction between Linguistic and Non-Linguistic Cognitive Control

Parallel activation and language switching in bilinguals require the use of linguistic cognitive control. More specifically, the link between language and cognition in bilinguals has led to a growing line of research exploring the effects of parallel language activation and linguistic and non-linguistic inhibitory control. Eye-tracking methodology has been used to index the relationship between lexical activation and inhibitory control. For instance, Blumenfeld and Marian (2011) used eye-tracking to examine the time course (i.e., duration) of *within*-language competition (e.g., English target *plum*, competitor *plug*) in bilinguals and in monolinguals. To measure how listeners used inhibitory control in managing lexical competition, each within-language competition trial was followed by a non-linguistic priming trial that measured listeners' residual (continued) inhibition of targets and competitors (see Figure 2).

---Insert Figure 2 Here---

Although bilinguals and monolinguals showed similar within-language competition, bilinguals demonstrated less competitor inhibition on the subsequent priming probe trials (i.e., fewer looks to the competitor asterisk), suggesting that bilinguals overcame linguistic interference more quickly and efficiently than monolinguals. In addition, Blumenfeld and Marian (2011) tested participants' performance on a non-linguistic Stroop task, where they indicated, via button press, the direction of an arrow, which was sometimes incongruent with the arrow's location on a screen (e.g., rightward pointing arrow on the left side of a screen; see Figure 1B for an example). The authors found that better performance on this task was related to better resolution of linguistic competition in bilinguals but not in monolinguals; bilinguals with greater cognitive control abilities in a *non-linguistic* task were better able to inhibit *linguistic* competition. These findings demonstrate a relationship between non-linguistic cognitive control and management of linguistic competition in bilinguals, as well as the impact of language experience on cognitive control.

To further explore the relationship between language activation and cognitive control, in a subsequent study, Blumenfeld and Marian (2013) measured *between*-language competition and cognitive control abilities in bilinguals. Monolinguals and both high- and low-proficiency bilinguals were presented with four objects and were asked to find the target object (e.g., *comb*) amongst a between-language competitor (e.g., *rabbit*/conejo) and two filler items. The high-proficiency bilinguals demonstrated increased early parallel activation (i.e., looks to the rabbit) and reduced later parallel activation relative to low-proficiency bilinguals. Stronger early parallel activation followed by reduced later parallel activation was associated with smaller Stroop effects (incongruent trials minus neutral trials, see Figure 1B), indicating more efficient non-linguistic inhibition in only the high-proficiency bilingual group. These findings are consistent with research demonstrating that asymmetrical language switch costs diminish with increased L2 skills (e.g., Costa & Santesteban, 2004), suggesting that increased abilities in the L2 lead to more efficient management of cross-linguistic interference. Similarly, brain imaging evidence indicates that bilinguals recruit cognitive control networks more extensively during language processing (e.g., Guo et al., 2011) relative to monolinguals (e.g., Abutalebi et al., 2008; Abutalebi et al., 2007), which results in more efficient performance on linguistic and non-linguistic tasks. Thus, we see a positive correlation between L2 proficiency and efficiency of cognitive control in bilinguals.

Research exploring the effect of bilingualism on language processing and cognitive control suggests that bilinguals' reliance on domain-general cognitive control mechanisms during language processing results in cognitive benefits. The cognitive benefits may arise from the need to manage switching between two languages that are activated in parallel. Importantly, the studies discussed in this section demonstrate that bilinguals can be considered experts at managing linguistic competition. This research paints a picture of a highly-plastic cognitive and neurological system that is sensitive to experience with multiple languages. The cognitive system adaptively changes in ways that are beneficial not only to bilingual language processing, but to cognition in general.

Bilingualism and Emotion

Effects of Bilingualism on Emotion Processing

Along with enhancements to cognitive control, bilingualism also impacts another higher order aspect of the cognitive system: emotion. When we think about emotional experiences, we often activate the language associated with those experiences. It has been suggested that across the world's languages, some concepts, words, and emotions may not transfer (Pavlenko, 2008, but see Odlin, 2005), and within a bilingual, we may see a "lost in translation" effect when attempting to express or process an emotion for which there is no label in one of his/her languages. Perhaps, then, it is no surprise that research on emotion in bilinguals has revealed mixed evidence on how bilinguals process emotions across both of their languages.

The emotional content of words appears to be processed differently in the L1 and the L2, especially with late L2 learners (see Pavlenko, 2012, for review). For example, processing emotion-laden words in the L1 is thought to be more automatic than in the L2, resulting in stronger reactions to emotion-laden words (e.g., *kiss*) in a bilingual's native language. For instance, emotion-laden words in a late bilinguals' L1 result in increased arousal (i.e., electrodermal reactivity: the skin's electrostatic response), relative to emotion-laden words in the L2 (e.g., Harris, Ayçiçegi, & Gleason, 2003). A possible explanation for the difference in L1 and L2 emotional word processing is that adult L2 learners process L2 emotional words at a more semantic rather than affective level (Pavlenko, 2012). In other words, although late bilinguals understand the meaning of L2 emotional words, they do not process emotional words in the L2 as deeply as in the L1.

It is important to consider the role of L2 proficiency when thinking about the factors that might modulate how emotional words are processed across the L1 and L2. Theoretical evidence from bilingual language models, such as the Revised Hierarchical Model (RHM: Kroll & Stewart, 1994), may offer insight into how proficiency modulates processing of the emotional content of words across the L1 and the L2. For unbalanced bilinguals, an L2 word requires a mediator – the L1 translation equivalent – in order to access its conceptual representation; thus the emotional word in the L2 is less directly linked to its conceptual representation than the L1 translation, suggesting that there may be an asymmetry in how each language accesses the deeper, affective meaning of the emotional word. However, as L2 proficiency increases and direct L2-to-concept links are strengthened, so too are the links between the concept and its corresponding emotional state, suggesting that balanced bilinguals may not show the same bias toward deeper emotional processing in their L1.

In contrast, there is also evidence suggesting that emotional words may be processed similarly across the L1 and L2 regardless of proficiency. Ferré, García, Fraga, Sánchez-Casas, and Molero (2010) tested memory of emotional words across three bilingual groups (early Catalan-Spanish bilinguals who were Catalan dominant, early Spanish-Catalan bilinguals who were Spanish dominant, and late Spanish-English bilinguals). All three bilingual groups recalled emotional words equally well in both languages, and factors such as age of acquisition, dominance, and similarity between language pairs (Spanish-English versus Spanish-Catalan) did not affect bilinguals' recall ability. Ferré et al. also suggested that, for proficient bilinguals, emotional words in the memory task had the same intensity or impact across the L1 and L2, supporting the notion that as L2 proficiency increases, so does the processing equivalence of emotional words across languages.

Further support for the relative equivalence in emotional word processing across languages comes from an investigation using the emotional Stroop task with bilinguals (Sutton Altarriba, Gianico, & Basnight-Brown, 2007). The emotional Stroop task requires participants to name the color that a word is printed in (e.g., red, blue, or black ink). Unlike the traditional Stroop task, there is no incongruent condition (e.g., left arrow pointing to the right, or naming BLUE when it is presented in red ink), and thus no incongruence effect. Instead, participants view both emotional and neutral words (e.g., they may see the word EXAM written in green ink, and would respond by saying "green"); emotional words typically result in slower response latencies than neutral words, suggesting that they interfere with the naming of the color ink by virtue of being processed more deeply. Sutton et al. (2007) found that balanced Spanish-English bilinguals' reaction times to emotional words were slower than reaction times to neutral words regardless of the language of presentation. In other words, the bilinguals in Sutton et al. (2007) processed emotional words equally across both L1 and L2. These findings are consistent with the Revised Hierarchical Model (Kroll & Stewart, 1994), which would predict that for balanced bilinguals, L1 and L2 translation equivalents are strongly connected to a shared conceptual representation, and balanced bilinguals can thus access the affective meaning of each word equally.

The findings from behavioral research on how bilinguals process emotions across both of their languages demonstrate the complexity of emotion processing in bilinguals, which is also highlighted within recent electrophysiological research. Conrad, Recio, and Jacobs (2011) examined the emotional valence, or the emotional response (positive, negative, or neutral) an individual may have to a word, of German and Spanish words in a visual lexical decision task with two groups of proficient bilinguals (German-Spanish and Spanish-German) whose skills across their two languages were not equivalent (i.e., unbalanced bilinguals). The authors found early posterior negativity (EPN) and late positive complex (LPC) components in both groups, which are believed to index emotional valence (e.g., Kissler, Herbert, Peyk, & Junghofer, 2007; Schacht & Sommer, 2009). However, while the EPN and LPC components were present when the bilinguals processed both the L1 and the L2, the onset of the EPN component was delayed (~50 ms) when bilinguals performed the task in their L2. This response was attributed to the delay in speed of retrieving the word in the L2 and not to qualitative differences in emotion representation in the L1 and L2. An alternative explanation provided by Opitz and Degner (2012) is that not only does the delay in the EPN component result from delayed lexical access to the L2, but also that access to emotionality in the L2 is less automatic and requires additional processing demands. Therefore, we see a diminished effect of a word's emotionality in the L2. However, supported by the evidence discussed on inhibitory control, as proficiency increases, cognitive control abilities may increase as well, making balanced bilinguals more efficient at accessing emotional content in the L2.

One way to reconcile conflicting findings of emotion processing across languages is to consider that although emotion processing in the L1 may be more automatic (i.e., occurs more quickly) than in the L2 (Opitz & Degner, 2012; Pavlenko, 2012), the *quality* of these emotional experiences (e.g., arousal, feelings towards a stimulus) may be similar across both languages (Conrad et al., 2011; Opitz & Degner, 2012). Language experience, specifically proficiency, also appears to play a role in the degree to which emotional words are processed similarly across the L1 and L2, with balanced bilinguals processing L1 and L2 emotional words more automatically and efficiently (e.g., Sutton et al., 2007) than unbalanced bilinguals (e.g., Opitz & Degner, 2012). The degree to which emotional words are processed equally across languages in bilinguals may also impact bilinguals' emotional memory. That is, how deeply the emotional content of an event is encoded may depend upon the language used at the time of the event, and this difference in encoding may influence bilinguals' ability to subsequently recall emotional events.

Effects of Bilingualism on Emotional Memory

Previous work on memory retrieval in bilinguals demonstrates that a memory is better expressed in the language in which it was encoded at the time the event took place (Marian & Fausey, 2006; Marian & Kaushanskaya, 2007; Marian & Neisser, 2000). Not only can the language of retrieval impact how well the event is expressed, but the language of retrieval can also affect the emotional content of the memory. In Marian and Kaushanskaya (2008), Russian-English bilingual participants were asked to describe (via narrative samples) their memories of immigration to the U.S. in either Russian or English to a Russian-English bilingual experimenter. The results demonstrated that the Russian-English bilinguals produced more emotional words in L2 narratives. One possible explanation for this finding could be that the L2 provides more distance from the emotional experience and is thought to be less emotionally-laden (Bond & Lai, 1986; Costa et al., 2014; Gonzalez-Reigosa, 1976; Harris, Gleason, & Ayçieçgi, 2006; Keysar, Hayakawa, & An, 2012). As a result, to convey emotion, more emotion words may be needed in L2 (where there is more distance from emotional experience) than in L1 (where there is less distance from emotional experience). In other words, the bilinguals in this study may have used more emotion words in their non-native language because the emotional content of the L2 words was less salient.

In addition to differences in emotionality across languages, the results of Marian and Kaushanskaya (2008) were impacted by age of immigration. When speaking Russian, immigrants who came to the U.S. from Russia early in life produced longer narratives, more positive emotion words, and used more emotional words overall than immigrants who arrived later. That is, bilinguals who immigrated earlier reconstructed their memory of the event based off of current experiences with the L2 culture, which tended to be more positive. The early immigrants in this study may have been less connected to their L1 by virtue of having additional years of experience using their L2. More time in an English environment may have resulted in English becoming their preferred language, and the results from Marian and Kaushanskaya demonstrated that the language of preference had an effect on the emotional content in immigrants' narratives. More broadly, age of immigration affects how language, emotion, and memory interact within the cognitive system.

Effects of Biculturalism on Emotion

In addition to the interplay between language, memory, and emotion, language and culture are closely intertwined. When exploring how bilingual experience impacts emotion, it is necessary to consider cultural influences, as culture imposes norms on how we interpret emotional events. Marian and Kaushanskaya (2004) explored the variability of the type of emotional words used to describe events across languages (and cultures) in Russian-English bilingual immigrants who came to the U.S. from the former Soviet Union. Participants were asked to describe two separate events (e.g., *birthday*, *snowfall*), one in each language. Pronoun usage was used to measure cultural influence: collectivism (i.e., emphasis on the group: former Soviet Union) was measured by the increased use of group pronouns, like "we," and individualism (i.e., emphasis on the individual: U.S.) was measured by the increased use of individual pronouns, like "I."

The results demonstrated that, consistent with the language-dependent memory hypothesis in which memories are best recalled when the language of encoding and retrieval match (e.g., Marian & Neisser, 2000), bilinguals produced narratives that were rated as more emotionally intense when the language of encoding and retrieval matched. In addition, bilinguals shifted towards a collectivist nature (use of *we, us, our* pronouns) when speaking in Russian and shifted towards an individualistic nature (use of *I, me, my* pronouns) when speaking in English. Because of cultural distinctions (e.g., collectivism versus individualism), immigrants may experience difficulty reorganizing their sense of self when immigrating to a foreign country in which cultural values are distinct from their native country. This, in turn, may force immigrants to adjust the way they view themselves, and society at large, which could affect not only their interactions with others, but also the way they organize and encode events and emotions. The results from Marian and Kaushanskaya (2004) suggest that the linguistic context and the culture with which one affiliates influence the organization of emotions and retrieval of memories within the cognitive system.

Evidence from processing, memory, and cultural effects of bilingualism on emotion demonstrates that the accessibility and processing of emotion is highly complex and influenced by language experience. We suggest that language proficiency, age of L2 onset, match between language of encoding and language of retrieval, and cultural values likely affect bilingual emotional experiences. Because language, emotion, and memory are tightly linked within the cognitive system, we also suggest that language usage drives bilinguals to remember events based on linguistic cues, and that memories themselves may store information or cues about the language, and by extension, the culture.

Effects of Bilingualism on the Intersection of Cognitive Control and Emotion

While bilingual experience impacts cognitive control and emotion independently within the cognitive system, experience with multiple languages can also shape how cognitive control and emotion interact with each other. In addition to research from Blumenfeld and colleagues suggesting that bilinguals activate their languages in parallel (2007, 2011, 2013), the valence of an emotional word also affects a bilingual's ability to activate or access its L1 translation equivalent when processing that emotional word in L2. Wu and Thierry (2012) found that bilinguals experienced restricted access to translation equivalents of emotional words with a negative connotation (e.g., *violence*), but emotional words with a positive or a neutral connotation (e.g., *holiday*, *theory*) resulted in simultaneous access (parallel activation) to translation equivalents. Interestingly, this effect occurred without the participants having to make an explicit judgment on the emotional valence of the words. One possible reason for this difference in emotional valence across the L1 and the L2 could be that when processing a word with negative valence in the L2, late L2 learners (as in Wu and Thierry's study) may inhibit access to the L1 translation equivalent. Words with negative valence may be particularly distressing and subsequently, the full semantic representation of the negative word may only become activated in the L2. More broadly, the results of this study suggest that when bilinguals process language, they deploy cognitive control mechanisms that limit cross-linguistic access based on the emotional content of translation equivalents.

Further evidence highlighting the interactivity between cognitive control and emotion comes from neural network research on humans and non-human animal models. Common to cognitive control and emotion is the anterior cingulate cortex (ACC), which may be involved in error detection and correction, and is activated during tasks that involve cognitive control and tasks that involve emotion processing (Bush, Luu, & Posner, 2000). In rhesus monkeys, the ventromedial frontal region, known as the limbic area of the frontal cortex, includes the anterior cingulate gyrus, which receives input from the amygdala (Porrino, Crane, & Goldman-Rakic, 1981). Evidence from these non-human primates sheds light on the interactivity of the regions associated with cognitive control (frontal areas, ACC) and emotion (amygdala, ACC), and suggests that the ACC serves as a processor and filter for both cognitive control and emotion. These same brain activation patterns in cognitive control (PFC and ACC; e.g., Abutalebi et al., 2007) and in emotion (amygdala and ACC; e.g., Killgore & Yurgelun-Todd, 2004) have been observed in humans as well. In addition, there is evidence to suggest that the prefrontal cortex (PFC) is activated when individuals are required to control or regulate emotional responses (see Ochsner & Gross, 2005, for review). Thus, the neural networks in human and non-human primates provide additional evidence that cognitive control and emotion are served by the same distributed neural and cognitive mechanisms.

It is clear that the neural network subserving cognitive control and emotion is highly integrated in humans, but what remains unclear is how this network is impacted by experience with managing multiple languages. In a language switching task, bilinguals activated cognitive control regions, such as the DLPFC, and also activated regions central to emotional processing, such as the amygdala, despite the fact that the stimuli used reflected low or neutral emotional valence (e.g., fruits, furniture) (Hernandez, 2009). Activation of the amygdala only occurred when the bilingual participants were naming pictures in their L1 (Spanish), and not in their L2 (English), despite the participants' dominant language being English. A possible explanation for this pattern of results, similar to the idea that bilinguals process emotional words differently across the L1 and L2, is that bilinguals attend to (neutral) words differently in their L1 and L2, and processing neutral words in the L1 may result in automatic activation of an emotional state by virtue of being processed in the L1. Therefore, while previous studies have shown the activation of cognitive control regions during emotional tasks and events, Hernandez (2009) demonstrates that bilinguals can activate brain areas associated with emotion during an emotionally-neutral linguistic/cognitive control task. The underlying cause for activation of overlapping areas involved in cognitive control and emotion in bilinguals remains unclear and is subject to future neuroimaging research. However, the evidence discussed in this section clearly suggests that experience with multiple languages affects the interplay between cognitive control and emotion.

Conclusion

Bilinguals are thought to be "mental jugglers" (Kroll, 2009), constantly having to navigate both of their languages, even under contexts in which only one language is required. The demands imposed by parallel activation and language switching appear to confer benefits to bilinguals in both linguistic and non-linguistic contexts. As reviewed in this chapter, bilinguals demonstrate advantages in cognitive control (e.g., Bialystok et al., 2008; Kroll & Bialystok, 2013; Luk et al., 2011; but see Hilchey & Klein, 2011; Paap & Greenberg, 2013) and lifelong bilingual experience delays the onset of the symptoms of Alzheimer's Disease (Alladi et al., 2013; Bialystok et al., 2007; Craik et al., 2010; Schweizer et al., 2012). Brain pathways and networks that are responsible for cognitive control and language control overlap in bilinguals, and the cognitive control network is enhanced and recruited more efficiently in bilinguals than in monolinguals during language processing (e.g., Abutalebi et al., 2008; Guo et al., 2011). Likewise, eye-tracking research demonstrates that linguistic and non-linguistic cognitive control are correlated in bilinguals (Blumenfeld & Marian, 2011, 2013), suggesting a tight relationship between language and cognition.

Research on bilingualism has also revealed a complex relationship between linguistic experience and emotional processing, where a bilingual's ability to access the emotional content of words or memories depends on the language being used at a given time. For instance, there is mixed evidence as to whether bilinguals process emotional content similarly across their languages. In unbalanced bilinguals, emotional word processing may be more automatic in the L1 than in the L2 (e.g., Pavlenko, 2012), but how emotion is represented in the brain may be similar across both languages (e.g., Conrad et al., 2011; Opitz & Degner, 2012). In balanced bilinguals, L1 and L2 emotional words may be processed equivalently (Sutton et al., 2007), as direct links to concepts are formed (Kroll & Stewart, 1994). In addition, evidence from bilinguals also demonstrates how emotion influences the encoding and retrieval of memories. Marian and Kaushanskaya (2004, 2008) showed high interactivity between emotion and memory, and experience with multiple languages affects how bilinguals form, store, and retrieve memories. Our emotional perception of an event is influenced by the linguistic and cultural context in which the event takes place, as well as the language in which the emotional event is retrieved.

We conclude that language, cognitive control, and emotion are intertwined. Indeed, cognitive control and emotion appeared to be both filtered through and filtered by language. Our perception of emotional experiences relies on cognitive control to modulate emotional reactions, and may use language to encode and express these reactions. The research explored in this chapter demonstrates that bilingual experience is unique in that knowing multiple languages can have profound effects on the cognitive system, altering the interactivity between cognitive control and emotion, as well as affecting each of these components independently. Experience with multiple languages can change how we think about and interpret daily events in the environment, allowing for more than one channel through which we view the world.

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Figures

Figure 1: (A) *Simon Task*, congruent trials represent the coinciding location of the target stimulus on the screen and the location of the response on the keyboard. Incongruent trials represent a conflict with the location of the target stimulus on the screen and the location of response on the keyboard. (B) Non-linguistic *Stroop Task*, congruent trials represent no conflict between the direction of the arrow and its location on the screen. Incongruent trials represent a conflict between the direction of the arrow and its location on the screen. (C) *Flanker Task*, congruent trials contain a target chevron embedded in a group of competitor chevrons pointing in the same direction of the target. Incongruent trials contain a target chevron embedded in a group of competitor chevrons pointing in the opposite direction of the target.

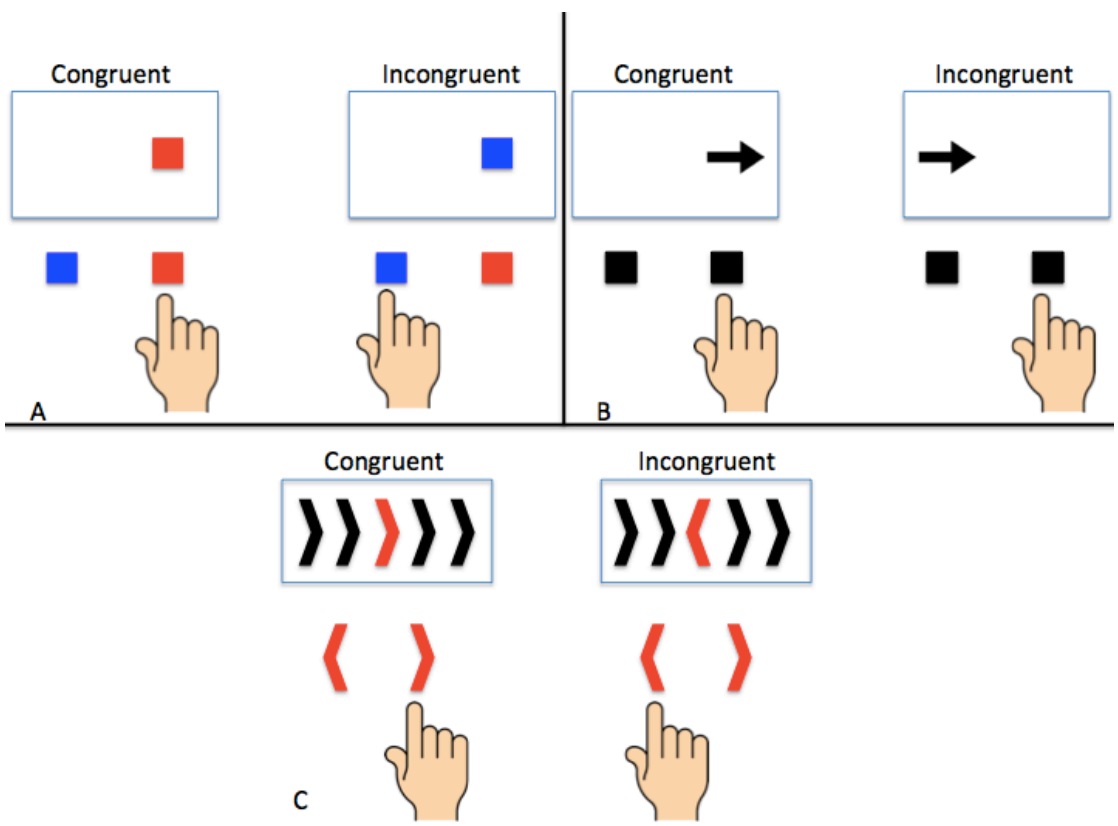

Figure 2: An illustration of the Eye-Tracking/Negative Priming Paradigm adapted from Blumenfeld and Marian (2011). Participants heard English words and identified corresponding pictures in the presence of English phonological competitor pictures while their eye-movements were tracked (top panel). Word Recognition trials were followed by priming probe trials (bottom panel) that probed inhibition of competitor words (grey asterisks in locations previously occupied by competitor pictures, column A), relative to control items (grey asterisks in locations previously occupied by control pictures, column B), and target items (grey asterisks in locations previously occupied by target pictures, column C). Participants responded by pressing one of four keys, arranged in a square corresponding to the location of items on the stimulus display.