Doctoral Dissertation

Prospective processing in bilinguals

Procesamiento prospectivo en bilingües

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A mi compañero de vida Javi,

porque este esfuerzo no es solo mío,

es NUESTRO.

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Dice el refrán que “es de bien nacidos ser agradecidos”, así que permitidme que dedique unas palabras a esas personas que me han acompañado en mi camino hasta aquí y han hecho de él un lugar bonito por el que transitar.

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Introductory Note

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The contents of this doctoral dissertation have been drawn up according to the regulations of the University of Granada to obtain the International Doctorate Mention in the Psychology Doctoral Programme. Accordingly, the majority of the thesis has been written in English. In particular, the theoretical introduction (Chapters 1, 2, and 3) is presented in English. After that, the empirical section (Chapters 4, 5, 6, and 7) and general discussion (Chapter 8) also continue in English. Finally, a chapter including a summary and conclusions of the thesis is presented in Spanish (Capítulo 9).

CONTENTS

PREFACIO

«La fuerza de la necesidad es irresistible.»

Esquilo de Eleusis

El bilingüismo siempre ha formado parte de mi historia familiar. Sin embargo, hasta el momento de escribir esta tesis, nunca había reparado en ello para darle el valor y reconocimiento que se le debe. Y es que viéndolo en perspectiva ahora puedo observar como, durante generaciones, la necesidad imperiosa de aprender nuevos idiomas ha sido una constante en mi familia. Como tantas familias españolas, mis abuelos maternos se vieron forzados a aprender francés tras emigrar a Francia para trabajar el campo. Allí mi madre, que tan solo era una niña de 5 años, tuvo que adaptarse a un nuevo colegio donde las lecciones eran en un idioma totalmente desconocido para ella. También allí, mi tía nació y pasó los primeros años de su vida expuesta a varios idiomas. Pero esta necesidad se extendió a aquellos que, aún permaneciendo en España, tuvieron que adaptarse a los nuevos tiempos. Por ejemplo, mi padre, siendo un joven mecánico de barcos en los años 70, entendió que el alemán era la llave que le abriría camino en el mundo de la náutica. Sin embargo, la necesidad de aprender idiomas no siempre surge de tener que anteponerse a circunstancias profesionales, sino también de la voluntad por abrirte a nuevos mundos y sus gentes. Así, mi hermano aprendió inglés de manera autodidacta para poder visitar países tan remotos como Nepal, India o Singapur. Y, de esta oportunidad que el bilingüismo le prestó, surgió la que es mi bilingüe favorita: mi sobrina Vandana. Para ella, aprender español e inglés no ha sido una necesidad impuesta por las circunstancias, sino más bien un hecho natural que forma parte inherente de su vida porque, a pesar de estar inmersa en un contexto de habla castellana, con su madre siempre habla en inglés (y con su tía Cristi a veces lo intenta, pero a está no la entiende tan bien).

Contando la historia del bilingüismo en mi familia simplemente quiero remarcar que, a pesar de lo que muchos y muchas pueden pensar, la presencia del bilingüismo en nuestra sociedad es un rasgo característico que debe ser tomado en consideración y puesto en valor. Especialmente, dadas las evidencias sobre sus implicaciones en nuestra manera de percibir y procesar el mundo que nos rodea. Y es que, hoy podemos afirmar que el idioma que usamos para afrontar ciertas actividades de nuestro día a día determina la manera en que realizamos dichas actividades. Por lo tanto, asumir el poder determinante que el lenguaje juega en nuestros comportamientos es el primer paso para comprender el impacto del bilingüismo tanto en la sociedad como en nuestra propia identidad.

«Si hablas a una persona en una lengua que entiende, las palabras irán a su cabeza.
Si le hablas en su propia lengua, las palabras irán a su corazón.»

Nelson Mandela

En esta tesis nos hemos esforzado por comprender cómo los efectos que producen en nuestras mentes el conocer y manejar varios idiomas pueden afectar a una tarea tan cotidiana como es el recuerdo de intenciones futuras. A través de ella, hemos observado la importancia del idioma en que realizamos estas actividades, así como de las características que nos definen como bilingües, modulando el procesamiento y recuerdo en dichas tareas. En conjunto, consideramos este trabajo un apasionante punto de partida sobre el que continuar avanzando para obtener una imagen más nítida de cómo el bilingüismo afecta la memoria.

Preface

"The strength of necessity is irresistible."

Esquilo de Eleusis

Bilingualism has always been part of my family story. However, until the moment of writing this thesis, I had never given it due consideration and accorded it the value and recognition it deserves. Looking at it in perspective, I can now see how, for generations, the imperative of learning new languages has been a constant in my family. My grandparents were forced to learn French after emigrating to France to work in the agricultural field. There, my 5-year-old mother had to adapt to a new school where the lessons were in a language totally unknown to her. Later, my aunt was born there, and she spent the first years of her life exposed to several languages. Similar to the story of my grandparents, in Spain, there were many families who, in those difficult times, were forced to learn new languages in order to build a future outside their native country. However, this need extended to those who, while remaining in Spain, had to adapt to the changing times. For example, my father, as a young boat mechanic in the 1970s, understood that German was the key that would open the way for him in the nautical world. However, the need to learn languages does not always arise from having to overcome professional challenges but also from the desire to open up to new worlds and their people. Thus, my brother learned English in a self-instructed way to be able to visit countries as remote as Nepal, India, or Singapore. And out of the opportunity that bilingualism gave him, my favourite bilingual was born: my niece Vandana. For her, learning Spanish and English has not been a necessity imposed by circumstances but rather a natural fact that is an inherent part of her life because, despite being immersed in a Spanish-native context, she always speaks English with her mother (and sometimes with her aunt Cristi, although she doesn't understand her as well).

Telling you the story of bilingualism in my family is a simple way to point out that, despite what many people might think, the presence of bilingualism in our society is a characteristic feature that should be taken into consideration and valued—especially given the evidence of its implications for our way of perceiving and processing the world around us. Today, we can confirm that the language we use to engage in certain daily life activities determines the way in which we carry them out. Therefore, recognising the power of language to determine our behaviours is the first step in understanding the impact of bilingualism, both on society and on our own identity.

"If you talk to a man in a language he understands, that goes to his head. If you talk to him in his own language, that goes to his heart."

Nelson Mandela

The current thesis endeavours to understand how the cognitive effects of knowing and managing two languages can affect an essential ability, namely, remembering future intentions. In researching it, we have observed the important role of the language in which these activities are performed, as well as the characteristics that define bilinguals. Overall, this work is an exciting starting point to guide my future research and my attempts to draw a broader picture of how bilingualism influences memory.

PART I

INTRODUCTION

CHAPTER 1.

BILINGUALISM MAKES A DIFFERENCE

Communication is one of the most influential tools that have made human evolution and global development possible. Knowledge from all fields has been transferred from generation to generation, thanks to the human ability to communicate. The main requirement of any form of communication is the existence of common codes that allow mutual understanding, and language has certainly been considered the most powerful code that allows intra- and interpersonal communication.

The power of language goes beyond the function of communication. Language shapes our minds, influencing how we perceive the world and how we construct our own life stories (Wolff & Holmes, 2011). Thus, for example, language determines the way in which we categorise colours (Davies & Corbett, 1997). Importantly, when we consider the role of language in cognition, we must not forget that people are frequently exposed to and speak two or more languages. Recent literature indicates that around 65% of the world's population is bilingual (Grosjean, 2021). As mentioned, each language is a universal code that allows us to communicate with those who speak using the same code. Thus, speaking more than one language allows us to enlarge the number of people with whom we can communicate and to partake in a variety of experiences (e.g., access to international information, getting to know different cultures, or visiting foreign countries) that might enrich and improve our lives (Ramírez-Esparza et al., 2020). In particular, bilingualism has been shown to have an impact on our health by modulating the effects of cognitive development or ageing (Bialystok, 2001; Bialystok et al., 2012, 2016). However, being bilingual also implies some cognitive costs stemming from the need to manage two languages in the mind when engaged in a wide range of activities (Marian & Spivey, 2003; Giezen et al., 2015).

Interestingly, the coexistence of two languages in one brain presents researchers with (1) the challenge of understanding the cognitive mechanism underlying language processing/control and (2) the opportunity to use bilingualism as a tool to investigate the malleability of the cognitive processes and brain networks involved in core functions, such as attention, learning, or memory (Kroll et al., 2012). This explains why, in recent decades, there has been a growing body of research focusing on the impact of bilingualism on the brain (for a review, see Kroll et al., 2015). Moreover, recent movements in this field point to the need to consider bilingualism as a form of human health capital (Rossi, 2023).

Nevertheless, defining bilingualism is a complex issue, given the variety of factors underlying this concept. For example, should a person be born and raised in the context of two languages to be considered bilingual or could a person who learned a second language as an adult also be considered bilingual? If the latter is included, are bilinguals those who speak two languages very fluently and without an accent? Or are they those who can use either language for daily tasks, even though they are not so fluent in one and have a strong accent? Or to be truly bilingual, is it necessary to command a large vocabulary in each language and to have a mastery of grammar and syntax? In sum, these and many other questions arise when we try to conceptualise the characteristics of a bilingual person. Unfortunately, there is no accurate definition that matches the variability of the bilingual experience spectrum (Costa, 2020). The age of acquisition, the extent of language and use, the frequency of language-switching, and proficiency are only some of the factors to be considered when defining a bilingual. For this reason, De Bruin (2019) suggested that studies on bilinguals have to include detailed descriptions of the samples, especially studies designed to explore the fine-grained effects of bilingual experiences on cognition. Consequently, recent articles point to the need to rethink this concept, including new variables (Titone & Tiv, 2023; Kroll et al., 2023) and new approaches (Kremin & Byers-Heinlein, 2021; Salig et al., 2021) to capture how the variability among bilinguals influences cognition.

Furthermore, research on bilingualism has stressed the need to define the real-world challenges that bilinguals face in daily life, which depend on the context in which they live. For example: imagine yourself as a young Spanish-English speaker living in Southern California. You were born in the United States, although your parents are of Latin origin. Thus, you grew up speaking Spanish at home, but you learned English at school. This experience made you an expert in selecting the appropriate language for each situation. Although one might think, "That's easy! Two languages, two contexts," the reality of this linguistic experience is more complex. Thus, the specific language that you are required to use depends on multiple factors, such as the people around you (Kaan et al., 2020; Tomić & Kaan, 2022), the topic that you are approaching (Hammer, 2017; Torres et al., 2018), or even your emotional state (Jackson et al., 2019; Thoma, 2023). This means that you must continuously pay attention to many external and internal cues to adapt and select the appropriate language at each moment. These cognitive challenges for the bilingual brain have different effects on other cognitive domains. In fact, there is a wide range of studies that have focused on exploring how performing some activities in our first (L1) or second (L2) language impacts our processing and execution of a variety of tasks, such as decision-making (Brouwer, 2021), visual attention (Chabal & Marian, 2015), perception of multisensory emotions (Chen et al., 2022), or even memory (Arndt & Beato, 2017; Marian et al., 2021).

In sum, this chapter is designed to address some of the most relevant theories and findings regarding bilingualism, which will provide a framework for understanding the main objectives and results of the present thesis. First, an overview is provided of how two languages coexist in the brain (i.e., parallel co-activation) and the cognitive processes involved in bilingual language control. There follows a description of the impact of bilingualism on cognition, considering the variety of bilingual experiences. Finally, we review some of the evidence on how the language that bilinguals use (L1 or L2) impacts the processing and execution of a variety of tasks from different domains.

BILINGUAL LANGUAGE PROCESSING AND CONTROL

In bilinguals, two languages are simultaneously active during language production and comprehension. Thus, many studies have shown parallel co-activation of both languages in a diverse set of tasks (Bobb et al., 2020; McDonald & Kaushanskaya, 2020; Sadat et al., 2015; Shook & Marian, 2019). Classically, this co-activation has been studied by means of experimental tasks involving the processing of cognates (i.e., words in different languages that have similar forms and meanings, such as *piano* in Spanish and English) or homographs (i.e., words that are similar in form but differ in meaning, such as *carpeta*, which is *folder* in Spanish and not *carpet*). This co-activation of languages is supported by results that show facilitation and interference in cognate and homograph processing, respectively, when bilinguals have been compared to monolinguals (Kroll et al., 2015). This effect has also been observed in reading (Dijkstra, 2005; Libben & Titone 2009; Schwartz & Kroll 2006; Van Hell & Dijkstra 2002), listening (Marian & Spivey, 2003b), and even writing production (Iniesta et al., 2021). Interestingly, this parallel activation appears even in situations in which only one language is required, independent of whether participants are using their first or second language (Macizo, 2016; Starreveld et al., 2014). Furthermore, evidence for language interconnections occurs not only for languages that share similar features but also with those that differ in their lexical form (e.g., Chinese-English; see Thierry & Wu, 2007, 2010; Zhang et al., 2011) or their perceptual aspects (e.g., bimodal bilinguals; see Giezen et al., 2015; Morford et al., 2011). Overall, these findings suggest that bilingual languages are integrated and interconnected in the brain.

The fact that bilinguals have to manage two languages in one mind implies the need for a control mechanism to regulate language selection. An influential theoretical framework considers that language control strategies require the engagement of inhibitory control to suppress the competition of the non-target language (Green, 1998; Kroll et al., 2008; see Declerck & Koch, 2022, for a recent review). In this regard, bilingual inhibitory control has been extensively explored by means of the language switching paradigm (see Figure 1 for a graphical description) (Blanco-Elorrieta & Pylkkänen, 2017; Christoffels et al., 2007; Declerck et al., 2017; Reynolds et al., 2016; Verhoef et al., 2009; Yahya & Özkan Ceylan, 2022). In this paradigm, participants name pictures or digits in their first or second language alternatively, and depending on the language of the previous trial, a switch trial (different language) or non-switch trial (same language) may follow (Costa & Santesteban, 2004; Meuter & Allport, 1999). The results usually show that (1) responses in switch trials are slower and more error prone than in non-switch trials (i.e., language switching cost) due to the higher difficulty of language management (see Declerck & Philipp, 2015, for a review), and (2) greater switching costs for the L1 compared to the L2 (i.e., asymmetrical switching cost; De Bruin et al., 2014; Macizo et al., 2012), indicating the engagement of strong inhibition processes to avoid competition between languages.

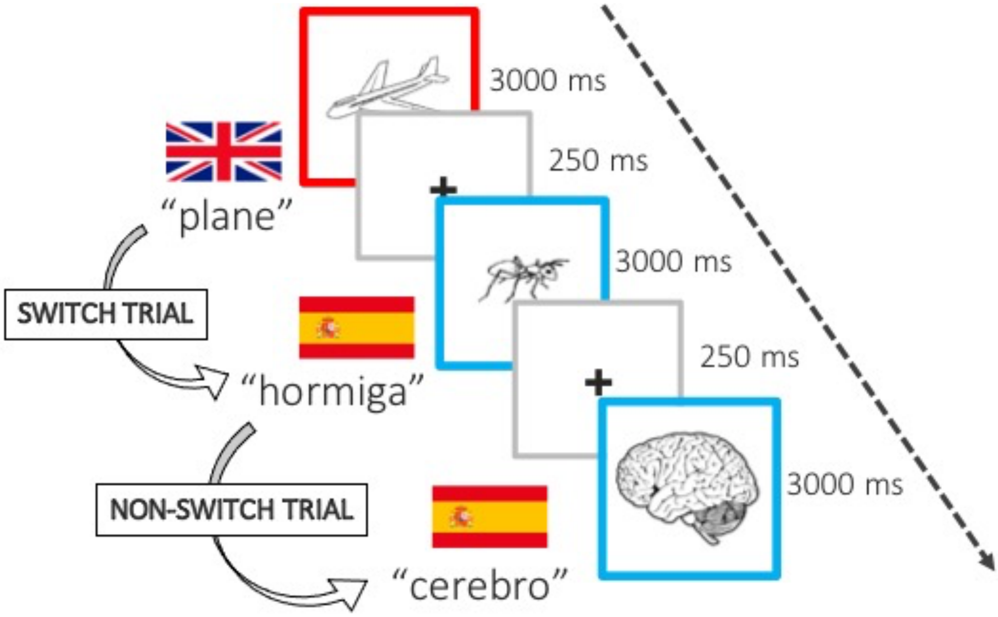

Figure 1. Example of a typical trial sequence used in the language switching paradigm. Each picture appears with a red or blue frame, indicating the language in which the picture should be named.

Therefore, the constant need to control the competition between languages can make bilingual people experts in conflict resolution. In fact, a large body of studies has tested this idea by comparing monolinguals' and bilinguals' performance in verbal and non-verbal tasks involving control processes (for a systematic review, see van den Noort et al., 2019). Classical studies in the field have found that bilinguals outperform monolinguals in attentional tasks that require cognitive control, especially in conditions that demand more monitoring (Colzato et al., 2008; Costa et al., 2008, 2009).

Moreover, other recent studies have reported data indicating better performance of bilinguals over monolinguals in resolving conflict-monitoring tasks (Blumenfeld & Marian, 2014; Cox et al., 2016; Desideri & Bonifacci, 2018; Teubner-Rhodes et al., 2016; but see Paap, 2019 for a contrasting view). In addition, results supporting the impact of bilingualism on cognition have been supported by neuroimage studies, suggesting greater engagement of the control networks in bilinguals than in monolinguals (Abutalebi et al., 2012; Gold et al., 2013; Grady et al., 2015; Kousaie & Phillips, 2017). Overall, these studies seem to indicate the existence of shared cognitive mechanisms for both bilingual language control and cognitive control.

In this regard, two main processes have been shown to be engaged during language control: reactive and proactive language control (see Declerck & Koch, 2022, for a recent review). From the perspective of the dual mechanism of cognitive control (Braver, 2012; Chiew & Braver, 2017), bilingual language selection requires the use of different control strategies, depending on the situation (see Dash et al., 2021, and Antoniou, 2023, for reviews). Thus, language selection sometimes requires a goal-maintenance approach that engages monitoring processes to anticipate the use of one language (i.e., proactive control). This anticipatory process allows responding in advance to cross-language interference, whereas other situations require activating bottom-up processes to select the appropriate language (i.e., reactive control) when a language conflict is detected. For this reason, bilinguals might be more efficient than monolinguals in resolving tasks in which these control strategies are required (e.g., on the AX-Continuous Performance Task [AX-CPT]). Specifically, Morales et al. (2013, 2015) found that bilinguals adjusted these proactive and reactive strategies more effectively to achieve better performance and reduce errors. However, further studies exploring this effect have found that the type of bilingual experience of the participants can modulate the use of proactive/reactive processes. For instance, Bonfieni et al. (2019) suggested that better performance on cognitive control tasks (e.g., fewer errors on the AX-CPT) was only evident in early, very proficient bilinguals compared to late, low-proficiency bilinguals. Similarly, Beatty-Martínez et al. (2019) observed that the linguistic context in which bilinguals are immersed modulates their control strategies. Specifically, participants from linguistically separated contexts relied more on reactive control processes, whereas proactive control processes were mainly used by participants in linguistically varied contexts.

The role of the bilingual experience as a modulator of domain-general cognitive control abilities gives rise to many interesting questions to investigate regarding the role of experience and control. Moreover, this interaction provides a powerful explanation for the controversial results found in the last decade regarding bilingualism and its cognitive implications (for a recent review, see Antoniou, 2019). Accordingly, in the section below, we describe previous research that explores how the bilingual experience modulates the behavioural and neural outcomes of different cognitive tasks. Finally, we detail the main frameworks that integrate and provide explanations for these findings.

THE BILINGUAL EXPERIENCE

As mentioned, there is no single definition that encompasses all the linguistic characteristics of a bilingual person. However, there has been some consensus in the field on defining bilinguals as people who have high proficiency in two languages, use them frequently, and/or are exposed to them daily. However, more recent approaches consider bilingualism as a continuum rather than as a category (Luk & Bialystok, 2013). From this perspective, measuring the bilingual experience is one of the greatest challenges in the field. Thus, there are different self-reports and standardised tests used in the literature to capture the type and degree of bilingualism (e.g., LEAP-Q, LHQ, LBQ) and the social diversity of languages by, for example, calculating indexes such as "language entropy" (Gullifer & Titone, 2020, 2021). Recently, Marian and Hayakawa (2021) proposed a "bilingualism quotient" (BQ) to operationalise the bilingual experience. They posit that factors such as age, manner of acquisition, proficiency, language use, switching, and identity might be included in this equation, where the weight assigned to each factor would depend on the research question.

Given the large range of factors modulating the bilingual experience, some authors have developed frameworks to explain how these factors affect other cognitive domains. For instance, DeLuca et al. (2020) established the *unifying the bilingual experiences trajectories* (UBET) model to indicate how certain factors of the bilingual experience may affect general cognitive domains differently. Specifically, they associated frequent use and balanced language proficiency with neural adaptation processes that benefit cognitive efficiency, whereas they associated diversity/intensity of use and frequent language switching with proactive control.

In this regard, the *adaptive control hypothesis* (ACH), proposed by Green and Abulatebi (2013), suggests that the processes engaged during language processing depend on the interactional context in which bilinguals are immersed. Thus, these authors signalled three possible linguistic contexts that varied in their requirements. First, they identified the single-language context where bilinguals use only one of their languages in a specific environment. Thus, this context requires goal maintenance to process the selected language. Interestingly, this type of context is prevalent in Granada (Spain). However, the dual-language context is more typical of other Spanish regions, such as Catalonia or Basque Country. In this context, there are situations (e.g., at school, work, or home) in which both languages are used but with different persons. The complexity of this type of context generates the need to be engaged in several cognitive processes, such as goal maintenance, interference control, cue detection, response inhibition, and task shifting. Finally, the third type of context is the dense code-switching context, where both languages are used with the same interlocutor in the course of a single utterance. This requires planning and less inhibition to be able to alternate between two languages. For example, there is a linguistic variety called *Llanito* that is spoken by the population of the British overseas territory of Gibraltar, whose speakers switch between English and Spanish in the same utterance.

Thus, if the bilingual context and experience have consequences for the processes engaged in language control, these variables should also have an effect on general domain control processes. Hence, for example, if bilinguals are immersed in contexts in which switching between languages is required (e.g., dual-language or dense code-switching contexts), they should also show a greater ability to engage in switching processes when performing other cognitive tasks that also require switching. This hypothesis has been tested in a large number of studies involving verbal and non-verbal tasks, and the results indicate smaller task-switching costs for bilinguals compared to monolinguals (Prior & Gollan, 2011; Verreyt et al., 2016). Importantly, comparisons between bilinguals immersed in either single-language or dual-language contexts have revealed smaller switching costs for the dual-language group, as members of that group usually engage in frequent switches between languages (Hartanto & Yang, 2016). Hence, language use and switching have been characterised as two of the main experience-based factors that modulate the brain and cognition. Interestingly, based on this idea, several studies have explored the impact of short-term language-switching training on non-linguistic tasks, demonstrating positive effects, for example, on monitoring and inhibition processes (Liu et al., 2019; Timmer et al., 2019). These effects have also been supported by studies using neuroimaging (Chen et al., 2021; Zhang et al., 2015).

The age of acquisition (AoA) of the second language has also been suggested as a powerful modulator of bilinguals' performance in cognitive tasks and of their underlying brain mechanisms. For example, Luk and colleagues (2011) compared the performance of bilinguals who acquired their L2 before (early bilinguals) and after (late bilinguals) the age of 10 years in a flanker task that required response inhibition. Their results showed smaller costs in early bilinguals compared to late bilinguals and monolinguals, whereas there were no differences between late bilinguals and monolinguals. These results signalled the role of AoA as a cognitive modulator associated with the bilingual experience. Similarly, other studies have found greater efficiency of early bilinguals over late bilinguals in processes such as inhibition (Hartanto & Yang, 2019), cognitive control (Bonfieni et al., 2019), or visual attention (D'Souza et al., 2021).

In sum, these studies indicate the need to consider the type of bilingual experience when defining and assessing bilingualism. In addition, they indicate that research should move forward from classical studies that compare bilinguals and monolinguals and design studies that consider the bilingual experience as a factor that may modulate cognitive outcomes and neural adaptations. Recent studies (e.g., Bice & Kroll, 2019) suggest that language experience lies on a continuum between monolingualism and bilingualism, since even monolinguals have some degree of exposure to an L2. Thus, recent reports (see Rothman et al., 2022, for a proposal) consider bilingual experiences as regressors by collapsing monolingual and bilingual groups in their analyses. Importantly, from this perspective, the field has to reconsider how knowing two or more languages modulates the way in which bilinguals engage in a wide range of linguistic and non-linguistic activities. These studies allow us to observe the influence of language on how we process the environment and the importance of considering bilingualism as a lens that shapes our relationship with the world. In a related way, in what follows, we review certain findings regarding how bilinguals engage in various across-domain activities in their second language; specifically, we describe some of the studies that have explored how bilingualism modulates our interaction with the world through the use of one or another language.

THE MIND THROUGH BILINGUALS' L1/L2 LENS

The fact that two different languages coexist in the brains of bilingual persons has major implications for the way they see and interact in the world. Thus, bilingualism acts as a lens that modulates their experiences and changes their perspective, depending on which language they "see" the world through. Consequently, we might expect differences in processing and outcomes when a task is completed in the native language versus the foreign language. Therefore, studying how the selection of a given language influences the performance of certain day-to-day activities is essential to understanding the impact of bilingualism on individual lives.

In this respect, there is an extensive body of research exploring the differences between languages in reading comprehension tasks. Specifically, classical studies have focused on investigating basic reading abilities and their underlying processes, such as word reading, vocabulary knowledge, and working memory (WM, Droop & Verhoeven, 2003; Geva & Siegel, 2000). Not surprisingly, the results indicate that bilinguals exhibit poorer comprehension in their L2 than in their L1 (for a review, see Melby-Lervag & Lervag, 2014). However, these results are mediated by factors such as proficiency in the L2 (Walter, 2004) and executive functions (Shin, 2020).

Most importantly, behind these basic processes, reading complex texts also requires high-cognitive processes that could be also modulated by the language in use. For example, previous research on this topic has shown an impairment in assessing coherence between distant sentences in the L2, whereas coherence between adjacent sentences was not affected by working in a less dominant language (Ushiro et al., 2022). This finding suggests that L2 comprehension difficulties may be experienced when monitoring coherence between distant sentences. Similarly, Pérez et al. (2019) reported data suggesting that monitoring and updating processes during text comprehension were engaged less efficiently in the L2 than in the L1. Overall, it has been suggested that more resources are required to anticipate upcoming linguistic information during successful L2 comprehension (Foucart et al., 2016; Kaan et al., 2016; Pérez et al., 2019), not only during reading comprehension but also during listening comprehension (Chun & Kaan, 2019; Filippi et al., 2012).

There is also increasing interest in the study of the relationship between memory and the language of the studied/retrieved materials. Even though not all memories are linguistic (they could instead be senso-motor, tactile, or olfactory), language is frequently used to describe, trigger, or evoke memories as well as to store them. For this reason, we could expect that L1 and L2 processing also modulate performance in memory activities. Thus, early research on bilinguals' ability to retrieve autobiographical and episodic memories reveals a linguistic dependence (Marian & Fausey, 2006; Marian & Neisser, 2000). Memories recalled in one's dominant language have been shown to evoke more details and more mental imagery than memories recalled in the non-dominant language (Schrauf, 2003; Schrauf & Rubin, 2004). This language dominance effect is particularly noticeable when the language of encoding and retrieval is the same (Bartolotti & Marian, 2012). In this regard, one of the most extensively explored hypotheses is the language-dependent memory effect. Studies exploring this effect indicate that memories become more accessible when the linguistic environment at retrieval matches the linguistic environment at encoding (Marian & Kaushanskaya, 2007; Marsh et al., 2015). Thus, bilingualism affects the recall and encoding of episodic information induced by the language in which they are processed. This effect has been found in autobiographical memories (Marian & Kaushanskaya, 2004, 2005; Marian & Neisser, 2000; Matsumoto & Stanny, 2006) but also in other domains, such as memory for academic material (Marian & Fausey, 2006).

Another interesting memory effect that is modulated by bilingual language processing is the generation of false memories (for a recent review, see Suarez & Beato, 2021). In general, studies have shown that more false memories are generated in the L1 than in the L2 (Anastasi et al., 2005; Arndt & Beato, 2017; Sahlin et al., 2005) and that these memory errors increase as bilinguals become more proficient in their L2 (Arndt & Beato, 2017). However, other studies have found that bilinguals are more vulnerable to memory distortions when working in their L2. Thus, recent studies (Calvillo & Mills, 2020; Dolgoarshinnaia & Martin-Luengo, 2021) suggest that L2 processing could modulate source monitoring processes, resulting in a misinformation effect (i.e., reporting post-event false information as the original; Loftus, 2005). Similarly, more false memories for bilinguals working in their L2 than for monolinguals working in their L1 have been reported by Bialystok et al. (2020), who compared bilinguals and monolinguals using the Deese–Roediger–McDermott false memory paradigm (DRM; Roediger & McDermott, 1995). The DRM task consists of studying sets of words associatively related to a non-presented critical word that is usually falsely recalled/recognised in a later memory task. In one of their experiments, Bialystok and colleagues found that bilinguals were less susceptible to the generation of semantic false memories than monolinguals, thus supporting previous research in the field (Anastasi et al., 2005; Kawasaki-Miyaji et al., 2003). However, when the words on the list were phonologically associated, the pattern was reversed, showing a cost for bilinguals compared to monolinguals, suggesting processing differences between them, and implying that these differences either protect them from or make them more prone to false memories.

Altogether, studies on the effects of bilingualism on memory suggest that bilingualism could entail costs and benefits (Schroeder & Marian, 2012, 2014). Hence, understanding the implications of languages for how we recall information and the types of memory errors we may make is essential, since we sometimes encounter situations in which we are forced to recall vital information in our L2 (e.g., if we witness an accident in a foreign country).

Overall, language processing affects how we access information in memory and the quality of this information; as a result, it can impact a variety of other domain-general cognitive tasks. In this regard, one of the most surprising findings is related to research on decision-making in bilinguals. In recent years, many studies have explored the effect of making moral judgments in a foreign language, finding that decision-making is modulated by the language in which people reason and make decisions (Costa et al., 2014, 2019; Hayakawa et al., 2016, 2017). Specifically, these studies showed that bilinguals are more prone to make rational decisions when they are working in their L2 rather than in their L1. Thus, when bilinguals face a moral dilemma in their L2, they systematically choose the solution that maximises the overall outcomes, even though this solution may cause certain harm. These findings have been explained as a consequence of (1) reduced access to episodic information, likely due to the cognitive load imposed by L2 processing (Hayakawa & Keysar, 2018), (2) reduced emotional response in the L2 compared to the L1 (Costa et al., 2014), and/or (3) reduced mental imagery with the use of the L2, which makes the scene of a moral dilemma scenario less vivid (Hayakawa & Keysar, 2018). Most interestingly, recent research on moral dilemmas in more naturalistic settings offers similar results (Hayawaka et al., 2021, 2022). For example, Hayawaka and colleagues have shown that people perceived some medical conditions as less distressing in their L1 than in their L2; similarly, they considered the consequences of a treatment or a disease less negative in their L1 than in their L2, modulating the probability of accepting or rejecting preventative treatment. In sum, the so-called foreign language effect (for a recent review, see Del Maschio et al., 2022; Stankovic et al., 2022) is clear proof of how the phenomenon of bilingualism affects bilinguals' thoughts.

To summarise, there is growing interest in studying how bilingualism modulates general cognitive processes and in understanding how the language that a bilingual uses affects everyday activities. Thus, if you are an English–Spanish bilingual in California and must therefore pay attention to your context to be able to use the appropriate language depending on the situation, this implies that in your daily life, you receive extensive practice in observing the environment, detecting cues, and switching between Spanish and English. If we go further, we can think of other daily activities that may also engage these highly practiced processes. Thus, the underlying idea directing the empirical work in this thesis is that there are many similarities between these bilingual situations and other situations in which we engage language and memory, such as the recall of future intentions (prospective memory [PM]). For example, imagine that while you are working, you get a message from your partner asking you to buy bread before dinner. As a consequence, in your "mental post-it notes," you write, "Buy bread!" Later, as usual, you put on your headphones to listen to your favourite podcast while you are walking home.

However, you must also pay attention to the environment to spot the bakery and perform your intention: buying bread. The difficulty of this kind of recall is that we must pay attention to the context to detect when it is the correct moment to perform the intention (i.e., when you see the bakery) and switch from the main activity (i.e., listening to the podcast) to the encoded intention (i.e., buying bread). The ability that allows us to recall these future intentions correctly is called prospective memory (PM). In the following chapter, we summarise the main research on this type of memory, the main theories about the cognitive mechanisms underlying the recall of future intentions, how PM is modulated by individual differences, and the neural correlates associated with prospective processing.

CHAPTER 2.

PROSPECTIVE MEMORY
TO RECALL FUTURE INTENTIONS

Our memory allows us to deal with the past, present, and even the future. For example, retrieving personal information from the past (autobiographical memory) is critical to forming our identity. In the same way, we need to recall facts (declarative memory) and procedures (procedural memory) that we learnt in the past to develop basic life skills. In the present, we also need to use our memory to retain and manipulate any information that we work with until our goal is completed (WM). Moreover, and contrary to what people commonly think, memories not only have to do with past or present moments, but they might also be related to the future. Thus, very frequently, we need to remember to perform a given intention in the future at the correct time or situation.

Memory for future intentions is usually termed prospective memory (PM). Defining PM as a cognitive construct is quite complex due to the multiple sub-domains that it involves. Thus, WM, monitoring and switching, retrospective memory, and even time perception have been suggested to play a role in this type of memory (see Cohen & Hicks, 2017, for a conceptualisation). Nevertheless, there is a consensus among researchers to define PM as the “memory for delayed intentions” (Ellis, 1996) or “remembering to remember/recall” (Schonfield & Stones, 1979; Wilkins &

Baddeley, 1978). These definitions are derived from the main function attributed to this memory, which is to create intentions to be executed in the future (McDaniel & Einstein, 2007). Thus, PM allows for the execution of a self-initiated intention previously encoded at a proper time or moment.

Many of the daily activities that we perform require the engagement of PM. Remembering to take medication at the proper time, turning off the gas after using it, attending an appointment, or paying the rent are only a few common activities that require performing delayed intentions that were previously encoded. Therefore, it is not surprising that failures to recall future intentions make up around 50%–70% of memory problems in everyday life (Kvavilashvili et al., 2001). Furthermore, forgetting future intentions may cause tragic events when it occurs in professional domains, such as aviation or medical surgery (Einstein & McDaniel, 2005). Thus, PM is an essential capacity in our lives, and probably for this reason, in recent decades, the body of research investigating the processes underlying PM has been growing.

In this chapter, we present an overview of the research dedicated to understanding PM, as well as an outline of some terms that are common in PM research and that we will use throughout this discussion. In the following sections, we introduce the main theoretical frameworks that describe the cognitive processes involved in PM and the laboratory paradigms employed to study it (i.e., time-based and event-based PM paradigms). In addition, we discuss the research on intrinsic (e.g., age or WM capacity) and extrinsic (e.g., the nature of the PM cue, effects of intention load, cognitive demands of the task, etc.) variables that modulate PM. Finally, we present a general outline of the neural correlates associated with PM processing and the main findings in this field.

RETRIEVING PROSPECTIVE MEMORIES: THEORIES AND LAB PARADIGMS

As mentioned, PM is inherent in many activities in our daily lives. For this reason, some of the earliest experiments have studied PM in naturalistic settings (Harris, 1984; Kvavilashvili, 1992). However, these naturalistic experiments did not allow for the control of all the possible confounding variables; consequently, experimental procedures and designs were developed to measure PM in the lab (Einstein & McDaniel, 1990). These procedures share common features, such as being focused on the future, self-initiated, and involved in the course of a main activity (i.e., ongoing activity). Moreover, each PM task has specific cues that trigger the retrieval of the prospective intention and indicate the proper time or moment to perform it (i.e., PM cues). Thus, there are two main categories of PM tasks: time-based and event-based.

Time-based refers to PM tasks in which the intention is self-initiated after a certain period. Thus, activities such as taking medication at the proper time or attending an appointment are time-based. In a laboratory version of this type of task, participants are required to respond in a particular way at specific time intervals (for example, every two minutes) while executing an ongoing activity (Cook et al., 2005). Commonly, they are provided with a clock in the peripheral area where the ongoing activity is taking place or with a hidden clock that can be made visible by pressing a button while they complete the ongoing activity. Thus, time-based PM tasks require monitoring the time, which results in clock-checking behaviours (Waldum & McDaniel, 2016). Field studies exploring this type of PM task have extensively used the Virtual Week procedure designed by Rendell and Craik (2000). This task allows for the measurement of PM in clinical and nonclinical populations by developing a weekly planner simulator in which participants have to complete everyday PM activities (Rendell & Henry, 2009). This task also includes day-to-day event-based tasks. Even though early research in this area argued that the self-initiated nature of time-based tasks could result in greater costs in the ongoing activity (i.e., PM interference) (Einstein et al., 1995), later studies signalled that event-based tasks caused greater interference in the ongoing activity associated with implementing a PM intention (Jäger & Kliegel, 2008; Marsh et al., 2006).

In an event-based task, the recall of a future intention is elicited by a specific contextual cue. For example, imagine that today is the birthday of your colleague, whom you want to congratulate at the office. In this case, there is an environmental cue that triggers the recall of the prospective intention. Similarly, many experimental tasks that measure PM under laboratory conditions are designed following this paradigm. Figure 2 shows the typical procedure for a classical event-based PM task (Einstein & McDaniel, 2005). First, participants are engaged in an ongoing task (e.g., a picture-naming task), and after practicing it, they are introduced to the PM intention and told that when the PM cue appears, they must perform the PM task (e.g., "Press the key with the star when a 'ball' appears on the screen"). Once they receive the instructions, participants start performing the ongoing task, and when the PM cues appear, they must stop the ongoing activity and shift to the PM task to accomplish the intention (i.e., the task-switch approach). Sometimes, the procedure differs regarding which participants could be asked to perform both the ongoing activity and the PM intention when the PM cue appears (i.e., the dual-task approach). Importantly, in these procedures, PM trials rarely appear during the task, thus forcing participants to engage in the main activity (i.e., the ongoing task). This specific characteristic of the task is critical because if the PM activity becomes very frequent, participants could view the task as a vigilance task and avoid some essential processes in prospective processing, such as recalling the intention from long-term memory (Brandimonte et al., 2001).

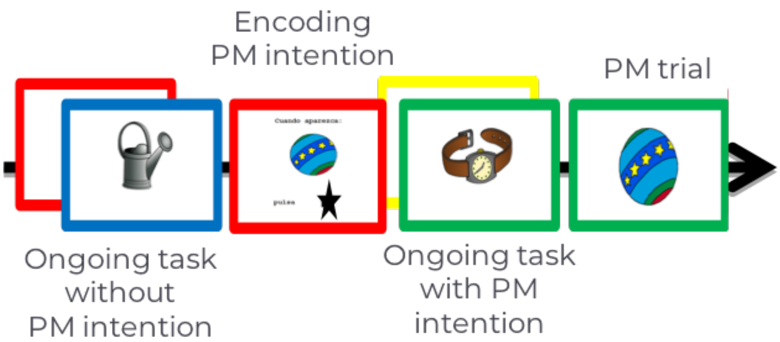

Figure 2. Typical procedure in an event-based PM task.

Interestingly, the design of controlled experimental environments has allowed the exploration of the mechanisms underlying the recall of future intentions and the development of different cognitive theories and frameworks. For example, *preparatory attentional and memory processes* (PAM) *theory* (Smith, 2003) suggests that to perform a prospective intention, people need to implement resource-consuming preparatory processes to search for contextual cues that trigger the recall of the prospective intention. Therefore, this theory claims that some degree of non-automatic strategic monitoring is required during the execution of a PM task. As a consequence, when a PM intention is implemented during an ongoing activity, the performance of this activity should be impaired. Previous studies have supported this argument, showing less accuracy and slower response times in an ongoing task when there is a concurrent PM intention compared to the same ongoing task performed alone (Cohen et al., 2012; Marsh et al., 2003; Park et al., 1997; Rummel et al., 2017). The PAM framework also suggests that some retrospective processes are engaged in successful prospective remembering (see the multinomial model proposed by Smith and Bayen, 2004); however, the main focus is on monitoring and the associated costs.

The assumption that PM always involves monitoring has been extensively debated in the field, resulting in alternative theories that either question the necessary presence of monitoring with the resulting cost or propose mechanisms other than monitoring to explain possible PM costs.

Thus, the *Multiprocess Framework* proposed by McDaniel and Einstein (2000, 2005) claims that monitoring processes during a PM task are not always involved but depend on the type of PM and the ongoing task. In many cases, when participants perform a complex event-based PM task with difficult-to-detect PM cues, they must pay attention to the environment to be able to detect these cues, and once they are detected, they must shift attention from the ongoing task to the PM to be able to recall the intention and execute it. Nevertheless, under some conditions, the intention might be "spontaneously retrieved"; in these cases, prospective recall may occur without cost to the ongoing activity (Brandimonte et al., 2001; Harrison et al., 2014; Rummel et al., 2012; Scullin et al., 2010). This proposal is especially relevant if we think that some PM intentions are significantly delayed in time (e.g., making a call to congratulate a friend on a birthday or remembering to request a medical check-up appointment after a few months), and it is reasonable to think that a less cognitively costly mechanism might be implemented that permits the retrieval of the intention without constant monitoring (Scullin et al., 2010). Thus, they proposed that some prospective actions could be spontaneously retrieved if there is a strong association between the cue and the intention and if the prospective cue is highly salient and easy to detect (Kretschmer-Trendowicz & Altgassen, 2016; Zhang et al., 2021). In these conditions, the intention may be executed through a direct and less effortful retrieval mechanism. Hence, according to this framework, strategic monitoring of the environment may or may not be engaged, depending on different factors.

Recently, the concept that PM does not always involve monitoring costs has been computationally implemented through the use of *race models* (Heathcote & Matzke, 2022). These models (e.g., *delay theory*; Heathcote et al., 2015) try to explain how different cognitive processes co-occur in the completion of a certain task. They assume that the cognitive processes associated with a given response are completed when they accumulate enough evidence to reach a threshold, in which case the response is initiated. For example, delay theory (Heathcote et al., 2015) suggests that instead of sharing cognitive resources to deal with the ongoing activity and the PM task, participants delay the ongoing response systematically to accumulate evidence for the PM response. Thus, PM performance depends on the ability of the participants to adjust the delay in the ongoing response. Whereas a sufficient delay would allow enough time to accumulate evidence supporting a successful PM response, a non-adjusted delay could impair PM performance (Anderson & McDaniel, 2019).

Also based on the architecture of a race model (*linear ballistic accumulator*; Brown & Heathcote, 2008) is the *theory of prospective memory decision control (PMDC*; Strickland et al., 2018), which assumes that ongoing and PM activities usually share common cognitive resources and that PM is therefore usually costly; however, this cost is only evident when the demands of the task overload these cognitive resources, and it becomes necessary to engage cognitive control to reduce the conflict between the two tasks. The PMDC suggests that different control mechanisms for prospective retrieval might be involved: proactive and reactive (*dual mechanism of cognitive control*; Braver, 2012). Proactive control may result in strategic delay of the ongoing responses to avoid conflict with the PM task before this conflict occurs; reactive control may result in retrieval of the PM response combined with inhibition of the ongoing response when the conflict arises. Hence, results indicating that PM entails a cost on the ongoing activity are explained as due to the involvement of proactive and reactive control to permit the execution of the two tasks (ongoing and PM) under highly demanding conditions.

Although these theories are able to explain the usual cost of PM over the ongoing task through different mechanisms (see Rummel & Kvavilashvili, 2023, for a recent review), the *multiprocess framework* (McDaniel & Einstein, 2000) is a theory that has produced and motivated extensive work (their article has been cited around 1,380 times) and provided theoretical support to behavioural and electroencephalographic PM data (Shelton et al., 2019). Therefore, it has been selected as the basis of our studies and predictions. Importantly, part of the work motivated by this framework has shown that the processes required to perform a prospective intention may vary depending on different intrinsic and extrinsic factors. Intrinsic factors such as age or WM capacity, and extrinsic factors such as task demands, have been demonstrated to be important in modulating the monitoring processes involved in PM (Anderson et al., 2019). In the next section, we discuss some of the main findings regarding individual differences in prospective processing and how they are influenced by task features.

INTRINSIC AND EXTRINSIC MODULATING FACTORS

Extrinsic factors, such as the degree of the demands of a PM task, the prospective load, or the nature of the PM cue, are critical variables that have been shown to influence prospective recall. Recently, Anderson et al. (2019) completed a meta-analytic review to identify different task features influencing the cost of monitoring a PM intention. For example, the number of PM cues to be remembered has been shown to be a modulating factor of PM performance, such that no significant cost is found with one or two PM cues, but performance decreases when three or more cues are included in the PM task (Cohen et al., 2008). In addition, the meta-analysis indicated that these findings are modulated by the focality of the PM cue, which refers to the degree of processing coincidence between the ongoing activity and the PM task (McDaniel & Einstein, 2000; see also Einstein et al., 2005). Focal cues are those that share similar processing to the ongoing activity. For example, in a picture-naming task, pressing a key whenever a picture name starts with "t" is considered a focal PM cue. On the other hand, non-focal cues are defined as PM cues that need extra processing because their detection requires processes that differ from those engaged by the ongoing activity. In the previous example, if the ongoing activity consists of picture-naming, a non-focal cue could be the appearance of a red frame. Importantly, as suggested by the *dual pathways model* (McDaniel et al., 2015), the importance of the focality of the cues lies in the type of cognitive processes (bottom-up vs. top-down) engaged to recall future intentions. Thus, focal cues are less costly because the overlap between the ongoing activity and the PM cues generates "spontaneous retrieval" of the PM intention (bottom-up). However, non-focal cues require top-down attentional control processes to elicit the recall of the prospective intention, resulting in a more cognitively demanding type of processing. Notice, however, that although this model suggests that strategic monitoring is required to carry out a non-focal task, sometimes focal tasks also recruit strategic monitoring despite being assumed to usually involve spontaneously retrieval of the intention (for an illustration of this assumption, see Figure 3).

Another important extrinsic factor is related to the type of ongoing task and the cognitive demands that it requires to perform the PM intention. The difficulty of the concurrent ongoing activity is essential to understand the cost of prospective remembering. For instance, previous experiments have manipulated task difficulty by including conditions with different WM loads (Kidder et al., 1997), and they have indicated greater costs under highly demanding conditions compared to low-demand conditions. Interestingly, Meier and Zimmerman (2015) reported data indicating that the load of the ongoing task hindered the processes involved in disengagement from the ongoing activity and the switch to the PM intention. Thus, the difficulty of the ongoing task can impair the detection of the PM cue or reduce the retrieval of the prospective intention.

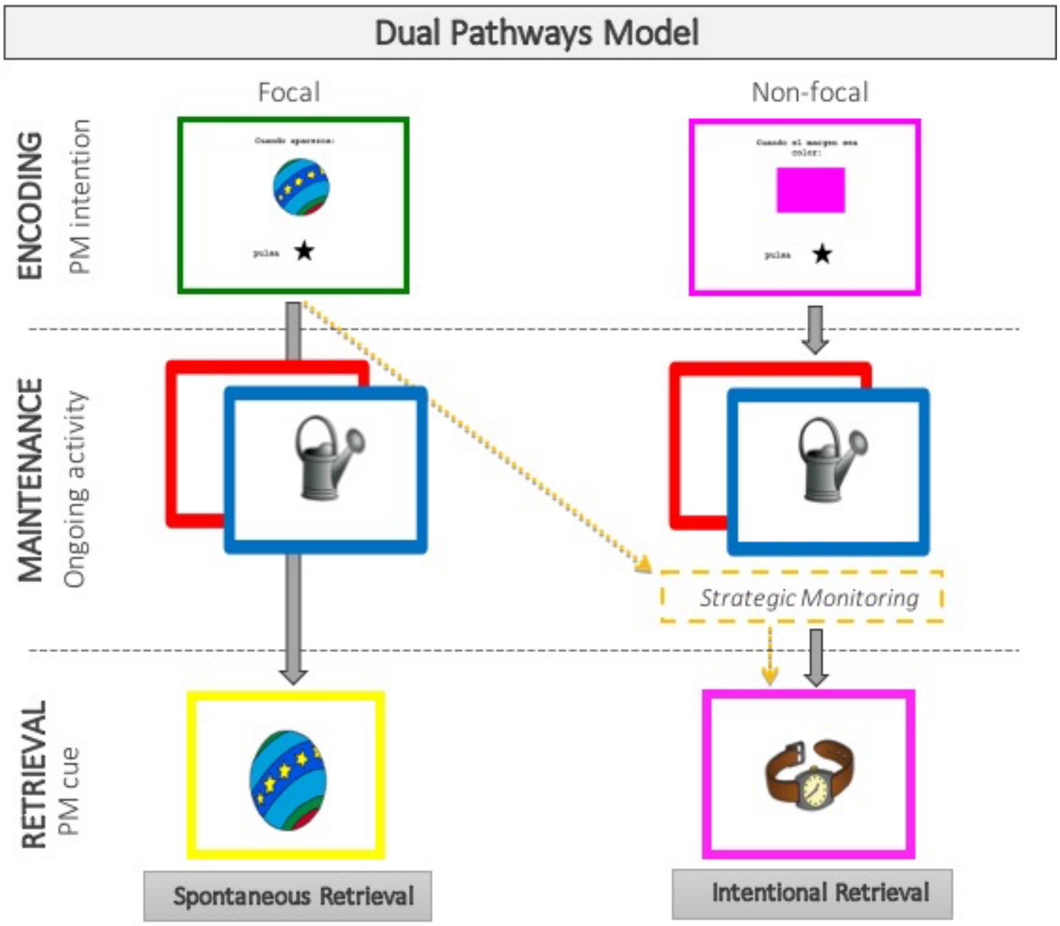

Figure 3. Graphical representation of the dual pathways model proposed by McDaniel et al. (2015). The solid arrows indicate the flow of processing during the phases of the PM task. The yellow lines indicate that strategic monitoring could be recruited even in the presence of focal cues.

To sum up, a large body of research in the field has explored the cognitive mechanisms that underlie PM and its modulating extrinsic factors. Overall, these studies suggest that monitoring processes are required to detect the cue indicating the correct moment to perform the prospective intention. Nevertheless, the monitoring demands of the task can be modulated by characteristics such as the focality of the cue or the different loads of the task (among others). Similarly, the language in which the PM is carried out (L1 or L2) can be a critical factor that modulates the monitoring demands of the task. However, this factor has never been investigated. Given that working in an L2 requires the brain to engage in complex cognitive processes, we hypothesise that PM can also be modulated by the language employed during the task. We investigated this hypothesis as part of our empirical work.

Furthermore, PM, similar to other types of memory, is affected by multiple variables associated with cognitive functioning. Here, we refer to these variables as *intrinsic factors*, understanding them as inherent characteristics of the person that result in cognitive modulations. Thus, individual differences play an essential role when we try to characterise the intrinsic factors that could modulate performance in prospective activities. For example, the influences of WM on PM have been widely studied, although with inconsistent results. While some studies suggest that WM capacity is not relevant for PM (Wang et al., 2013), others indicate that a high WM span is related to better performance in a prospective activity (West et al., 2006). Furthermore, previous studies have found strong associations between updating, shifting, or inhibition and prospective performance (Schnitzspahn et al., 2013; Zuber et al., 2016), thereby revealing evidence of associations between executive functions and PM that has inspired theoretical frameworks that link both abilities, such as the *executive framework of PM development* proposed by Mahy et al. (2014). This approach suggests that the enhancement of executive functioning during childhood underlies the parallel increment of performance in prospective activities. This conception allows us to understand why performance in PM tasks across an individual's lifespan takes the shape of an inverted U with poorer performance at early and late ages. In addition, this idea highlights the importance of studying age as an intrinsic factor that modulates PM.

Interestingly, a large body of literature in the field has explored PM across the human lifespan. As mentioned, studies focusing on the development of PM in children have suggested that during the first years of school, their performance in PM tasks increases due to the maturation of the executive functions. For instance, Spiess et al. (2016) conducted a longitudinal study of school-aged children and found that these functions predicted PM performance. Similarly, Cejudo et al. (2019) studied age differences in a PM task that varied in its monitoring demands. These authors found that members of the 11-year-old group were able to adjust the strategies to the demands of the task and show a smaller cost in the less demanding task condition. However, members of the 6-year-old group failed to modulate their performance as a function of the monitoring requirements of the task. These findings suggest that strategic monitoring develops across childhood and modulates PM performance. Additional studies have also explored the progress of PM during adolescence; however, the evidence is mixed, with some studies observing lower PM performance in adolescents when compared to young adults (Altgassen et al., 2014) and others not showing any difference (Kretschmer-Trendowicz & Altgassen, 2016). A possible explanation for these discrepancies is the variability in the age range of the participants across experiments, which might indicate that PM abilities are established during adolescence.

Similar to studies with adolescents, studies on older adults and PM have shown a different pattern of results that seems to depend on the context in which the PM task is performed. Thus, Rendell and Craik (2000) suggested that older adults exhibit poorer performance than younger adults in lab-based

PM tasks, whereas this pattern might be reversed in naturalistic tasks, with older participants performing better than younger participants (Schnitzspahn et al., 2011). Similarly, evidence for PM age differences is found for tasks with a higher demand for cognitive control, whereas these differences are largely reduced for low-demand tasks (Henry et al., 2004). Although the specific mechanisms underlying these findings are still unclear, factors such as motivation or metacognitive abilities might modulate the age paradox. Also, the type of PM task (i.e., event-or time-based) could modulate these age-related differences (see Laera et al., 2023, for a recent meta-analysis of ageing in time-based PM).

In sum, the literature suggests that the processes involved in completing a PM task are influenced by individual factors, such as WM ability or age. Among these intrinsic factors, being bilingual can be a relevant variable that can modulate PM performance, as bilingualism involves frequent context monitoring, which can also modulate the cognitive processes involved in the selection of the PM cue in a prospective memory task. Consequently, we hypothesise that bilinguals may be more proficient in detecting a suitable cue for executing a prospective intention by monitoring the context.

Although we have thus far discussed the behavioural data supporting the possible impact of bilingualism on PM, in our studies, we take into consideration both the behavioural and neural correlates of bilingual PM performance. Therefore, in the next section, we address the neural markers of prospective processing and the processes with which they have been associated.

NEURAL CORRELATES OF PROSPECTIVE PROCESSING

As previously described, multiple sub-domains are involved in a PM task (see Cohen & Hicks, 2017). From this perspective, an interesting approach to understanding the cognitive mechanisms that support PM is exploring the implications of different brain regions during prospective processing. Hence, during the past decades, a number of studies employing neuroimaging techniques, such as positron emission tomography (PET) or functional magnetic resonance imaging (fMRI), have signalled the involvement of different cerebral regions in PM. For instance, the anterior prefrontal cortex (aPFC) and frontoparietal networks are the main areas activated during prospective processing (Burgess et al., 2001; Beck et al., 2014; Oksanen et al., 2014). However, other brain regions, such as the cingulate, insular area, and temporal or subcortical structures (the thalamus, putamen, caudate nucleus, and cerebellar area), have been shown to be associated with PM performance (for a review and meta-analysis, see Cona et al., 2015, 2016). In Table 1, we summarise the main regions involved in PM and their functional roles (Cona & Rothen, 2019).

However, the low temporal resolution of the PET and fMRI techniques led to the increased use of electrophysiological measures to identify which cognitive processes were specifically engaged in each phase of a PM task. Thus, event-related potentials (ERPs) have been widely used in experimental studies designed to explore the mechanisms of PM. As a result, a set of ERP components has been associated with prospective processes, such as cue monitoring, activity switching, or recall of the intention. Below, we describe these components and the main findings concerning PM tasks (Table 2 presents a summary of the ERP components of PM and the associated cognitive processes).

Table 1. Functional role of main brain regions related to prospective memory.

Anterior prefrontal cortex (aPFC)	▪Retention of PM intentions in the mind ▪Attention to internal intention representations (lateral) ▪Attention to external stimuli in the context (medial)
Dorsal frontoparietal network	▪Strategic monitoring (top-down attention) ▪Time monitoring
Ventral frontoparietal network	▪PM cue detection ▪Spontaneous retrieval (bottom-up attention) ▪Intention retrieval from memory
Anterior cingulate cortex and insula	▪Coordinating conflict between ongoing and PM response
Posterior cingulate cortex	▪Shifting attention from the external PM cue to the internal representation of the intention
Medial temporal regions	▪Spontaneous retrieval of the intention
Other subcortical areas: thalamus, cerebellum, putamen, caudate nucleus	▪Emotion-cognition integration processes ▪Familiarity-based recognition processes ▪Implicit processing of motor intention

Adapted from Cona & Rothen (2019)

Detection of the PM cue, prospective monitoring and switching

The *N300* has been associated with the detection of the PM cue. Typically, this component is defined as a negative deflection of the wave for PM trials compared to ongoing trials at around 300–400 ms in the occipital–parietal region. However, some studies have shown that it could appear earlier in time (i.e., at around 200 ms; West & Ross-Munroe, 2002). Usually, the N300 is accompanied by enhanced positivity across the frontal regions around 300–500 ms, indicating greater positivity for the PM trials compared to ongoing trials (West, 2007). This component is called *frontal positivity* (or

FN400), and it seems to be related to switching processes between the ongoing and PM activities (Bisiacchi et al., 2009). These two components have been found in a variety of PM tasks with different PM cues and ongoing activities (West et al., 2001; West & Krompinger, 2005), suggesting that they are related to general processes to detect PM cues, independently of their physical features or the demands of the ongoing task (West, 2011). However, findings pertaining to the effects of cue salience on these components are still not clear, especially in the N300. Whereas some studies have found modulations of both components to be associated with salient cues (Cejudo et al., 2022; West, 2007; West et al., 2007), Cona and colleagues (2014) did not find any effects on the N300 component associated with processing focal and non-focal cues (see also Hering et al., 2016; West et al., 2003). Interestingly, the N300 has been differentiated from the N200 component. Although the timing and spatial characteristics of both components are very similar, they are supposed to reflect different attentional processes. Whereas the N200 is associated with visual search (Luck & Hillyard, 1994) and visual discrimination (Eimer, 1996), the N300 refers to a specific prospective process that indicates the discrimination of the PM cue. Thus, previous experiments have tested these hypotheses, finding that the N300 and frontal positivity were elicited by PM cues, whereas the same stimulus embedded in a visual search task (e.g., oddball task) elicited an N200 component (West et al., 2003; West et al., 2004).

Retrieval of the intention and updating of working memory

There are other typical components of PM associated with retrospective processes engaged during the recall of the future intention. For example, the parietal positivity component is related to the realisation of delayed intentions (Cona et al., 2014; West, 2011). The parietal positivity is defined as a sustained positivity from 400–1200 ms after stimulus onset in the central, parietal, and occipital regions of the scalp (West, 2008). However, the parietal positivity is composed of at least three ERP subcomponents with specific functions and different temporal distributions: the *P3b*, the *old-new effect*, and the *prospective positivity* (West, 2011). The P3b is a positive deflection over parietal regions around 300–400 ms after the appearance of a target or PM cue. This component reflects WM and context-updating processes (Polich, 2007; West et al., 2003), indicating the monitoring of the future intention during the context of a PM task. Previous studies have shown that incrementing the WM load during the ongoing activity results in a reduced P3b (West & Bowry, 2005; West et al., 2006), whereas the prospective positivity was not modulated by the WM demands of the task. The prospective positivity is characterised by a sustained positivity over parietal regions at 600–700 ms associated with post-retrieval monitoring processes. Even though both components (i.e., P3b and prospective positivity) have been demonstrated to be sensitive to some characteristics of the task, they reflect different neurocognitive processes and are influenced distinctively by the characteristics of the tasks (West & Wymbs, 2004). The third subcomponent, the recognition old-new effect, is a parietal positivity that appears after 400–800 ms and reflects the controlled processes involved in retrieving the intention from memory (West, 2007). Some studies have found that this component elicited a positive wave deflection for recognition and PM hits compared to ongoing trials, indicating the engagement of explicit episodic memory (West & Krompinger, 2005).

Finally, the *frontal-slow wave* component (also called sustained frontal activity; see, for example, Czernochowski et al., 2012) is associated with memory processes engaged in the correct recall of the PM intention; it appears around 400 ms after the stimulus onset and is maintained until 1,000-1,200 ms. The frontal-slow wave has been studied previously in relation to episodic memory and has been found to reflect successful encoding and recollection of an intention (Donchin & Fabiani, 1991; Mangels et al., 2001). However, the nature of this component in the framework of PM tasks is still unclear. Based on early work (West & Ross-Munroe, 2002) that indicated greater negativity for PM hits compared to PM misses, West (2011) characterised frontal-slow waves as a negativity of the PM trials compared to the ongoing trials (Zölling et al., 2010). In contrast, the pattern of results in recent studies has exhibited a greater frontal positivity of PM trials compared to ongoing trials (Cejudo et al., 2022; Cona et al., 2014; Cona et al., 2013; West & Krompinger, 2005). A possible explanation for these mixed findings is the complex nature of the frontal-slow waves. Recently, Hering et al. (2020) signalled the biphasic nature of this component, defining it as a positivity deflection between 400 and 800 ms that turned into a negative-going slow wave from 850 to 1650 ms. Nevertheless, the findings about this component reflect the existence of post-retrieval mechanisms of recollection in a PM task (Hockey & Cutmore, 2021). In line with the Multiprocess Framework (McDaniel & Einstein, 2000), Cona et al. (2014) observed greater frontal-slow waves for non-focal cues compared to focal cues, suggesting effortful retrospective retrieval, as well as the engagement of controlled processes to coordinate the PM and ongoing responses. They suggest that this sustained activity could reflect the engagement of monitoring processes during the task to adopt a “retrieval mode” to actively maintain intentions in memory (Guynn 2003, 2008).

In summary, the study of ERP components disentangles the different cognitive processes engaged in a PM task. As previously mentioned, the aim of this study is to explore how bilingualism can modulate the execution of PM activities. In this context, differences between bilinguals and monolinguals in terms of ERP components related to PM cue detection and monitoring can be critical. Additionally, since some of these components have been shown to be sensitive to task demands, differences between the L1 and L2 are also expected. These hypotheses will be elaborated on in more detail in the next chapter.

Table 2. ERP correlates of prospective processing.

ERPs	PM processes	
N300	Perceptual detection of the PM cue	Detection of the PM cue
Frontal positivity	Switching between ongoing activity and the PM response	
P3b	Monitoring of the intention and updating processes	Retrieval of the prospective intention
Prospective positivity	Controlled processes to retrieve the intention from memory	
Old-new effect	Post-retrieval of the intention monitoring processes	
Frontal-slow waves	Retrieval mode processes	

CHAPTER 3.

PROSPECTIVE MEMORY IN BILINGUALS: AIMS AND OUTLINE OF THE EXPERIMENTAL SERIES

The study of the effect of bilingualism on general cognition has gained relevance in recent decades (Antoniou, 2019; Baum & Titone, 2014; Bailey et al., 2020; Bialystok, 2017; Bialystok & Craik, 2022). Although the first studies focused on exploring cognitive differences between monolinguals and bilinguals in a variety of tasks that involved WM, inhibition, or cognitive control (Costa et al., 2008, 2009; Hernández et al. 2013; Prior & Gollan 2013; Prior & MacWhinney 2010), in the last few years, a common approach to the bilingual phenomenon has been to study the different cognitive outcomes derived from diverse bilingual experiences (De Bruin, 2019; Khodos et al., 2021; Luk et al., 2011; Sabourni & Vinerte, 2018). From this research, we know that bilinguals' language history (e.g., age of acquisition of the L2 and their language contexts) plays an important role in cognition by leaving a unique print on their brains and behaviours (DeLuca et al., 2020; Tao et al., 2021). However, research on this topic has not been limited to this question. Interestingly, the fact that bilingual people engage in daily activities in their first (L1) or second language (L2) raises interesting questions, such as how the linguistic context (L1 vs. L2) in which bilinguals complete a specific activity influences their processing and final performance. Thus, a large body of literature has studied the effects of L1 and L2 processing across a wide range of language (Foucart et al., 2016; Ushiro et al., 2022), memory (Arndt & Beato, 2017; Bialystok et al., 2020; Marian & Fausey, 2006; Marian & Neisser, 2000), and reasoning tasks (Hayakawa et al., 2016, 2017), revealing significant differences between languages. Overall, working in the L2 requires the brain to engage in complex cognitive processes. As a result, previous studies have found that working in the L2 impairs the prediction and updating processes required during text comprehension (Foucart et al., 2016; Kaan et al., 2016; Pérez et al., 2019), prevents source monitoring during retrieval from memory (Calvillo & Mills, 2020; Dolgoarshinnaia & Martin-Luengo, 2021), and modulates moral judgments by reducing emotional decisions (Costa et al., 2014, 2019).

However, the effects of bilingualism the recall of future intentions, have not been investigated. This is surprising, since there are similarities between the context-monitoring strategies that bilinguals must implement to select the correct language in each situation and the monitoring processes required to detect a PM cue in the environment and to perform the prospective intention. Thus, for example, bilinguals immersed in contexts with frequent switches between languages need to monitor contextual cues to facilitate language selection, and these processes might be similar to the processes of cue detection and switching involved in correctly completing a PM task.

In light of the above, the present dissertation focuses on two general aims. Our first objective was to study the possible effects on prospective processing stemming from using two or more languages. Specifically, we aimed to observe the role of the bilingual experience in PM by comparing bilinguals and monolinguals who differed in their linguistic history (Experiments 1 and 2). With the same aim, we explored whether previous practice in language switching transfers to a PM task (Experiment 4). Hence, we not only explored the effect of natural language switching inherent in bilinguals' language context (Experiments 1 and 2), but we also observed the effect of language switching experience by introducing an experimental language switching practice procedure (Experiment 4).

Our second objective was to investigate how monitoring, cue detection, and switching processes are influenced by the linguistic context in which a PM task is performed (L1/L2). Thus, we asked bilingual participants to complete a PM task in their L1 and L2, and we compared their performance in each linguistic context (Experiments 2 and 3).

In addition, in different experiments, we manipulated the monitoring demands of the PM tasks and the nature of the ongoing activity to observe possible differences in PM monitoring processes due to bilingualism. Accordingly, in some experiments, we manipulated the focality of the PM cue (Experiments 1–3), and across experiments, we varied the linguistic nature of the ongoing task (categorisation, text comprehension, and n-back) and its WM demands. Importantly, in most experiments, we implemented electrophysiological measures to observe how bilingualism modulates the neural correlates of the recall of future intentions. Using this EEG technique allowed us to dissociate the effects of the bilingual experience and L2 processing in the prospective and retrospective cognitive processes of PM. Below, we describe the series of four experiments that we designed to accomplish our aims. Each study corresponds with a published article (Experiments 1–3) or to a submitted article (Experiment 4).

The **first experiment** was entitled **"Prospective Memory in Bilinguals and Monolinguals: ERP and Behavioural Correlates of Prospective Processing in Bilinguals"** and has been published in *Brain and Language* (López-Rojas, Rossi, Marful, & Bajo, 2022).

The objective of this study was to investigate whether different bilingual experiences had an impact on the performance of a PM task that varied in its monitoring demands (i.e., using focal and non-focal PM cues). Previous studies have demonstrated that the bilingual experience (i.e., the age of acquisition of the L2 or the interactional language context in which the bilingual is immersed) affects context monitoring (Hartanto & Yang, 2019; Jiao et al., 2019). Thus, in this study, we compared monolinguals, late bilinguals, and early bilinguals, who completed an event-based PM task where the nature of the PM cues (focal vs. non-focal) was manipulated. In addition, the bilingual groups differed in terms of the linguistic context in which they were immersed. Whereas early bilinguals were immersed in a context in which both languages were in constant interaction, late bilinguals used both languages in separate contexts. In this study, we also recorded brain activity to analyse the ERP components associated with this PM task.

We expected that participants' language experience would modulate their performance in the PM tasks, as previous studies had shown a greater ability of bilinguals versus monolinguals to adjust their cognitive control strategies to the task demands (Morales et al., 2013, 2015). As such, we anticipated that bilinguals would demonstrate a greater ability to adapt their responses to the monitoring requirements of the task, particularly with regard to the focality of the cue. Thus, we expected bilinguals to be more efficient than monolinguals in engaging monitoring processes during the PM task, especially in the more demanding non-focal condition. Furthermore, we anticipated that the impact of bilingualism on PM performance would be more noticeable among individuals who became bilingual at an earlier age compared to those who learned a second language later in life (D'Souza et al., 2021). Finally, we predicted differences in the ERP components associated with PM detection and monitoring processing. In particular, we expected differences in amplitudes for PM trials compared to ongoing trials in the N300 and P3b components (West, 2011) as a function of the different variables manipulated in the experiment.

The **second experiment** was entitled **"Prospective Memory in Bilinguals: Recalling Future Intentions in First and Second Language Contexts"** and has been published in *Bilingualism: Language and Cognition* (López-Rojas, Marful, Pérez, & Bajo, 2023).

Experiment 2 aimed to determine whether PM performance was influenced by the language in which the task was carried out (L1 or L2). This distinction is important because the higher cognitive load imposed by working in an L2 can reduce the available resources to process the PM task (Pérez et al., 2019; Horiba & Fukaya, 2015; Yang, 2002).

For this reason, in Experiment 2, we explored potential differences between monolingual and bilingual participants performing a PM task that varied in its linguistic context. To this end, we asked our participants to complete a PM task in their L1. Additionally, bilingual participants completed the same task in their L2. Thus, we compared monolinguals' and bilinguals' performance during the recall of future intentions in L1, as well as bilinguals' task performance in their L1 versus L2.

In this study, we were specifically interested in observing whether monitoring and switching processes were modulated by the language (L1 or L2) in which the task was performed. To achieve this aim, we adapted the text comprehension task developed by Pérez, Cain, Castellanos, and Bajo (2015) to create an ongoing PM task of a linguistic nature. This new task allowed us to manipulate the linguistic difficulty of the ongoing activity and to generate an activity that was similar to certain linguistic contexts into which bilinguals might be inserted in their daily life. We also manipulated the PM cues' monitoring requirements (focal vs. non-focal cues).

Based on previous studies (Morales et al., 2013, 2015), we expected an overall better performance of bilinguals compared to monolinguals, especially in the more challenging conditions of the task. On the other hand, looking at the comparison between bilinguals' performance in their L1 and L2, we anticipated a general impairment during the costlier L2 processing (Pérez et al., 2019; Horiba & Fukaya, 2015; Yang, 2002) in both the ongoing activity and in the detection and execution of the PM intention.

The **third experiment** was entitled **"ERP and Behavioural Correlates of Prospective Memory in Bilinguals during L1 and L2 Processing"** and has been published in *Brain Sciences* (López-Rojas, Csilinkó, Bajo & Marful, 2023).

In Experiment 3, we registered EEGs (as in Experiment 1) to explore the neural correlates of PM in bilinguals during L1 and L2 processing (as in Experiment 2). We used this technique to unravel the underlying cognitive mechanisms involved in PM when working in a less dominant language. Since monitoring and switching are the main cognitive processes required to successfully implement the PM intention (Bisiacchi et al., 2009; Scullin et al., 2015), we studied how their neural correlates are affected by the linguistic context in which the recall of future intentions took place. With this aim, bilingual participants were asked to perform a PM task in both their L1 and L2. Similar to our previous studies, we manipulated the monitoring requirements of the PM task (focal and non-focal) to observe the effect of the attentional demands, and we analysed the N300 and P3b ERP components to observe potential neural changes elicited by dealing with the recall of future intentions in an L2 (see Cona et al., 2014; West, 2007; West et al., 2003).

Overall, we expected to find poorer behavioural performance when participants completed the task in their L2 compared to their L1. As we hypothesised in Experiment 2, working in a less dominant language imposes additional cognitive demands that may result in fewer cognitive resources being available to perform the PM task (Horiba & Fukaya, 2015; Pérez et al., 2019; Yang, 2002). This effect should be more evident in the condition where more monitoring is required (non-focal cues). On the other hand, for L1, we expected larger N300 and P3b in the more demanding non-focal condition compared to the focal condition. However, in the L2 context, we expected two possible results: 1) the differences in amplitudes between monitoring conditions would be reduced due to greater difficulty in adjusting their monitoring processes because of the cognitive overload imposed by the L2, or 2) larger amplitude differences between focality conditions, reflecting the need to engage more cognitive resources to both process the L2 and complete the PM intention.

The **fourth experiment** was entitled **"Exploring the Effect of Language Switching Practice over Prospective Memory in Bilinguals"** and has been submitted to *Cognition* (López-Rojas, Marful, & Bajo).

In Experiment 4, we approached the question of how language experience influences the recall of PM intentions by introducing a training procedure. Specifically, we aimed to explore whether practicing switching between languages can affect the processes engaged to complete a PM task. This idea was motivated by previous studies that observed that bilinguals immersed in a context where both languages are used in interaction (mixed/dual-language context) and who switch frequently between languages are more efficient at adjusting their cognitive control strategies than those immersed in contexts in which the languages are used separately (single-language context) (Beatty-Martínez et al., 2020; Hartanto & Yang, 2016). In addition, several studies have explored the effects of specific training in language switching on other domain-general cognitive tasks, finding a benefit of language-switching practice regarding monitoring or inhibition (Liu et al., 2019; Timmer et al., 2019).

Given that language switching has this beneficial effect on cognitive control capacities, we hypothesised that if bilinguals immersed in a single-language context received training in language switching, they would improve their performance on tasks that require monitoring and switching, such as the PM tasks. Specifically, we expected this beneficial effect in the PM task to be limited to the processes that resemble the language-switching task (i.e., PM cue detection and switching from the ongoing to the PM trials).

Thus, in the fourth experiment, we selected bilinguals immersed in a single-language context. Half of them received brief training in language switching prior to completing a PM task (switching group), whereas the other half did not (control group). As mentioned, we expected an effect of training in detecting the PM cue and switching from the ongoing to the PM trials. However, because these processes are prospective in nature, we expected that the retrospective processes associated with updating and retrieving the intention from long-term memory would be less influenced by this manipulation. Thus, regarding the prospective components (i.e., N300 and frontal positivity), we anticipated greater differences in amplitudes between ongoing and PM trials in the switching group when compared to the control group. However, for the retrospective components (i.e., P3b and frontal-slow waves), we did not expect differences between the groups.

Altogether, the general questions posed in this dissertation regarding the effects of bilingualism and L2 processing on prospective memory generated a variety of specific questions that we addressed individually in our experiments. In the next four chapters, we address these different questions and discuss the results of the experiments designed to address them. These chapters are intended to develop new knowledge on how the bilingual brain is modulated by the linguistic context and to discover whether and how language experience affects the recall of future intentions.

PART II

EXPERIMENTAL SECTION

CHAPTER 4.
EXPERIMENT 1

The **first experiment** was entitled **"Prospective memory in bilinguals and monolinguals: ERP and behavioural correlates of prospective processing in bilinguals"** and has been published in *Brain and Language* (López-Rojas, Rossi, Marful & Bajo, 2022).

ABSTRACT

Prospective memory (PM) allows us to form intentions and execute them in the future. Successful retrieval of prospective intentions depends on adequate context monitoring and disengagement from the ongoing task. These processes are also central in predicting incoming language information and guiding language production in bilinguals. We investigated if different bilingual experiences (early/late bilinguals, monolinguals) modulate performance in PM tasks that varied in attentional requirements (focal vs. non-focal). Behavioural and event-related potential (ERP) results indicated that early bilinguals differed from late bilinguals and monolinguals in how they performed the prospective task. Specifically, they showed larger differences between the ongoing activity and the prospective task in the N300 and P3b components when performing the more difficult non-focal PM task, indicating that they engaged in monitoring/updating to adapt to the task's demands. These differences were not observed in late bilinguals and

monolinguals, suggesting that prospective processing is dependent on the bilingual experience.

Keywords: prospective memory, focality, monitoring, ERP, bilingualism, language control, bilingual experience, N300, P3b

INTRODUCTION

Planning and remembering future events are essential processes in everyday activities. Prospective memory (PM) allows us to create intentions and execute them in the future. Although there are different approaches on how PM tasks are performed (Hohwy, 2013; Vecchi & Gatti, 2020), executing the intention in the right moment involves monitoring the context for the time or the target cue that indicates when the intention should be implemented and switching from the ongoing task to the prospective task to execute the prospective action in the appropriate moment (Scullin et al., 2015). Therefore, PM requires the successful involvement of executive functions such as monitoring and switching to prepare for a given task and to avoid incoming interference. In PM literature, monitoring processes reflects the strategic allocation of attentional resources required to detect a target cue (Ballhausen et al., 2017), whereas switching processes refers to the disengagement from the ongoing activity to remember the intention in a PM task (Cona et al., 2015). Thus, PM is usually assumed to be composed by prospective components including context monitoring, cue detection and switching and a retrospective component which includes actual remembering of the intention (McDaniel & Einstein, 2007). These Prospective processes are used daily to remember intended critical actions such as taking medication, getting to an appointment, or giving a message to a friend at the proper time (PM). However, prospective processing occurs in very different contexts and over different cognitive operations and type of intentions. This prospective processing refers to proactive cognitive control strategies involving monitoring the context and preparing for an incoming event (Lamichhane et al., 2018).

For example, in the language context, prospective processing has been proposed as central in predicting incoming language information and in directing language production. In the context of bilingual language comprehension and production, prospective processing has also been proposed as a mechanism that facilitates language selection in bilinguals (Wu & Thierry, 2017). This prospective processing is especially important because many studies have shown that bilinguals co-activate their two languages, even if only one language is required (Blumenfeld & Marian, 2007; Dijkstra, & Kroll, 2005; Hoshino & Thierry, 2011; Kroll & Stewart, 1994; Macizo et al., 2010). As a result, bilinguals need to negotiate their languages to avoid competition and select the more appropriate language for a given context (Morales et al., 2013; Morales et al., 2015). Recent research has shown that bilingual language selection is, in part, subserved by prospective processing of the environment for contextual cues to use the appropriate language. For example, visual cues such as the sociocultural identity of a face (Asian facial features versus occidental features; Li et al., 2013) or previous face-language associations (Woumans et al., 2015) have been shown to facilitate processing of the more expected language in the presence of the contextual facial cue. Similarly, bilinguals seem to adapt more easily to between-language switching when the presence of a bilingual person cues a bilingual context than when the presence of a monolingual person cues the use of a single language. For example, in a recent experiment by Kaan et al. (2020), Spanish-English bilinguals were asked to read sentences with and without between-language switches when they were in the presence of another Spanish-English bilingual or of an English monolingual. Their electroencephalograms (EEGs) were recorded while reading, and event related potentials (ERPs) were locked to the critical point where language switched. Results showed that the early fronto-central positivity elicited by language switching was attenuated when a bilingual was present at the start of the study compared to when a monolingual was present. Hence, bilinguals monitored the context in a prospective manner to prepare for the appropriate language.

The concept that bilinguals activate their two languages and use executive control mechanisms, including monitoring and prospective preparation for language use, raises interesting questions regarding their performance in other prospective tasks. Context monitoring for bilingual language selection should be similar to monitoring in PM, and thus, one might expect that bilingualism would modulate the cognitive processes that emerge during prospective remembering. Hence, one might hypothesize that bilinguals might be better at monitoring the context to detect the appropriate cue to perform the prospective intention (Jiao et al., 2019a).

A factor that can affect monitoring in bilinguals is the environment in which they are immersed (i.e., their recurrent pattern of conversational exchanges). Thus, for example, monitoring demands may vary greatly depending on the interactional language context in which bilinguals are immersed (Green & Abutalebi, 2013). From this perspective, bilinguals immersed in a context where two languages are at competition (e.g., talking to some persons in L1 and to others in L2) will need to monitor the context to a greater extent and will be more vulnerable to conflict than bilinguals that recurrently and freely switch between languages within the same utterance, who would use their languages in a more cooperative way. Consequently, it is possible that, due to the differences in language control demands, bilinguals that interact in language settings with different monitoring requirements will also adjust their monitoring capacities in a PM task. Similarly, if the age at which the bilinguals acquired their second language (L2) modulates how they control their languages, it might also influence the strategies that bilinguals use to monitor the context in a PM task (Luk et al., 2011). Age of acquisition of L2 has been demonstrated to play a critical role in the cognitive effects associated to bilingualism with longer active bilingual practice promoting adaptive transfer from language control to domain-general cognitive control (Bonfieni et al., 2019; Hartanto & Yang, 2019). For example, D'Souza et al., (2021) found that early age of acquisition was related with higher ability in change detection in adults. In addition, neuroimaging studies indicate that the age of acquisition of L2 affects the temporal and topological properties of the language network (Liu et al., 2020). Although the processes which support these cognitive differences are not clear, and they might be task depent (De Bruin, 2019), the effect of bilingual experience over prospective memory seem to be more evident in early than late bilinguals.

Thereby, the goal of this study was to investigate how monitoring skills during a PM task are modulated by differences in the bilingual experience. Towards that goal, performance during a PM task was compared between a group of early English-Spanish bilinguals from Southern California (USA) who acquired their two languages during childhood (early bilingual group) and a group of late Spanish-English bilinguals from Granada (Spain) who acquired their L2 (English) during adolescence/adulthood (late bilingual group). This group of speakers were immersed in a Spanish context but used English daily in certain contexts. We compared these two extreme groups of bilinguals differing in interactional context and language experience to maximise between group differences. Hence, the two groups not only differed in age of acquisition, but also frequency of language use, switching behaviour and context, etc., although all participants were selected to have native-like language scores in their weaker language (see Table 3). We termed the two groups as early and late bilinguals to stress one of the main features in which they differed.

Critically, the nature of the PM task was also manipulated to increase or decrease the monitoring demands. Recent research suggests that the monitoring demands of the PM task depend on the focality of the cue signalling the prospective task. Importantly, focal and non-focal cues differ to the extent to which the processing of the cue engages the main features of the ongoing activity (Kliegel et al., 2008). An example of a focal PM task would be the following: participants receive instructions to name famous faces out loud when presented on a screen (ongoing task), while they are also instructed to stop naming out loud when the name starts with a given letter (e.g., the letter "B") and instead, press a key. For example, the face of Brad Pitt (the name starts with "B") is considered a focal cue because naming this face is involved in both the ongoing activity and processing of the prospective cue (start with "B"). In contrast, during a non-focal PM task, the cues in the main features of the PM cue are different than those of the ongoing activity. Taking the previous example: if participants are asked to stop naming out loud when the face on the screen wears glasses, the glasses represent a non-focal cue, since the identification of a face with glasses differs from the ongoing activity (naming faces), and since this critical feature differs from the operations needed to perform the ongoing activity (wearing glasses is not important for face naming). The manipulation of the focality is theoretically important since it has been proposed that the focality of the PM cues might induce different types of prospective processes. According to the multiprocess framework (McDaniel & Einstein, 2000) very salient or focal cues elicit a "spontaneous retrieval of the intention" without costly monitoring or retrieval (Einstein & McDaniel, 2005; Scullin et al., 2015). As such, non-focal cues, compared to focal cues, require more attentional prospective processing resulting in more difficulty and lower accuracy rates (Cona et al., 2014; McDaniel et al., 2015). We therefore predict that differences in language control due to differential bilingual experience will interact with the focality effect in a PM task, since non-focal cues are more demanding on context monitoring than focal cues, and bilinguals will have to adapt to the monitoring requirements of the task. This focality manipulation is important because recent research suggests that processing differences between bilinguals and monolinguals usually arise in more demanding conditions (Jiao et al., 2019b).

The neurocognitive mechanisms of PM have also been explored by looking at different ERP components (West, 2011). Specifically, the detection of the prospective cue has been associated with the N300 component, a negative deflection that is observed in a 250–500 ms time period after presentation of the prospective cue, detected mostly in parietal-medial and parieto-occipital scalp regions. This negative deflection is elicited by the PM cue in correct PM trials and differs from the relatively less negative response in correct ongoing trials (Cona et al., 2014). In addition, this component is usually accompanied by a positive deflection (P3b) to correct PM trials in central-parietal electrodes, with an onset of 300–400 ms and up to 600–800 ms after presentation of the PM cue and relative to ongoing trials. Studies suggest that the P3b is elicited by stimuli that work as targets or PM cues, reflecting the activity of processes related to working memory and context updating (Polich, 2007; West et al., 2003), and therefore, it is also considered as signalling monitoring within the PM context. We focused on the N300 and P3b ERP components because previous PM studies have related them to cue detection and monitoring, the prospective processes underlying PM (West, 2011). Other ERP components such as the frontal positivity (FN400, a positive deflection occurring between 300 and 500 ms after PM cue onset), the later parietal positivity (400-800 ms after PM cue presentation) or the prospective positivity (sustained parietal positivity between 400 and 1200 ms after PM cue onset) have been linked to the retrospective components linked to the noticing of the cue and retrieval of the intention (FN400 and parietal positivity), or to task reconfiguration (prospective positivity) (e.g., West & Krompinger 2005; West et al. 2006; West, 2011), and therefore, they were not the focus of our research. The N300 and P3b, on the other hand, have been shown to be sensitive to the distinctiveness, salience and focality of the PM cue (Donchin & Fabiani, 1991; Jie et al., 2021), and this feature is especially relevant in this study where we manipulated the focality of the PM cues.

Thus, in this study, we aimed at observing whether different bilingual experiences had an effect on the performance of a PM task that varied in monitoring demands (focal or non-focal tasks). To this end, monolinguals, late and early bilinguals performed an event-based task in which the nature of the PM cue (focal vs. non-focal) was manipulated. The neural activity was recorded to investigate the ERP components associated with prospective processing in PM tasks, and bilingual and monolingual brain activity as a function of the cue conditions (focal and non-focal) were compared (Cona et al., 2014; Cona et al., 2015).

Overall, we expected to observe better behavioural performance in focal compared to non-focal cues due to the more demanding monitoring conditions of the latter (McDaniel & Einstein, 2000). In addition, as other studies have shown (Cona et al., 2014; West, 2011; West et al., 2003), we also expected non-focal cues to elicit greater EEG amplitude differences between PM and Ongoing trials for the N300 and P3b components since they have been associated with prospective cue detection and monitoring processes. Hence, they would reflect the different prospective processing associated with both types of cues (McDaniel et al., 2015). The focus on these components will allow us to observe whether early and late bilinguals and monolinguals differ in the way they confront the monitoring demands of the PM task. In general, we expected the language experience of the participants to modulate PM performance such that bilinguals would better adjust to the monitoring demands of the task (focality of the cue) and adjust their strategies to the focality of the cue to a greater extent than monolinguals. This prediction will be in agreement with theoretical positions suggesting that the locus of differences in executive control between monolinguals and bilinguals lies in their capacity to regulate processing across a variety of task demands (Hilchey & Klein, 2011; Morales et al., 2013). Hence, we expected that bilingual would adjust their monitoring strategies to the contextual demands, and that possible differences between monolinguals and bilinguals might be more evident in the more demanding non-focal condition (Jiao et al., 2019b). In addition, we also expected this adjustment to vary depending on the bilingual language experiences (early and late bilinguals). Previous research has shown that early active bilingualism promotes greater transfer to domain-general cognitive control (Bonfieni et al., 2019; D'Souza et al., 2021; Hartanto et al., 2019), and therefore, we expected that the effects of bilingual experience over PM performance would be more evident in early than late bilinguals.

Furthermore, we expected that these differences would be reflected on differences in amplitudes for N300 and P3b between the type of trials and cue focality. Thus, we expected that N300 and P3b differences in amplitude between Ongoing and PM trials would be larger in monolinguals than bilinguals, indicating more efficient prospective processing in the bilinguals. Furthermore, we expected that these processing differences would be more evident in the non-focal condition. Thus, for both, N300 and P3b components, our monolingual group should show greater amplitude differences between PM and Ongoing trials for the non-focal than focal cues due to the more demanding monitoring processes engaged to detect non-focal cues. More importantly, we predicted that these differences might be reduced for bilinguals and more so for the early than late bilingual groups.

METHODS

Participants

This study has been approved by the Research Ethics Commission of the University of Granada (registration number, 84 / CEIH/2015). A sample size of 78 was required to obtain 95% power to detect a Cohen's effect of f = .40. This value is considered a large effect size in Cohen, (1969) and it corresponds to η^2= .14. based on the G*power analysis program (Faul et al., 2007) of a 3 x 2 x 2 mixed ANOVA. A total of 80 right-handed adults participated in this study (19 men; mean age = 21.9, SD = 2.6), and 30 were in the monolingual group, 29 in the late bilingual group, and 21 in the early bilingual group. Table 3 reports sociodemographic characteristics and language competences in this sample. The participants from the monolingual and late bilingual groups were recruited from the University of Granada. The participants in the early bilingual group were recruited from California State Polytechnic University (California). Participants in the two bilingual groups had Spanish as their mother-tongue first language (L1) and English as their secondly acquired language (L2). Early bilinguals were those who had acquired English fluency during childhood, whereas late bilinguals acquired fluency in English during adolescence or adulthood. The monolingual participants were native Spanish speakers who were not proficient in any other second language. Participants completed a sociodemographic questionnaire, from which basic personal information (gender, date of birth, illnesses, etc.) was obtained. Participants also completed the LEAP-Q (Marian et al., 2007) to obtain the history of language use of the bilinguals, including age of acquisition of the different languages, linguistic experiences with them, their self-evaluation of their

proficiency in their L1 and L2, the frequency of use, and the frequency of language exposure and language switching. In addition, to assess the participants' proficiency in their less frequently used language we included objective measures: The Michigan English Language Institute College Entrance Test (MELICET) for the monolinguals an late bilinguals, and the Diploma of Spanish as a Foreign Language (DELE) for the early bilinguals. Only participants who obtained direct scores of 35 or more out of 50 in the questionnaire were selected into the bilingual groups. Previous studies indicate that native speakers usually obtain scores in the 36-49 range (Kaan et al., 2020), and therefore, our participants were selected to have native-like proficiency. Those who scored 25 or less were classified as monolingual (monolinguals: M=19.19, SD=4.65; late bilinguals: M=39.72, SD=4.06; early bilinguals: M=41.76, SD=3.94; comparisons between groups indicate significances differences ($p < .05$) only for monolinguals group) (see Chun & Kaan, 2019; Contemori & Tortajada, 2020; Torres & Sanz; 2015). Table 3 reports a summary of the average scores provided by the different groups of bilinguals in the questionnaire LEAP-Q (Marian et al., 2007). Inspection of this Table indicates that early and late bilinguals differ not only in the age at which they acquired language fluency in English, but also in language exposure, language preference, feeling of language competence etc. Correlational analyses indicated that all these variables highly correlated with each other
($p_s > .05$).

Psychology students received course credits, while the remaining participants received € 21 or 20$ for their participation. All participants gave written informed consent.

Table 3. Background information for the monolingual, late and early bilingual groups. Asterisks (*) means differences (p <.05) between the three groups. When the asterisk is located in a specific mean of a group indicate that the difference is significant (p <.05) only for these groups with respect to the others.

	Monolinguals	**Late bilinguals**	**Early bilinguals**
Exposure to English*	10% (7.76)	18% (9.57)	60% (13.66)
Exposure to Spanish*	86% (9.79)	76% (15.23)	40% (13.11)
Preference to speak in English*	8% (12.27)	36% (21.15)	62% (18.88)
Preference to speak in Spanish*	82% (22.63)	51% (26.03)	38% (18.72)
Predominant language during instruction	Spanish	Spanish	English
Age (years)	22.6 (3.04)	21.4 (2.52)	21.1 (1.85)
Level of education	University	University	University
Years of education	19.63 (3.31)	18.24 (2.13)	15.9 (1.39)*
Age of English Acquisition (years)*		6.47 (2.76)	3.64 (1.39)
Age of English fluency (years)*		15.35 (4.13)	6.54 (3.24)
Self-competence in English (from 0-10)*		8.05 (.97)	9.21 (0.77)
Frequency of failures remembering English words (from 0–10)		5.15 (2.15)	4.14 (3.14)
Frequency of language switching (from 0-10)*		4.35 (2.43)	6.78 (3.12)

Design

The experiment employed a 3 x 2 x 2 mixed factorial design using groups (monolingual, early, and late bilinguals) as a between subject factor variable and focality of the cue (focal, non-focal) and type of trial (ongoing, PM) as within subject factors.

Procedure

The tasks were carried out in well-lit, individual rooms that were isolated from external noise. The study consisted of two sessions of approximately 90 minutes each. There was a time interval of one week between each session. Part of this sample took part in a larger individual differences study from which other non-overlapping findings had been already reported (Aguerre et al., 2020). For this study, however, we focused on the PM task performed in the second session.

PM task. Participants performed a PM task while EEG brain activity was recorded using an EEG. We employed the PM task used by Cejudo et al. (2019). This task has the advantage of producing high levels of performance which is ideal for subsequent EEG analyses (very few trials are eliminated due to erroneous responses). The PM task consisted of three blocks of trials (see Figure 4). In the first block, participants were asked to practice the ongoing activity by itself which consisted of a categorization task with pictures. They were instructed to press the "yes" key when the picture presented on the screen was an animal and the "no" key in all other cases. In the second and third blocks, the participants had to also perform the ongoing activity, but they were also asked to implement the prospective intention. The prospective cues were either focal or non-focal. In the focal condition, participants had to press the "k" key whenever the picture of a ball appeared and the "l" key when presented with the picture of a kite. These cues were considered focal because they were part of the features of the ongoing activity (identifying the contents of the picture) and thus, were within the focus of attention of the participant. In the non-focal condition, participants were asked to press "k" when the frame bordering the screen was magenta and "l" when it was grey. These cues were considered non-focal because participants did not need to focus on the colour of the frame when performing the ongoing activity. For both focal and non-focal cues, participants were asked to interrupt the ongoing activity and execute the prospective intention when the cues were presented. Trials where the prospective cues were presented will be referred to as “PM” because they correspond to the PM task. In the results section, the trials with no prospective cues where the participants performed the ongoing activity, will be referred to as “ON”. The focal and non-focal blocks were counterbalanced, while the block in which the ongoing activity was performed by itself was always done first since trials in this block were mainly practice trials. For the stimulus materials, we used 65 images from Rossion and Pourtois (2004). Each image appeared twice during the three parts of the experiment. Images were centred on the screen and surrounded by a 15-pixel colour frame, which was randomly changed for each trial (red, blue, green, or yellow). Each block in both the focal and non-focal conditions consisted of 300 trials of the ongoing task and 30 trials in which prospective cues were presented for participants to perform the intention. Each trial presentation was established to be between 1600–2800 ms. If participants responded after 1600 ms, the subsequent trials occurred after an interval between stimuli (ISI) of 250 ms. However, if participants responded before 1600 ms, a black screen was presented up to 1600 ms, followed by the ISI. In cases where the participants did not respond before 2800 ms, the ISI appeared. The task described in this section were carried out on a computer using the E-Prime 2.0 software.

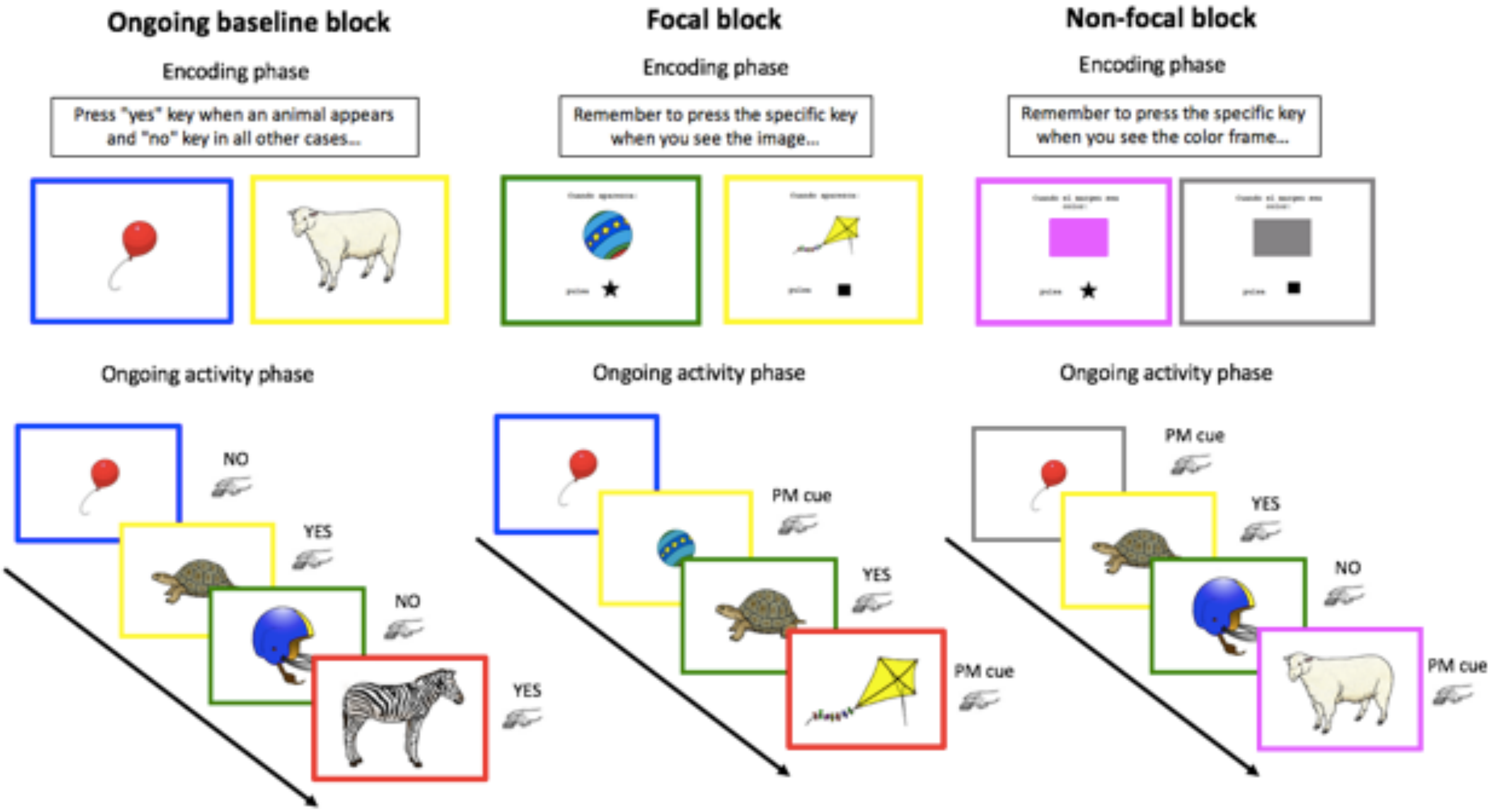

Figure 4. Example of a trial sequence for each block: ongoing, focal, and non-focal blocks. Each block was composed of an encoding phase followed by an ongoing activity (ongoing block) or by an ongoing activity where focal or non-focal PM trials were interleaved (focal and non-focal block, respectively).

EEG recording and pre-processing. For the monolingual and late bilingual group, the EEG data was recorded using the Neuroscan Synamps2 (El Paso, TX) and 40 Ag/AgCl electrodes distributed on the scalp. The EEG for the early bilingual group was recorded using an actiCHamp amplifier (Brain Products GmbH, Munich, Germany) with 32 Ag/AgCl electrodes distributed on the scalp. The data processing was performed with EEGLAB 14.1 (Delorme & Makeig, 2004), running in a Matlab environment (Version 7.4.0, MathWorks, Natick, MA, USA). We imported the files from Brain Vision Software and integrated data from the two systems by using the EEGLAB "bva-io" plugin (available at http://sccn.ucsd.edu/wiki/EEGLAB_Extensions_and_plug-ins). Moreover, we used the same coordinates to match the electrodes from the systems (see Bergmann et al., 2015; Bice & Kroll, 2019 for other studies using different systems across different bilingual groups). Except for this difference, the rest of the EEG recording parameters and off-line processing was identical for the three groups. Two pairs of bipolar electrodes were placed vertically and horizontally to record eye movements. The EEG analogue signal was amplified and digitised at a sampling frequency of 1000 Hz. The impedances of the electrodes were maintained at <10 kΩ during recording. The ground electrode was placed along the midline in front of the Fz position. All electrodes were referenced off-line to the average of both mastoids. The EEG data was bandpass filtered between 0.5 and 1000 Hz during online recording. Also, a high pass filter of 0.1Hz and a low-pass filter 30Hz were also applied offline to the data. Moreover, we applied a notch filter to clean the electronic noise in the signal. For the groups tested in Spain the filter was of 50Hz and for the group tested in the USA the filter was 60Hz. Artefacts were also removed through visual inspection. Thus, channels with a high level of artefacts were detected by careful visual inspection and interpolated from neighbouring electrodes. The temporal windows were located at the appearance of the stimulus, that is, when the cue appeared. The times for the ERP analysis were a 200 ms pre-stimulus period used as a baseline correction and 1200 ms of post-stimulus activity. Artefact correction was done using the independent component analysis (ICA) toolbox in EEGLAB for semi-automatic artifact removal. The epoch rejection was performed with a cutoff of ± 100 μV (< 25% per participant). The number of epochs used for analyses was similar for the different conditions (59, 57 and 55 for the focal trials in the monolinguals, late bilinguals and early bilinguals, respectively. For the non-focal trials these values were 60, 57 and 54, respectively).

Data analysis

Behavioural analyses

Accuracy and response times in the PM task were analyzed. First, we filtered the data following the criteria used by Czernochowski et al. (2012), that is, RTs faster than 200 ms and participants with accuracy scores greater than three times the interquartile range were removed from the analyses. This resulted in the removal of five participants (three participants from the late bilingual group and two from the early bilingual group).

All these analyses were carried out on the ON and PM trials for each focality condition in each group. To ensure the same number of trials in each condition and to reduce variability due to changes in attention across the experimental session, we only selected the ON trials that appeared before the PM cue. Thus, for each PM trial (a total of 30), the previous ON trials (30) were considered for comparison (see Cejudo et al., 2019 for a similar procedure). Thus, we performed 3 x 2 x 2 mixed factorial ANOVA with group (monolingual, late bilingual, and early bilingual), cue focality (focal vs. non-focal) and type of trial (ON vs. PM) as independent variables. When appropriated, Bonferroni correction for multiple comparisons for post hoc tests was applied.

The order of presentation of focal and non-focal conditions was analysed, and there were no differences due to the order of presentation (p_s > .05), and therefore, this variable would not be considered any further.

Electrophysiological data analysis

To explore ERP modulations as a function of task, focality, and group, we selected two time periods that have been associated with prospective components in previous PM studies (Cona et al., 2014; West et al., 2006). For each of these components, we explored ERPs for hits in PM and ON trials. Thus, to study the N300 component associated with cue detection, we selected the 175–300 ms time window over the centro-posterior regions (West, 2011). As mentioned, the N300 refers to the reduction in amplitude observed in central-posterior electrodes upon presentation of the PM cue and relative to ON trials. In addition, the P3b component associated with working memory (WM) updating upon cue detection was registered at 300–400 ms in posterior regions (West, 2011; West et al., 2003)[1]. Besides, prior to the actual analysis, non-parametric cluster-based permutation analysis as implemented in the Fieldtrip Matlab toolbox software (Oostenveld et al., 2011) was performed to identify the electrodes for each time window that maximised the differences between the PM and ON trials. An advantage of this procedure is that the selection of a particular region of interest (electrode cluster) is defined in a data-driven manner and not based on the sometimes inconsistent Regions of

[1] Note that these two components that usually appear in studies exploring prospective memory need to be dissociated from the attentional P200 that occurs at 200-300 ms intervals at fronto-central electrodes. Inspection of Figure 5, indicates that the earlier 175-300 ms interval the PM produced more negative amplitudes than the ON trial, and the positive deflection of PM relative to ON trials occurred at a later interval.

Interests (ROIs) from previous studies or by assumptions regarding the sampling distribution under the null hypothesis. Results of these analyses indicated that electrodes CP3, CPZ, CP4, P3, PZ, O1, OZ, and O2 yielded significant differences ($p < .05$) for 175-300 ms intervals. For the 300–400 ms time window, the cluster included the electrodes CP3, CPZ, P3, PZ, O1, OZ, and O2 ($p < 0.05$). Hence, these electrodes correspond to the usual posterior site of the N300 and to the parietal site of the P3b.

For each ERP component, the mean amplitude for each cluster of electrodes and condition was averaged and introduced into a 3 (group) x 2 (cue focality) x 2 (type of trial) mixed factorial ANOVA. After pre-processing the EEG data, 16 participants (8 monolinguals, 8 late bilinguals) were eliminated due to high levels of noise in the EEG signals or a high rejection of epochs. Thus, data from 22 monolinguals, 21 late bilinguals, and 21 early bilinguals were entered into the ANOVA.

Finally, correlations between electrophysiological and behavioural data were carried out. Specifically, we examined the correlations between the N300 and P3b components and the accuracy and RTs in ON and PM trials respectively.

RESULTS

We will report the behavioural results (response times and accuracy) followed by ERP analyses of the electrical activity and correlational analysis between the behavioural and EEG data.

Behavioural results

We performed 3 x 2 x 2 mixed factorial ANOVA with group (monolingual, late bilingual, and early bilingual), focality of the cue (focal vs. non-focal), and type of trial (ON vs. PM) as the independent variables on response times (RTs) and accuracy (see Table 4).

Table 4. Means of accuracy (ACC) and response times (RTs; standard deviation in brackets) by type of trial, group and focality in the PM task

Type of trial	**Monolinguals**		**Late Bilinguals**		**Early Bilinguals**		**TOTAL**	
	ACC	RT	ACC	RT	ACC	RT	ACC	RT
ON focal	.97	604	.97	589	.96	660	.97	613
	(.04)	(68)	(.03)	(95)	(.04)	(124)	(.04)	(97)
ON non-focal	.92	756	.94	691	.92	765	.92	736
	(.05)	(142)	(.03)	(127)	(.04)	(144)	(.04)	(139)
PM focal	.95	698	.95	742	.95	764	.95	730
	(.05)	(110)	(.11)	(227)	(.05)	(145)	(.08)	(167)
PM non-focal	.70	918	.64	944	.67	947	.67	935
	(.13)	(168)	(.17)	(250)	(.20)	(144)	(.17)	(194)

Response times. We averaged response times (for correct responses) per participants and condition and submitted them to a 3 (group) x 2 (cue focality) x 2 (type of trial) mixed factorial ANOVA. The result of this analysis showed that the main effects of focality ($F(1,72) = 152.982$; $p < .0001$; $\eta_p^2 = 0.680$) and type of trial ($F(1,72) = 154.258$; $p < .0001$; $\eta_p^2 = 0.682$) were significant, indicating that, in general, responses to the focal condition were faster (M = 671.5, SD = 132) than responses to the non-focal condition (M = 835.5, SD = 166.5) and that participants were faster in performing the ON trial (M = 674.5, SD = 118) than the PM trial (M = 833, SD =180.5). The interaction focality by type of trial ($F(1,72) = 21.812$; $p < .0001$; $\eta_p^2 = 0.233$) indicated that the difference between the ON (M = 613; SD = 97) and the PM trial (M = 730; SD = 167) was greater in the non-focal condition (ON: M = 736, SD = 139; PM: M = 935, SD = 194; $t(76) = -13.399$; $p < .0001$; $d = -1.20$) than in the focal condition (ON: M = 613, SD = 97; PM: M = 730, SD = 167; $t(77) = -7.703$; $p < .0001$; $d = -0.86$).

There was no main effect of group ($F(2,72) = 0.767$; $p = .468$; $\eta_p^2 = 0.021$). However, an interaction between type of trial by group was significant ($F(2,72) = 3.530$; $p = .034$; $\eta_p^2 = 0.089$). This interaction revealed that the difference between the three groups was not significant in the PM trial ($F(2,72) = 0.570$; $p = .568$; M = 856, SD = 131 for early bilinguals; M = 843, SD = 218 for late bilinguals; and M = 808, SD = 123 for monolinguals), whereas there was a trend towards significance in the ON trial ($F(2,72) = 2.730$; $p = .072$; M = 712, SD = 122 for early bilinguals; M = 640, SD = 102 for late bilinguals; and M = 680, SD = 95 for monolinguals), suggesting that early bilinguals were slower in performing the ON trial than the late bilinguals ($t(43) = -2.178$; $p = .035$; $d = -1.54$) with monolingual response times in between those of the two bilingual groups ($t(47) = -1.064$; $p = .293$; $d = -0.30$ for the monolingual and early bilingual comparison and $t(54) = 1.512$; $p = .136$; $d = 2.48$ for the monolingual and late bilingual comparison). For the three groups, the PM versus ON comparisons were significant with all p values < .0001. All other interactions were not significant (focality by group: $F(2,72) = 1.072$; $p = .348$; $\eta_p^2 = 0.029$ and focality by type of trial by group: $F(2,72) = 0.329$; $p = .721$; $\eta_p^2 = 0.009$).

Accuracy. The number of correct responses to ON and PM trials was averaged for each condition and submitted to a 3 x 2 x 2 mixed ANOVA. The result of this analysis indicated a main effect of focality ($F(1,72) = 365.536$; $p < .0001$; $\eta_p^2 = 0.835$) and type of trial, indicating that the focal condition led to a better performance (M = 0.96, SD = 0.06) than the non-focal condition (M = 0.80, SD = 0.11), and that the ON trial led to more accurate responses (M = 0.95, SD = 0.04) than the PM trial (M = 0.81, SD = 0.13; $F(1,72) =$

143.183; $p < .0001$; $\eta_p^2 = 0.665$). The interaction between focality by type of trial ($F(1,72) = 197.971$; $p < .0001$; $\eta^2 = 0.733$) was also significant, indicating that the better performance in the ON trial (M = 0.97; SD = 0.04) relative to the PM trial (M = 0.95; SD = 0.08) was greater in the non-focal (ON: M = 0.92, SD = 0.04; PM: M = 0.67, SD = 0.17; $t(76) = 14.404$, $p < .0001$, $d = 2.03$) than in the focal condition (ON: M = 0.97, SD = 0.04; PM: M = 0.95, SD = 0.05; $t(77) = 2.272$, $p = .026$, $d = 0.33$).

The main effect of group ($F(2,72) = 0.199$; $p = .820$; $\eta_p^2 = 0.005$) and the interactions involving this variable, namely, focality by group ($F(2,72) = 1.118$; $p = .333$; $\eta_p^2 = 0.835$), type of trial by group ($F(2,72) = 1.141$; $p = .325$; $\eta_p^2 = 0.031$), and focality by type of trial by group ($F(2,72) = 1.490$; $p = .232$; $\eta_p^2 = 0.040$) were not significant.

In summary, behavioural results indicated that the early bilinguals slowed down their responses during the ON trial relative to the late bilinguals, suggesting that they might have been engaging in different monitoring strategies when performing the ON trial.

Electrophysiological results: ERP

N300. Averaged amplitudes per participant and condition were submitted to a 3 (group) x 2 (cue focality) x 2 (type of trial) mixed factorial ANOVA (see Table 5 and Figure 5). Results indicated that the main effect of focality ($F(1,61) = 16.569$; $p < .0001$; $\eta_p^2 = 0.214$; focal condition: M = 2.379, SD = 2.136; non-focal condition: M = 1.703, SD = 1.61) and type of trial ($F(1,61) = 32.625$; $p < .0001$; $\eta_p^2 = 0.348$; ON trial: M = 2.441, SD = 1.845; PM trial: M = 1.641, SD = 1.902) were significant. In contrast, the main effect of group ($F(2,61) = 1.515$; $p = .228$; $\eta_p^2 = 0.047$) and the interaction between focality by group ($F(2,61) = 2.305$; $p = .108$; $\eta_p^2 = 0.070$), type of trial by group

(F(2,61) = 0.108; p = .897; η_p^2 = 0.348), and focality by type of trial (F(1,61) = 1.266; p = .265; η_p^2 = 0.020) were not significant.

Most importantly, the focality by type of trial by group interaction was statistically significant (F(2,61) = 4.505; p = .015; η_p^2 = 0.129). To explore this interaction, we performed a 3 (group) x 2 (type of trial) ANOVA for each focality condition. Analysis on the focal condition indicated that the effect of type of trial was significant (F(1,61) = 8.069; p = .006; η_p^2 = 0.117), with more negative amplitudes in the PM (M = 2.054, SD = 2.311) than in the ON trial (M = 2.704, SD = 1.961). However, the main effect and the interaction involving group were not significant (group effect: F(2,61) = 2.185, p = .121, η_p^2 = 0.067; type of trial by group: F(2,61) = 1.700, p = .191, η_p^2 =0.053).

In contrast, for the non-focal condition, although the main effect of group was not statistically significant (F(2,61) = 0.727; p = .487; η_p^2 = 0.023), the main effect of type of trial (F(1,61) = 35.481; p < .0001; η_p^2 = 0.368) and the type of trial by group interaction (F(2,61) = 3.418; p = .039; η_p^2 = 0.101) were significant. This interaction indicated that the greater negativity for the PM trials compared to the ON trials was larger for the early bilinguals (ON: M = 2.644, SD = 2.127; PM: M = 1.105 SD = 1.380; t(20) = 4.804, p < .0001, d = 0.86) than for the group of monolinguals (ON: M = 1.677, SD = 1.069; PM: M = 1.113, SD = 1.403 ; t(21) = 2.556, p < .0001, d = 0.46) or late bilinguals (ON: M = 2.237, SD = 1.782; PM: M = 1.469, SD =1.719; t(21) = 2.655, p < .0001, d = 0.45).

Table 5. Mean wave amplitudes (standard deviation in brackets) by focality, type of trial, group, and the interactions in the N300 component (175–300ms in parieto-occipital regions)

EFFECTS	GROUPS			
	Monolinguals	**Late bilinguals**	**Early bilinguals**	**TOTAL**
Focality				
Focal	1.88 (1.98)	2.23 (2.25)	3.06 (2.06)	2.38 (2.14)
Non-focal	1.40 (1.24)	1.86 (1.75)	1.88 (1.26)	1.70 (1.61)
Type of trial				
Ongoing	2 (1.45)	2.45 (1.86)	2.87 (1.63)	2.44 (1.85)
PM	1.27 (1.77)	1.6 (2.14)	2.06 (1.67)	1.64 (1.90)
Focality by type of trial				
Ongoing focal	2.32 (1.83)	2.73 (1.93)	3.09 (2.13)	2.70 (1.96)
PM focal	1.43 (2.13)	1.73 (2.57)	3.03 (1.99)	2.05 (2.31)
Ongoing non-focal	1.68 (1.07)	2.24 (1.78)	2.64 (2.13)	2.18 (1.73)
PM non-focal	1.11 (1.40)	1.47 (1.71)	1.12 (1.38)	1.23 (1.50)
Group	1.40 (1.61)	2.04 (2)	3.29 (1.91)	

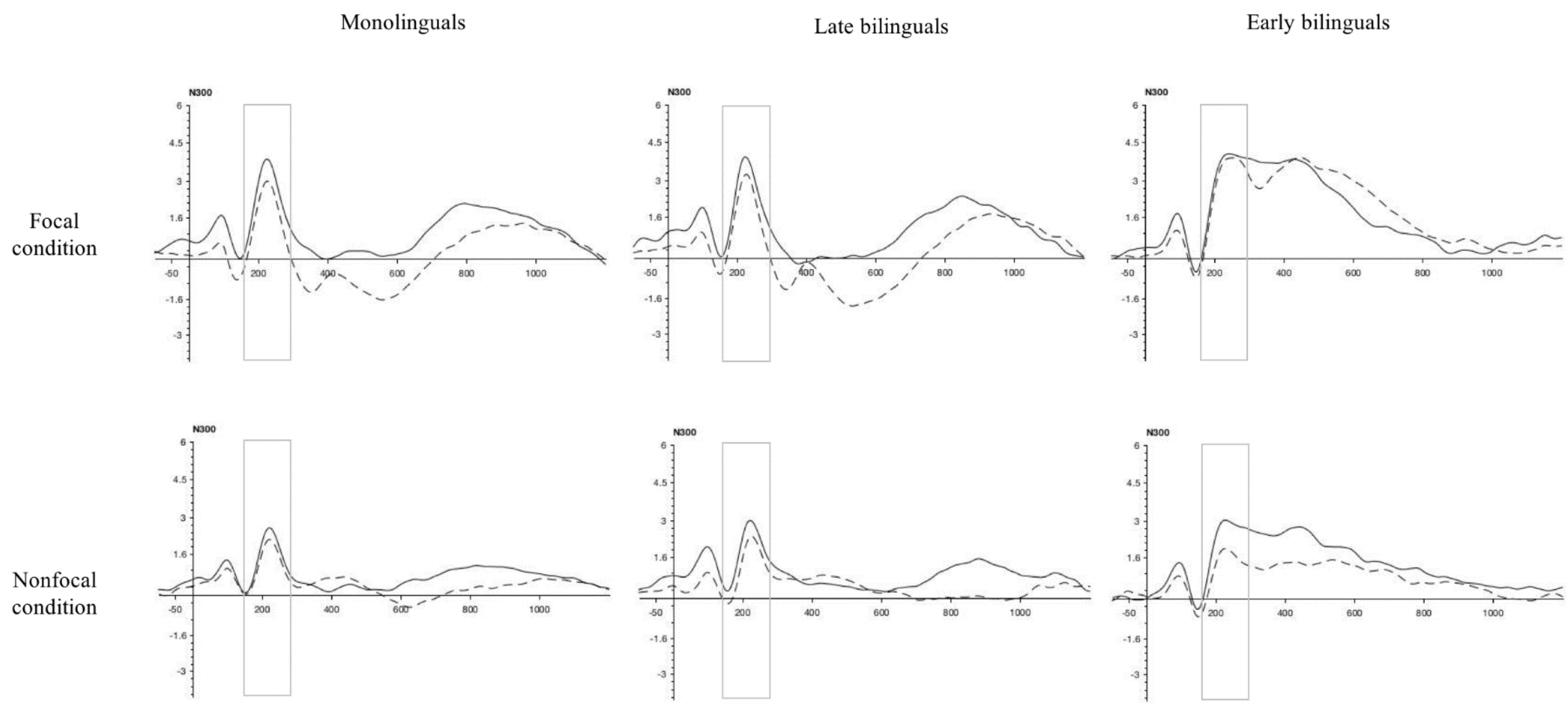

Figure 5. Grand-averaged event-related potentials (ERPs) at occipital-parietal electrodes demonstrating N300 for the ongoing and PM trials in the focal and non-focal conditions for each group. Legend:—— ongoing trial /- - - PM trial

P3b. To explore this component, we performed a 3 (group) x 2 (cue focality) x 2 (type of trial) mixed factorial ANOVA (see Table 6 and Figure 6). We observed that the main effects of focality ($F(1,61) = 4.019$, $p = .049$, $\eta_p^2 = 0.062$; focal condition: M = 0.54, SD = 1.97; non-focal condition: M = 1.130, SD = 1.994), type of trial ($F(1,61) = 17.474$, $p < .0001$, $\eta_p^2 = 0.223$; ON trial: M = 1.07, SD = 1.85; PM trial: M = 0.80, SD = 1.94) and group ($F(2,61) = 22.258$, $p < .0001$, $\eta_p^2 = 0.422$; monolinguals: M = -0.07, SD = 1.77; late bilinguals: M = 0.03, SD = 1.9; early bilinguals M = 2.61, SD = 2.04) were significant. In addition, all the interactions containing these variables were significant (focality by type of trial: $F(1,61) = 5.493$; $p = .022$; $\eta_p^2 = 0.083$; focality by group: $F(2,61) = 16.737$; $p < .0001$; $\eta_p^2 = 0.354$; and type of trial by group: $F(2,61) = 3.227$; $p = .047$; $\eta_p^2 = 0.096$).

To explore the higher order focality by type of trial by group interaction ($F(2,61) = 8.972$; $p < .0001$; $\eta_p^2 = 0.227$), a 3 (group) x 2 (type of trial) ANOVA was performed for each focality condition. For the focal condition, we found that the effect of group ($F(2,61) = 37.374$; $p < .0001$; $\eta_p^2 = 0.551$; monolinguals: M = -1.28, SD = 1.75; late bilinguals: M = -1.45, SD = 2.1; early bilinguals M = 3.27, SD = 2.06) was significant. Also, the main effect of type of trial ($F(1,61) = 16.582$; $p < .0001$; $\eta_p^2 = 0.214$; ON trial: M = 1.12, SD = 2.52; PM trial: M = 0.11, SD = 2.88) was significant. However, the type of trial by group interaction ($F(2,61) = 0.466$; $p = .630$; $\eta_p^2 = 0.015$) was not significant, indicating that the difference between the ON and PM trials did not significantly differ for the three groups: the early bilinguals (ON trial: M = 3.6, SD = 2.13; PM trial: M = 2.93, SD = 1.99), the late bilinguals (ON trial: M = -0.14, SD = 1.83; PM trial: M = -1.31, SD = 2.37), and the monolinguals (ON trial: M = -0.05, SD = 1.54; PM trial: M = -1.23, SD = 1.95).

For the non-focal condition, the 3 (group) x 2 (type of trial) ANOVA indicated that the main effect of type of trial ($F(1,61) = 2.781$; $p = .101$; $\eta_p^2 = 0.044$) was not significant. However, the main effect of group ($F(2,61) = 4.293$; $p = .018$; $\eta_p^2 = 0.123$) was modulated by a type of trial by group interaction ($F(2,61) = 16.172$; $p < .0001$; $\eta_p^2 = 0.347$) that indicated that, while there were no differences between groups in the PM trial ($F(2,61) = 0.140$; $p = .870$; monolinguals: M = 0.77, SD = 1.96; late bilinguals: M = 0.91, SD = 1.61; early bilinguals: M = 1.05, SD = 1.76), in the ON trial, there were group differences ($F(2,61) = 11.219$; $p < .0001$), indicating that early bilinguals showed more positive amplitudes (ON trial: M = 2.83, SD = 2.31) than late bilinguals (ON trial: M = .58, SD = 1.83) and monolinguals (ON trial: M = .24, SD = 1.61). These results suggested that during the ongoing non-focal activity, the early bilingual group engaged in monitoring processes to update the context and respond successfully to the non-focal cue. Interestingly, while late bilinguals ($t(20) = -1.016$; $p = .301$; $d = -0.193$) and monolinguals ($t(21) = -2.249$; $p = .096$; $d = -0.147$) performed the ON and PM trials in a similar way, early bilinguals showed significant differences between both trials ($t(20) = 4.698$; $p < .0001$; $d = 0.865$). These results indicate that early bilinguals adapt their strategies to the demands of the trial.

Table 6. Mean wave amplitudes (standard deviation in brackets) by focality, type of trial, group and the interactions in the P3b component (300-400 ms in parieto-occipital regions)

EFFECTS	GROUPS			
	Monolinguals	Late bilinguals	Early bilinguals	TOTAL
Focality				
Focal	-1.28 (1.75)	-1.45 (2.1)	3.27 (2.06)	0.54 (1.97)
Non-focal	0.51 (1.79)	0.75 (1.72)	1.94 (2.04)	1.07 (1.85)
Type of trial				
Ongoing	0.19 (1.58)	0.44 (1.83)	3.22 (2.22)	1.28 (1.88)
PM	-.46 (1.96)	-0.40 (1.99)	1.99 (1.88)	.80 (1.94)
Focality by type of trial				
Ongoing focal	-0.05 (1.54)	-0.14 (1.83)	3.6 (2.13)	1.12 (2.52)
PM focal	-1.23 (1.95)	-1.31 (2.37)	2.93 (1.99)	0.11 (2.88)
Ongoing non-focal	0.24 (1.61)	0.58 (1.83)	2.83 (2.31)	1.20 (2.23)
PM non-focal	0.77 (1.96)	0.91 (1.61)	1.05 (1.76)	0.91 (1.76)
Group	-0.07 (1.77)	0.03 (1.9)	2.61 (2.04)	

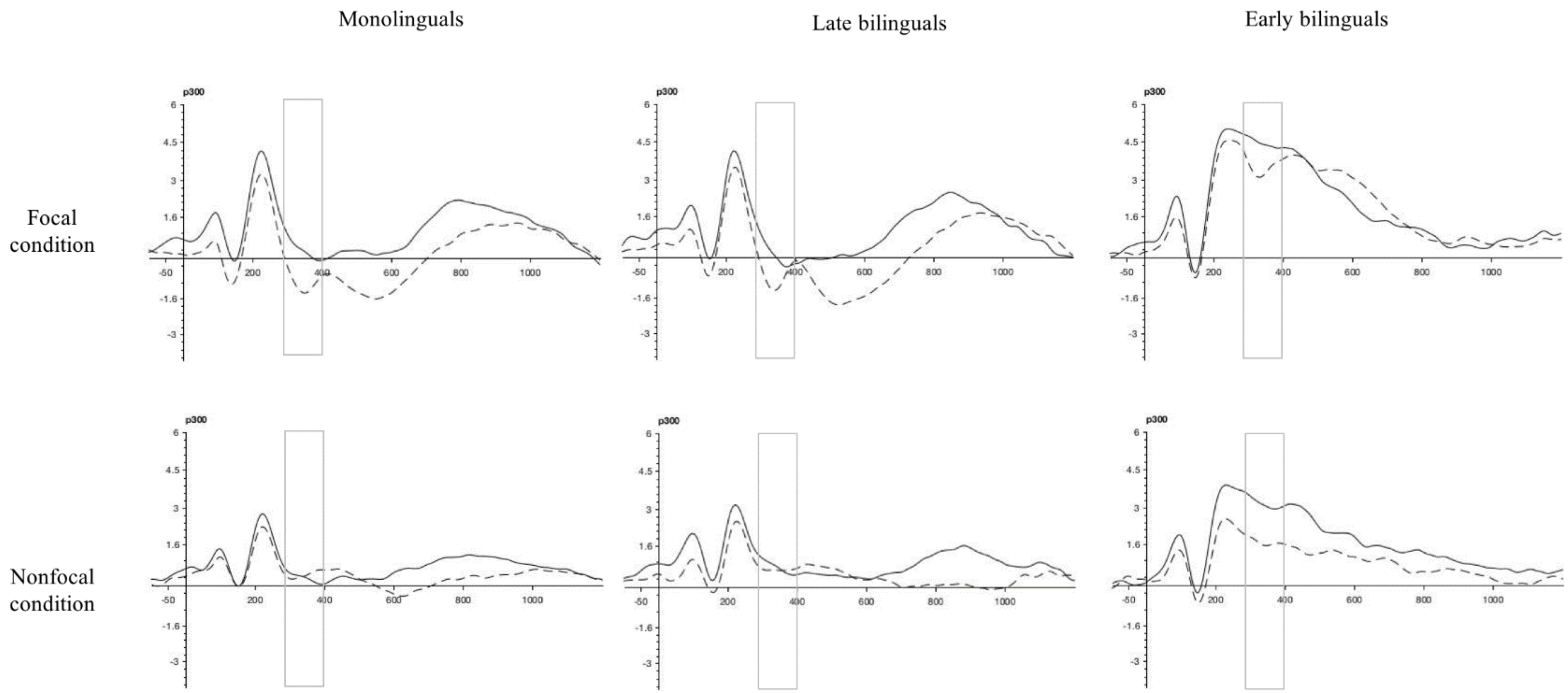

Figure 6. Grand-averaged event-related potentials (ERPs) at occipital-parietal electrodes demonstrating P3b for the ongoing and PM trials in the focal and non-focal conditions for each group. Legend: ——ongoing trial / - - - PM trial

Correlational analysis

Correlations between the N300 and P3b components and the accuracy and RTs in ON and PM trials were carried out. For the ERPs we created an index representing the PM/ON effect captured by the N300 and P3b respectively (ON-PM/ON+PM *100), then we calculated the correlation between these indexes and response times and accuracy. Note that behavioral differences were evident in the ON trial for the early bilinguals, but they were not present in the PM trials. We first performed the correlations with the complete sample of participants, but none of the correlations were significant (all $p_s > .05$). Second, since the behavioral effects were only present in the early bilingual group, we performed the correlations only for this group, but all the correlations were also non-significant ($p_s > .05$).

DISCUSSION

The aim of this experiment was to explore whether different language experiences (monolinguals and early and late bilinguals from different contexts) modulated the cognitive processes underlying prospective memory in tasks with varying monitoring requirements. Consistent with the Multiprocess Framework for prospective memory (McDaniel & Einstein, 2000), participants performed better in focal than in non-focal conditions. According to this framework, focal cues elicit “spontaneous recovery” of the intention in contrast to non-focal cues that require monitoring processes, resulting in longer response times and poorer accuracy.

More importantly, our results provided evidence suggesting that the participants’ language experiences modulate how they confront the difficulties of the prospective task. Thus, behavioural and neural results showed that early bilinguals differed from the monolinguals and late bilinguals in the ways they performed the tasks. Behaviourally, early bilinguals slowed down their response times during the ongoing trials relative to the groups of late bilinguals and monolinguals (although the differences with monolinguals did not reach significance), suggesting that they carefully monitored the environment for prospective cues during the ongoing trial to a greater extent than participants in the other groups. This result is important because it points to the need of studying the specific characteristics of the different groups of bilinguals (De Bruin, 2019). Our data demonstrates that some of the cognitive differences related to bilingualism are driven by experience-based individual differences associated with multilingualism, such as the age of acquisition or the linguistic context where the bilingual is immersed. In this sense, bilingual studies should clearly specify the linguistic and contextual variables defining their bilingual participants since results are very dependent on their language experience.

In our study, the differences between monolinguals, late and early bilinguals were still more evident when considering the ERP data for N300 and P3b. Consistent with other PM experiments, we found larger N300 amplitudes for the PM trials than for the ongoing trials (West, 2011) and for the non-focal PM trial than for the focal PM trial (Cona et al., 2014). Thus, the difference between focal and non-focal conditions was larger for the early bilinguals compared to the late bilinguals and monolinguals. In addition, for the more difficult non-focal condition, early bilinguals showed stronger differences between the PM and ongoing trials than the late bilinguals and monolinguals, suggesting that they engaged in monitoring processes related to cue detection during the more demanding non-focal condition to a greater extent than participants in the late bilingual and monolingual groups. This was also supported by the pattern of results regarding the P3b component with a significant interaction between focality, group and trial. In our study, focal cues produced less positive amplitudes than non-focal cues, and ongoing trials produced more positive amplitudes than PM trials, signalling that WM and context updating were more strongly involved (Cona et al., 2014; West et al., 2003). More interestingly, the interaction between focality, group, and trial indicated that for the focal condition, the differences between the ongoing and PM trials were similar for the three groups, with early bilinguals showing a greater overall positivity. In contrast, for the non-focal condition, there was a significant interaction between type of trial and group, indicating that the differences between the PM and ongoing trials were stronger for the bilingual group. Interestingly, these stronger differences for the early bilinguals compared to the late bilinguals and monolinguals were produced by the greater positivity of the early bilinguals for the ongoing trials relative to the late bilinguals and the monolinguals (these differences were not evident for the PM trials). This pattern of results suggests that the early bilinguals modulated their strategies to adjust to the task's demands. Thus, in the focal condition, where the ongoing and PM trials were highly similar in terms of attentional demands, early bilinguals did not differ from the other groups. However, in the non-focal condition, where processing of the PM cue was more demanding, early bilinguals engaged in monitoring and updating processes to adjust their strategies depending on the task's demands.

The overall pattern of behavioural and neural results is in line with that of previous studies indicating that early bilinguals are able to adjust their monitoring strategies to the demands of the task compared to late bilinguals (Tao et al., 2011). Consistent with our hypotheses, different bilingual experiences have different effects on the processes underlying PM performance. Thus, whereas early bilinguals adjusted their response times and neural ERPs (N300, P3b) so that they differ from those of the monolinguals, late bilinguals did not differ from the monolinguals in their behavioural or neural patterns. This idea is consistent with the proposal of the adaptive control model (Green & Abutalebi, 2013) that language control and its possible consequences over general executive control, depend on the interactional language context of the participants. Our early bilingual group differed from the late monolinguals not only in the age of acquisition, but also in their language use and preferences. For example, in the LEAP-Q questionnaire, early bilinguals reported being more prone to language switching than the late bilinguals and distribute the time between the two languages in a more balanced way than the late bilinguals (see results of LEAP-Q in Table 1). Hence, these features of their language experience could have potentiated context monitoring to facilitate switching to the prospective action. In line with this, it has been suggested that bilinguals who are immersed in an environment with a varying linguistic context are more likely to trigger more proactive cognitive control strategies due to the need to monitor the context (Gullifer et al., 2018). Thus, the early bilinguals might be more sensitive to cue detection and might be able to better adjust their cognitive performances to the demands of the PM task (Prior & Gollan, 2011).

However, overall, our data supports conceptual frameworks suggesting that different bilingual experiences are associated with differences in the engagement of cognitive control strategies (Green & Abutalebi, 2013; Beatty-Martínez et al., 2020; De Bruin, 2019; DeLuca et al., 2020). For example, according to the unifying the bilingual experience trajectories (UBET) framework proposed by DeLuca et al., (2020) efficient language control may depend on the relative proficiency and duration of the bilingual experience. According to this proposal, diversity/intensity of use and frequent switching will increase executive control and will result in more general reliance on proactive control strategies. The early bilingual group in our study clearly matched these particular features of language use, and therefore, according to the proposal they may have been engaged in more proactive processes than the monolinguals and late bilinguals, resulting in different behavioral and neural pattern when performing the PM intention.

Although our ERP data clearly show differences between early bilinguals, monolinguals and late bilinguals in prospective memory, the study is not without limitations. First, behavioural differences were small and they were only found on response times. This could be due to a possible ceiling effect in the levels of accuracy in our task. However, it is important to remark that some previous studies showed that electrophysiological differences in cognitive processes between groups of bilinguals and monolinguals that were not evident in the behavioural data (Grundy et al., 2017; Kousaie & Philips, 2012). Thus, some changes due to bilingualism in cognitive processes might be only captured in brain activity but not in behavioural performance. Second, we considered two very different groups of bilinguals differing in more than one linguistic and contextual difference. This approach had the advantage of maximizing differences between the groups but at the cost of not being able to assess the relative merit of each variable in producing the effects. Further research should try to take a continuous approach to bilingualism so that the relative contribution of different variables might be evaluated. (DeLuca et al., 2020; Kaushanskaya & Prior, 2015; Luk & Bialystok, 2013; Sulpizio et al., 2020). Notice that, we created different categorical groups in the current experiment (i.e., we created extreme groups based on the age of acquisition of L2 and other linguistic features defined by the language context). Thus, it would desirable that future studies collected background information (fluid and crystallized intelligence, linguistic and sociodemographic information) to have a widen perspective of the characteristics of the participants that allows to study the different dimensions of the bilingual continuum.

In summary, the findings from the behavioural and ERP results are in line with the wide body of literature that suggests better cognitive strategy adjustment in bilinguals compared to monolinguals (Morales et al., 2013, 2015). In addition, this study shows differences in processing between groups of bilinguals due to their different language experiences. Furthermore, one of the most obvious findings that emerges from this study is that the age of acquisition of the second language and/or the linguistic context where the bilingual is immersed plays an essential role in cognitive processing. Future studies should try to differentiate between the role of language immersion and age of acquisition. In addition, future studies should also test the possible contribution of heritage languages in the PM task. Heritage bilinguals are speakers who have some degree of proficiency in the heritage language from an early age but whose dominant language shifted to L2 during their school-age years (Polinsky & Kagan, 2007). Given that our early bilingual participants come from California and most of them belonged to immigrant Latino families, it is very possible that they acquired their L1 at home and L2 at school. Future experiments should also try to explore the role of heritage languages in modulating PM processes, beyond language immersion and early acquisition.

CONCLUSIONS

In conclusion, to the best of our knowledge, this is the first study to explore the influence of bilingualism in PM. The observed results support our hypothesis that differences in prospective processes might be due to the different language experiences of the participants. We observed that the language context of the participants modulated the cognitive processes involved in updating and cue detection to adapt them to the task's demands. Thus, early bilinguals were able to selectively adjust their executive control mechanisms in order to detect and respond to the PM cue. These results were attributed to their different language experiences (Green & Abutalebi, 2013). These results enhance our understanding about executive control processes in bilinguals and indicate that factors such as the age of L2 acquisition or linguistic context could be modulators of these cognitive differences (Beatty-Martínez et al., 2020; De Bruin, 2019).

CHAPTER 5.

EXPERIMENT 2

The **second experiment** was entitled **"Prospective memory in bilinguals: Recalling future intentions in first and second language contexts"** and has been published in *Bilingualism: Language and Cognition* (López-Rojas, Marful, Pérez & Bajo, 2023).

ABSTRACT

Recalling future intentions (i.e., prospective memory, PM) plays an essential role in everyday life, but sometimes, if the person is involved in a demanding ongoing task, PM is unsuccessful. This is especially relevant for bilinguals who in many situations, have to recall intentions while performing a task in their second language (L2). Our aim was to explore whether PM is modulated by the linguistic context in which PM takes place. In this study, bilinguals performed a PM task in their first (L1) or second language (L2). We also manipulated the demands of the ongoing task (early/late updating) and the PM cue (focal/non-focal). In general, results showed an overall impairment in the recall of future intentions when the task was performed in L2. This impairment was especially evident in the more demanding conditions, suggesting that increments in attentional demands due to L2 processing hinder the processes required for prospective remembering.

Keywords: prospective memory; bilingualism; linguistic context; prospective processing; bilingual language processing

INTRODUCTION

Daily, bilingual people confront the need to control their languages and also the challenge of having to perform many tasks in their second language. A large body of research suggests that bilinguals access information from their two languages even in situations where only one language is required (Blumenfeld & Marian, 2007; Dijkstra, 2005; Hoshino & Thierry, 2011; Kroll et al., 2015; Kroll & Stewart, 1994; Macizo et al., 2010). As a result, bilinguals need to negotiate their languages to avoid competition and must select the more appropriate language for a given context (Morales et al., 2013, 2015; Green & Abutalebi, 2013). This, in turn, influences language production and comprehension (Ma et al., 2016; Pérez et al., 2019; Roessel et al., 2019). Thus, there is a vast literature on second language (L2) reading comprehension indicating that bilinguals are less efficient and/or poorer comprehenders in their second than in their first language (L1; for a revision see Melby-Lervag & Lervag, 2014). Most of this literature has focused on exploring the underlying abilities related to reading comprehension such as word reading, vocabulary, and working memory (Droop & Verhoeven, 2003; Geva & Siegel, 2000; Lesaux et al., 2006), but also high cognitive processes such as prediction or updating that may also determine the success and/or the cost of comprehending in L1 and L2 (Foucart et al., 2016; Pérez et al., 2019). The results of the later studies suggest that the cognitive patterns shown in L2 discourse comprehension are similar to those shown in L1 comprehension, but that there are qualitative differences in the ERP components elicited by incongruent information, indicating extra processing in updating information in L2 comprehension (Foucart et al., 2016). In addition, Pérez et al. (2019)

also found that differences in executive control differentially affected L1 and L2 text comprehension, with higher proactive control being predictive of L2 comprehension compared to the L1, which required a more balanced proactive/reactive control. Overall, these studies suggest that the ability to generate predictions, detect incongruences (i.e., monitoring comprehension), and update information to accommodate new information, is costlier in the L2 than in the L1.

Interestingly, research has also shown that encoding information in the L2 has effects that go beyond language processing in the purely linguistic sense (Bialystok et al., 2020; Morales et al., 2015; Rosselli et al., 2018; Schroeder & Marian, 2014). For instance, it has been shown that decision making is modulated by the language in which people are reasoning (Costa et al., 2014, 2019; Hayakawa et al., 2016, 2017). Explanations to these results include reductions in a) emotional responses (Costa et al., 2014), b) mental imagery or c) the access to episodic information when bilingual people work in a foreign language (Hayakawa & Keysar, 2018). Moreover, the impact of being bilingual has been reflected across other domains such as visual attention (Chabal & Marian, 2015), perception of multisensory emotions (Chen et al., 2022), and long-term memory (Marian et al., 2021). Consequently, given the implications of being bilingual on a high range of cognitive domains, we would expect that working in a L2 has an influence in a wide set of real-world phenomena. This idea is especially relevant if we think that people who speak more than one language constantly face different linguistic contexts that force them to use one language or the other (or even both at the same time) while they perform different tasks in day to day life. Therefore, it is relevant to explore how using a non-native language may modulate performance in different cognitive tasks that are also used in daily life.

In this regard, recalling future intentions plays an essential role in everyday experiences. Prospective memory (PM) allows us to create intentions and to execute them in the future. Many critical actions such as taking medications at the proper time, getting to an appointment on time, doing the shopping when needed, or taking the cake out of the oven before it gets burned, depends on efficient PM functioning. In a PM task, participants are asked to carry out an ongoing activity (e.g., object naming) while maintaining the intention to perform a certain action (prospective intention) when they encounter a specific contextual cue (e.g., pressing a specific key on the keyboard when the object is of a specific colour). Thus, participants might receive instructions to name objects as they are presented on the screen (i.e., *ongoing task*), and to remember to stop naming when the presented object is in a particular colour (e.g., the colour "red") in which case they have to press a specific key (i.e., *prospective action*). Successfully remembering a prospective action involves monitoring the time or the context to perform the prospective task and switching from the ongoing task to the prospective task (Bisiacchi et al., 2009; Scullin et al., 2015). Similarly, prediction, monitoring, and switching abilities are also engaged during language processing especially in bilingual situations (Beatty-Martínez et al., 2019; Martin et al., 2013; Moreno et al., 2010). Bilingual people must engage these abilities to choose the correct language in each situation (Declerck et al., 2017; Adamou & Shen, 2019). Thus, one might expect that the bilingual experience in monitoring and switching would modulate the cognitive processes that emerge during prospective remembering. In this line, López-Rojas et al., (2022) found differences in prospective memory between bilinguals and monolinguals. Specifically, they explored how different bilingual experiences (i.e., age of acquisition and the linguistic context in which the bilingual was immersed) modulated the performance in a PM task and the neural correlates associated to prospective processing. Hence, participants with different linguistic history were asked to complete a PM task with prospective cues varying in distinctiveness (focal vs non-focal cues). Additionally, brain activity during the task was recorded to explore ERP components related to prospective recall (N300 and P3b). Differences in the wave amplitudes between ongoing and prospective trials in the N300 and P3b components have been associated to efficient monitoring and updating strategies (West, 2011). Results by López Rojas et al. (2022), showed larger differences between the ongoing activity and the prospective intention in the N300 and P3b components for early bilinguals compared to late bilinguals or monolinguals, suggesting enhanced monitoring for early bilinguals. The fact that these differences were found in the more difficult PM conditions also suggest that early bilinguals adapted their monitoring processes to the requirements of the task. Similar ERP patterns, that is, ERP differences between ongoing activity and prospective intention depending on the monitoring capacities of the group, have also been found when comparing children, or older people with younger adults (Cejudo et al., 2022; Hering, et al., 2020).

Hence, López-Rojas et al. (2022) showed how the bilingual experience influences prospective memory processes when bilinguals performed the PM task in their L1. However, they did not manipulate the language in which they completed the PM task, and therefore, they could not assess whether the differences were also modulated by whether the task was executed in the L1 or the L2. In the present study, we aimed to investigate possible differences between monolinguals and bilinguals when performing a PM task in different linguistic contexts. Our critical manipulation specifically assesses whether prospective remembering varies if it is performed in a L1 or L2 continuous task context. We argue that, given that L2 processing is costlier and more resource–consuming (Morishima, 2013; Pérez et al., 2019), when the PM task is carried out in the context of a L2 ongoing task, the bilingual capacity to dedicate executive control to monitor the environment for prospective cues and to switch from the ongoing task to the prospective intention might be compromised. At the moment, to the best of our knowledge, there are no studies exploring the influence of L2 processing during PM activities.

Therefore, the purpose of the current study is to explore how PM processes such as monitoring and switching are modulated when the ongoing task involves L1 or L2 processing. With this aim, we introduced an adapted version of the text comprehension task developed by Pérez, et al., (2015) as the ongoing task in the PM procedure. The aim of introducing this task was to manipulate the linguistic requirements of the ongoing activity. This task requires participants to read short narrative texts in which information can be congruent or incongruent with a previous generated inference. When incongruences are encountered, participants need to be able to monitor their comprehension by detecting the mismatch, and subsequently update the initial (but no longer plausible) interpretation, which can occur either early or late in the text, followed by comprehension questions about the texts. Previous experiments have shown that a late updating is more demanding than an early updating (Pérez et al. 2015, 2019), and therefore, this manipulation allows us to explore whether PM is affected by more difficult language conditions. Moreover, the purpose of using this comprehension task it is to resemble the rich and complex linguistic context in which bilinguals are immersed in their daily activities.

In addition, we manipulated the nature of the prospective memory task to vary its cognitive demands. Recent research suggests that the monitoring demands of the PM activity depend on the focality of the cue signaling the prospective task. Focal and non-focal cues differ in the extent to which processing of the cue engages the main features of the ongoing activity (Kliegel et al., 2008). For example, a focal condition may consist of participants receiving instruction to name the colour of objects as presented on the screen (ongoing task), and remember to stop naming when the presented object is in a particular colour (e.g., the colour "red") and instead, press a key. In this example, the item "heart" (that is red) is considered a focal cue because identifying the colour is involved in both the ongoing activity and processing of the prospective cue (colour red). In contrast, non-focal PM tasks refer to tasks where processing of the PM cues differ from the processing needed for the ongoing activity. In the previous example, if participants are asked to stop naming when the item on the screen belongs to a given category (e.g., parts of the human body), the category represent a non-focal cue, since the identification of a category differs from the ongoing activity (the colour naming task). This manipulation is theoretically important since it has been proposed that focal cues have higher probability of eliciting "spontaneous retrieval of the intention" without engagement of costly monitoring or retrieval processes (Einstein & McDaniel, 2005; McDaniel & Einstein, 2000; Scullin et al., 2015), whereas non-focal cues induce monitoring and costlier retrieval. In consequence, non-focal cues (compared to focal) require more attentional prospective resources resulting in more difficult and less accurate performance (Cona et al., 2014; McDaniel et al., 2015).

Similar to studies where the L2 modulated performance in linguistic and non-linguistic tasks (Costa et al, 2014; Foucart et al, 2016; Hayakawa & Keysar, 2018; Pérez et al., 2019), we expected that the language in which the prospective task is performed interacted with the focality of the PM task to modulate performance. Thus, we assumed that monitoring and switching would be more demanding in the L2 than in the L1.

In summary, the purpose of this experiment was to study possible changes in PM processes when the prospective task was performed in the context of an L1 or L2 ongoing task. To this end, monolinguals and bilinguals performed an event-based task in which the nature of the PM cue (focal vs. non-focal) and the linguistic requirements of the ongoing task (early updating vs. late updating) were manipulated. As mentioned, the manipulation of the cue focality (focal vs. non-focal) referred to the PM task, whereas manipulations of the language (L1 vs. L2) and updating conditions (early vs. late), referred to the ongoing task. We introduced additional baseline ongoing conditions in which the ongoing task was performed by itself (varying language and updating conditions) to be able to assess the cost associated with monitoring when the PM task has to be additionally performed. Thus, analyses of the task involve time and accuracy in the comprehension ongoing task as well as time and accuracy on the PM task. These analyses permit assessment of cue monitoring during the ongoing task, and cue detection and execution of the intention in PM trials. In addition, direct comparison between the ongoing trials (ON trial) and PM trials would allow us to assess switching processes. Note also that by comparing monolinguals and bilinguals, and by having the bilingual participants perform the task in their L1 and L2 allowed us: 1) to compare possible differences between monolinguals and bilinguals, and 2) to assess bilingual PM performance in L1 and L2 contexts. Also, since PM involves performance in the ongoing task (engaging context monitoring for cue detection), performance in the PM tasks (engaging cue detection, retrieval and implementation of the intention) and performance differences between ongoing and PM (engaging switching processes), we had specific predictions for each of these processes.

Regarding the ongoing comprehension task, we expected to observe better and faster performance when the ongoing task was performed by itself (baseline) compared to when participants performed the PM intention during the ongoing activity (focal and non-focal conditions). This effect would reflect the cost associated with cue monitoring, and we expected it to be larger for non-focal than focal condition. Additionally, we predicted this cost to also vary depending on the language and updating conditions. Specifically, we expected a greater comprehension cost when the updating requirements were introduced late in the text (Pérez et al., 2015, 2019), and more so when the task was performed in the L2. Overall, we anticipated that introducing cognitive demanding conditions either in the ongoing comprehension tasks (late vs. early updating; and L2 vs. L1) or in the PM (focal and non-focal PM vs. baseline), would affect comprehension with longer and less accurate performance in the more difficult conditions. Moreover, as long as bilinguals benefit by their context monitoring experience, we would expect better performance than their monolingual counterparts when they were both working in their L1 task.

With regard to the PM tasks, we expected better performance in the focal than in the non-focal trials due to the more demanding monitoring requirements of the non-focal cues (McDaniel & Einstein, 2000). We also predicted an interaction between cue focality and updating and language conditions, which should be reflected in slower and/or less accurate performance in the most difficult L2 non-focal-late updating condition. Regarding monolingual and bilingual comparisons in PM performance, we expected bilinguals to better adjust to the task demands and to reduce differences between the focal and non-focal conditions relative to the monolinguals (see Morales et al., 2013; Morales et al., 2015 for a similar conclusion in a different tasks).

Finally, regarding switching, that is, the comparison between the ongoing (ON) and PM trials, we expected an effect of cue focality, indicating that focal cues are more easily detected than non-focal cues (McDaniel et al., 2015), and an effect of language and updating, where the more demanding L2 language and late updating conditions would result in a costlier switching performance. Again, we expected differences between bilinguals and monolinguals if their language experience influences PM performance.

METHODS

Participants

This study was approved by the Research Ethics Committee of the University of Granada (registration number, 2262/CEIH/2021). Sample size analysis (power = 90%, α = .05) in G*power (Faul et al., 2007) revealed that a sample of 34 participants per group was enough to detect a large effect (Cohen's f effect = .40) in an ANOVA with repeated measures and between/within interactions. In addition, similar studies on the field with a sample size of thirty (or fewer) participants per group (e.g., López-Rojas et al., 2022) have found medium to large effect sizes, which provides additional evidence for the selected sample size.

A total of 67 young adults from the University of Granada participated in this study and received course credits per participation (mean age = 22.87, SD = 3.59; mean years of education = 17.64, SD = 3.73). Of those, 35 were Spanish monolinguals and 32 Spanish-English bilinguals. Data from other 6 participants were also removed after data trimming (see analysis section). The study was disseminated by mean of an institutional emailing list and the institutional online platform for experiments. All participants fulfilled the following criteria: 1) they were between 18-35 years old; 2) they had Spanish as a native language; 3) they reported normal or corrected-to-normal vision; 4) and they had no language disorders. Furthermore, monolinguals were explicitly required to have a very basic, almost null, level in any possible L2. Although they reported having enrolled in the mandatory English courses at school, they all reported being functionally monolinguals (Beatty-Martínez et al., 2012), since they had not used English after high school (Granada is a very monolingual community where most people only speak/understand Spanish). In contrast, bilinguals were required to have at least a C1 level in English (corresponding to a proficient use of this language), and they reported to use English frequently in their daily life. Hence, both groups of participants differed extensively in their use of English (see Table 7). Whereas bilingual participants, used English daily in different contexts, monolingual participants had a minimum exposure to it.

In addition, we verified participants' English self- informed proficiency by means of the Michigan English Language Institute College Entrance Test (MELICET). This test consisted of two exercises to assess English grammar through 50 cloze questions with three answer options. Higher scores in this test revealed an advanced knowledge of English grammar. For this reason, participants who obtained a direct score of 35≤ (out of 50) in this questionnaire were included in the bilingual group (32 participants). Those who scored 25 or less were classified as monolinguals (35 participants). Notice that this questionnaire was applied as a screening test, therefore, those potential participants with an intermediate level of English (scores between 26 to 34) did not qualify to participate in the study and were not invited to participate in the experiment. We also collected data from the LEAP-Q (Marian et al., 2007) to obtain the history of language use of the bilinguals and monolinguals. The questionnaire consisted of a first section with questions related to the participant's linguistic history, such as listing the languages they know (even in a basic way), percentage of exposure to them, and preference for reading/speaking in each language. In a second section, questions regarding the use and exposure to their native language were presented. Both sections were completed by monolingual and bilingual participants in Spanish. Additionally, those participants who reported knowing a second language at an advanced level and qualified as bilinguals in the MELICET test, were asked to complete the section about the use and exposure to their L2. That section was presented in English. Table 7 reports a summary of the average scores provided by bilinguals and monolinguals to relevant items from the questionnaire. Finally, a standard digit span task was used to ensure baseline working memory scores were comparable between groups (monolinguals: $M = 9.42$, $SD = 2.98$; bilinguals: $M = 10.82$; $SD = 2.54$; $t(59) = -1.95$; $p > .05$; $d = -0.51$). All participants gave written informed consent and filled out a sociodemographic questionnaire (e.g., age, illnesses, years of education, etc.). The two groups matched in their sociodemographic characteristics (all $p_s > .05$).

Table 7. Mean score and standard deviations in questions about L1 and L2 from the LEAP-Q for the monolingual and bilingual group.

	L1 Monolinguals	L2 Monolinguals	L1 Bilinguals	L2 Bilinguals
Mean percentage of current exposure to the language	93%*	18%*	68%*	37%*
Mean percentage of preference to read in each language	94%*	14%*	58%*	40%*
Mean percentage of preference to speak in each language	93%*	13%*	67%*	29%*
Mean age of beginning acquisition (years)	0.78 (0.96)	-	0.50 (0.76)	5.76 (2.67)
Mean age of becoming fluent (years)	3.91 (1.40)	-	3.90 (1.95)	12.67 (4.27)
Mean level of self-competence (from 0–10)	9.61 (0.69)	-	9.80 (0.48)	8.50 (1.04)
Mean level of language exposure with family or friends (from 0–10)	9.83 (0.44)	-	9.27 (1.20)	2.14 (1.70)
Mean level of reading exposure (from 0–10)	9.15 (1.4)*	-	7.90 (2.12)*	7.92 (1.29)
Mean level of language exposure by TV or radio (from 0–10)	7.83 (2.95)*	-	5.80 (1.28)*	5.38 (3.61)
Mean level of language exposure by self-learning (from 0–10)	8.79 (1.82)*	-	5.90 (3.50)*	6.72(2.97)

*Indicated significant differences ($p < .05$) between monolinguals and bilinguals group comparisons.

Design

We followed a factorial mixed design using Group (monolinguals vs. bilinguals) as a between subject factor and level of Prospective load (baseline vs. focal vs. non-focal), Updating (early vs. late), Focality (focal vs. non-focal) and Language (L1 vs. L2) as within subject factors. Since language was not completely crossed with all other variables (monolinguals could not perform the task in an unknown language), we performed analyses for monolinguals and bilinguals without considering language, and for L1 and L2 languages considering only the bilingual group.

Procedure and materials

The experimental procedure consisted of a first session of approximately 60 minutes where participants carried out first the MELICET and LEAP-Q (Marian et al., 2007). Later, they performed the PM task during text comprehension in the L1 and, finally, the digit span working memory task as a control measure. Additionally, in a second session, only for bilinguals, participants completed the PM task in the L2 text comprehension context. For these participants, the order of the two sessions was counterbalanced, to avoid undesirable order effects between the two language contexts. The study was programmed using Gorilla Experiment Builder (Anwyl-Irvine et al., 2020) and conducted online.

PM task during text comprehension. The text comprehension task was adapted from the situation model revision task used by Pérez et al. (2019; see Table 8). In each text, the first two sentences (Introduction) primed a specific inference (for example, the concept of "guitar"). Later, this inference was replaced with new information that required revising their initial interpretation and encoding an alternative inference (i.e., piano). This updating process might occur either in Sentence 3 (early updating) or in Sentence 4 (late updating). Results by Pérez et al. (2015, 2019) indicated that late updating produces slower and less accurate performance than early updating texts, and therefore, we used this manipulation to vary the linguistic difficulty of the ongoing task. For this task, we measured, first, the reading times for the complete text. Then, as each text was followed by a comprehension cloze question with three response options (participants were asked to respond by pressing the key corresponding to the correct option), we measured accuracy and response times to the question (see Figure 7). Hence, we assessed the following dependent variables for the ongoing text comprehension task: 1) text reading times; 2) accuracy and response times in the cloze question; 3) reading times in responding to the cloze question.

Across the short-texts, we manipulated the baseline and focal conditions. On the one hand, there was a baseline condition where the ongoing comprehension task was performed by itself, with no mention of PM instructions. Notice that this baseline condition permits us to assess performance in the ongoing task without the possible cost of PM instructions. On the other hand, there were two blocks where the PM task was introduced to the participants after explaining the ongoing comprehension task. The PM cue appeared exclusively at the end of six texts from the block (composed of a total of 30 texts) as part of the response options to the cloze comprehension questions (care was taken that across trials the PM appeared unpredictably in different points in the block). In the PM focal condition, participants were instructed to press a specific key whenever the words “necklace” or “bicycle” appeared among the three response options of the comprehension cloze question. These cues were considered focal because they were part of the features of the ongoing activity (identifying the correct word to answer the question) and thus, they were within the focus of attention of the participant. In the PM non-focal condition, participants were asked to press a specific key when a word belonging to the semantic category “profession” or “city” appeared among the response options. These cues were considered non-focal because the detection of the PM cues involved additional processing (semantic classification) that was not required for PM detection. It is important to remark that, for both focal and non-focal cues, participants were asked to interrupt the ongoing activity and execute the prospective intention by pressing a specific key which was different from the keys used to respond to the comprehension question. Performance in the PM task was assessed by accuracy scores and response times in the comprehension cloze questions were the prospective cues (i.e., the words necklace/bicycle or words belonging to "profession" or "city" categories) appeared among the response options; here they are termed "PM" because they correspond to the PM task. Trials in the comprehension cloze question that did not contain the prospective cues were termed ON trials (ongoing trials) and they were used for comparison with the PM trials to assess the cost of the disengaging from the ongoing linguistic task and switching to the PM task. Baseline, focal and non-focal block were counterbalanced across participants. Instructions were provided at the beginning of each block defining the PM conditions (baseline, focal and non-focal).

As stimulus materials, we used 150 experimental texts counterbalanced across the focality conditions and languages. Also, the texts rotated between updating conditions and type of trial (ongoing vs PM). Additionally, 3 practice trials were performed at the beginning of each condition.

Each trial started with a fixation point ('+') that remained on the screen until the participant pressed the space bar to see the first sentence. Sentences 1–4 were presented one sentence at a time, and participants were instructed to read each sentence at their own pace, pressing the space bar to display the next sentence. The positions of the correct answer or the prospective cue in the questions were randomized. Texts were printed in black and appeared centred on the screen in a white background. Both groups of participants performed the task in Spanish. In addition, the bilingual group performed the task in English. The order in which the bilingual participants performed the task was counterbalanced across sessions. The order in which bilingual participants carried out the task (first Spanish or first English) did not have an effect either in RTs or accuracy (all $p_s > .05$), so this variable was not considered in the following analyses. Finally, in order to control overall language abilities in the L1, we compared reading times to the first and second sentence (introduction) in the ongoing baseline block for both groups. Results indicated no significant differences between monolinguals and bilinguals (all $p_s > .05$).

Table 8. Example of a text trial (late updating vs early updating). Each trial was composed of two introduction sentences, the third sentence with two types of sentences (congruent/incongruent) and the fourth sentence with two conditions of inference updating (non-updated/updated). Finally, a comprehension question with three answer options appeared.

	LATE UPDATING	EARLY UPDATING
SENTENCE 1 Introduction	Last year Bob started playing in a Jazz band.	
SENTENCE 2 Introduction	His musical instrument is golden and shiny, and it is played with the fingers.	
SENTENCE 3	Bob loves to practice along with the trumpeter while he plays his instrument.	Bob loves to practice playing the black and white keys of his instrument.
SENTENCE 4	This year Bob's band is giving a concert, so he must practice several hours a day playing the **piano**.	
QUESTION	Bob plays the _____. saxophone piano clarinet	

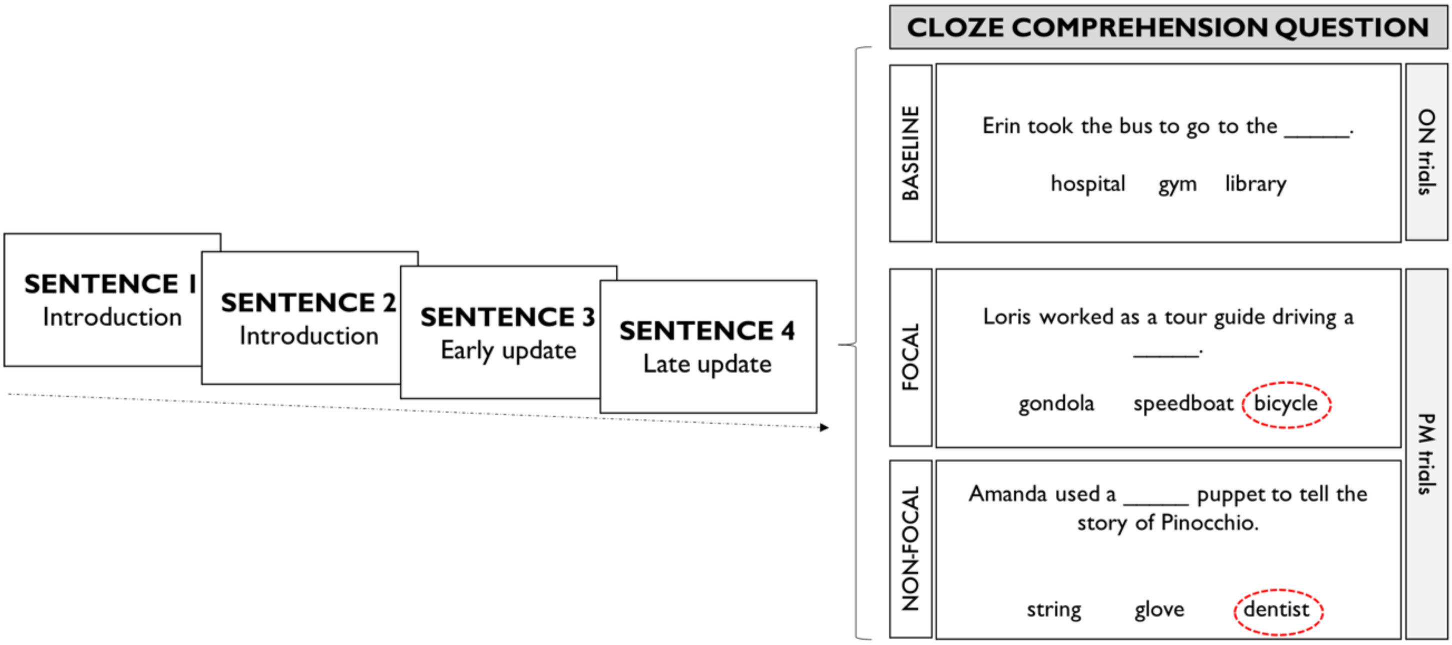

Figure 7. Example of a cloze comprehension question (comprehension question and three response options) for each block: baseline, focal, and non-focal blocks. The baseline condition served as an ON trial. Whereas, the focal and the non-focal conditions were the PM trials in which a focal PM and a non-focal cue respectively, appeared between the response options (marked in red).

Data analysis

Our results are organised into two broad sections: 1) comparison between monolinguals and bilinguals in the shared L1, and 2) comparison between the L1 and L2 contexts, only for the bilingual group. Within each of these sections, subsections referred to whether the comprehension ongoing task, the PM task, or an index for ON-PM switching, were considered.

Ongoing text comprehension was assessed by calculating reading times for each text and averaging them for updating (early and late) and PM (baseline, focal and non-focal condition). In addition, we calculated mean accuracy in and response times to the comprehension questions for ongoing trials as a function of conditions. Thus, for these measures, we averaged across trials defining the updating (early and late) and PM conditions (baseline, focal and non-focal) for each group in ON trials. Note that ON trials were cloze questions where the PM cue was not presented among the response options. In order to equate the number of PM and ON trials, we selected the ON trials that preceded PM trials. Thus, for each PM trial in the focality conditions (a total of 6), the previous ON trials (6) were considered for comparison (see Cejudo et al., 2019, for a similar procedure).

PM performance was assessed by analysing response times and accuracy for PM trials in L1 for each focality condition and group (or L1/L2 language in bilinguals). For these analyses, averaging was done for PM trials (trials where the cloze questions contained the PM cue) and considering the updating (early vs late) and focality conditions (focal vs non-focal) for each group (monolingual vs bilingual) or language (L1 vs L1 condition in bilinguals).

ON-PM switching was assessed by the subtraction between ON and PM trials. In this third analysis, we aimed to explore the processes of monitoring and switching that take place during the implementation of the prospective intention. As mentioned, in order to equate the number of trials in the ON and PM condition, for these analyses we also selected the responses to the questions of the ON trials that appeared before the PM trials.

For all the analyses, data trimming was performed by removing participants with accuracy or response times greater than three times the interquartile range in the ON task for at least two levels of prospective load conditions. This resulted in the removal of two monolinguals and four bilinguals.

For simplicity, in the results section, we only included significant effects and interactions. In Appendix A, we detail all the statistics for significant and non-significant effects and interactions.

RESULTS

Monolinguals vs Bilinguals in L1

Online text comprehension: Text reading times in ON trials

We averaged total reading times in the text per participants and condition and submitted them to a 3 x 2 x 2 mixed factorial ANOVA with Group (monolingual vs bilingual), Prospective load (baseline vs focal vs non-focal) and Updating (early vs late) as factors (for means and standard deviations per condition see Table 9A). The results of this analysis indicated that the main effect of group was marginally significant, $F(1,59) = 3.631$; $p = .062$; $\eta_p^2 = 0.058$, indicating that, in general and independently of the prospective load and updating condition, reading times in the bilingual group were faster (M = 3159, *SD* = 968) than in the monolingual group (*M* = 3682, *SD* = 1474).

Off-line text comprehension: Accuracy to the comprehension question

Averaged ON responses to the cloze questions in ongoing trials were submitted to a 3 x 2 x 2 mixed ANOVA with Group (monolingual vs bilingual), Prospective load (baseline vs focal vs and non-focal), and Updating (early vs late) as factors (see Table 9B). Results showed that the main effect of group was significant, $F(1,59) = 4.465$; $p < .05$; $\eta_p^2 = 0.070$, with greater accuracy in bilinguals (*M* = .88, *SD* = .15) than in monolinguals (*M* = .82, *SD* = .19). Moreover, the main effect of prospective load, $F(1,59) = 4.944$; $p < .05$; $\eta_p^2 = 0.077$ was significant, indicating that text comprehension in the baseline block led to more accurate responses (*M* = .87, *SD* = .18) than comprehension during the focal (M = .82, *SD* = .18) and the non-focal blocks (*M* = .84, *SD* = .18); and the main effect of updating, $F(1,59) = 22.719$; $p < .0001$; $\eta_p^2 = 0.278$, where early updating led to better performance (*M* = .89, *SD* = .15) than the late updating condition (*M* = .82, *SD* = 0.20). Overall, these results showed that PM instructions had a cost in text comprehension as suggested by the higher accuracy in the baseline condition. More importantly, however, the pattern of data demonstrates better performance of bilinguals over monolinguals independently of the prospective load or difficulty of the updating process. This pattern suggests that bilinguals compared to monolinguals might monitor more efficiently the context for appropriate cues independently of the difficulty of the prospective task.

Off-line text comprehension: Response times to the comprehension question

We averaged the response times (for correct responses) per participants and condition and submitted them to a 3 x 2 x 2 mixed factorial ANOVA with Group (monolingual vs bilingual), Prospective load (baseline vs focal vs and non-focal), and Updating (early vs late) as independent variables (see Table 9B). A main effect of prospective load, $F(1,59) = 15.972$; $p < .0001$; $\eta_p^2 = 0.213$) showed faster response times in the baseline (M = 3033, *SD* = 1357) when compared to focal (*M* = 3540, *SD* = 1414) and non-focal (*M* = 3752, *SD* = 1726) conditions. Interestingly, the interaction prospective load by group was also significant, $F(1,59) = 4.129$; $p < .05$; $\eta_p^2 = 0.065$, indicating that the difference between monolinguals and bilinguals was significant in the non-focal condition (monolinguals: M = 4171, *SD* = 1901; bilinguals: M = 3258, *SD* = 1280; $t(59) = 1.952$; $p < .05$; $d = 0.51$). This suggests that, in general, bilinguals were faster answering to the comprehension question. However, these differences between groups did not appear in the focal (monolinguals: M = 3679, *SD* = 1390; bilinguals: M = 3376, *SD* = 1445; $t(59) = 0.883$; $p = .381$; $d = 0.23$) and baseline (monolinguals: M = 3153, *SD* = 1499; bilinguals: M = 2891, *SD* = 1168; $t(59) = 0.787$; $p = .434$; $d = 0.26$) conditions. Thus, these results indicated greater efficiency of bilingual people adapting their monitoring abilities to perform the more resource-demanding PM activity. Nevertheless, in the blocks where monitoring was not required (i.e., focal and baseline) both groups performed in a similar way.

Prospective performance accuracy

Average PM responses to the cloze questions containing the prospective cue were submitted to a 3 x 2 x 2 mixed ANOVA with Group (monolingual vs bilingual), Focality (focal vs non-focal), and Updating (early vs late) as factors (see Table 9C). These results showed a significant main effect of group, $F(1,59) = 15.129$; $p < .0001$; $\eta_p^2 = 0.240$, with greater accuracy in bilinguals (*M* = .78, *SD* = .30) than in monolinguals (*M* = .51, *SD* = .40). Interestingly, the interaction between focality and group was also significant, $F(1,59) = 9.539$; $p < .05$; $\eta_p^2 = 0.139$, indicating that bilinguals were equally accurate in the focal than in the non-focal condition, $t(27) = -1.106$; $p = .396$; $d = -4.32$, while monolinguals showed greater accuracy for focal cues than for non-focal cues, $t(32) = 3.136$; $p < .05$; $d = 1.63$.

Prospective performance response times

We averaged response times per participants and condition for prospective cloze trials and submitted them to a 3 x 2 x 2 mixed factorial

ANOVA with Group (monolingual vs bilingual), Prospective load (focal vs non-focal), and Updating (early vs late) factors (see Table 9C). The results of this analysis indicated that group was the only significant effect, $F(1,59) = 7.618$; $p < .05$; $\eta_p^2 = 0.114$, indicating that, in general, bilinguals were faster responding to the PM cues (M = 2847, *SD* = 1212) compared to monolinguals (M = 3722, *SD* = 1758).

In sum, the analyses of the prospective task indicate that bilingual participants were not affected by the difficulty of detecting the prospective cues given their high performance in both the focal and non-focal conditions. However, overall, monolinguals showed less accuracy. These results could indicate that bilingual participants may have a better ability to involve cue detection than their monolingual counterparts. This was also reflected in their overall faster response times to the PM.

Switching between ON and PM tasks accuracy

The switching cost index was submitted to a 2 x 2 x 2 mixed ANOVA with Group (monolingual vs bilingual), Focality (focal vs non-focal), and Updating (early and late) as factors (see Table 9D). The main effect of group was marginally significant, $F(1,59) = 3.802$; $p = .056$; $\eta_p^2 = 0.061$, with less cost in bilinguals (M = .10, *SD* = .39) than in monolinguals (M = .26, *SD* = .46). The other two main effects were significant: focality, $F(1,59) = 7.628$; $p < .05$; $\eta_p^2 = 0.114$, indicating greater cost in the non-focal (M = .25, *SD* = .44) than in the focal block (M = .13, *SD* = .42); and updating, $F(1,59) = 15.198$; $p < .001$; $\eta_p^2 = 0.205$, with greater cost for early updating (M = .26, *SD* = .44) than for late updating (M = .13, *SD* = .44). More importantly, the focality by group interaction was significant, $F(1,59) = 19.177$; $p < .0001$; $\eta_p^2 = 0.245$, indicating that monolinguals showed greater cost for non-focal than for focal cues, $t(32)$

= -4.368; $p < .001$; $d = -2.15$, whereas this effect was not significant for bilinguals, $t(27) = 1.030$; $p = .276$; $d = 7.96$ (see Table 9C).

Switching between ON and PM response times

We averaged response times per participants and condition and submitted them to a 3 x 2 x 2 mixed factorial ANOVA with Group (monolingual and bilingual), Focality (focal, and non-focal), and Updating (early and late) (see Table 9D). The main effects and interactions did not reach significance.

Overall, when considering switching from the ON task to the PM tasks bilinguals seem to overcome the cost of task switching more efficiently than the monolinguals, and they did so in both focal and non-focal conditions (no difference between conditions), whereas monolinguals evidenced greater cost in the more difficult non-focal condition. This pattern, however, was only evident when looking at the accuracy data and not to the response times.

Table 9. Mean score and standard deviations in behavioural data for the monolingual and bilingual group in L1 as a function of the experimental conditions.

A. Mean score and standard deviations in **online text comprehension** (Reading Times).

	L1 Monolinguals Reading Times			L1 Bilinguals Reading Times		
	Early	Late	**Total**	Early	Late	**Total**
Baseline	3575 (1342)	3735 (1978)	3655 (1660)	3124 (843)	3197 (769)	3161 (806)
Focal	3569 (1296)	3531 (1217)	3550 (1257)	3237 (866)	3085 (894)	3161 (880)
Non-focal	3816 (1522)	3863 (1489)	3840 (1506)	3189 (977)	3122 (859)	3156 (877)
Total	3653 (1387)	3710 (1561)		3183 (895)	3135 (841)	

B. Mean score and standard deviations in **off-line text comprehension** (ACC and RT).

	L1 Monolinguals ACC		L1 Monolinguals RT				L1 Bilinguals ACC		L1 Bilinguals RT			
	Early	Late	Early	Late	**Total ACC**	**Total RT**	Early	Late	Early	Late	**Total ACC**	**Total RT**
Baseline	.87 (.18)	.83 (.21)	3187 (1380)	3118 (1617)	.85 (.20)	3153 (1499)	.95 (.09)	.84 (.19)	2757 (1005)	3025 (1330)	.90 (.14)	2891 (1168)
Focal	.81 (.15)	.72 (.20)	3660 (1255)	3697 (1525)	.77 (.18)	3679 (1390)	.87 (.17)	.87 (.14)	3308 (1169)	3443 (1720)	.87 (.16)	3376 (1445)
Non-focal	.86 (.17)	.81 (.20)	4206 (1954)	4136 (1848)	.84 (.19)	4171 (1901)	.93 (.11)	.85 (.20)	3365 (1320)	3152 (1239)	.90 (.16)	3258 (1280)
Total	.85 (.17)	.79 (.20)	3684 (1530)	3650 (1663)			.92 (.12)	.85 (.18)	3143 (1165)	3207 (1430)		

C. Mean score and standard deviations in accuracy (ACC) and response times (RT) in the **PM trials.**

	L1 Monolinguals						L1 Bilinguals					
	ACC		RT				ACC		RT			
	Early	Late	Early	Late	**Total**		Early	Late	Early	Late	**Total**	
					ACC	**RT**					**ACC**	**RT**
Focal	.60 (.37)	.64 (.36)	3393 (1443)	3496 (1433)	.62 (.37)	3445 (1438)	.81 (.29)	.68 (.33)	2959 (1660)	2649 (996)	.75 (.27)	2804 (1328)
Non-focal	.38 (.42)	.40 (.44)	4179 (2490)	3821 (1666)	.40 (.43)	4000 (2078)	.80 (.29)	.81 (.28)	2822 (957)	2957 (1235)	.81 (.23)	2890 (1096)
Total	.49 (.40)	.52 (.40)	3786 (1967)	3658 (1550)			.81 (.29)	.75 (.31)	2891 (1309)	2803 (1116)		

D. Mean score and standard deviations in accuracy (ACC) and response times (RT) in the **switching cost index**.

	L1 Monolinguals						L1 Bilinguals					
	ACC		RT				ACC		RT			
	Early	Late	Early	Late	**Total**		Early	Late	Early	Late	**Total**	
					ACC	**RT**					**ACC**	**RT**
Focal	.18 (.44)	.03 (.44)	733 (811)	747 (2149)	.11 (.44)	740 (1480)	.20 (.36)	.07 (.41)	904 (1495)	797 (1608)	.14 (.39)	851 (1552)
Non-focal	.46 (.50)	.39 (.46)	346 (3201)	356 (1693)	.43 (.48)	351 (2447)	.14 (.36)	-.02 (.43)	643 (1288)	532 (1877)	.06 (.40)	582 (1583)
Total	.32 (.47)	.21 (.45)	540 (2006)	552 (1921)			.17 (.36)	.03 (.42)	774 (1392)	665 (1743)		

Bilinguals L1 vs L2

With the aim of exploring the language effect in monitoring cost, prospective performance and switching processes, we ran the same analyses on bilinguals and compared their performance when the task was done in the L1 and the L2.

Online text comprehension: Text reading times in ON trials

We averaged reading times per participants and condition and submitted them to a 3 x 2 x 2 within participants ANOVA with Language (L1 vs. L2), Prospective load (baseline vs. focal vs. and non-focal), and Updating (early vs. late) as factors (see Table 10A). The main effect of language was significant, $F(1,27) = 32.366$; $p < .0001$; $\eta_p^2 = 0.545$, indicating faster reading times in the L1 (M = 3159; *SD* = 868) than in the L2 (M = 4324; *SD* = 1085).

Overall, the language in which the task was executed modulated online text comprehension. Thus, when participants were reading texts in their L1 they were faster independently of the prospective load and updating conditions.

Off-line text comprehension: Accuracy to comprehension questions

The number of correct responses to the ON task in the cloze questions were averaged per subject and condition and submitted to a 3 x 2 x 2 within ANOVA with Language (L1 vs. L2), Prospective load (baseline vs. focal vs. non-focal), and Updating (early vs. late) as factors (see Table 10B). The main effects of language, $F(1,27) = 6.532$; $p < .05$; $\eta_p^2 = 0.195$, and updating, $F(1,27) = 35.781$; $p < .0001$; $\eta_p^2 = 0.570$, were significant. Importantly, there was a significant interaction of language by updating, $F(1,27) = 7.692$; $p < .05$; $\eta_p^2 = 0.222$, indicating that although the updating effect (i.e., higher accuracy in the early than late conditions) was significant in both the L1,($t(27) = -3.070$, $p <$

.05, d = -1.70), and the L2 ($t(27)$ = -4.957 , $p < .0001$, d = -4.38), the effects differed in size, that is, there was larger effect size in the L2 than in the L1.

Off-line text comprehension: Response times to the comprehension question

Response times (for correct responses) were averaged per participant and condition and submitted to a 3 x 2 x 2 mixed factorial ANOVA with Language (L1 vs. L2), Prospective load (baseline vs. focal vs. non-focal), and Updating (early vs. late) as factors (see Table 10B). The result of this analysis showed a significant main effect of language, $F(1,27) = 19.728$; $p < .0001$; η_p^2 = 0.473, indicating that response times were faster in the L1 (M = 2950, SD = 1261) than in the L2 (M = 3865, SD = 1224).

Altogether, these results indicate that language modulated accuracy and response times to the comprehension questions. Comprehension was faster in the L1 than in the L2. In addition, processing in the L2 led to a larger updating effect, this is to say, L2 comprehension seems to be especially impaired in the most linguistically complex late updating condition.

Prospective performance accuracy

Average PM responses to the cloze questions with prospective cues were submitted to a 2 x 2 x 2 within ANOVA with Language (L1 vs. L2), Focality (focal vs. non-focal), and Updating (early vs. late) as factors (see Table 10C). The interaction of language by focality was significant, $F(1,27) = 4.278$; $p <$ .05; η_p^2 = 0.137, showing that in L1 there was no difference between focal and non-focal cues ($t(27)$ = -1.106; p = .278; d = -0.24), whereas in L2 the difference was marginally significant ($t(27)$ = 1.966; p = .060; d = 8.00), indicating greater accuracy in focal cues than in non-focal cues (see Table 10C).

Prospective performance response times.

We averaged response times per participants and condition and submitted them to a 2 x 2 x 2 within factorial ANOVA with Language (L1 vs.

L2), Focality (focal vs. non-focal), and Updating (early vs. late) as factors (see Table 4C). There was a significant main effect of language, $F(1,27) = 7.125$; $p < .05$; $\eta_p^2 = 0.209$, indicating that, in general, L1 responses to the PM cues were faster (*M* = 2847, *SD* = 1212) compared to L2 (*M* = 3982, *SD* = 2643). The main effect of language was modulated by the language by updating interaction, $F(1,27) = 4.509$; $p < .05$; $\eta_p^2 = 0.143$. This interaction indicated that there was no difference between the late and early updating conditions in the L1 ($t(27) = -0.618$; $p = .541$; $d = -11.60$), while in the L2 this difference was significant ($t(27) = 2.103$; $p < 0.05$; $d = 5.46$), with slower response times in the late than in the early updating condition (see Table 10C).

In sum, in the L1, bilinguals seemed to be able to overcome the difficulties associated with the focality of the cue and the updating requirements of the text. However, when they performed the task in their L2, the cost associated with processing in their less dominant language produced focality effects in accuracy and updating effects in response times.

Switching between ON and PM tasks accuracy.

The switching cost index calculated from the PM and ON questions were submitted to a 3 x 2 x 2 within ANOVA with Language (L1 vs. L2), Focality (focal vs. non-focal), and Updating (early vs. late) as factors (see Table 10D). The main effect of updating was significant, $F(1,27) = 22.409$; $p < 0.001$; $\eta_p^2 = 0.454$, reflecting that the difference between ON and PM trials was smaller in the late updating (*M* = -.01; *SD* = .46) compared to the early updating condition (*M* = .12; *SD* = .36).

Switching between ON and PM tasks response times.

We averaged response times per participants and conditions and submitted them to a 2 x 2 x 2 within ANOVA with Language (L1 vs. L2), Focality (focal vs. non-focal), and Updating (early vs. late) (see Table 10D). The main effects and interactions did not reach significance.

All in all, our results showed smaller differences in accuracy between ON and PM trials in the more demanding late updating condition. This effect was however not evident in response times. Interestingly, the effect of updating in accuracy was independent of the language in which the ON task was performed (and language did not yield significant effects), suggesting that switching was not influenced by the language in which the task was performed.

Table 10. Mean score and standard deviations in behavioural data for the bilingual group in L1 and L2 as a function of the experimental conditions.

A. Mean score and standard deviations in **online text comprehension** (Reading Times)**.**

	L1 Bilinguals Reading Times			L2 Bilinguals Reading Times		
	Early	Late	**Total**	Early	Late	**Total**
Baseline	3124 (843)	3197 (769)	3161 (806)	4299 (928)	4264 (862)	4282 (895)
Focal	3237 (866)	3085 (894)	3161 (880)	4274 (741)	4200 (821)	4237 (781)
Non-focal	3189 (977)	3122 (859)	3156 (877)	4373 (1224)	4538 (1931)	4455 (660)
Total	3183 (895)	3135 (841)		4315 (964)	4334 (1205)	

B. Mean score and standard deviations in **off-line text comprehension** (ACC and RT).

	L1 Bilinguals ACC		L1 Bilinguals RT				L2 Bilinguals ACC		L2 Bilinguals RT			
	Early	Late	Early	Late	**Total ACC**	**Total RT**	Early	Late	Early	Late	**Total ACC**	**Total RT**
Baseline	.95 (.09)	.84 (.19)	2656 (969)	2788 (1228)	.90 (.14)	2722 (1099)	.89 (.14)	.69 (.32)	3947 (1557)	3602 (1042)	.79 (.23)	3775 (1300)
Focal	.87 (.17)	.87 (.14)	3068 (1096)	3207 (1482)	.87 (.16)	3138 (1289)	.90 (.16)	.68 (.28)	3647 (1012)	3975 (1260)	.79 (.22)	3811 (1136)
Non-focal	.93 (.11)	.85 (.20)	2993 (1228)	2990 (1566)	.90 (.16)	2992 (1397)	.83 (.18)	.70 (.31)	4083 (1247)	3939 (1228)	.77 (.25)	4011 (1238)
Total	.92 (.12)	.85 (.18)	2906 (1098)	2995 (1425)			.87 (.16)	.69 (.31)	3893 (1272)	3839 (1177)		

C. Mean score and standard deviations in accuracy (ACC) and response times (RT) in the **PM trials.**

	L1 Bilinguals						**L2 Bilinguals**					
	ACC		**RT**				**ACC**		**RT**			
	Early	Late	Early	Late	**Total**		Early	Late	Early	Late	**Total**	
					ACC	**RT**					**ACC**	**RT**
Focal	.81 (.29)	.68 (.33)	2959 (1660)	2649 (996)	.75 (.27)	2804 (1328)	.78 (.28)	.87 (.24)	3695 (2906)	3805 (1954)	.83 (.21)	3750 (2430)
Non-focal	.80 (.29)	.81 (.28)	2822 (957)	2957 (1235)	.81 (.23)	2890 (1096)	.75 (.34)	.70 (.32)	3825 (1923)	4603 (3789)	.73 (.29)	4214 (2856)
Total	.81 (.29)	.75 (.31)	2891 (1309)	2803 (1116)			.77 (.31)	.79 (.28)	3760 (2415)	4204 (2872)		

D. Mean score and standard deviations in accuracy (ACC) and response times (RT) in the **switching cost index**.

	L1 Bilinguals						**L2 Bilinguals**					
	ACC		**RT**				**ACC**		**RT**			
	Early	Late	Early	Late	**Total**		Early	Late	Early	Late	**Total**	
					ACC	**RT**					**ACC**	**RT**
Focal	.20 (.36)	.07 (.41)	904 (1495)	797 (1608)	.14 (.39)	851 (1552)	.12 (.34)	-.23 (.43)	567 (1883)	1170 (2204)	-.11 (.39)	869 (2044)
Non-focal	.14 (.36)	-.02 (.43)	643 (1288)	532 (1877)	.06 (.40)	582 (1583)	.04 (.38)	.01 (.56)	2394 (4294)	259 (2198)	.03 (.47)	1327 (2346)
Total	.17 (.36)	.03 (.42)	774 (1392)	665 (1743)			.08 (.36)	-.22 (.50)	1481 (3089)	715 (2201)		

DISCUSSION

In the present study we examined the influence of bilingualism on prospective memory. First, we explored possible differences between monolinguals and bilinguals in a PM task, which varied in monitoring demands (baseline –without PM instructions-, focal PM- or non-focal PM-tasks) and the linguistic requirements (early updating vs. late updating). Second, we compared bilingual PM performance when the task was carried out in the in first (L1) and second (L2) language. To this end, monolinguals and bilinguals performed an event-based task in which the nature of the PM cue (focal vs. non-focal) and the linguistic requirements of the ongoing task (early updating vs. late updating) were manipulated. Additionally, bilingual participants performed the PM task in both their L1 and L2. Below, we discuss the findings of our study in the same order of presentation used in the Results section.

Monolinguals vs Bilinguals in L1

Bilinguals showed better performance in text comprehension during the ongoing task with faster reading times (online text comprehension), higher response accuracy and faster response times (off-line text comprehension) to the comprehension questions. In general, this advantage was independent of the monitoring requirements of the prospective task and the linguistic difficulty of the ongoing activity, suggesting that overall bilinguals were more efficient L1 comprehenders than monolinguals when they faced inferential revision during text comprehension. However, regarding response times to the comprehension question, we found that bilinguals were faster compared to monolinguals only in the more resource-demanding PM activity. This suggested a higher ability of the bilingual participants facing activities where monitoring is required. Notice that, this does not necessarily suggest that each of the underlying reading comprehension processes are affected by bilingualism, but that higher-levels processes such as inferencing, monitoring and revision, involved in our text comprehension task were modulated by language use.

Studies comparing differences in text comprehension between monolinguals and bilinguals, Teubner-Rhodes et al., (2016) have also found that bilingual readers show better performance than monolinguals in their offline comprehension of syntactically ambiguous sentences, also suggesting that their previous language experience may enhance general performance in language comprehension. Similarly, Afsharrad and Sadeghi Benis (2017) also showed that successful L2 learners outperformed unsuccessful L2 learners classified as monolinguals, in a reading comprehension task, and they attributed this reading comprehension advantage to bilinguals' better use of metacognitive strategies. Moreover, Filippi et al., (2012) studied the effect of interference in an auditory sentence comprehension task finding that bilingual speakers outperformed their monolingual peers in the more interfering condition, suggesting that better cognitive control abilities in bilinguals might allow them to control the interference. Hence, our results add to the evidence suggesting that the bilingual experience modulates high-level comprehension processes, leading to better performance than the monolinguals.

Interestingly, inferential revision in text comprehension has been linked with different executive functions. For example, a recent study (Pérez et al., 2020) showed differences in text comprehension performance due to inhibitory control mechanisms. Specifically, they found that higher compared to lower inhibitory control comprehenders had better performance in a comprehension question when conflicting information was presented in the text. Similarly, inferential text revision requires successful monitoring processes to detect incongruences and to update the mental representation of the text to ensure coherence (Kintsch, 1998; Perfetti et al., 2013). Despite the fact that different underlying abilities have been proposed for reading comprehension (Li et al., 2020), we suggest that differences in monitoring abilities are the main factor that explain our findings, given the critical role of monitoring in tracking text coherence during the inferential revision (Pérez et al., 2015) and during the PM task (Ball & Bugg, 2018). Thereby, we interpret that the higher performance found in bilinguals during the execution of the PM trials is explained by greater monitoring abilities. Consequently, it is possible that our bilingual participants engaged the monitoring processes required for high-level text comprehension more efficiently, and therefore, they outperformed monolinguals. This assumption is in line with previous studies in the field of bilingualism and cognitive functions which have shown better monitoring capacity in bilinguals than monolinguals, not only at the behavioral level, but also at the neural level (Abutalebi et al., 2012; Costa, Hernández et al., 2009; Hilchey & Klein, 2011; Morales et al., 2013, 2015; Kousaie & Phillips, 2012, 2017).

As we previously mentioned, this idea is also supported by the findings regarding the prospective task, where bilinguals showed overall faster response times and higher accuracy than the monolinguals. Thus, the bilingual group seemed to overcome the difficulties in prospective performance associated with the monitoring demands of the task, showing similar performance in the more demanding (non-focal) conditions compared with the less demanding (focal) conditions. These findings suggest that bilinguals can adapt their capacities to the demands of the task and engage in prospective processing strategies, enabling them to successfully perform the PM task even in the more challenging conditions. These results support previous studies, similarly suggesting that bilinguals may have better cognitive strategy adjustment than monolinguals (Morales et al., 2013, 2015). This pattern of results also resembles previous data on PM and bilingualism that observed how bilingual experience modulates the cognitive processes involved in updating and cue detection to adapt them to the PM task's demands (López-Rojas et al., 2022). There is also the possibility that the better PM performance in bilinguals (compared to monolinguals) could be explained by a general higher linguistic capacity in the bilingual group and not by their knowledge of a second language. However, given that reading times to the first and second sentence in the ongoing baseline trials did not differ between monolinguals and bilinguals, we consider that L2 learning (and not a general language capacity) is the responsible for their better PM performance.

Similarly, bilinguals also seemed more efficient when switching between activities (ON-PM tasks), as we found smaller switching cost for bilinguals than monolinguals in accuracy. The smaller cost for bilinguals was similar for the focal and non-focal conditions, whereas monolinguals' cost was affected by the difficulty of the PM task, with greater cost in non-focal than in focal conditions.

The pattern of focality effects observed in monolinguals in their prospective performance and in their switching cost can be easily explained by the Multiprocess framework proposed by McDaniel & Einstein (2000). According to this framework, focal cues elicit "spontaneous retrieval" of the intention in contrast to non-focal cues that require more costly monitoring processes which in turn results in longer response times and poorer accuracy. However, the lack of focality effects in bilinguals suggested that they overcame the processing difficulties associated with the focality of the cue. These findings support the idea that bilingualism modulates the processes engaged in PM processing.

In sum, when focusing on differences between bilinguals and monolinguals in L1, the general pattern of results showed between-group differences in performance with faster and more accurate responses in bilinguals. More importantly, bilingual participants seemed to be able to overcome the monitoring demands imposed by the nature of the PM cue as compared to monolinguals, who show the usual impairment with increments in monitoring demands.

L1 vs L2 in Bilinguals

Language comparisons in online (short-text readings times) and offline (accuracy and response times in cloze-questions) indicated faster and more accurate reading in the L1 compared to L2 comprehension. This is in line with previous studies in the field of reading comprehension in foreign language (Melby-Lervag & Lervag, 2014). In our data we found an impairment in text comprehension when working in a less dominant language. Although this effect was independent of inference updating and prospective load when focusing on reading times during online text comprehension and response times to the comprehension questions, accuracy during offline comprehension was modulated by the updating condition. Specifically, between-language differences in accuracy increased for the more demanding late updating condition, indicating that L2 comprehension is selectively impaired in difficult conditions. This pattern of results supports the findings by Pérez et al., (2019) suggested that the efficiency of predictive processes and inferential revision (a highly demanding updating process) is reduced in the L2, compared to the L1. Pérez et al., (2019) argued that the differences between languages might be because during L2 comprehension, cognitive resources might mainly engage in lower-level features processing and, consequently, less resources might be available to process conceptual features (Horiba & Fukaya, 2015; Segalowitz et al., 1995; Yang, 2002).

Regarding performance in the prospective memory task, we found that when the task was performed in the L2, bilinguals showed a focality effect with better accuracy for the focal than for the non-focal condition. However, when bilinguals performed the task in L1, cue-focality did not have an effect and there were no differences in PM performance between the focal and non-focal conditions. These effects suggest that bilinguals, when working in their L1, seem to be able to adjust their performance to the monitoring demands of the task to overcome the difficulty of non-focal monitoring. However, when the task is performed in the more demanding L2 language, bilinguals may have fewer resources for strategic processing and adjustment; we see this in the standard focality effect, i.e., lower performance in the non-focal when compared to the focal condition. These results are in agreement with previous studies on the role of working memory (WM) in highly demanding inferential reading tasks. For instance, Alptekin and Erçetin (2010) reported differences in WM processing depending on the language. Concretely, participants were more accurate in L1 than in L2, and they argued that reading complex texts in L2 comprehension pose higher demands on WM decreasing their performance in this task. Similarly, and due to the fact that our bilinguals were relatively less proficient in their L2 than in their L1, our results are consistent with previous studies reporting differences between poor and good comprehenders in meta-comprehension monitoring when presented with texts that varied in difficulty (Maki et al., 2005). Thus, Maki et al. (2005) found that good comprehenders were more precise than poor comprehenders when making prospective judgments to difficult texts, where more monitoring was required. However, in the easier texts, there were no differences between the two groups. These results suggest that poor comprehenders monitoring capacity was reduced when reading difficult texts. In line with this hypothesis, Han (2012) observed worse comprehension monitoring for low-proficiency foreign language readers compared to highly proficient foreign language readers (but see Silawi et al., 2020), that failed to find correlations between monitoring in reading comprehension and language proficiency). Altogether, we suggest that the impairment in PM when bilinguals performed the task in their less dominant language was due to reduced cognitive resources and the need to re-allocate attention to the main task.

Finally, analyses comparing the cost of switching between the ongoing and the prospective tasks when working in L1 and L2 indicated that there were no differences between the two languages. Surprisingly, the only observed effect in this analysis involved smaller cost in accuracy in the late updating condition, indicating that while switching was affected by the conditions of the ongoing task, participants were able to disengage from the ongoing task and switch to the prospective task.

Thereby, the overall pattern of results seems to indicate that L2 processing has a cost in ongoing performance and prospective memory, especially in the more demanding L2 processing conditions and when the PM cue requires effortful monitoring processing. However, once that monitoring results in cue detection, L2 processing does not affect switching to the PM and implementing the action intention.

In sum, our study adds to a wide range of literature suggesting that bilinguals are able to better adjust their cognitive strategies to task demands in comparison to monolinguals (Costa et al., 2008; Morales et al., 2013, 2015; Prior & Macwhinney, 2010; see Antoniou (2019), for a review). More importantly, our results support and extend previous studies (López-Rojas et al., 2022) indicating the influence of bilingualism in PM, and the influence of L2 processing on PM performance. Thus, our findings showed an impairment in PM associated with L2 processing. This cost was especially evident in the more demanding conditions suggesting that increments in attentional load due to L2 processing may have impaired the monitoring processes required for prospective remembering.

Prospective memory plays a fundamental role in daily activities. In fact, PM failures (i.e., forgetting to turn off the oven) can result in dramatic consequences when they occur in real life context. Understanding whether and how its underlying cognitive mechanisms can be modulated by bilingualism, allows us to accurately address the challenges of today's world. In this line, studies focused on exploring the interaction between different individual characteristics, such us bilingualism and prospective memory, are of especial interest to address different questions. First, these studies add to studies in other domains suggesting that learning a second language (or being immersed in a L1 or L2 context) can impact perception, attention and memory and in turn many real-world phenomenon such as the recall of future intentions (e.g., send a pending email or attending a scheduled meeting). Second, bilingualism can serve as a tool to study in depth the different cognitive mechanisms involved in the prospective recall (e.g., strategic monitoring).

Overall, our findings suggest that some memory processes might vary depending on the linguistic context. Therefore, this research provides a base for future studies about the impact of bilingualism on prospective memory. Further studies are needed to fully understand the dynamic interaction between L1 and L2 processing during recall of future intentions, as well as possible differences of this interaction by comparing different bilingual experiences.

CONCLUSION

In conclusion, the observed results support our hypothesis that differences in prospective processes might be due to bilingualism and the linguistic context in which bilinguals perform a prospective memory task. We observed that in L1 contexts, bilingualism modulates the cognitive processes involved in updating and cue detection to adapt them to the task demands. Bilinguals were able to engage executive control mechanisms to a greater extent than monolinguals, in order to detect and respond to the PM cue. By contrast, recalling future intentions in an L2 context resulted in an impairment of the performance, especially in the more challenging cognitive conditions. These findings suggest the importance of studying how linguistic context modulates certain memory processes.

Appendix A

Table 1. Statistical effects from data analysis in monolinguals vs bilinguals.

	MONOLINGUALS VS BILINGUALS
Statistical effects	**Online text comprehension (Reading Times)**
Group	$F(1,59) = 3.631; p = .062; \eta_p^2 = 0.058$
Prospective load	$F(1,59) = 0.403; p =.528; \eta_p^2 = 0.007$
Updating	$F(1,59) = 0.006; p =.939; \eta_p^2 = 0.00$
Group by prospective load	$F(1,59) = 0.454; p =.503; \eta_p^2 = 0.008$
Group by updating	$F(1,59) = 1.077; p =.304; \eta_p^2 = 0.018$
Prospective load by updating	$F(1,59) = 0.705; p =.405; \eta_p^2 = 0.012$
Group by prospective load by updating	$F(1,59) = 0.007; p =.934; \eta_p^2 = 0.000$

Statistical effects	Off-line text comprehension ACC	Off-line text comprehension RT
Group	$F(1,59) = 4.465; p < .05; \eta_p^2 = 0.070$	$F(1,59) = 2.283; p = .136; \eta_p^2 = 0.037$
Prospective load	$F(1,59) = 4.944; p < .05; \eta_p^2 = 0.077$	$F(1,59) = 15.972; p < .0001; \eta_p^2 = 0.213$
Updating	$F(1,59) = 22.719; p < .0001; \eta_p^2 = 0.278$	$F(1,59) = 0.025; p = .876; \eta_p^2 = 0.000$
Group by prospective load	$F(1,59) = 1.315; p = .272; \eta_p^2 = 0.022$	$F(1,59) = 4.129; p < .05; \eta_p^2 = 0.065$
Group by updating	$F(1,59) = 0.002; p =. 968; \eta_p^2 = 0.000$	$F(1,59) = 0.277; p = .601; \eta_p^2 = 0.005$
Prospective load by updating	$F(1,59) = 0.488; p = .615; \eta_p^2 = 0.008$	$F(1,59) = 1.055; p = .351; \eta_p^2 = 0.018$
Group by prospective load by updating	$F(1,59) = 2.891; p = .059; \eta_p^2 = 0.047$	$F(1,59) = 0.829; p = .439; \eta_p^2 = 0.014$

Statistical effects	PM ACC	PM RT
Group	$F(1,59) = 15.129; p < .0001; \eta_p^2 = 0.240$	$F(1,59) = 7.618; p < .05; \eta_p^2 = 0.114$
Focality	$F(1,59) = 3.356; p = .072; \eta_p^2 = 0.054$	$F(1,59) = 3.490; p = .067; \eta_p^2 = 0.056$
Updating	$F(1,59) = 2.450; p = .123; \eta_p^2 = 0.040$	$F(1,59) = 0.793; p = .377; \eta_p^2 = 0.013$
Group by focality	$F(1,59) = 9.539; p < .05; \eta_p^2 = 0.139$	$F(1,59) = 1.875; p = .176; \eta_p^2 = 0.031$
Group by updating	$F(1,59) = 1.834; p = .181; \eta_p^2 = 0.030$	$F(1,59) = 0.028; p = .867; \eta_p^2 = 0.000$
Focality by updating	$F(1,59) = 2.028; p = .160; \eta_p^2 = 0.033$	$F(1,59) = 0.001; p = .978; \eta_p^2 = 0.000$
Group by focality by updating	$F(1,59) = 0.220; p = .641; \eta_p^2 = 0.004$	$F(1,59) = 2.637; p = .110; \eta_p^2 = 0.043$

Statistical effects	Switching ON-PM ACC	Switching ON-PM RT
Group	$F(1,59) = 3.802; p = .056; \eta_p^2 = 0.061$	$F(1,59) = 0.379; p = .540; \eta_p^2 = 0.006$
Focality	$F(1,59) = 7.628; p < .05; \eta_p^2 = 0.114$	$F(1,59) = 1.240; p = .270; \eta_p^2 = 0.056$
Updating	$F(1,59) = 15.198; p < .001; \eta_p^2 = 0.205$	$F(1,59) = 0.069; p = .793; \eta_p^2 = 0.001$
Group by focality	$F(1,59) = 19.177; p < .0001; \eta_p^2 = 0.245$	$F(1,59) = 0.047; p = .830; \eta_p^2 = 0.001$
Group by updating	$F(1,59) = 0.367; p = .547; \eta_p^2 = 0.006$	$F(1,59) = 0.111; p = .740; \eta_p^2 = 0.002$
Focality by updating	$F(1,59) = 0.064; p = .801; \eta_p^2 = 0.001$	$F(1,59) = 0.000; p = .994; \eta_p^2 = 0.000$
Group by focality by updating	$F(1,59) = 0.438; p = .510; \eta_p^2 = 0.007$	$F(1,59) = 0.000; p = .999; \eta_p^2 = 0.000$

Table 2. Statistical effects from data analysis in bilinguals L1 vs L2.

	BILINGUALS L1 VS L2
Statistical effects	**Online text comprehension (Reading Times)**
Language	$F(1,27) = 32.366; p < .0001; \eta_p^2 = 0.545$
Prospective load	$F(1,54) = 0.898; p = .352; \eta_p^2 = 0.032$
Updating	$F(1,27) = 0.080; p = .779; \eta_p^2 = 0.003$
Language by prospective load	$F(1,27) = 1.343; p = .257; \eta_p^2 = 0.047$
Language by updating	$F(1,27) = 0.368; p = .549; \eta_p^2 = 0.013$
Prospective load by updating	$F(1,27) = 0.016; p = .901; \eta_p^2 = 0.001$
Language by prospective load by updating	$F(1,27) = 0.460; p = .503; \eta_p^2 = 0.017$

Statistical effects	**Off-line text comprehension ACC**	**Off-line text comprehension RT**
Language	$F(1,27) = 6.532; p < .05; \eta_p^2 = 0.195$	$F(1,27) = 19.728; < .0001; \eta_p^2 = 0.473$
Prospective load	$F(2,54) = 0.506; p = .606; \eta_p^2 = 0.018$	$F(2,54) = 2.550; p = .125; \eta_p^2 = 0.104$
Updating	$F(1,27) = 35.781; p < .0001; \eta_p^2 = 0.570$	$F(1,27) = 0.034; p = .856; \eta_p^2 = 0.002$
Language by prospective load	$F(2,54) = 0.894; p = .415; \eta_p^2 = 0.032$	$F(2,54) = 0.025; p = .875; \eta_p^2 = 0.001$
Language by updating	$F(1,27) = 7.692; p < .05; \eta_p^2 = 0.222$	$F(1,27) = 0.567; p = .459; \eta_p^2 = 0.025$
Prospective load by updating	$F(2,54) = 1.863; p = .165; \eta_p^2 = 0.065$	$F(2,54) = 0.031; p = .862; \eta_p^2 = 0.001$
Language by prospective load by updating	$F(2,54) = 2.594; p = .084; \eta_p^2 = 0.088$	$F(2,54) = 1.040; p = .319; \eta_p^2 = 0.045$

Statistical effects	**PM ACC**	**PM RT**
Language	$F(1,27) = 0.001; p = .973; \eta_p^2 = 0.000$	$F(1,27) = 7.125; p < .05; \eta_p^2 = 0.209$
Focality	$F(1,27) = 0.315; p = .579; \eta_p^2 = 0.012$	$F(1,27) = 2.083; p = .160; \eta_p^2 = 0.072$
Updating	$F(1,27) = 2.933; p = .098; \eta_p^2 = 0.098$	$F(1,27) = 1.944; p = .175; \eta_p^2 = 0.067$
Language by focality	$F(1,27) = 4.278; p < .05; \eta_p^2 = 0.137$	$F(1,27) = 1.472; p = .235; \eta_p^2 = 0.052$
Language by updating	$F(1,27) = 0.921; p = .346; \eta_p^2 = 0.033$	$F(1,27) = 4.509; p < .05; \eta_p^2 = 0.143$

Statistical effects	**Switching ON-PM ACC**	**Switching ON-PM RT**
Language	$F(1,27) = 3.090; p = .090; \eta_p^2 = 0.103$	$F(1,27) = 1.371; p = .252; \eta_p^2 = 0.048$
Focality	$F(1,27) = 0.001; p = .976; \eta_p^2 = 0.000$	$F(1,27) = 0.120; p = .731; \eta_p^2 = 9.004$
Updating	$F(1,27) = 22.409; p < 0.001; \eta_p^2 = 0.000$	$F(1,27) = 2.199; p = .150; \eta_p^2 = 0.075$
Language by focality	$F(1,59) = 4.126; p = 0.052; \eta_p^2 = 0.133$	$F(1,27) = 1.949; p = .174; \eta_p^2 = 0.067$
Language by updating	$F(1,27) = 0.172; p = .682; \eta_p^2 = 0.006$	$F(1,27) = 1.343; p = .257; \eta_p^2 = 0.047$
Focality by updating	$F(1,27) = 3..449; p = .074; \eta_p^2 = 0.113$	$F(1,27) = 4.113; p = .053; \eta_p^2 = 0.132$
Language by focality by updating	$F(1,27) = 3.388; p = .077; \eta_p^2 = 0.112$	$F(1,27) = 3.615; p = .068; \eta_p^2 = 0.118$

CHAPTER 6.

EXPERIMENT 3

The **third experiment** was entitled **"ERP and Behavioural Correlates of Prospective Memory in Bilinguals during L1 and L2 Processing"** and has been published in *Brain Sciences* (López-Rojas, Csilinkó, Bajo & Marful, 2023).

ABSTRACT

Language influences how we process information from multiple domains. Thus, working in first (L1) or second language (L2) can modulate bilinguals' performance on basic activities, such as visual search, decision-making, or reading. However, few studies have explored the role of L1 and L2 processing during an essential ability, such as Prospective Memory (PM). This type of memory allows us to set intentions to perform in the future (e.g., to attend an appointment). Thus, this is a novel study that allows us to explore the influence of bilingual language processing on certain cognitive abilities, which have not been deeply studied yet, such as the recall of future intentions. Thereby, this study aimed to explore the neural and behavioural correlates of bilinguals during L1 and L2 processing in a PM task where participants had to carry out an ongoing task while recovering a prospective intention given a PM cue. Importantly, the nature of the PM cue (focal or non-focal) varied the monitoring demands of the task. Behavioural and Event-Related Potential (ERP) results indicated greater engagement of monitoring processes in the PM task during L2 processing. Specifically, in L2, we found lower accuracy rates in the ongoing task and smaller amplitude differences between the focal and non-focal conditions in the P3b. Altogether, these findings suggest an impairment in prospective processing due to working in L2 contexts, supporting previous research on the impact of the bilingual experience over PM.

Keywords: bilingual language processing; prospective memory; bilingualism; event-related potentials (ERPs)

INTRODUCTION

Language processing is inherent in every activity that we face in our daily life. Beyond common activities, such as reading the news, having a discussion with your colleague, or writing an email, language processing is also critical when we are planning, making decisions, or generating new ideas. Research on linguistic relativity has focused on exploring how different languages modulate the way in which we think (Wolff & Holmes, 2011). Thus, language processing influences how we integrate and interpret information from multiple domains (for a recent conceptual review see Thierry, 2016). For instance, classic studies (Davies & Corbett, 1997) showed that the way in which we categorize colours depends on the language we speak. More recently, He et al. (2019) evaluated Mongolian and Chinese speakers' colour perception and found better colour discrimination in Mongolian speakers (who have two words to describe light blue and dark blue) compared to Chinese speakers (who have only one word to describe both colours). The possible influence of language in how we process the environment is especially critical for bilingual people who have to manage the use of two or more languages when they are faced to multiple situations. Previous studies indicated that bilinguals co-activate both languages even if only one is required during the task (Bobb et al., 2020; Iniesta et al., 2021). This co-activation results in the need to negotiate between both languages to avoid competition when selecting the appropriate language for the context. Importantly, this co-activation impacts the way in which bilingual people perceive the world and the underlying cognitive processes (Blumenfeld & Marian, 2013), especially when these activities are performed in their less dominant language (Athanasopoulos, 2009). Interestingly, a vast body of literature has shown the consequences of second language processing on cognitive processes, such as visual attention (Chabal & Marian, 2015), perception of multisensory emotions (Chen et al., 2022), and long-term memory (Marian et al., 2021). These findings demonstrate the relevance of exploring how bilingual people face daily activities in their first (L1) or second (L2) language and, more specifically, how bilingual language processing modulates specific real-world phenomena.

If we think about different tasks in day-to-day life, we can easily imagine situations in which the recall of future intentions is relevant. For example, making a call at a specific time, remembering to go to the grocery store to replenish or going to a scheduled appointment. Recalling future intentions is termed Prospective Memory (PM). To study PM in controlled experimental settings, participants are asked to perform a main activity, such as a picture naming task (i.e., ongoing task). Additionally, participants are instructed to perform an additional task (i.e., PM task) that involves the recall of a future intention in the presence of a PM cue previously encoded. For example, participants may be told that while they are performing the picture naming task (ongoing task), they have to press the key labeled in green when the picture of a ball (i.e., PM cue) appears on the screen. This event-based PM paradigm has been extensively used to study PM in the lab (Smith et al., 2007).

Cognitive processes, such as monitoring or switching (Bisiacchi et al., 2009; Scullin et al., 2015), have been proposed to underlie the correct performance in this type of activity. Interestingly, the attentional processes engaged to perform the PM intention has been shown to be modulated by the type of PM cue (focal vs. non-focal cues). Thus, as stated in the Multiprocess Framework (McDaniel & Einstein, 2000), properties of the focal cues engage processes that are also the main focus of the ongoing activity (e.g., a specific picture in the naming task) and can elicit the "spontaneous retrieval of the intention" without the engagement of costly monitoring or retrieval processes [16]. In contrast, when non-focal cues are presented, participants are required to pay attention to elements that are not involved in the ongoing task (e.g., detecting a specific colour framing in the screen during a picture naming task) and that signal the moment to perform the intention (i.e., PM cue). Consequently, when non-focal cues signal the PM, extra processing is required to detect this PM cue. In sum, PM allows us to create future intentions at the proper time or situation by engaging prospective processes that vary depending on the attentional demands of the task.

Similarly, bilingual people also pay attention to the environment to detect contextual cues that allow them to select the correct language in each situation (Kaan et al., 2020). Hence, this expertise in managing two languages might transfer to an essential ability, such as PM, which engages similar cognitive processes. The role of bilingualism on PM is a relevant question to be investigated since it will contribute to understanding the processes involved in both prospective memory and bilingual processing and how they modulate each other. Thereby, we describe below recent studies that address some of the relevant questions related to this topic.

In this regard, previous studies have focused on exploring the role of bilingualism as a modulator factor of performance in PM activities. For instance, López-Rojas et al. (2022) studied how different bilingual experiences influence the recall of future intentions. Interestingly, they evaluated participants that differed in their bilingual experience (monolinguals, late bilinguals from a single-language context, and early bilinguals from a context with frequent language-switching). In this experiment, participants completed a non-verbal PM task that varied in their monitoring requirements (focal vs non-focal cues). In addition, online EEG brain activity was recorded during the task to explore the N300 and P3b components (West, 2011) that are related to the detection of the PM cue and to intention monitoring processes, respectively. Thus, for the N300, the early bilingual group showed an enhancement of the monitoring processes engaged to detect the PM cue during the more demanding condition (non-focal) compared to the monolinguals and late bilinguals. However, the differences associated with the bilingual experience were not evident in the less costly condition (focal). Most importantly, the P3b showed that early bilinguals adapted their monitoring strategies not only to detect the PM cues, but also during the ongoing activity to refresh the PM intention and perform it at the proper time. Nevertheless, given that the PM task in this study (López-Rojas et al., 2022) was basically non-verbal, an intriguing question to study is how these processes vary when the PM task involves language processing and when this processing is performed in the participants' first (L1) or second languages (L2). Thereby, López-Rojas et al. (2023a) aimed to explore how bilinguals' performance in a verbal PM task varied when they completed it in L1 or L2 and how the linguistic complexity and the attentional requirements associated with the PM task varied. In a within/between subject design, they compared monolinguals' and bilinguals' performance in L1, but also how bilinguals differed when the task to be performed was in their L1 or in their L2. Overall, bilinguals outperformed monolinguals in L1 with faster response times and greater accuracies in the more demanding PM condition. This pattern of results suggested greater efficiency of the bilingual group in engaging the monitoring abilities required by the PM task, supporting previous studies that indicated the ability of bilinguals to adapt their cognitive strategies to the demands of the task (Hayakawa et al., 2016; López-Rojas et al., 2022; Morales et al., 2013; 2015). Critically, in agreement with previous results in the field [24], the comparisons between L1 and L2 for bilinguals in López-Rojas et al. [20] indicated a cost associated to work in their less dominant language. In general, bilinguals showed slower response times and lower accuracies in L2 compared to L1. Again, these effects were modulated by the monitoring demands of the task so that the differences between L1 and L2 appeared in the more demanding condition (non-focal), whereas they were not evident in the less demanding focal task. Altogether, these findings indicate the critical role of bilingualism in modulating the recall of future intentions, especially when the ongoing and PM activities are performed in a second language. Unfortunately, electrophysiological data was not collected in this study, so there was no evidence of the neural correlates of the PM task in L1 and L2. These data are important given the fine-grained sensitivity of electroencephalogram information to detect the underlying cognitive processes of the bilingual experience in general cognition and, specifically, in the way in which bilingual language processing modulates certain memory processes. In this line, this experiment supposes an important contribution to the psycholinguistic field in its effort to understand how bilingualism shapes our mind and brain.

Aims and Hypotheses

The main goal of the present experiment is to study the behavioral and electrophysiological correlations associated to first or second language processing during a PM task. To this end, our bilingual participants were asked to complete a PM task in Spanish (L1) and in English (L2). In addition, and following previous studies in the field (López-Rojas et al., 2022, 2023a) the nature of the PM task, i.e., focal and non-focal, was manipulated to obtain conditions that varied in their monitoring requirements (Kliegel et al., 2008). This manipulation is theoretically relevant because it allows us to study the influences of the monitoring demands in the prospective processes engaged during a PM task that requires language processing.

Additionally, during the PM task, we recorded brain activity to observe the event-related potentials (ERPs) elicited by the activity. In particular, we aimed to explore the ERPs classically associated to prospective processing during a PM task: P3b and N300 (Polich, 2007; West, 2007, 2011; West et al., 2003). The P3b is a positive deflection in PM trials when compared to ongoing trials over centro-parietal regions around 300–400 ms after the stimulus onset and lasting to 600–800 ms after the appearance of the stimuli. Usually, the P3b is associated to stimuli that work as targets or PM cues, reflecting working memory processes and context updating. Therefore, it is considered as signaling monitoring within the PM context (Zhang et al., 2021). On the other hand, the N300 component is a negative deflection in the occipital and parietal regions elicited by the detection of the PM cue around 300–500 ms after the stimulus appears. This component reflects a negative amplitude of the PM cues compared to the ongoing trials, which present a greater positive wave amplitude (Cona et al., 2014).

Hence, at a behavioural level, we expected to find lower performance when the task is carried out in L2 compared to L1. As previous research suggests (López-Rojas et a., 2022), the recall of future intentions in L2 could be costlier and more demanding (Horiba & Fuyaka, 2015; Meier & Zimmermann, 2015) and, consequently, fewer resources might be available to detect the PM cue and process the PM intention. Thus, we expected to observe slower response times and lower accuracies when the PM task is performed in L2 compared to L1. Similarly, we expected to observe the classic focality effect in our data, that is, faster response times and greater accuracies for the focal condition compared to the non-focal condition. Focality effects have been reported in a wide body of studies in the field Cejudo et al., 2019; Hunter Ball & Bugg, 2018; Wang et al., 2011), supporting the existence of dual pathways in prospective remembering (McDaniel et al., 2015).

In addition to the behavioural effects, we expected that L1 and L2 differences might also be reflected in the ERP components. Interestingly, to the best of our knowledge, this is the first study to explore the neural correlates associated with PM performance during first or second language processing. Based on previous results (López-Rojas et al., 2022; Cona et al., 2014; West, 2011), we expected that the P3b and N300 components associated with differences between PM and ongoing trials would be modulated by focality and language. Thus, we expected to find a focality effect with greater amplitude-differences in the non-focal than focal conditions (that is more positive amplitude for the P3b in the non-focal than focal condition, and more negative amplitudes for the N300 in the non-focal than focal conditions). Because these focality effects reflect the capacity to adjust the monitoring and detection processes to the demands of the task, we expected that they would interact with language resulting in a lower capacity to adjust these processes when the language involved is the more demanding L2 (reflected in the ERPs with similar amplitudes for focal and non-focal conditions in L2). It is also possible, however, that L2 processing may result in larger amplitude changes in the non-focal condition relative to the focal, reflecting larger difficulties in prospective processing during the more demanding condition (non-focal) and the need to engage more cognitive resources to perform the task.

Although both hypotheses are possible, as we previously described, results comparing monolingual with early and late bilinguals (López-Rojas et al., 2022) suggest that more difficult L2 processing might be related to impaired capacity to adjust strategies (i.e., focality effects were stronger for early bilinguals when compared with late bilinguals and monolinguals who were unsuccessful in adjusting their performance to the monitoring demands). Hence, if we assume that L2 processing will act to reduce the bilinguals' capacity to adjust their strategies, we would expect that the effect of focality will also be reduced in L2 when compared with L1.

METHODS

Participants

This study was approved by the Research Ethics Committee of the University of Granada (registration number, 84/CEIH/2015). A sample size of 30 was necessary to detect a medium Cohen's d effect of 0.5 (power = 96%; α =.05) for a 2 × 2 repeated measures ANOVA, based on the PANGEA power analysis program. A total of 31 Spanish-English bilingual volunteers (5 men; mean age = 23.06, SD = 3.425) that were university students participated in this study. All volunteers were native Spanish speakers who acquired English (L2) high fluency during childhood. In order to gain knowledge about the participants' language experience and background, several measures were collected. Thus, the Language Experience and Proficiency Questionnaire (LEAP-Q) (Marian et al., 2007) is a validated questionnaire used to collect self-reported information about linguistic experience in the native (L1) and second language (L2), age of acquisition, frequency of language use, and exposure to each language. Additionally, to assess participants English language proficiency, the Michigan English Language Institute College Entrance Test (MELICET) was applied. The questionnaire evaluates grammar through 50 cloze questions with three answer options. Following previous studies (Kaan et al., 2020; López-Rojas et al., 2022), participants who obtained a direct score of 35 or more out of 50 were included in our experiment. Due to the fact that the MELICET was applied as a screening test, those potential participants that obtained direct scores lower than 35 did not qualify to participate in the study and were not invited to participate in the experiment. Hence, participants in the current study were preselected to reach native-like proficiency levels (M = 37.9; SD = 7.35). Table 11 reports a summary of the average scores provided by this sample to relevant items from the LEAP-Q.

Table 11. Mean score and standard deviations in L1 and L2 questions from the LEAP-Q.

	L1	L2
Proportion of current exposure to the language	.64 *(0.16)	.30 * (0.14)
Proportion of preference to read in each language	.51 * (0.23)	.43 * (0.21)
Proportion of preference to speak in each language	.54 * (0.29)	.35 * (0.22)
Mean age of beginning acquisition (years)		4.71 (2.66)
Mean age of becoming fluent (years)		12.87 (4.94)
Mean level of self-competence (from 0–10)		8.5 (1.26)
Mean level of language exposure with family or friends (from 0–10)		3.87 (3.25)
Mean level of reading exposure (from 0–10)		5.93 (3.69)
Mean level of language exposure by TV or radio (from 0–10)		8.58 (2.19)
Mean level of language exposure by self-learning (from 0–10)		2.54 (3.29)

* Indicated significant differences ($p < .05$) between L1 and L2 comparisons.

Design

In this experiment a 2 (language: L1, L2) × 2 (focality: focal, non-focal) factorial within-subject design was employed to examine participant's performance on the PM and ongoing (ON) tasks.

Procedure and Materials

All participants signed a written consent form before being evaluated. The tasks were performed in well-lit, isolated, individual rooms. The experiment consisted of two sessions in order to properly assess bilinguals' PM performance where the PM task were carried out in their first (L1) and second (L2) language. Each experimental session lasted 90 min each, with a week in between sessions. During the first session, participants filled out the MELICET and the LEAP-Q questionnaire (Marian et al., 2007). Then, they carried out the PM task while their brain activity was recorded using an electroencephalogram (EEG). The language of the PM task (L1 or L2) was counterbalanced across participants. During the second session participants carried out the PM tasks in the correspondent language while EEG was recorded.

Prospective Memory Task. The task consisted of three blocks of trials: baseline, focal, and non-focal. The PM task always started with the baseline block, and then, the focal or non-focal blocks occurred in a counterbalanced order. During the baseline block, participants only carried out the ongoing trial. Thus, they had to press the "yes" key when a name of an animal appeared on the screen, in any other case they were instructed to press the "no" key. Words were selected from the English Lexicon Project (Balota et al., 2007) and were controlled for length and frequency of use based on the English and Spanish corpus (Guasch et al., 2013). During the second and third block of trials, beside the ongoing task, participants were also requested to carry out the prospective intention. The cues of the prospective task were either focal or non-focal. In the focal condition participants were instructed to press “k” or “l” if the words “ball” or “kite” respectively appeared on the screen. Whereas in the non-focal condition participants were instructed to press the “k” or “l” keys when the frame bordering the screen was magenta and grey, respectively. In both conditions when the PM cues appeared, participants should interrupt the ongoing task in order to perform the prospective task. The number of trials within each block were 300 for the ongoing task and 30 for the PM task. Each word appeared until response for a maximum of 2800 ms. If participant response lasted more than 1600 ms, the following trials occurred after an inter stimuli interval (ISI) of 250 ms. When participant response was shorter than 1600 ms a black screen appeared up to 1600 ms, followed by the ISI. Presentation of the stimuli and recording of the responses were carried out on windows-based computers using E-prime 2.0 software (Psychology Software Tools, Pittsburgh, PA, USA). Figure 8 shows the trial sequence of the PM task.

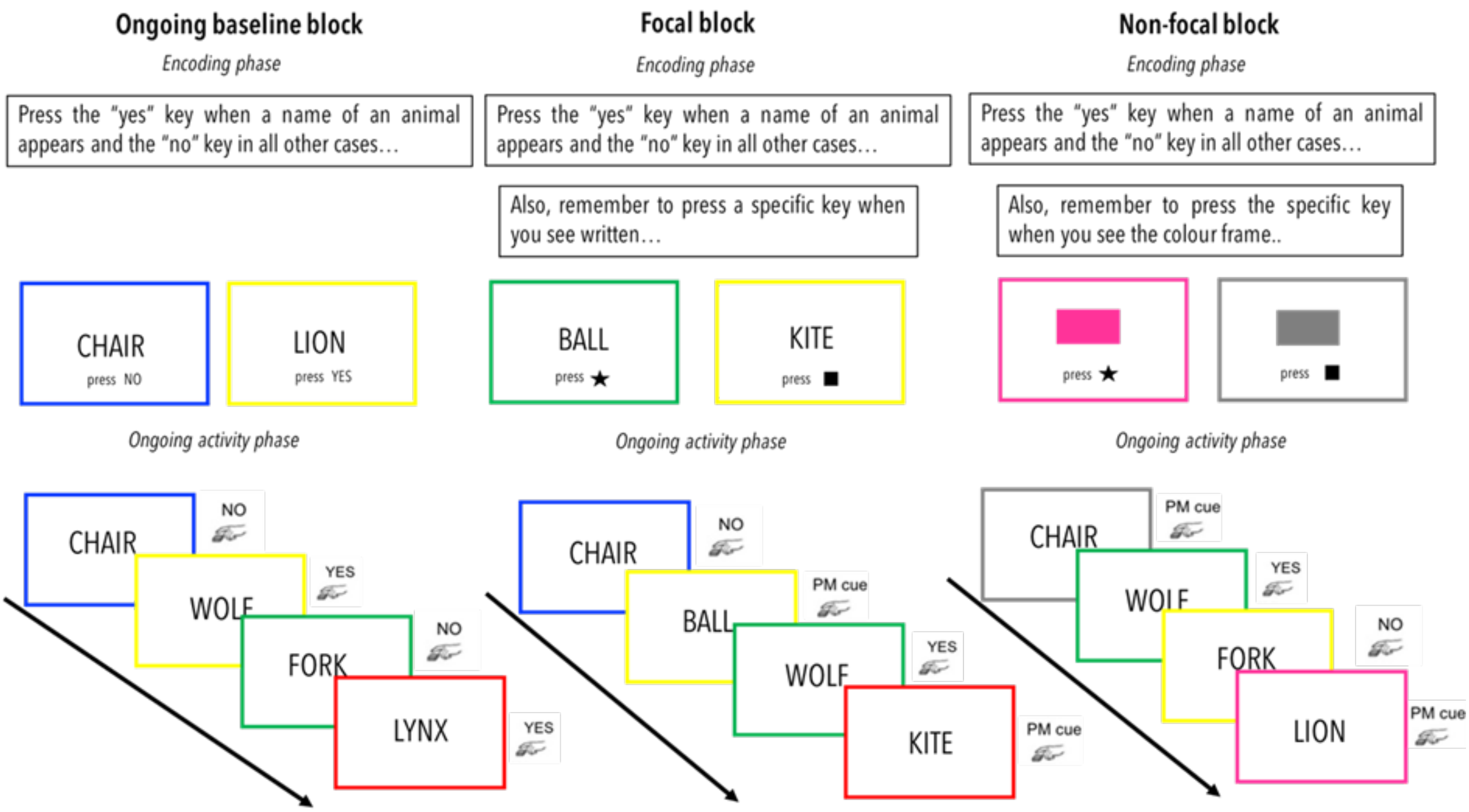

Figure 8. Representation of the PM task in each block condition (baseline, focal and non-focal). All the blocks started with an encoding phase succeeded by the ongoing activity alone (ongoing baseline block) or the ongoing activity with the PM intention implemented (focal and non-focal blocks). The trial sequence in each block is signaled by the black arrow. In the focal and non-focal conditions PM cues appeared intercalated.

EEG Recording and Pre-Processing

Participants' brain activity was recorded using Neuroscan Synamps2 (El Paso, TX) by means of 40 Ag/AgCl electrodes allocated on the scalp. To record eye movements, two pairs of bipolar electrodes were horizontally and vertically allocated. The ground electrode was positioned in front of Fz, along the midline. The analogue EEG signal was amplified and digitised at a sampling frequency of 1000 Hz. Electrodes' impedances were kept at <10 kΩ during recording. The EEG recording was established in an average reference. Additionally, data processing was carried out with EEGLAB 14.1 (Delorme & Makeig, 2004) using Matlab environment (Version 7.4.0, MathWorks, Natick, MA, USA). The EEG data had an online bandpass filter between 0.5–1000 Hz. Detection of channels with high levels of artefacts were identified by cautious visual inspection and interpolation method was used with neighbouring electrodes. Placement of temporal windows were following cue appearance when the stimuli were shown. The times for the ERP analysis include 200 ms pre-stimulus period used as baseline correction and 1200 ms of post-stimulus activity. Artifact correction was done using the independent component analysis toolbox (ICA) in EEGLAB with a cut of ±100 μV epoch rejection. The percentage of rejected times was always <25% for each participant after the rejection of the artefacts.

DATA ANALYSES

Behavioural Analyses

In our study, we analysed the response times and accuracy in the PM task following the procedure of previous studies (Czernochowski et al., 2012; López-Rojas et al., 2022). Thus, accuracy scores greater than three times the interquartile range were removed from the analysis. This resulted in the removal of one participant. Additionally, individual trials with RTs faster than

200 ms were removed from the analyses. Therefore, the analyses were applied both on the PM and ON trials for each participant in each language condition (L1 and L2). Notice that only the ON trials that appeared prior to the PM cue were selected to this analysis to avoid changes due to attention fluctuation and to have the same number of ON and PM trials. Consequently, for every PM trial (30 in total) the prior ON trials (30) were included in the analysis, following a similar approach used by López-Rojas et al. (2022) (Cejudo et al., 2022). Accordingly, 2 (language: L1, L2) × 2 (focality: focal, non-focal) repeated measures ANOVAs for the ongoing and PM were carried out. When required, post hoc tests with Bonferroni corrections for multiple comparisons were carried out. Accuracy and RTs means in the Ongoing and PM trials in both language conditions (L1 vs. L2) were reported in Table 12.

Electrophysiological Data Analysis

Given that PM components directly compare ON vs. PM waves, a 2 (language: L1, L2) × 2 (focality: focal, non-focal) × 2 (type of trial: ON, PM) repeated measures ANOVA was carried out. Time periods were determined based on previous PM studies (Cona et al., 2014; López-Rojas et al., 2022; West et al., 2003). Therefore, we studied the P3b component connected with working memory (WM) monitoring and updating during cue detection that was registered at 300–500 ms in posterior regions (López-Rojas et al., 2022; West et al., 2003) and reflects more positive amplitudes when the PM is displayed compared to the ON trials. Furthermore, we studied the N300 component, i.e., a reduction in central-posterior electrodes subsequent to the display of PM cue and relative to ON trials that is related to monitoring and (PM) cue detection. The time frame selected was between 200 to 300 ms in central-posterior regions as in previous experiments (Cejudo et al., 2022; López-Rojas et al., 2022). In addition, prior to the actual analysis, non-parametric cluster-based permutation analysis, as implemented in the Fieldtrip Matlab toolbox software (Oostenveld et al., 2010), was performed to identify the electrodes for each time window that maximised the differences between the PM and ON trials. An advantage of this procedure is that the selection of a particular region of interest (electrode cluster) is defined in a data-driven manner and not based on the sometimes-inconsistent Regions of Interests (ROIs) from previous studies or by assumptions regarding the sampling distribution under the null hypothesis. Results of these analyses indicated that electrodes CP3, CPZ, CP4, P3, PZ, P4, O1, OZ, and O2 yielded significant differences ($p < .05$) for 175–300 ms intervals. For the 300–400 ms time window, the cluster included the electrodes CP3, CPZ, P3, PZ, P4, O1, OZ, and O2 ($p < .05$). Hence, these electrodes correspond to the usual posterior site of the N300 and to the parietal site of the P300.

After EEG data pre-processing data from five participants in L1 and one participant in L2 were eliminated due to high levels of noise in the EEG signals or a high rejection of epochs. Therefore, data was analysed with repeated measures ANOVAs of 24 participants in total.

RESULTS

Behavioural Results

Ongoing Activity Performance. First, we analysed participants' performance during the ongoing activity. To that end, 2 (focality: focal vs. non-focal) by 2 (language: L1 vs. L2) ANOVAs were conducted on mean response times and proportion of correct responses.

Response Times. The analysis yielded a statistically significant main effect of focality condition, $F(1,29) = 10.464$; $p < .05$; $\eta_p^2 = 0.265$, showing faster response times for the ongoing activity in the focal condition (M = 832.158, SD = 122.252) than in the non-focal condition (M = 878.308, SD = 154.869).

However, the main effect of language $F(1,29) = 0.247$; $p = .623$; $\eta_p^2 = 0.008$, and the focality by language interaction $F(1,29) = 0.240$; $p = .628$; $\eta_p^2 = 0.008$ did not reach significance.

Accuracy. The analysis showed a significant main effect of focality, $F(1,29) = 87.435$; $p < .01$; $\eta_p^2 = 0.751$, indicating higher accuracy rates in the focal condition (M = .96, SD = .03) than in the non-focal condition (M = .93, SD = .04). Furthermore, there was a significant main effect of language, $F(1,29) = 14.128$; $p < .001$; $\eta_p^2 = 0.328$, with more accuracy in L1 (M= .956; SD= .031) than in L2 (M= .934; SD = .04). However, the language by focality interaction was not significant $F(1,29) = 0.867$; $p = .360$; $\eta_p^2 = 0.029$.

In sum, analyses in the ongoing activity showed a main effect of focality in response times and accuracies, indicating an impairment in the performance for the more attentional demanding conditions (i.e., non-focal). Importantly, we found a main effect of language in accuracy signalling fewer correct responses to the ongoing activity during L2 processing.

PM Task Performance. In order to examine PM task performance, 2 (focality: focal vs. non-focal) by 2 (language: L1 vs. L2) ANOVAs were conducted on mean proportions of correct responses and response times.

Response Times. The main effects of focality, $F(1,28) = 1.951$ $p = .173$; $\eta_p^2 = 0.065$, language $F(1,28) = 0.705$; $p = .408$; $\eta_p^2 = 0.025$, and the focality by language interaction $F(1,28) = 3.236$; $p = .083$; $\eta_p^2 = 0.104$ did not reach the statistical significance.

Accuracy. The main effect of focality reached statistical significance $F(1,28) = 31.080$; $p < .01$; $\eta_p^2 = 0.526$, indicating greater accuracy in the focal (M = .884, SD = .149) than in the non-focal condition (M = .763, SD = .119). However, the main effect of language $F(1,28) = 2.207$; $p = .149$; $\eta_p^2 = 0.073$

and the focality by language interaction were not significant $F(1,28) = 0.833$; $p = .083$; $\eta_p^2 = 0.104$.

In sum, PM performance was not modulated by language condition. However, we found differences in accuracy between monitoring conditions with greater accuracy in the less demanding (i.e., focal) condition.

Table 12. Means ACC and RTs (with standard deviation in parentheses) by type of trial and language session in PM task.

	L1		L2	
Type of Trial	**ACC**	**RT**	**ACC**	**RT**
ON trials focal	.97 (.03)	836 (142)	.95 (.03)	828 (102)
ON trials non focal	.94 (.03)	889 (184)	.92 (.04)	868 (126)
PM trials focal	.85 (.19)	1059 (256)	.92 (.1)	1002 (199)
PM trials non focal	.75 (.14)	1069 (206)	.78 (.1)	1071 (189)

Electrophysiological Results

For each ERP component (P3b and N300), mean amplitudes across electrodes and conditions were averaged and adhered to a 2 (language) × 2 (focality) × 2 (type of trial) within measures ANOVA. Figure 9 shows the P3b and N300 components in function of language (L1 vs. L2) in the focal and non-focal condition in the PM and ON trials.

Electrophysiological Results: P3b

Although the main effects of focality $F(1,23) = 0.007$; $p = .935$; $\eta_p^2 = 0.000$, and language $F(1,23) = 0.123$; $p = .729$; $\eta_p^2 = 0.005$ did not reach statistical significance, the main effect of type of trial $F(1,23) = 4.519$; $p = .044$; $\eta_p^2 = 0.164$ was significant, indicating greater positive amplitude in PM trials (M = 0.555; SD = 1.03) compared to ON trials (M = 0.321; SD = 1.18). Interestingly, the focality by type of trial interaction reached statistical significance $F(1,23) = 8.179$; $p = .009$; $\eta_p^2 = 0.262$, indicating that there were no significant differences between ON (M = 0.465; SD =1.39) and PM trials (M = 0.423; SD =1.16) ($t(24) = 0.303$, $p = .764$, $d = 0.03$) in the focal condition. However, in the non-focal condition the differences between type of trials reached significance (ON: M = 0.177; SD =0.97; PM: M = 0.686; SD = 0.91; $t(24) = -3.305$, $p < .05$, $d = -2.03$). Thus, the standard P3b appeared in the non-focal condition but not in the focal condition. Additionally, the focality by language interaction $F(1,23) = 4.518$; $p = .044$; $\eta_p^2 = 0.164$ revealed that the focality effect associated to P3b appeared in L1 $t(24) = -1.910$, $p = .068$, $d = -0.34$ (i.e., greater positivity in non-focal M = 0.593; SD = 0.777 than in the focal condition M = 0.278; SD = 1.109) but it was not evident in L2 (focal, M = 0.742; SD = 1.350; non-focal M = 0.350; SD = 0.745) $t(28) = 1.623$, $p = .116$, $d = 0.33$. Nevertheless, the interactions of language by type of trial $F(1,23) = 0.195$; $p = .663$; $\eta_p^2 = 0.008$, focality by language by type of trial $F(1,23) = 0.249$; $p = .623$; $\eta_p^2 = 0.011$ were not significant.

In sum, the P3b component (higher amplitudes in the PM when compared to the ON) appeared in the non-focal condition, where more involvement of monitoring processes were expected. Interestingly, the differences between monitoring conditions disappeared when the task was performed in L2, suggesting a general impairment in the available cognitive resources to face the task during second language processing.

Electrophysiological Results: N300

The main effect of focality was significant $F(1,23) = 10.282$; $p = .004$; $\eta_p^2 = 0.309$ with more negative amplitudes in the non-focal condition (M = 1.088; SD = 1.51) compared to the focal condition (M = 1.66; SD = 2.02). This indicated greater engagement of monitoring processes to detect the non-focal PM cue. None of the remaining main effects or interactions reached statistical significance (type of trial $F(1,23) = 1.900$; $p = .181$; $\eta_p^2 = 0.076$;

language condition $F(1,23) = 0.002$; $p = .967$; $\eta_p^2 = 0.000$; focality by type of trial interaction $F(1,23) = 1.214$; $p = 0.282$; $\eta_p^2 = 0.050$; focality by language $F(1,23) = 2.400$; $p = 0.135$; $\eta_p^2 = 0.094$; type of trial by language $F(1,23) = 0.092$; $p = 0.765$; $\eta_p^2 = 0.004$; focality by type of trial by language $F(1,23) = 0.164$; $p = .689$; $\eta_p^2 = 0.007$).The N300 analyses indicated a lack of differences between ON and PM trial processing, suggesting the same engagement of detection processes for both types of trials. However, we found that the N300 was modulated by the monitoring condition. We will go back to this result in the next section.

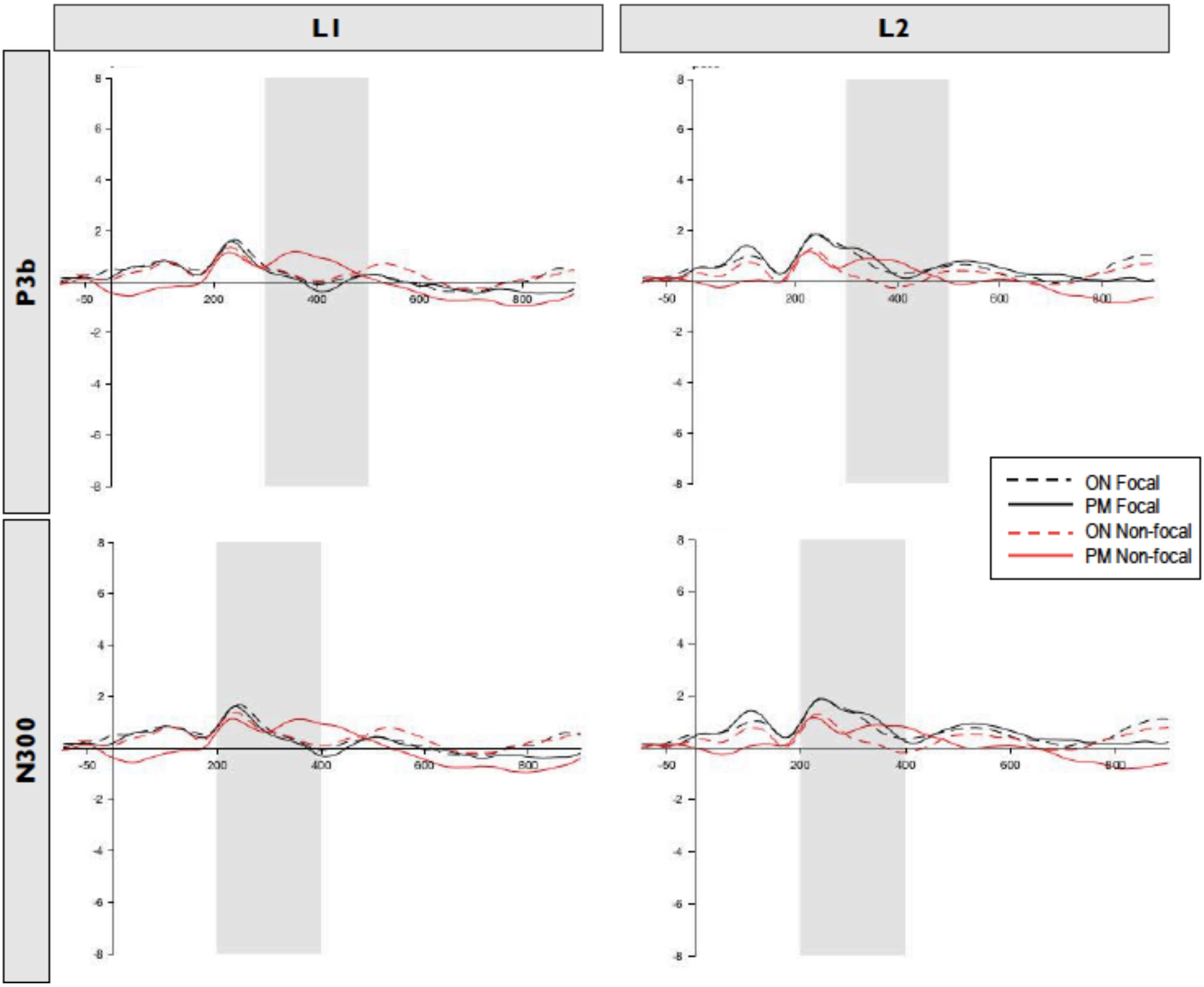

Figure 9. Grand-averaged event-related potentials (ERPs) at occipital-parietal electrodes indicating P3b and N300 components in function of language (L1 vs. L2) in the focal and non-focal condition of the ON and PM trials.

DISCUSSION

In the current study, we aimed to shed light on the impact of bilingualism over the recall of future intentions. Particularly, we focused on examining behavioural and neural correlates associated to focal and non-focal PM tasks when they were performed in the first or second language of bilingual's participants. Thus, bilingual participants completed a PM task that varied in its monitoring (focal and non-focal conditions) and language requirements (i.e., L1 and L2). During the task, participants' brain activity (EEG) was recorded to be able to identify the prospective processes that may be affected by the language used in the PM task.

Behavioural data from the ongoing task clearly yielded significant differences between focality conditions, showing faster response times and higher accuracy rates for the ongoing activity (ON) in the focal condition compared to the non-focal condition. This better performance for the focal condition when compared to the non-focal condition was also observed for the PM task with a significant effect in accuracy. This pattern of results is in agreement with the Multiprocess Framework for Prospective Memory (McDaniel & Einstein, 2000) in suggesting that "spontaneous recovery" of the PM intention is more likely to occur when focal cues are presented, resulting, thus, in higher accuracy and faster RTs for focal than non-focal cues, which usually require monitoring processes (i.e., the so-called focality effect (Cona et al., 2014; Scullin et al., 2015). Thus, our results support previous findings in the field, which observed focality effects in different populations (Cejudo et al., 2019, 2022).

Most importantly, participants reached lower accuracy rates in the L2 condition than in the L1 when performing the ongoing task. This pattern of results supports previous findings exploring the impact of the bilingual experience over a PM task (López-Rojas et al., 2022). Specifically, the impairment in performance when the ongoing activity was in the participants' less dominant language is consistent with previous findings by López-Rojas et al. (2023a) that found lower ongoing performance in bilinguals that worked in their L2. Similar to the present study, this impairment was independent of the monitoring demands of the task. Altogether, these results indicated that the processing of a second language requires the engagement of cognitive resources (Pérez et al., 2019) and, as a result, fewer resources may be available to prospective processing during the ongoing task. Interestingly, this pattern of data is in agreement with a vast body of literature on L2 reading comprehension which showed lower performance when reading in a foreign language (for a revision see Melby-Lervåg & Lervåg, 2014). Similarly, Pérez et al. (2019) found an impairment in the high cognitive processes engaged during inferential text revision in L2. Therefore, this study adds new evidence on the impact of second language processing during a memory task.

Nevertheless, performance in the PM task (detection of the cue and execution of the intention) was not influenced by language and showed similar focality effects for L2 and L1, a result that differed from López-Rojas et al. (2023a) where stronger focality effects were found in L2 than in L1. This different pattern of results in the PM task can be due to the higher linguistic demands in López-Rojas et al. (2023a), where the PM cues were embedded in a highly demanding sentence comprehension task, when compared to the current study, where the PM consisted in identifying a frame colour or a given word. Hence, we suggest that future research might design more linguistically complex PM tasks to measure the fine-grained behavioural effects of recalling a future intention in L2.

Interestingly, the impairment of prospective processing during second language processing were indicated by the ERP analysis. First, an analysis of the P3b evidenced a main effect of type of trial, showing greater positive amplitude in the PM trials compared to the ongoing trials. This finding is in line with the results observed in the behavioural data, namely PM trials engaged monitoring processes related to cue detection. In addition, we observed focality effects in the non-focal condition that were not evident in the focal condition. These patterns of results suggest that WM and context updating may be more strongly involved when the nature of the ON cue elicits monitoring and not spontaneous retrieval as is the case of non-focal cues (Cona et al., 2014; West et al., 2003). This pattern is consistent with previous results in López-Rojas et al., (2022) where, in the more difficult non-focal condition, early bilinguals showed larger differences between ON and PM trials compared to late bilinguals and monolinguals, whereas these differences were not present in the focal condition. Thus, they suggested that early bilinguals engaged in monitoring processes related to prospective processing to adapt to the task's demands. Therefore, our results suggest that PM can be modulated depending on the bilingual experience. In consequence, these data are consistent with results from previous studies indicating that bilingual experience shapes our brains and modulate cognitive processes such as monitoring or switching (see Antoniou, 2019).

Most importantly, in the current study the interaction focality by language yielded significant results showing that the focality effect associated to P3b appears in L1, with greater positivity in the non-focal condition, compared to the focal condition. However, in L2, these differences between focal and non-focal were not significant. These patterns of results suggest that while bilinguals successfully modulated their strategies to adjust to the task's demands in L1, this is not possible in the L2 probably due to the higher cognitive load in the second language. Therefore, consistent with López-Rojas et al.(2022), in L1 participants successfully engaged in updating and monitoring processes with the aim to adjust their strategies to the demands of the task in the more demanding non-focal condition. By contrast, when immersed in L2, the higher attentional load might possibly impair the monitoring processes required for prospective remembering. These results are in line with previous results indicating that an enhancement in conflict resolution when the task was performed in a bilingual context was related to a reduction in the P3b (Wu & Thierry, 2013). In summary, the present pattern of data suggests that L2 processing reduced the participants' capacity to adjust their PM strategies to the demands of the task so that the differences between focal and non-focal conditions were no-longer present.

However, results for the N300 were puzzling. Although the typical focality effect was evidenced by the data and non-focal cues produced more negative amplitudes than focal cues (the usual effect of type of trial (ON vs. PM)), the effect of language or their interactions were not significant. The lack of differences between PM and ON trials is surprising since the N300 component is characterized by a negative deflection triggered by the PM trials in comparison to the ON trials (West, 2011), signaling the engagement of prospective processes during PM cue detection. Notice, however, that the N300 has not always been detected in some PM studies (Wang et al., 2013; West et al., 2007, 2011; Wilson et al., 2013), which points to the elusive nature of this component.

The fact that we found a significant focality effect independently of the type of trial suggests that the component captured by our analysis in the time window from 200 to 300 ms might be better characterized as an N200 (for a characterization see Patel & Azzam, 2005) than as an N300. Several studies have explored the role of N200 in different memory tasks (Hockey & Cutmore, 2021; Morrison et al, 2019). Specifically, in PM tasks this component reflects more negative amplitudes over posterior regions around 200–350 ms (Folstein & Van Petten, 2008) in conditions where the ongoing trial is concurrent with a PM intention when compared to baseline conditions where the ongoing trials are not accompanied by the PM intention (Cousens et al., 2015; Cruz et al., 2016). The interpretation of this effect as an N200 component would be consistent with our current pattern of data: a focality effect with greater negativity in the non-focal condition where extra monitoring is required to detect the PM cue and absence of differences between ON and PM trials. Moreover, the N200 has been characterized as a neural correlate of monitoring during visual detection (Morrison et al, 2019) with more negative amplitudes with perceptual cues (Cruz et al., 2016). Thereby, it might be possible that our pattern of results indicated greater engagement of monitoring processes during the non-focal condition due to the perceptual nature of the PM cue and the need of checking the colour frame to detect the PM trials. Thus, although this interpretation needs further research, both the more perceptual nature of the PM cue and the higher monitoring demands in the non-focal condition support the presence of a more negative N200 component in this condition when compared to the focal condition.

In sum, the present study supports previous findings in the field about the role of bilingual experience and linguistic contexts on the processes that underlie PM performance (López-Rojas et al., 2023a). Hereby, we showed the impact of language processing on an ability such as prospective processing. PM plays a fundamental role in daily activities, and failures may result in dramatic consequences (i.e., forgetting to turn off the oven). Hence, studies exploring whether and how the cognitive mechanisms underlying PM can be modulated by the use of different languages are critical. Our findings highlight the importance of the linguistic context where we encode and recall future intentions, signalling possible impairments in PM when the task involves L2 processing. Behavioural and ERP data support this suggestion with worse performance in L2 ongoing activity and the absence of focality effects in P3b during L2 processing. To the best of our knowledge, this study is the first to examine the neural correlates associated to PM tasks during first and second language processing. Future research should explore the impact of language processing during a more linguistically complex PM task that resembles the rich linguistic context in which bilinguals are immersed in their daily activities (e.g., a text comprehension task). In addition, future studies should explore the role of the linguistic context during the encoding and recall of future intentions, and how language-incongruent encoding and recall of PM intentions can modulate performance. Finally, it is important to remark on the applied relevance of this study in the educational field or in the professional area, especially if we think about bilingual environments where bilingual people encode and execute future intentions in their second language. Given this, future studies should deepen in the relationship between linguistic context and memory processes.

CONCLUSION

This study highlights the importance of working in a first or second language during the retrieval of future intentions (PM task). Interestingly, we found distinct impacts of language over the ongoing and PM activity, suggesting that L2 processing produce a general impairment in performing PM tasks. Our behavioural and neural (P3b) results suggest that processing a second language could impose a load on the available cognitive resources and, as a result, fewer resources remain available to face the main activity. Altogether, this experiment raises interesting conclusions about the role of language processing in daily activities, such as the recall of future intentions, and opens up new venues for inquiry.

CHAPTER 7.

EXPERIMENT 4

The **fourth experiment** was entitled **"Exploring the effect of language switching practice over prospective memory in bilinguals"** and has been submitted to *Cognition* (López-Rojas, Marful & Bajo).

ABSTRACT

Prospective memory (PM), memory for future intentions, highly depends on switching processes to change from the ongoing activity to performance of the intention (prospective task) upon detection of the PM cue signaling execution of the intention. Similarly, bilinguals immersed in dual-language contexts where two languages are used in interaction, are frequently required to switch between languages. To study the possible effect of language switching on PM, we experimentally simulated the exposure to a dual-language switching context in a sample of single language-context bilinguals. Thus, a group of bilinguals (practice group) practiced language switching previous to the PM task. Their performance in the PM task was compared to a group of single language-context bilinguals that did not received this switching practice (control group). Behavioral data and event-related potentials (ERPs) were collected. Results indicated that the practice group showed greater waves amplitudes than the control group in the prospective components associated to monitoring, detection and switching processes (i.e., N300 and frontal

positivity). In contrast, language switching practice did not affect the retrospective components associated with the retrieval of the intention from memory (i.e., P3b and frontal-slow-waves). These data demonstrated that the interactional context in which bilinguals are immersed modulates their cognitive control strategies in charge of recalling future intentions.

Keywords: prospective memory; bilingualism; prospective processing; language switching; event-related potentials.

INTRODUCTION

Recalling future intentions allow us to perform many activities that are essential for our daily life. For example, if you are cooking a cake you will need to create the future intention of removing it from the oven when properly baked. Thus, if, in the meantime, you are watching a movie on the TV, you will have to monitor the time and supervise the cake to take it out of the oven before burns! The ability that allows us to recall future intentions is called Prospective Memory (PM) and it has been widely explored in the literature (Einstein & McDaniel, 2005; Kliegel et al., 2004; Smith, 2003; West & Krompinger, 2005). Usually, in a PM task participants are asked to perform a main task called ongoing activity. In addition, they have to encode a prospective memory intention that should be performed only when a specific cue (termed PM cue) appears. Thus, the PM cue is a signal that indicates the moment to perform the prospective activity and the recall of the intention. In the previous example, watching the movie could be the ongoing activity whereas removing the cake from the oven would be the prospective intention. In this example, the golden brown on the top of the cake would constitute the PM cue which indicates that it is the correct moment to remove the cake from the oven. In the lab, prospective memory is also studied by using lab-based ongoing-task and PM-cue procedures. Thus, for example, participants may be asked to carry out a 2-back task consisting in pressing a key if the current presented letter appeared two trials before (ongoing task), and also receive the instructions of pressing a different key when a given letter appears (PM task).

Previous research indicates that the successful response to a PM cue while carrying out an ongoing task highly depends not only on the retrospective retrieval of the activity to be done, but also on the processes involved in the monitoring of the experimental context that allow detecting the PM cue, interrupting the ongoing activity and switching to the prospective response (e.g., see the PM Multiprocess Framework by Einstein & McDaniel, 2000).

Interestingly, the monitoring of the environment that occurs in PM activities is very similar to the processes that bilingual people use when they are looking for contextual cues to choose the right language in each situation. Thus, when bilinguals are immersed in contexts with frequent switches between languages, they need to pay attention to some specific cues in the environment to predict the incoming language. For example, being presented with a given face (Asian or Caucasian) before performing a picture naming task in Chinese or English has been shown to modulate the activation of these two languages (Liu et al., 2019), suggesting that contextual cues may facilitate language selection. These results are consistent with the adaptive control hypothesis (Green & Abutalebi, 2013) which suggests that the context in which bilinguals are immersed can modulate how they control their language production. However, these interactions are not reduced to the language control attentional network. Additional studies have found that bilingual immersion-experience influences domain-general cognitive control (Beatty-Martínez et al., 2020; Jiao et al., 2020; Timmer et al., 2021).

In fact, recent research has shown a relation between different bilingual experiences and modulations in PM at behavioral and neural levels (López-

Rojas et al., 2022). Specifically, Lopez-Rojas et al. found that bilinguals who (1) were immersed in bilingual contexts with frequent between-language switches and (2) acquired their second language (L2) during childhood, showed larger differences between the ongoing activity and the prospective intention in ERP components related to PM performance (N300 and P3b) compared to monolinguals or to non-immersed bilinguals who acquired the L2 in the adolescent/adulthood. These differences were found in the more attentional demanding PM conditions indicating that this type of bilinguals was able to adapt their prospective processes to the demands of the PM task.

The concept that bilingualism modulates prospective processing raises interesting questions related to the way in which bilingualism affects the underlying processes associated with PM. Thus, López-Rojas et al. (2022) suggested that being immersed in a bilingual linguistic context adapted their monitoring and switching strategies to the conditions of the PM task. Thus, it was suggested that bilinguals that were used to switch between languages were better able to adapt their monitoring processes to the PM task demands than monolinguals and bilinguals immersed in non-switching language context. In the present study, we took a different approach to language switching experience by experimentally providing participants with language switching practice to investigate how practice in language switching could impact the cognitive processes engaged in PM. In addition, we aimed to identify the specific PM processes affected by language switching experience. Our assumption was that the mechanisms that naturally emerge in natural dual-contexts where bilinguals frequently switch between languages are similar to the processes elicited by a language switching task in which bilinguals from single-language contexts are forced to change between languages (Timmer et al, 2019), and therefore, we expected that these mechanisms were modulated by language switching experience.

In the field of bilingualism, several studies have explored the impact of language switching training over other tasks that require cognitive control. For example, Liu et al. (2019) explored if language switching training facilitated the performance in two tasks that required monitoring (mixing-cost) and inhibitory control (anti-saccade). Their hypotheses were that given that during language switching the bilingual needs to monitor the conflict between languages and to inhibit cross-language representations, switching training should facilitate performance in the mixing-cost and anti-saccade tasks where these processes were also involved. Their results indicated that language switching training improved performance in both components. Similarly, Timmer et al. (2019) compared two groups of bilinguals (language switching group vs language-control group) that completed a non-linguistic task in a pre/post-training session. In the post-training session, they found that the switching training group (but not the control group) improved their performance when measuring the switching cost (i.e., comparison between switch vs non-switch trials) in the non-linguistic task, concluding that at least some mechanisms of control are shared across different domains.

These conclusions have also been supported by studies with different neuroimaging techniques. For example, Chen et al. (2021) explored the neural adaptations induced by language switching by using fMRI. Their findings indicated a reduction in the connectivity from the right thalamus to the dorsal anterior cingulate cortex/pre-supplementary motor area (dACC/pre-SMA) after language switching training. The connections between these regions were stronger when executing more demanding cognitive control processes. Therefore, these results suggested that after a language switching training, less neural connectivity is demanded to complete the same cognitively demanding task. In addition, Zhang et al. (2015) observed an enhancement in the use of proactive control strategies after a 10-day language switching training compared to a pre-training condition. In fact, language switching training produced an increase in the BSI index of the AX-CPT that indicates higher proactivity and a greater N2 component triggered by the cue that has been related to cognitive control. Altogether, behavioural and neural results suggest that bilinguals who completed a short-term language switching training tend to change their strategies when completing a cognitive control task.

However, the effect of language switching training on PM has not been directly tested. This is important since identifying the PM processes affected by language switching is instrumental for both (1) characterising and dissociating different PM processes, and (2) identifying the effects of language in cognitive domains that have not yet been explored.

Thereby, in this study, we aimed to investigate whether language switching practice modulates bilinguals' performance in a PM task, and if so, to specify the nature of this change. Specifically, our study evaluated Spanish-English bilinguals from Spain, immersed in a single-language context, this is, a context in which one language is used and the other language is employed in a second distinct environment (Green & Abutalebi, 2013). Studying training effects in bilinguals in single-language contexts is important since previous studies have demonstrated that these bilinguals use different modes of cognitive control compared to bilinguals immersed in dual-language contexts (Timmer et al., 2021; Jiao et al., 2020). For example, Hartanto & Yang (2016) found that bilinguals immersed in a dual-language context outperformed bilinguals immersed in a single-language context in cognitive control tasks. Interestingly, Beatty et al. (2020) showed that bilinguals in separated contexts (e.g., South Spain) depended on reactive processes to a greater extent than bilinguals in contexts where both languages are indistinctly and more cooperatively used. Thus, given that our bilinguals were immersed in a single-language context we expected to observe a substantial training effect in a PM task.

To test this hypothesis, the total sample was divided into two groups: 1) the language switching practice group (hereinafter switching group) where participants carried out a picture naming L1/L2 language-switching task at the beginning of the experiment and before performing a PM task; 2) the language-control group where participants did not perform the picture naming task previous to the PM. Hence, we compared two groups of bilinguals immersed in identical single-language context, but only one of them was exposed to language switching practice before performing the experimental PM task. The PM task consisted of a 2-back task (ongoing-task) where colored letters were presented and participants were asked to recall if a given stimulus (a given letter or a color) appeared two trials before. Additionally, participants completed a block in which a PM intention was implemented during the ongoing activity. Hence, participants had to press a different key when a previously encoded PM cue appeared (i.e., certain stimuli colors or some specific letters). To assess possible changes in the specific processes involved in PM, we recorded the brain activity during the PM and ongoing tasks and analyzed the ERPs components associated to different PM processes.

A wide body of literature has explored the ERP components associated with PM (for a revision see West, 2011). Thus, a number of so-called "prospective components" have been associated with the detection processes required to detect the PM cue in the course of the ongoing activity whereas some other "retrospective components" have been related to the recall and updating of the intention from long-term memory. Specifically, the N300 and frontal positivity have been described as prospective components related to the detection of the PM cue in the environment. Thus, N300 is characterized by a negative deflection in the PM trials compared to the ongoing trials around

200 ms that could be extended until 300-500 ms. Interestingly, López-Rojas et al. (2022) found that bilinguals immersed in an interactional context where both languages work in a cooperative way showed larger N300 in the more challenging conditions. Frequently, the N300 is accompanied by the frontal positivity, a positive deflection between 300-500 ms after stimulus onset that differentiates PM trials from ongoing trials. This component seems to be related to switching processes between ongoing and PM activities (Bissiachi et al., 2009).

On the other hand, the P3b and frontal slow waves have been associated with retrospective processes such as the retrieval from long-term memory or the realization of delayed intentions (Cona et al., 2014). Critically, the P3b has been characterized by a positive amplitude between 300-400 ms to 600-800 ms elicited by the PM trials compared to the ongoing trials. This component reflects the activity of processes related to working memory and context updating (Polich, 2007; West et al., 2003). This component has been shown to be larger in bilinguals immersed in a language interactional context with high task demands (López-Rojas et al., 2022). Similarly, the frontal slow waves, a component defined by a positive amplitude over the frontal region that begins around 500 ms after the stimulus onset (Cona et al., 2013) is considered to reflect post-retrieval monitoring processes when a PM cue is detected (West et al., 2003).

Since our previous language-switching training was assumed to engage monitoring and switching processes, we expected that the two prospective ERPs components (N300 and frontal positivity) would be modulated by switching-practice that would result in greater ON-PM differences in amplitudes for the practice than the control group. Given the prospective nature of our training, we expected that the retrospective components (P3b and frontal slow waves) that are associated with updating and retrieval of the intention from long-term memory should be less affected by our language switching manipulation.

METHOD

Participants

This study has been approved by the Research Ethics Committee of the University of Granada (registration number, 2262/CEIH/2021). A sample size of 54 was required to obtain 80% power to detect a Cohen's effect of f = .40. This value is considered a high effect size in Cohen, (1969) and it corresponds to η^2= .14 based on the G*power analysis program (Faul et al., 2007) of a 2 (IV: between-subject) x 2 (IV: within-subject) repeated measures ANOVA.

We evaluated a total of 56 Spanish-English (11 men; mean age = 20.9, SD = 2.9) that were students from the University of Granada.
Participants were randomly assigned to the switching group (n= 28), where they completed a language switching training before the PM task, or to the control group (n= 28), where there was not language switching training. Language background MELICET, LEAP-Q (Marian et al., 2007) tests, and a working memory task (digit span) were administered before the experimental task to control individual differences between groups. The two groups matched in their working memory scores (p <.05) (see Table 13).

Psychology students received course credits, while the remaining participants received 18 € for their participation. All participants gave written informed consent.

Procedure

The experiment consisted of a two-hour session with two phases. In the first phase, the participants in the switching group underwent a language switching training for approximately 20 minutes. In the second phase, both groups of participants performed the PM task while brain activity (EEG) was recorded. The tasks were carried out in well-lit, individual rooms that were isolated from external noise.

Table 13. Mean score and standard deviations in questions from the LEAP-Q, MELICET and the working memory task, for the control and switching group

	Control group		Switching group	
	L1	**L2**	**L1**	**L2**
Mean age of beginning acquisition (years)	0.52 (1.07)	5.19 (2.89)	0.32 (0.66)	4.90 (2.34)
Mean age of becoming fluent (years)	3.65 (1.49)	13.94 (3.09)	4.02 (2.20)	13.54 (3.67)
Mean level of self-competence (from 0–10)	9.30 (1.88)	8.10 (1.67)	9.62 (0.49)	8.46 (0.62)
Mean level of language exposure with family or friends (from 0–10)	8.69 (2.21)	2.36 (2.25)	9.68 (0.95)	2.54 (1.78)
Mean level of reading exposure (from 0–10)	7.04 (2.65)	7.04 (1.95)	6.93 (2.39)	6.64 (2.33)
Mean level of language exposure by TV or radio (from 0–10)	5.78 (2.67)	6.34 (2.39)	5.88 (2.96)	6.96 (2.50)
Mean level of language exposure by self-learning (from 0–10)	3.04 (3.51)	5 (3.12)	3.14 (3.87)	5.29 (3.54)
MELICET	37.32 (6.89)	-	38.78 (6.48)	-
Working Memory (Digit span)	7.93 (1.77)	-	7. 54 (2.85)	-

Tasks

Language switching training task. A cued picture naming task was used as the training task. The entire task lasted for 20 minutes. The participants in the experimental group named the pictures either in their L1 (Spanish) or L2 (English), according to the frame color of the pictures. Line drawings were selected from the database of Snodgrass & Vanderwart (1980). A total of 150 pictures were used in the formal training session, and an additional eleven pictures were used in a previous practice phase. The training session consisted of two blocks with a break in the middle, each including 150 pictures. In each block there were 75 switching trials and 75 non-switching trials. Also, half of the trials were in L1 (Spanish) and the other half in L2 (English). Each trial began with a fixation point appearing in the middle of the screen for 250 ms. Thereafter, a picture surrounded by a blue or red frame appeared at the center of the screen until response for a maximum of 4000 ms. The correspondence between the color of the frame and language was counterbalanced across blocks and participants.

PM task. Participants performed a PM task while EEG brain activity was recorded. We employed an adaptation of the PM task used by West and Bowry (2005). The task consisted of a main task (ongoing activity) that might be interrupted when a PM cue appeared. Specifically, during the ongoing task colored letters appeared for a 2-back task. To avoid any possible effect of the type of item, for half of the participants, the ongoing task was pressing the "yes" key when the letter presented on the screen matched with the letter appearing 2 trials before and the "no" key in all other cases. For the other half, the ongoing tasks was of pressing "yes" when the color of the presented stimuli matched the color that appeared 2 trials before and pressing the "no" key in all other cases. There was a first block in which participants carried out this ongoing task that served as a baseline. Importantly, after this baseline block, there was a block where participants had also to perform the ongoing task, but, in addition, they were asked to implement the prospective intention. Thus, for each participant, the instructions for the prospective task consisted in pressing a different key when the screen presented a given letter or color. Thus, for half of the trials, participants were told that the PM cues were the letters D, H, L, and S and they should press the keys 1, 2, 9, or 0 respectively when one of these cues appeared. For the other half of the trials, they were instructed to press the 1, 2, 0, and 9 keys when the colors magenta, grey, lime, and blue appeared. The order of these two prospective task instructions and the baseline block were counterbalanced across participants.

Henceforth, trials where the prospective cues were presented will be referred to as "PM" trials because they correspond to the PM task. The remaining trials that did not contain the PM and the participants performed the ongoing activity, will be referred to as "ON" trials. The baseline block consisted in 300 trials where participants should respond "yes" to 35% of the stimuli and "no" to the remaining 65%. The PM block consisted of 600 trials where 536 trials corresponded to the ongoing task (ON trials) and 64 trials contained the prospective cues to perform the intention (PM trials). Before these blocks, a practice phase of 20 trials was carried out.

The stimuli were 10 consonants (B, D, F, H, K, L, N, S, V, Z) presented in the red, blue, lime, magenta, yellow, gray, black, maroon, purple and cyan colors with a 15 mm x 10 mm size. Each trial consisted in the stimulus presentation (centered for 2000 ms) where participants give a response and it was followed by a blank screen (1500 ms).

The tasks described in this section were programmed using the E-Prime 2.0 software.

EEG recording and pre-processing. We used a Neuroscan Synamps2 (El Paso, TX) system to collect EEG data with the Curry acquisition software (version 7; compumedicsneuroscan.com) and 64 Ag/AgCl electrodes distributed on the scalp. The data processing was performed with EEGLAB 14.1 (Delorme & Makeig, 2004), running in a Matlab environment (Version 7.4.0, MathWorks, Natick, MA, USA).

Two pairs of bipolar electrodes were placed vertically and horizontally to record eye movements. The EEG analogue signal was amplified and digitized at a sampling frequency of 1000 Hz. The impedances of the electrodes were maintained at <10 kΩ during recording. The ground electrode was placed along the midline in front of the Fz position. All electrodes were referenced off-line to the average of both mastoids. The EEG data were bandpass filtered between 0.5 and 1000 Hz during online recording. Also, a high pass filter of 0.1Hz and a low-pass filter 30Hz were also applied offline to the data. Moreover, we applied a notch filter of 50Hz to clean the electronic noise in the signal. Artefacts were also removed through visual inspection. Thus, channels with a high level of artefacts were detected by careful visual inspection and interpolated from neighboring electrodes. The temporal windows were located at the appearance of the ongoing and PM stimulus. The times for the ERP analysis were a 200 ms pre-stimulus period used as a baseline correction and 1200 ms of post-stimulus activity. Artefact correction was done using the independent component analysis (ICA) toolbox in EEGLAB for semi-automatic artifact removal. The epoch rejection was performed with a cutoff of ± 100 μV (< 25% per participant).

Design

The experiment conformed a 2 x 2 mixed factorial design using groups (switching group and control group) as between-subject factor and type of trial (ongoing, PM) or prospective load (baseline, with PM) as within-subject factors.

RESULTS

First, we report the analyses performed on the behavioural data (accuracy and response times) for the language switching task in the training condition. Second, the analyses performed on the prospective memory task (accuracy and response times) are described. This section includes 1) analyses to assess differences in cue detection and retrieval of the intention, and 2) analyses to assess monitoring cost. Finally, ERP data analyses are reported with subsection for different ERP components. Behavioural analyses including counterbalancing conditions are included in the supplementary material.

Language switching training task

For the language switching group, we analysed the data from the naming task. We performed a 2 (language: L1, L2) x 2 (switch/non-switch) repeated measures ANOVA on accuracy and RTs. Data cleaning was performed in raw response times removing data greater than three times the interquartile range. Also, a 200 ms cut-off was applied to remove automatic responses.

For both accuracy and RTs, we averaged participants' correct responses to the pictures and submitted them to a 2 (language: L1 vs L2) x 2 (switch trial: switch/non-switch) repeated measures ANOVA. Finally, in all the analyses, Bonferroni correction for multiple comparisons for post hoc tests was applied when it was appropriated.

For *accuracy*, the analyses showed significant main effects of language $F(1,27) = 46.94$; $p < .0001$; $\eta_p^2 = 0.635$ and type of switch $F(1,27) = 28.076$; $p < .0001$; $\eta_p^2 = 0.510$ were found, indicating better performance in L1 (M = .96, *SD* = .04) than in L2 (*M* = .85, *SD* = .10), and in non-switch trials (*M* = .92, *SD* = .10) than in switch trials (*M* = .89, *SD* = .08). Interestingly, the interaction $F(1,27) = 46.94$; $p < .05$; $\eta_p^2 = 0.243$ involving both variables was also significant, showing greater differences between switching (L2 switch: M = .82, *SD* = .11) and non-switching trials (L2 non-switch: *M* = .87, *SD* = .08) trials in L2 ($t(27) = 4.848$; $p < .0001$; $d = 0.51$) than in L1 (L1 switch: *M* = .95, *SD* = .04; L1 non-switch: *M* = .96, *SD* = .03 $t(27) = 2.854$; $p < .05$; $d = 0.48$).

For *response times*, the analyses showed no significant effect or interaction [language $F(1,27) = 0.304$; $p = .586$; $\eta_p^2 = 0.012$; type of switch $F(1,27) = 0.383$; $p = .541$; $\eta_p^2 = 0.015$; language by type of switch $F(1,27) = 0.151$; $p = .701$; $\eta_p^2 = 0.006$].

Altogether, results in the picture naming task indicated an advantage in both switch and non-switch trials when naming in L1 compared to L2. Interestingly, that contrast with previous results that showed impaired performance when getting into L1 from L2 due to the inhibition processes needed for language control. However, usually, the impairment in L1 compared to L2 in a switching naming task has been reported in response times, but not in accuracy (Meuter & Allport, 1998).

Prospective memory (PM) task

We have organized the behavioral results for the prospective memory tasks into two main sections. First, we include the analysis regarding *the PM cue detection and the retrieval of the intention*, and second analyses focusing on *the cost of PM monitoring in the ongoing task.* Within each section, we include analyses for accuracy and response times (RTs). Previously, data trimming was performed by filtering the data following the criteria used by López-Rojas et al. (2022), that is, RTs faster than 200 ms were removed. Also, we looked for outlier participants by checking mean accuracy greater than three times the interquartile range in the ON task, although we did not have to remove any data for the analysis as a result.

PM cue detection and retrieval of the intention. For these analyses, we compared trials where the PM cue appeared (PM trials) with trials where participants performed the ongoing task (ON trials). In order to reduce the interference of attentional changes during the experiment, only the ON trials that appeared just before the PM trials were selected (Cejudo et al., 2022). For both, accuracy and RTs we averaged for each type of trial (ON and PM) and group (switching and control). Thus, a 2 (type of trial: ON, PM) x 2 (group: switching, control) repeated measures ANOVA was carried out (see Table 14A). Accuracy's analyses showed that the main effect of type of trial $F(1,46) = 152.949$; $p < .0001$; $\eta_p^2 = 0.769$ was significant, indicating better performance in ON trials (M = .89, *SD* = .09) compared to PM trials (M = .61, *SD* = .16). However, no significant effects or interactions involving the group variable were found in this analysis [group $F(1,46) = 0.503$; $p = .482$; $\eta_p^2 = 0.011$; type of trial by group $F(1,46) = 0.135$; $p = 0.715$; $\eta_p^2 = 0.003$].

Similarly, for response times, we only found a main effect of type of trial $F(1,46) = 89.520$; $p < .0001$; $\eta_p^2 = 0.661$, where ON trials (M = 1030, *SD* = 153) presented faster response times than the PM trials (M = 1223, *SD* = 144) [group $F(1,46) = 2.230$; $p = .142$; $\eta_p^2 = 0.046$; type of trial by group $F(1,46) = 0.231$; $p = 0.633$; $\eta_p^2 = 0.005$]. Altogether, the behavioural results did not show an effect of the language-switching practice in the performance of the PM intention.

The cost of PM monitoring in the ongoing task. To investigate monitoring effects, we performed analyses comparing the ON trials in the ongoing baseline block with the ON trials from the block in which the PM intention was implemented. Thus, a 2 (group: switching and control) x 2 (prospective load: baseline, with PM intention) repeated measures ANOVA on accuracy and RTs in the ON trials were carried out (see Table 14B). Note that for these ANOVAs all ON trials precondition were averaged and included in the analyses.

Results performed on the accuracy data indicated a significant main effect of prospective load, $F(1,47) = 8.330$; $p < .05$; $\eta_p^2 = 0.151$, with greater accuracy in the baseline condition (M = .88, *SD* = .06) compared to the PM condition (M = .85, *SD* = .10). Even so, in accuracy there were not significant effects of group $F(1,47) = 0.378$ $p = .542$; $\eta_p^2 = 0.008$ or interaction between the variables group and prospective load $F(1,47) = 0.281$ $p = .599$; $\eta_p^2 = 0.006$. For response times, we found the same pattern of results where the main effect of prospective load reached significance $F(1,47) = 8.330$; $p < .0001$; $\eta_p^2 = 0.151$, indicating faster response times in the baseline condition (M = 837, *SD* = 150) compared to the PM condition (M = 1010, *SD* = 142). No other main effects or interactions were significant [group $F(1,47) = 1.183$; $p = .282$; $\eta_p^2 = 0.025$; prospective load by group $F(1,47) = 0.028$; $p = 0.869$; $\eta_p^2 = 0.001$].

In sum, our data showed an impairment in the performance of the ongoing activity (accuracy and response times) when the PM intention was implemented, compared to the condition without PM intention (baseline condition).

Table 14. Mean score and standard deviations (in brackets) in behavioural data for the switching and control group in the different experimental conditions.

A. Mean score and standard deviations in accuracy (ACC) and response times (RT) for analysis of PM **cue detection and retrieval of the intention in the ON and PM trials**.

	ACC		RT		Total	
	Switching	Control	Switching	Control	**ACC**	**RT**
ON trials	.90 (.16)	.88 (.11)	1008 (138)	1054 (166)	.89 (.14)	1030 (153)
PM trials	.63 (.16)	.60 (.16)	1192 (141)	1257 (142)	.62 (.16)	1223 (144)
Total	.77 (.16)	.74 (.14)	1100 (140)	1156 (154)		

B. Mean score and standard deviations in accuracy (ACC) and response times (RT) for analysis of the **cost of PM monitoring in the ON trials**.

	ACC		RT		Total	
	Switching	Control	Switching	Control	**ACC**	**RT**
Baseline	.88 (.06)	.87 (.06)	815 (153)	860 (147)	.88 (.06)	837 (150)
PM condition	.85 (.08)	.84 (.10)	991 (129)	1029 (154)	.85 (.09)	1010 (142)
Total	.87 (.07)	.86 (.08)	903 (141)	945 (151)		

Electrophysiological data: ERPs

To investigate the modulations associated to language switching practice in the PM task, we compared the ERPs for hits in PM and ON trials for each group (switching vs control group). Thus, to study the prospective components of the PM task we explored the N300 and frontal positivity components that usually appear together, and that have been associated with strategic monitoring processes in cue detection during a PM task. Following visual inspection of the waveforms and previous studies analyses we selected the time window from 175 to 300 ms to analyse both components (Cejudo et al., 2022; López-Rojas et al., 2022). The N300 was located over parietal-occipital electrodes (PO5, PO3, POZ, PO4, PO6, O1, OZ, O2) and the frontal positivity over electrodes in the midline frontal region (F3, F1, FZ, F2, F4, FC3, FC1, FCZ, FC2, FC4). In addition, we analyzed two other components that have been related with the retrospective memory components of PM: the P3b and the slow wave component. The P3b component is associated with working memory (WM) updating upon cue detection, and it was registered at 300-400 ms in parietal regions (P3, P1, PZ, P2, P4, PO5, PO3, POZ, PO4, PO6). Finally, to capture the frontal slow waves that have been related to monitoring and evaluation of the retrieved intention we analyzed the time window from 500 to 1200 ms in frontal regions (F3, F1, FZ, F2, F4, FC3, FC1, FCZ, FC2, FC4). After preprocessing the EEG data, one participant was eliminated due to his/her high levels of noise in the EEG signals producing high epoch rejection. Thus, data from 28 participants in the switching group, and 27 in the control group were entered into the analyses.

Thus, for each component, we averaged the mean amplitudes across electrodes and conditions and submitted them into a 2 (group: switching, control) × 2 (type of trial: ON, PM) repeated measures ANOVA.

N300. We averaged the amplitudes per participant and submitted them to a 2 (group: switching, control) × 2 (type of trial: ON, PM) repeated measures ANOVA (see Figure 10). The main effect of type of trial ($F(1,50) = 3.733$; $p = .059$; $\eta_p^2 = 0.069$; ON trial: M = 0.0643, *SD* = 3.36; PM trial: *M* = -0.226, *SD* = 3.38) was marginally significant, with more negative amplitudes in the trials where the PM cue appeared compared to the ON trials. However, the main effect of group $F(1,50) = 0.226$; $p = .636$; $\eta_p^2 = 0.005$ was not significant. Most importantly, the interaction type of trial by group $F(1,50) = 10.376$; $p < .05$; $\eta_p^2 = 0.172$ was significant. Analyses of this interaction showed that there were significant differences between type of trials for the switching group (ON: *M* = 0.468, *SD* = 3.703; PM: M = -0.218, *SD* = 3.642; $t(27) = 4.046$, $p < .0001$, $d = 0.19$), whereas in the control group, the differences between trials did not reach significance (ON: M = -0.407, *SD* = 2.934; PM: *M* = -0.235, *SD* = 3.167; $t(23) = -0.822$, $p = .420$, $d = -0.06$).

Frontal positivity. To study this component, we performed a 2 (group: switching, control) × 2 (type of trial: ON, PM) repeated measures ANOVA (see Figure 10). The main effects of type of trial $F(1,51) = 15.171$; $p < .0001$; $\eta_p^2 = 0.229$ was significant, indicating greater wave positivity in the PM trials (M = 0.517, *SD* = 2.056) compared to the ON trials (M = 0.018, *SD* = 2.090). The main effect of group $F(1,51) = 0.025$; $p = .875$; $\eta_p^2 = 0.00$ was not statically significant. In contrast, the interaction between the type of trial and group $F(1,51) = 7.300$; $p < .05$; $\eta_p^2 = 0.009$ reached significance, indicating significant differences between ON (M = -0.180, *SD* = 2.467) and PM (M = 0.633, *SD* = 2.209) trials in the switching group $t(27) = -4.494$, $p < .0001$, $d = -0.347$, in contrast to the control group where there were no differences between types of trials (ON: *M* = 0.241, *SD* = 1.583; PM: *M* = 0.388, *SD* = 1.906; $t(24) = -0.895$, $p = .379$, $d = -0.08$).

P3b. A repeated measures ANOVA with 2 (group) x 2 (type of trial) was conducted to explore the P3b component. Figure 11 shows mean amplitudes for this component. There was a significant main effect of type of trial $F(1,50) = 12.258$; $p < .05$; $\eta_p^2 = 0.197$ with ON trials (M = 1.578, SD = 2.535) showing greater positive amplitude compared to PM trials (M = 1.110, SD = 2.597). By contrast, the main effect of group $F(1,50) = 0.020$; $p = .887$; $\eta_p^2 = 0.00$ and the type of trial by group $F(1,50) = 0.262$; $p = .611$; $\eta_p^2 = 0.005$ were not significant.

Frontal slow waves. A 2 (group) x 2 (type of trial) ANOVA for repeated measures was conducted (see Figure 11 for a graphic representation of this component). The main effect of type of trial $F(1,50) = 27.230$; $p < .0001$; $\eta_p^2 = 0.353$ was significant, indicating lower positive amplitude in ON trials (M = 0.001, SD = 2.454) than in PM trials (M = 1.249, SD = 2.796). In contrast, none of the other effects and interactions reached significance [group $F(1,50) = 0.113$; $p = .738$; $\eta_p^2 = 0.002$, type of trial by group $F(1,50) =3.084$; $p = .085$; $\eta_p^2 = 0.058$].

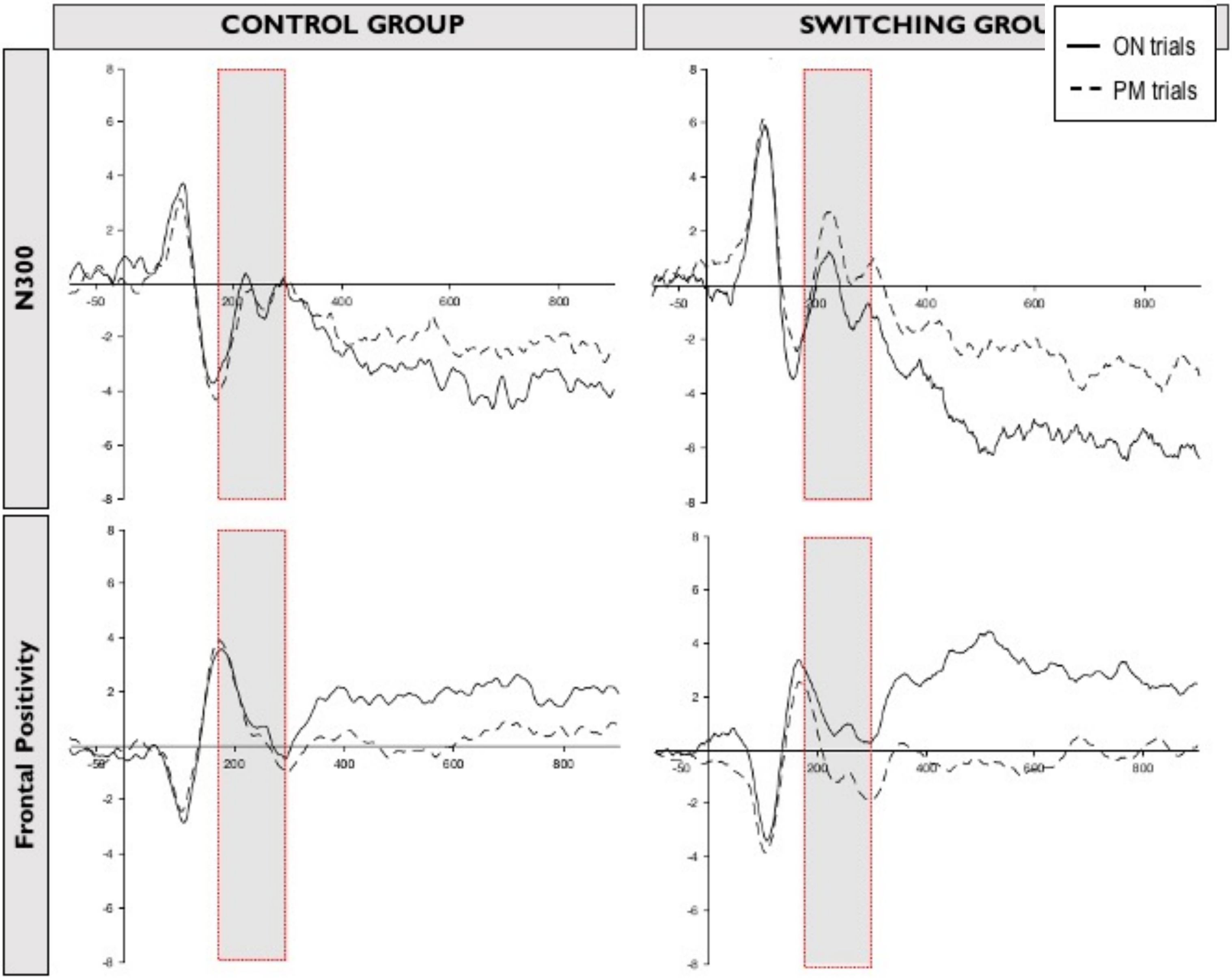

Figure 10. Grand-averaged for event-related potentials at brain regions of interest for the N300 (top row) and the Frontal Positivity (bottom row). Solid lines represent mean amplitudes in microvolts for ON trials, whereas dashed lines represent PM trials. Time windows of interest in each component are framed in red.

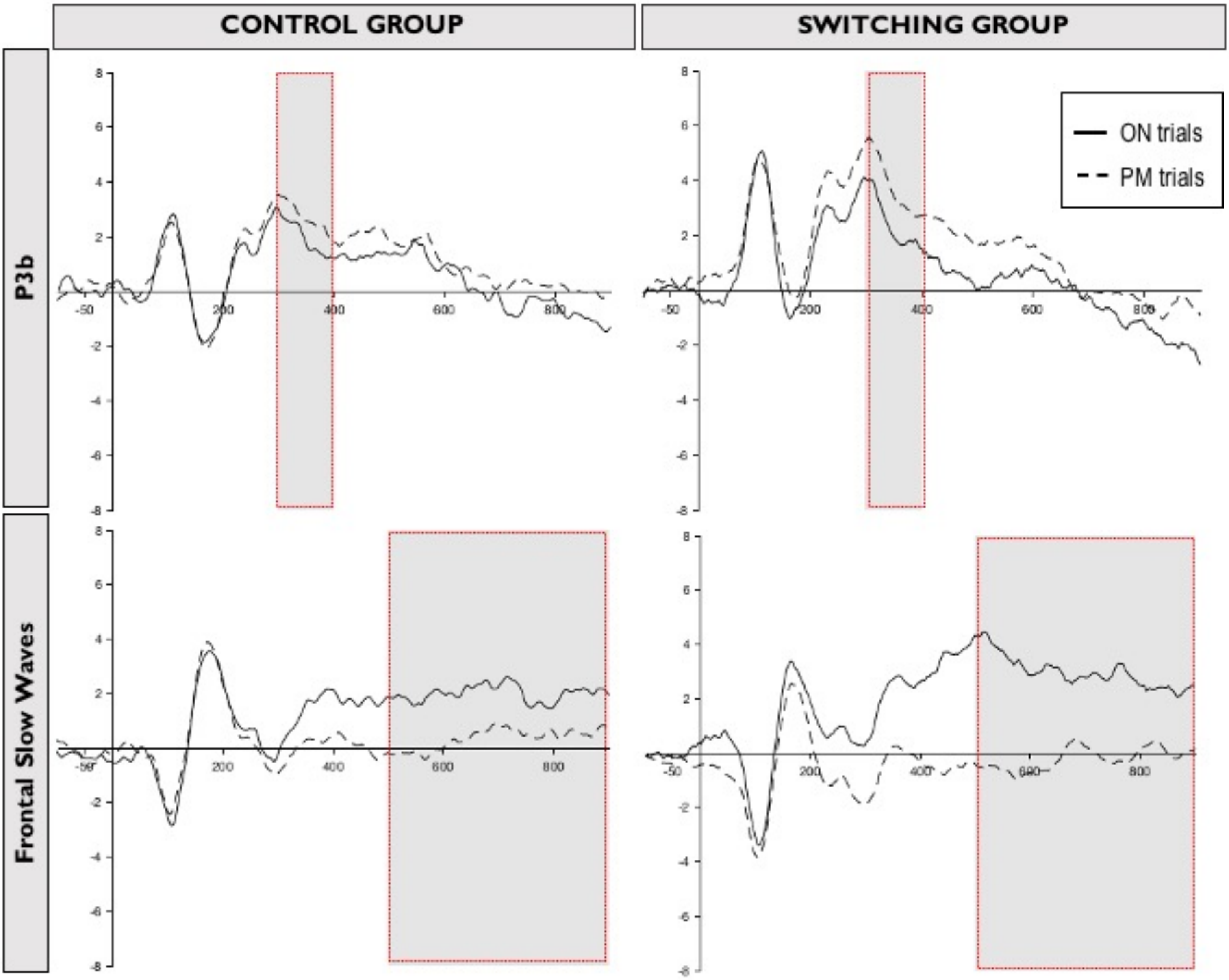

Figure 11. Grand-averaged for event-related potentials at brain regions of interest for the P3b (top row) and the Frontal Slow Waves (bottom row). Solid lines represent mean amplitudes in microvolts for ON trials, whereas dashed lines represent PM trials. Time windows of interest in each component are framed in red.

DISCUSSION

Previous research has shown that language experience influences attention, reasoning etc. However, little research has been directed to understanding the effect of language experience on prospective remembering (see López et al., 2022, 2023ab). The aim of this study was to investigate whether previous practice in language switching in Spanish-English bilinguals modulated their performance in a subsequent Prospective Memory task, and if that was the case, to identify the PM processes affected by the practice. With this aim, late bilingual participants carried out a language switching task previous to the execution of a PM task and we compared their performance with an equivalent late bilingual group without previous switching experience. During the task, we recorded brain activity with EEG in order to qualify the nature of these changes and identify the ERPs components associated with different PM processes.

Interestingly, results indicated that practicing language switching did not have evident behavioral effects on PM performance, but selectively modified some ERPs components associated to PM processing. The lack of effects or interactions of language switching practice on the behavioral data occurred despite the fact that the analyses captured the usual effect of type of trial. Thus, accuracy and RTs clearly showed the usual differences between trials where the ongoing task was performed by itself (ON trials) and those where the PM cues have to be detected and the prospective intention implemented (PM trials). Higher accuracy and faster response times in the ON trials compared to the PM trials (Ballhausen et al., 2017) is expected since correct performance in the PM trials requires the detection of the PM cue, interrupting the ongoing activity, shifting attention to recall the PM intention, and executing it (Kliegel et al., 2011). Similarly, the pattern of results indicated a cost in the ongoing activity when the PM intention was implemented compared to when it was performed in isolation (Marsh et al., 2002). Again, larger accuracy and faster response times in the baseline condition compared to the condition with PM intention suggests that remembering a future intention while an ongoing activity is being carried out, requires reallocating the attentional resources, resulting in a performance decrease (Smith, 2003). While the usual PM behavioral effects were evident in our data, switching practice did not modulate these effects.

In contrast, differences in the PM task due to exposure to language switching appeared in the ERP data. Similar to other studies (Grundy & Bialystok, 2018), even in the absence of behavioral modulations, we found differences between the control and switching groups in the ERP analyses. Most importantly, these modulations appeared only in the ERP components associated with prospective processing (i.e., N300 and frontal positivity), whereas no modulations were found in the retrospective components (i.e., P3b and frontal slow waves).

Thereby, we found a larger N300 amplitude for the PM trials than for the ongoing trials (West, 2011), indicating the engagement of detection processes when the PM cue appeared. Similarly, we found a general effect of the type of trial in the frontal positivity component, with more positive wave amplitudes for the PM trials than for the ongoing trials. More importantly, analyses indicated that, for both the N300 and the frontal positivity, participants in the switching group showed greater negative and positive amplitudes, respectively, in the PM trials compared to the ongoing trials. However, participants in the control group did not show differences between the two types of trials in these ERP components. The larger significant differences between PM and ON trials in the language switching groups and the lack of significant differences in the control groups suggest that the two groups differ in the degree to which they engage monitoring resources during the PM task.

Altogether, the pattern of results in the prospective components indicate that a short practice in language switching has neural consequences in strategic monitoring processes involved in the detection in the environment of the PM cue. These results agree with the findings by López-Rojas et al. (2022) which indicated that bilinguals immersed in a context with frequent switching between languages showed greater N300 compared to bilinguals and monolinguals from a single-language context. Similarly, the effect of the practice group in the frontal positivity component resembles the data of previous studies with tasks that involved language switching (Kuipers & Thierry, 2010). For example, Beatty-Martínez & Dussias (2017) found that non-code switchers-bilinguals had an enhancement in frontal positivity during code-switching processing relative to unilingual processing. Also, Kaan et al. (2020) reported evidence that, in the presence of a monolingual, bilinguals showed greater frontal positivity when a trial with unexpected language switching appeared compared to non-switch trials, indicating the role of this component as a marker of language control in interactional contexts (Beatty-Martínez & Titone, 2021).

Furthermore, our data evidence the transfer of processes from a pure language control task (e.g., naming task) to a more domain-general task (e.g., PM task). Hence, results in the N300 and frontal positivity suggested greater engagement of monitoring and switching processes by the switching group to complete the task. In contrast, the retrospective components (i.e., P3b and frontal slow waves) did not show between-group differences suggesting that, differently to the prospective components, training in language switching did not affect the memory updating processes involved in PM.

Similar to other previous studies (West, 2011), analyses of the P3b component showed differences between types of trials. Nevertheless, we found greater positivity in the ON trials than in the PM trials which is different from the more positive amplitude for PM trials relative to ON trials found in other PM studies (West et al., 2003). However, our pattern of results is in agreement with López-Rojas et al. (2022) where bilinguals exposed to frequent language switching, and bilinguals and monolinguals from a single-language context showed greater P3b wave positivity during the ongoing activity compared to the PM trials. They argued that the different pattern may be related to the monitoring requirements imposed by the task, so that in difficult monitoring conditions participants might engage to a greater extent in working memory and updating processes during the ongoing activity to overcome the monitoring cost associated to retain and recall the PM intention from memory. In line with this idea, previous studies showed that increasing the working memory load of the ongoing activity resulted in a reduced P3b in the PM trials (West & Bowry, 2005; West et al, 2006). Thus, it might be possible that the nature of the ongoing activity in the present study (i.e., an N-back), resulted in a highly demanding working memory condition during the ongoing task that reversed the wave amplitudes in the P3b.

Similarly, the frontal slow waves component (more positive amplitudes in the PM trials compared to the ongoing trials) that were also independent of the between-groups manipulation was observed. This component indicated the presence of retrieval monitoring processes when a PM cue is detected (Rösler et al., 1993; West et al., 2003). However, the frontal slow waves component has been demonstrated to be sensitive to the retrieval demands of the PM task. Thus, previous studies indicated greater frontal slow waves in more-demanding PM conditions, reflecting the engagement of a more effortful retrospective retrieval (Cona et al., 2014). Hence, the absence of differences between groups in our study suggested that participants were similarly engaged in the retrieval processes needed to recall the future intention.

This pattern of results is important because identifies and dissociates the PM processes influenced by language- switching experience. Whereas language switching practice influences the prospective components of PM (i.e., N300 and frontal positivity), no modulations were found in the retrospective components (P3b and frontal slow waves). In addition, this dissociation is theoretically consistent because language switching involves context monitoring and cue detection (Declerck & Philipp, 2015; Macizo et al., 2012), processes that have also been proposed as involved in PM tasks (Ballhausen et al., 2017; Scullin et al., 2015). In contrast, language switching does not require memory retrieval, and therefore, language training practice modulated the ERP components associated with the prospective processing, but not those components engaged in the retrieval of the intention from long-term memory.

Interestingly, the fact that language training had no effect at a behavioral level but it did so at a neural level, points to the high-sensitivity of EEG to explore fine-grained neurocognitive processes. A number of previous studies have also shown language related brain differences without evident behavioural effects in bilinguals (Ansaldo et al., 2015; DeLuca et al., 2020; Luk et al., 2010; Rodríguez-Pujadas et al., 2013). The lack of behavioral effects has been suggested as advantageous since it rules out interpretations due to possible confounds emerging from differences in performance and favors interpretations based on the functional neural modulations of language experience (Luk et al., 2010; Grundy et al., 2017) (for an opposite argument see de Bruin et al., 2021).

In fact, previous neuroimaging studies on language switching training have highlighted how different bilingual experiences can produce distinct neurocognitive adaptations (for a recent framework see DeLuca et al., 2020). For example, Kang et al., (2017) found that after a short-term language switching training bilinguals showed reduced activation in language control brain areas such as the anterior cingulated cortex and the caudate. Moreover, these changes correlated with a reduction in switching costs, indicating a benefit in general conflict monitoring processes engaged in the language switching task. Similarly, previous studies have shown how bilingual language switching modified the activation in the anterior cingulate making the control of cognitive conflict more efficient (Abutalebi et al., 2012). Hence, due to the significant role of the anterior cingulate cortex in the top-down control processes elicited when a PM cue appears (Botvinick et al., 2001; Cona et al., 2015), we suggest that the language-switching practice in our bilingual participants could affect the activation in this area modulating the strategic monitoring processes involved during the PM task. Further neuroimaging studies should address how variations in the bilingual experience differently modulate the brain regions associated with the prospective and retrospective processes engaged in a PM task (for a meta-analysis see Cona et al., 2015).

Additionally, these findings are in line with a wide body of literature that explores the influence of the interactional context in which bilinguals are immersed over different cognitive outcomes (Beatty-Martínez et al., 2020; Hartanto & Yang, 2016; Howeber et al., 2016). More importantly, the pattern of results supports previous studies indicating that language-switching training could impact general cognition beyond pure linguistic tasks (Chen et al.; 2021; Liu et al., 2019; Timmer et al., 2019.; Zhang et al., 2015).

In sum, this study provides evidence of the impact of language switching in the recall of future intentions. Thereby, we suggest that different patterns of L2 use and exposition could modulate the cognitive processes underlying prospective processing. Additionally, these data agree with previous studies exploring the effect of language switching practice over cognitive processes such as monitoring or inhibition (Liu et al., 2019; Timmer et al., 2019; Zhang et al., 2015). Future research should explore deeply how PM can be modulated by factors related to language switching such as immersion in different interactional contexts (Kroll, Dussias & Bajo, 2018), use of code-switching (Comić & Valdés Kroff, 2022) or language entropy (Gullifer & Titone, 2020).

CONCLUSION

Practice in language switching has notorious effect on the prospective neural correlates of prospective memory. These data show the power of language to modulate cognitive processes such as attention, perception or long-term memory (Arndt & Beato, 2017; Bialystok et al., 2020; Chabal & Marian, 2015; Del Maschio et al., 2022; D'Souza et al., 2021) and support previous findings about the role of the interactional context in which bilinguals are immersed on cognitive control (Gullifer et al., 2018; Hartanto & Yang, 2020; Khodos et al., 2021).

Supplementary Material

Table 1. Statistical effects from data analysis including the different counterbalance and order conditions.

Cue detection and retrieval of the intention in the ON and PM trials	Statistical effects	
	ACC	RT
Group	$F(1,41) = 0.500$; $p = .484$; $\eta_p^2 = 0.012$	$F(1,41) = 1.873$; $p = .179$; $\eta_p^2 = 0.044$
Type of trial	$F(1,41) = 163.049$; $p = .000$; $\eta_p^2 = 0.799$	$F(1,41) = 101.379$; $p = .000$; $\eta_p^2 = 0.712$
Blocks order	$F(1,41) = 1.624$; $p = .209$; $\eta_p^2 = 0.073$	$F(1,41) = 1.865$; $p = .168$; $\eta_p^2 = 0.083$
Letter/colour condition	$F(1,41) = 1.329$; $p = .256$; $\eta_p^2 = 0.031$	$F(1,41) = 0.235$; $p = .630$; $\eta_p^2 = 0.006$
Group by type of trial	$F(1,41) = 0.139$; $p = .711$; $\eta_p^2 = 0.003$	$F(1,41) = 0.277$; $p = .601$; $\eta_p^2 = 0.007$
Group by blocks order	$F(1,41) = 1.067$; $p = .353$; $\eta_p^2 = 0.049$	$F(1,41) = 2.280$; $p = .115$; $\eta_p^2 = 0.100$
Group by letter/colour condition	$F(1,41) = 0.217$; $p = .037$; $\eta_p^2 = 1.575$	$F(1,41) = 3.617$; $p = .064$; $\eta_p^2 = 0.081$
Group by type of trial by blocks order	$F(1,41) = 0.238$; $p = .790$; $\eta_p^2 = 0.011$	$F(1,41) = 1.312$; $p = .280$; $\eta_p^2 = 0.601$
Group by type of trial by letter/colour condition	$F(1,41) = 2.710$; $p = .107$; $\eta_p^2 = 0.062$	$F(1,41) = 2.710$; $p = .107$; $\eta_p^2 = 0.062$
Group by blocks order by letter/colour condition	$F(1,41) = 2.710$; $p = .107$; $\eta_p^2 = 0.062$	$F(1,41) = 0.462$; $p = .501$; $\eta_p^2 = 0.011$
Cost of PM monitoring in the ON trials	**ACC**	**RT**
Group	$F(1,42) = 0.110$; $p = .742$; $\eta_p^2 = 0.003$	$F(1,42) = 0.688$; $p = .412$; $\eta_p^2 = 0.016$
Prospective load	$F(1,42) = 7.467$; $p = .009$; $\eta_p^2 = 0.151$	$F(1,42) = 119.709$; $p = .000$; $\eta_p^2 = 0.740$
Blocks order	$F(1,42) = 0.108$; $p = .898$; $\eta_p^2 = 0.005$	$F(1,42) = 0.439$; $p = .648$; $\eta_p^2 = 0.020$
Letter/colour condition	$F(1,42) = 0.031$; $p = .862$; $\eta_p^2 = 0.001$	$F(1,42) = 0.535$; $p = .468$; $\eta_p^2 = 0.013$
Group by prospective load	$F(1,42) = 1.303$; $p = .260$; $\eta_p^2 = 0.030$	$F(1,42) = 0.464$; $p = .499$; $\eta_p^2 = 0.011$
Group by blocks order	$F(1,42) = 1.778$; $p = .182$; $\eta_p^2 = 0.078$	$F(1,42) = 3.064$; $p = .057$; $\eta_p^2 = 0.127$
Group by letter/colour condition	$F(1,42) = 0.794$; $p = .378$; $\eta_p^2 = 0.019$	$F(1,42) = 1.095$; $p = .301$; $\eta_p^2 = 0.025$
Group by prospective load by blocks order	$F(1,42) = 0.452$; $p = .639$; $\eta_p^2 = 0.021$	$F(1,42) = 0.304$; $p = .739$; $\eta_p^2 = 0.014$
Group by prospective load by letter/colour condition	$F(1,42) = 0.671$; $p = .417$; $\eta_p^2 = 0.016$	$F(1,42) = 0.033$; $p = .857$; $\eta_p^2 = 0.001$
Group by blocks order by letter/colour condition	$F(1,42) = 2.710$; $p = .107$; $\eta_p^2 = 0.062$	$F(1,42) = 0.462$; $p = .501$; $\eta_p^2 = 0.011$

PART III

DISCUSSION AND CONCLUSIONS

CHAPTER 8.

GENERAL DISCUSSION AND CONCLUSIONS

In a world where bilingualism is more the rule than the exception, understanding the implications of multilingualism is a critical research focus that is generating interest across multiple fields, such as linguistics, education, sociology, anthropology, and even computational sciences. In this general discussion, we adopt a cognitive neuroscientific perspective to examine how bilingualism shapes our brains and behaviours.

Bilinguals are constantly dealing with the need to control both languages in their minds. Language control processes are required to reduce the activation of the non-target language to select the language most appropriate for the context (Costa et al., 1999; Dijkstra & Kroll, 2005; Kroll et al., 2008; Marian & Spivey, 2003a; Thierry & Wu, 2007 Wu & Thierry, 2010). Thus, frequent use of language control processes contributes to cognitive flexibility and overall cognitive abilities (Hernández et al., 2010; Marzecová et al., 2013). In this line of research, a number of previous studies have shown enhanced cognitive control abilities in bilinguals, which are not limited to language processing but extend to other cognitive domains (Morales et al., 2013, 2015; Timmer et al., 2021). For example, bilinguals are usually required to search for contextual cues to select the correct language, and this benefits monitoring and context-updating processes compared to monolinguals (Kaan et al., 2020; Martin et al., 2016). Given the effects of bilingualism on general cognition, the main aim of this dissertation was to explore the link between diverse linguistic experiences (i.e., from monolinguals to a variety of bilinguals) and an essential cognitive ability—the recall of future intentions.

Recalling a future intention requires engaging a set of cognitive processes for encoding the intention, maintaining this intention while completing other activities, and detecting the proper time or moment to retrieve the intention from memory and perform it. This set of processes has been subsumed under the umbrella term *prospective memory* (PM), which refers to the memory that allows us "to remember to remember." Many of the activities that we engage in daily could be classified as delayed actions, requiring the use of the PM mechanism to be correctly completed (e.g., remembering to water the plants each week). Importantly, it has been suggested that strategic monitoring and switching processes are particularly important in the course of a PM activity (Ballhausen et al., 2017; Scullin et al., 2015) and that language control processes in bilinguals could impact these PM processes. For this reason, the present discussion focuses on the effects of bilingualism on PM activities. However, these effects could be influenced by the multiple sides of bilingualism. Therefore, the series of experiments presented in this thesis were designed, first, to outline *how bilinguals with diverse linguistic histories and monolinguals execute a variety of PM tasks that differ in their complexity (Experiments 1, 2, and 4)*, and second, to understand how the languages in which bilinguals (L1 vs. L2) complete a specific activity affect PM processing and final performance (Arndt & Beato, Bialystok et al., 2020, 2017; Foucart et al., 2016; Marian & Fausey, 2006; Marian & Neisser, 2000; Ushiro et al., 2022). Given that working in a second language requires the brain to engage in complex cognitive processes (Calvillo & Mills, 2020; Costa et al., 2014, 2019; Dolgoarshinnaia & Martin-Luengo, 2021; Foucart et al., 2016; Kaan et al., 2016; Pérez et al., 2019), an important focus of this discussion lies in *the cost and benefits associated with completing the PM task in a first (L1) or second (L2) language (Experiments 2 and 3).*

This chapter provides a summary of the key findings of the four experiments that form part of this dissertation, along with a discussion of their theoretical implications for PM and bilingualism. In the upcoming sections, we will examine the evidence regarding the role of prior bilingual experience in PM, as well as the effects of processing PM tasks in either the L1 or L2. Finally, we will draw a general conclusion based on the findings of the current set of experiments.

PRIOR BILINGUAL EXPERIENCE MODULATES PROSPECTIVE MEMORY

One of the main aims of the present dissertation was to explore the impact of bilingualism on the recall of future intentions. Since many studies have reported enhanced ability of bilinguals compared to monolinguals to adjust their cognitive strategies to the demands of tasks (Bonfieni et al., 2019; Greve et al., 2021; Grundy & Timmer, 2016; Morales et al., 2013, 2015), we hypothesised that bilingualism would have a cognitive impact that could influence the ways prospective processes are engaged during PM tasks. Following previous studies in the field of bilingualism (for a review, see van den Noort et al., 2019), we approached this objective by comparing bilinguals' and monolinguals' performance in a variety of PM tasks included in Experiments 1 and 2.

The clearest evidence of the effect of bilingualism on the recall of future intentions is provided by the behavioural findings of Experiment 2. In this study, our participants (monolinguals and bilinguals) carried out a PM task in their L1. Participants were instructed to read short texts and then answer a text comprehension question. Additionally, they had to carry out a prospective intention when specific PM cues appeared while reading the text. This task was specifically designed to resemble a highly demanding linguistic environment, similar to contexts in which bilinguals are usually immersed. We also manipulated the monitoring requirements of the texts that were part of the ongoing task (i.e., by using texts that included inferential revisions of varying complexity), as well as the monitoring demands of the PM cues (focal and non-focal). These manipulations allowed us to observe the ability of bilinguals and monolinguals to adjust their cognitive strategies to the demands of the task.

Our results indicated that *bilinguals were better at recalling the future intention than monolinguals*. As hypothesised, bilingualism resulted in a benefit for PM. Thus, we inferred that bilingual language control influences the monitoring processes engaged during a prospective activity (Hunter Ball & Bugg, 2018). We also found that bilinguals exhibited more efficient L1 comprehension than monolinguals. Although this finding contrasted with the previous literature reporting better performance of monolinguals over bilinguals in L1 verbal tasks (Bialystok & Craik, 2010; Michael & Gollan, 2005), this result was expected given the inferential revision nature of our ongoing task, which made it extremely dependent on highly cognitive processes, requiring the constant engagement of monitoring processes to revise the inference (Pérez et al., 2015). Thus, the enhanced ability of the bilinguals in comprehending the text might have been due to their efficiency in engaging monitoring processes that impacted both the updating of the inference during the ongoing task and the completion of the PM task.

Experiment 1 also provided evidence for enhanced monitoring in the bilingual participants, although this evidence was somewhat weaker. In this experiment, we also tested the effect of bilingualism on PM but employed a less linguistically demanding task wherein participants were asked to categorise pictures (ongoing activity), and the PM cues were either certain specific pictures (focal) or frame colours (non-focal). Our participants were classified as monolinguals, late bilinguals, and early bilinguals. It is important to remark that late bilinguals differed from early bilinguals not only in terms of the age of acquisition of the L2 but also in terms of the interactional linguistic context in which they were immersed. Hence, the late bilinguals were immersed in a Spanish context in which English was used exclusively under certain conditions. However, the early bilinguals were from a context with high interaction between both languages and frequent switching requirements.

The results showed that the monolinguals and late bilinguals did not differ in their performance on the PM task. In fact, we found similar patterns of results for the two groups in both the behavioural and ERP data, which contrasts with the clear differences between monolinguals and bilinguals in Experiment 2. These differences between the two experiments are possibly due to the different language requirements of the PM tasks in the two experiments, which may have attenuated the group differences in Experiment 1. Nevertheless, the results indicate that the PM performance of the early bilinguals differed from that of the monolinguals and late bilinguals. Specifically, early bilinguals showed delayed response times during the ongoing activity compared to monolinguals and late bilinguals, although these differences were not present in their responses in the PM trials. We argue that these delayed response times during the ongoing activity might have been due to stronger recruitment of monitoring processes by early bilinguals compared to monolinguals and bilinguals in order to detect and update the prospective intention during the tasks. Previous studies with monolingual participants also suggest that PM interference (slower response times in the ongoing activity when a PM task is implemented) is generated by the resource-consuming preparatory processes engaged to maintain PM intention and monitor the context for the PM cues (Marsh et al., 2006; McNerney & West, 2007; Smith & Bayen, 2004).

This interpretation was supported by the results from Experiments 1 and 2 regarding the focality of the cue. As mentioned, focality effects in PM are defined as greater costs in performance generated by more effortful monitoring of non-focal than focal cues, where the latter are assumed to elicit "spontaneous retrieval" (Einstein et al., 2005; McDaniel et al., 2015). Experiment 2 evidenced the ability of bilinguals to overcome the costs stemming from the focality of the cue. Thus, we found an overall impairment in the monolinguals' performance of the ongoing and PM tasks compared to the bilinguals, although this impairment was only evident when the cues were non-focal. Thus, although we did not find differences between the groups when the PM task involved focal cues, we found better performance for bilinguals when the cues were non-focal. Hence, the benefit of bilingualism was observed only in the PM condition in which monitoring was required (i.e., non-focal). In addition, bilinguals showed similar performance for both focal and non-focal cues, suggesting that they can adjust their monitoring strategies to the demands of the task. Interestingly, findings regarding the non-focal condition indicated that bilinguals were able to overcome the cost of switching from the ongoing activity to the PM intention compared to monolinguals (Experiment 2). These results agree with those of previous studies that showed more flexibility in cognitive control strategies in bilinguals (Bonfieni et al., 2019; Morales et al., 2013, 2015). Moreover, it has been suggested that PM tasks involve the flexible engagement of proactive and reactive mechanisms, as described by the *dual mechanisms of cognitive control* framework (Braver, 2012) (Lamichhane et al., 2018; McDaniel et al., 2013; Strickland et al., 2018). Therefore, it is possible that the bilingual experience of our participants made them more efficient in the flexible use of cognitive control strategies, which adapted their performance to the monitoring demands of the PM task.

Additionally, the patterns of ERP data from Experiment 1 revealed differences in the prospective monitoring processes of the early bilinguals compared to the monolinguals and late bilinguals. Specifically, the early bilinguals exhibited greater amplitude in the N300 component than monolinguals and late bilinguals only in the non-focal condition, suggesting that they engaged in cue detection processes to a greater extent than the other groups of participants. However, these differences did not appear in the focal condition. Similarly, the greater amplitudes in the P3b component for the early bilinguals compared to the late bilinguals and monolinguals in the focal and non-focal conditions suggest that the early bilinguals engaged in monitoring the intention and context-updating processes during the PM task to a greater extent than the monolinguals or late bilinguals. Interestingly, in the non-focal condition, this difference appeared exclusively in the ongoing trials, indicating that they continuously engaged in these processes to facilitate the monitoring of the intention. Thus, the findings of Experiments 1 and 2 indicate that prior language experience (in monolinguals and bilinguals with different bilingual experiences) modulated the monitoring processes engaged to complete a PM task. Note that differences between monolinguals and late and early bilinguals have also been observed in other cognitive tasks. For instance, Luk et al. (2011) observed that whereas early bilinguals exhibited lower inhibition costs, monolinguals and late bilinguals did not. Kapa and Colombo (2013) also found an advantage in attention control for early bilingual children compared to monolinguals and late bilinguals.

Moreover, the results of Experiment 1 raise interesting questions about how the bilingual experience, such as being immersed in a single- or dual-language context, influences PM. In this regard, it has been argued that being immersed in a dual-language context requires constant management of both languages, resulting in greater cognitive control efficiency when compared to bilinguals from a single-language context (Han et al., 2022). For this reason, in Experiment 4, we selected bilinguals from a single-language context and exposed them to language-switching practice to recreate the cognitive effects of being immersed in a dual-language context. This manipulation aimed to test whether switching practice transfers to the execution of a PM task. To test this, we had a late bilingual group complete a language-switching task prior to the PM task; then, we compared their performance to that of an equivalent late bilingual group without previous switching experience. In addition, we recorded brain activity to observe the neural changes associated with practicing language switching during the PM task.

Although we did not observe behavioural differences between the groups, the pattern of findings derived from the ERPs generated novel and interesting insights. For example, we observed that the practice of language switching selectively modified the activity of ERP components associated with monitoring, cue detection, and switching. Specifically, we selected the N300 and frontal positivity components to study the set of processes related to the monitoring and detection of the PM cue (prospective components; see Bisiacchi et al., 2009; West, 2007), whereas the P3b and frontal-slow waves were studied as correlates of PM processes related to the maintenance and retrieval of the intention from memory (retrospective components; see Cona et al., 2014; Hockey & Cutmore, 2021; Polich, 2007; West et al., 2003). Since our previous language-switching training was assumed to engage monitoring and switching processes, we expected that the two prospective ERP components (N300 and frontal positivity) would be modulated by switching practice, which would result in greater ON-PM differences in amplitudes for the practice group than the control group. However, we expected that the retrospective components (P3b and frontal-slow waves) associated with the maintenance and retrieval of the intention from long-term memory would be less affected by our language-switching manipulation.

As expected, the pattern of results indicates that the practice of language switching modulated the prospective components (i.e., N300 and frontal positivity) but had no effect on the retrospective ones (i.e., P3b and frontal-slow waves). Thus, participants exposed to the switching task showed greater amplitude differences between the ongoing and PM trials in the N300 component. Given that this component has been associated with PM cue detection processes, we infer that our manipulation resulted in adaptations of the prospective processes engaged to detect the PM cue in the context. This notion is consistent with the findings of Experiment 1, in which early bilinguals exhibited a greater N300 component compared to monolinguals and late bilinguals. Thus, the similarities between the two experiments regarding the N300 support the interpretation that the interactional context plays an essential role in the modulation of the prospective processes reflected in the N300. Similarly, in Experiment 4, we also found neural adaptations in the frontal positivity due to language practice. Greater wave amplitudes for this component were found in the group with language switching practice compared to the control group. This component has been associated with switching processes between ongoing and PM activities (Bisiacchi et al., 2009), which is relevant since these results are in line with results of Experiment 2 indicating lower behavioural switching costs from the ongoing to the PM activity for the bilingual group. Hence, our results indicate that language-switching practice (natural or induced by the experimental context) modulates prospective processes related to the monitoring and switching processes in PM.

In contrast, activity in the retrospective components of PM (P3b and frontal-slow waves) was not affected by the language-switching practice. This pattern suggests that previous training in language switching did not affect the memory-updating processes involved in the retrieval of the PM cue. Thus, given that language switching does not require memory retrieval, language training practice modulated the ERP components associated with prospective processing but not those components engaged in the retrieval of the intention from long-term memory.

An intriguing question is why the early bilinguals from dual-language contexts in Experiment 1 (a group that should be equivalent to our switching practice group in Experiment 4) exhibited higher amplitudes in the P3b retrospective component compared to the other groups. It is possible that this retrospective component, which is associated with context updating and working memory processes that monitor PM intention (West & Bowry, 2005; West et al., 2006), was affected by the age of acquisition of the L2 but not by the interactional context. Notably, previous studies on the effect of the age of L2 acquisition on working memory indicated an advantage for earlier compared to later bilinguals (Delcenserie & Genesee, 2017; Vejnovic et al., 2010). Hence, it is possible that the differences in the age of acquisition between the early bilinguals (Experiment 1) and the bilinguals in the switching practice group (Experiment 4) explain the differential effects found in P3b. Further research is needed to explore the nature of the dissociation between the prospective and retrospective components of PM.

In sum, the results of Experiment 4 highlight, from an experimental perspective, the essential role that the interactional context plays in the modulation of the prospective processes. Moreover, although previous studies have proposed that the context in which the bilingual is immersed has an effect on language control processes (e.g., see the *adaptive control hypothesis* in Green & Abutalebi, 2013; for previous data, see Gullifer et al., 2018; Hartanto & Yang, 2020; Khodos et al., 2021), the present study goes further, demonstrating that the interactional context determines the neural correlates of PM, which highlights the importance of considering the interactional context when studying the impact of bilingualism on cognition.

The results of the four experiments reported in this thesis are also relevant to understanding the complex pattern of the results of the many studies investigating the influences of bilingualism on the mind. Classically, the beneficial effects of bilingualism in general domain cognitive tasks have been termed “the bilingual advantage” (De Bruin et al., 2021; Kroll and Bialystok, 2013). However, studies comparing bilingual and monolingual participants in a variety of non-verbal tasks have found mixed results that have not allowed for clear conclusions about when and how bilingualism modulates cognition (Antoniou, 2019; Bialystok, 2017; Donnelly et al., 2019; Hilchey et al., 2015; Lehtonen et al., 2018; Paap, 2019).

Our findings contribute to this stream of literature by extending this research to a cognitive ability not previously explored (i.e., the recall of future intentions) and, more importantly, by indicating that some of the bilinguals' differences may reflect changes in processing strategies that may be reflected (or not) in better performance than the monolinguals. This is especially reflected in the pattern of the ERP results, where we observed that bilinguals recruited neural circuits for PM in different ways than monolinguals, engaging prospective processes in some conditions where monolinguals did not engage them. Moreover, the appearance and magnitude of these effects due to bilingualism were modulated by extrinsic (e.g., PM cue focality, the nature of the PM task) and intrinsic (e.g., type of bilingual experience) factors, signalling the need to extend the debate about "the bilingual advantage" (or the bilingual [*dis*]*advantage*, as suggested by Luk, 2022) beyond a simple comparison between monolinguals and bilinguals. New approaches to this phenomenon are needed to include the wide spectrum of bilingual experiences as well as a set of cognitive tasks that vary in their nature. Only systematic variations of these factors have the potential to lead to a more complete understanding of the nuances associated with bilingual processing.

L1 AND L2 PROCESSING IN PROSPECTIVE MEMORY

An important second focus of this dissertation was to investigate the costs and benefits associated with completing a PM task in the first (L1) or second (L2) language. This question is important, since many cognitive tasks are performed in a non-dominant language, and even in these L2 situations, people are expected to recall and perform intentions when appropriate. Overall, we expected that the retrieval of future intentions would be affected by the language in which the ongoing task was performed, with the assumption that processing would be more effortful when the language involved is the L2 rather than the L1 (Hernández & Meschyan, 2006; Linck et al., 2014). To assess this expectation, we designed Experiments 2 and 3 to compare bilinguals' performance in tasks that required the recall of future intentions in either Spanish (L1) or English (L2). Additionally, across experiments, we manipulated the monitoring requirements of the ongoing and PM tasks (e.g., text updating difficulty and focality of the cues).

In Experiment 2, we assessed the cognitive costs of L2 processing by using a highly demanding ongoing task (inferential text revision), in which participants were confronted with incongruent information that forced them to update their text representation. As expected, the results for both the ongoing activity and PM tasks (identifying specific words in questions evaluating text comprehension) revealed an overall impairment in L2 performance (see Melby-Lervåg & Lervåg, 2014, for similar results with a reading task); that is, accuracy was poorer and RTs were slower in the L2 than in the L1. This L2 impairment was also evident in Experiment 3, which involved a less linguistically demanding categorisation task, although the differences between the L1 and L2 were only evident in the ongoing task and not in the PM task. The differences between the two experiments suggest that the relative effect of L2 processing depends on the cognitive demands of the task (text comprehension vs. categorisation). In a similar vein, the results of Experiment 2 (text comprehension) also indicate that increments in the linguistic demands of the task (i.e., the late updating condition in Experiment 2) magnified the differences between the L1 and L2. Hence, when the linguistic demands decreased (Experiment 3), the differences between the L1 and L2 were reduced in relation to those obtained under more demanding conditions (i.e., Experiment 2).

Overall, the impairment in PM performance is consistent with the findings of previous studies that have demonstrated that working in the L2 imposed high cognitive demands that impaired bilinguals' performance of various cognitive tasks, such as reading (Alptekin & Erçetin, 2010). These studies (e.g., Mitsugi & MacWhinney, 2016; Segalowitz & Frenkiel-Fishman, 2005) indicated a reduced ability to anticipate information in the L2 in situations with greater cognitive load, especially when these predictions rely on complex linguistic patterns (Ito et al., 2017; Kaan et al., 2014). In sum, the behavioural effect of language on PM seems to depend on the demands imposed by the ongoing task. Thus, if, in the real world, we are engaged in reading and understanding a complex research article in the L2, the probability of forgetting a simple PM task, such as sending a message to a colleague, is highly probable.

In addition, our results indicate that the effect of language is also dependent on the nature of the PM cue and on whether this cue is focal or non-focal. Although there was an overall focality effect (i.e., lower performance in the non-focal condition than in the focal condition in Experiments 1 and 2), this focality effect was especially visible during the ongoing task and when the demands of the tasks were high (in the L2 PM trials in Experiment 2). Thus, when the task demands decreased (as in the L1 PM trials in Experiment 2 and the L1 and L2 PM trials in Experiment 3), bilinguals were able to overcome the costs of the cue focality and reduce the focality effects. The pattern of results of bilinguals in their L1 and L2 resembles the pattern observed when we compared monolinguals and bilinguals, finding that bilinguals (but not monolinguals) were also able to overcome the costs of non-focal cues and reduce the effect of focality.

Hence, our behavioural results led us to conclude that in conditions where the demands of the task are high, L2 processing leads to impaired performance by bilinguals in PM tasks and to a pattern similar to that of the monolinguals. This effect of task demands on bilinguals' performance is supported by a recent review by Matos and colleagues (2020), which indicated that people are more prone to forget a future intention when their cognitive resources are taxed by ongoing demanding tasks. They also showed that the more an ongoing activity requires from working memory and attentional resources, the more PM activity is impaired (Lewis-Peacock et al., 2016; Marsh & Hicks, 1998; Möschl et al., 2019).

ERP data in Experiment 3, in which the L1 and L2 were compared in a categorisation task and EEGs recorded, also provided support for this idea. Thus, the P3b component, which has been associated with working memory and the updating of the intention, also signalled the costs of L2 processing in the neural correlates of PM. Specifically, in the L1, we observed a typical pattern of greater positivity for the more demanding non-focal cues, indicating that participants were able to adjust their working memory and update strategies to the demands of the task. However, when participants performed the PM tasks in L2, the wave amplitudes for focal and non-focal cues were similar for both conditions. Hence, in line with the behavioural data, this pattern indicates that L2 processing changed the participants' processing strategies so that they did not adjust their working memory resources in accordance with the demands of the task. Overall, then, the cognitive overload imposed by working in the L2 impaired the ability of our bilingual participants to adjust their monitoring strategies to the demands of the tasks, which was evident in both the behavioural and ERP data. Nevertheless, as we will discuss later, the effects of language and cognitive demands were not evident in all

PM components, suggesting that different processes are affected by language processing.

COGNITIVE AND NEURAL PROCESSES IN PROSPECTIVE MEMORY

Throughout this thesis, we have argued that bilingualism is a useful tool for understanding the cognitive mechanism underlying PM and the neural correlates of these processes. In this section, we summarise the experimental findings that contribute to defining the cognitive and neural processes associated with PM, along with their functional roles, by looking at PM processes through bilinguals' lenses.

In the following paragraphs, we discuss the processes involved in PM processing, the ERP components reflecting these processes, and some nuances that require further investigation. Finally, we provide an overall picture of the processes involved in PM processing.

N300 and cue detection. First, in Experiments 1 and 4, we observed a typical N300 component related to the detection of the PM cue (West, 2011). Here, we found a negative deflection for the PM trials compared to the ongoing trials. Moreover, this effect was modulated by the focality of the PM cue (Experiment 1), exhibiting greater negativity for non-focal cues than for focal cues. Given the assumptions of the Multiprocess Framework (Einstein et al., 2005; McDaniel & Einstein, 2000), this greater negativity in the non-focal condition was indicative of effortful monitoring of the environment to detect the PM cue (Cejudo et al., 2022). This pattern of ERP data for the N300 provides support to the notion that the N300 reflects monitoring processes engaged in detecting the cue, and that these are modulated by the nature of the PM task.

However, the results of Experiment 3 regarding the N300 were puzzling since we observed similar amplitudes for the ongoing and PM trials in the brain area and time window selected for the N300. Note, however, that this finding is not without precedent, since other studies have failed to find an N300 component associated with PM tasks (McNerney, 2006; Wang et al., 2013; Wilson et al., 2013). These contrasting results suggest that the N300 might be modulated by specific characteristics of the task. For example, Cousens and colleagues (2015) demonstrated that the N300 was clearly elicited by perceptual, but not by semantic, PM cues; therefore, it is possible that the N300 is more easily captured when the PM cues are perceptual in nature. Thus, the semantic nature of the focal and non-focal PM cues in Experiment 3 could explain the absence of the type of trial effect for the N300. As mentioned, an alternative explanation is that this early component might be interpreted as an N200 (and not an N300) component. The N200 component has been associated with visual attention and reflects the ability to determine whether a current stimulus matches a stored memory representation (Patel & Azzam, 2005; Morrison et al., 2019). Further research is needed to clarify the nature of these early components, but our research suggests that they are modulated by the nature of the cue and the type of task to be performed.

Frontal positivity, prospective monitoring, and switching. Another ERP component that has been studied in relation to the N300 is the frontal positivity. In fact, it has been proposed that both components are part of a set of wave changes that occur in coordination to allow prospective processing (West, 2011). This component is defined in the present context as a positive frontal deflection in the wave for PM trials compared to ongoing trials, reflecting the engagement of switching processes between ongoing and PM activities (Bisiacchi et al., 2009).

We analysed the frontal positivity in Experiment 4 and found a positive deflection for the PM trials compared to the ongoing trials that was more notorious in the language-switching practice group. The fact that the N300 and frontal positivity were affected by the same manipulation provides support for the notion that they both reflect the functioning of prospective monitoring mechanisms in charge of cue detection and switching. In addition, the observed effect that language-switching practice had on these two components suggests that the recurrent use and control of languages has cognitive effects that specifically transfer to PM cue detection. Therefore, these results agree with our prior hypothesis about the neural adaptations expected in bilinguals and that this effect might be derived from language-switching processes and the constant need to pay attention to and monitor the environment to identify the signals that indicate the appropriate language for the situation.

P3b working memory updating and retrieval of the intention. The P3b is considered a retrospective PM component related to updating the intention in memory during retrieval (West & Krompinger, 2005). We observed that this component was modulated by the focality of the cue (Experiments 1 and 3), with greater positivity for non-focal cues compared to focal cues. Thus, these findings support the notion of a less costly mechanism that allows the "spontaneous retrieval" of the intention for focal cues, whereas non-focal cues demand the allocation of strategic monitoring processes to monitor and update the intention in memory (McDaniel et al., 2015).

Although evidence for this component has been shown in Experiments 1, 3, and 4, the specific direction of the ON-PM differences varied between experiments. Thus, in Experiment 3, we found that the PM trials elicited greater positivity compared to the ongoing trials (West et al., 2003). However, in Experiments 1 and 4, greater positivity was found for the ongoing trials. We argue that these discrepancies are due to the mechanisms of context updating during the ongoing task. Thus, under difficult conditions, the intention might be constantly updated during the performance of the ongoing task, and therefore, working memory updating of the intention will not necessarily be linked to the appearance of the PM cue. In fact, more positive amplitudes for the ongoing task appeared with higher task demands (i.e., the non-focal condition in Experiment 1 and the demanding n-back ongoing task in Experiment 4). Similarly, a number of previous studies did not observe increments in positive amplitudes in PM trials compared to ON trials with tasks involving high cognitive load (West & Bowry, 2005; West et al., 2006). We also found that bilingual participants did not exhibit this component when they completed the PM task in their L2 (Experiment 3). Overall, the general pattern of the P3b results indicates that the monitoring of the intention and context updating in PM depends heavily on task demands.

Frontal-slow wave and retrieval of the intention. We analysed the *frontal-slow wave* in Experiment 4, in which we found greater positivity for PM trials when compared to ON trials (Cejudo et al., 2022; Cona et al., 2014; Cona et al., 2012; West & Krompinger, 2005; but for a different pattern, see West, 2011; West & Ross-Munroe, 2002; Zöllig et al., 2010). The frontal-slow wave has been related to the retrieval of the content of the intention. The fact that it varied in similar ways to the P3b component and was not affected by switching practice suggests that they are both dependent on retrospective components, which do not benefit from prospective monitoring or switching practice.

Taking all the ERP components together, the overall pattern of results across experiments suggests that the prospective and retrospective components studied (e.g., the N300 and P3b) were modulated by both the type of bilingual experience and the focality of the PM cue (Experiments 1 and 3). In addition, practice in language switching (Experiment 4) resulted in the selective modulation of prospective processes, such as cue detection and monitoring, and was reflected in their underlying neural components (i.e., the N300 and frontal positivity), whereas actual performance on the PM task in a second language (Experiment 3) specifically affected PM components related to retrospective neural components (i.e., the P3b and frontal-slow waves). This overall pattern supports theoretical models of PM, such as the Multiprocess Framework (Einstein & McDaniel, 2005; McDaniel & Einstein, 2000), which proposes that the engagement of prospective monitoring processes and effortful retrospective retrieval of the intention depend on contextual conditions (Hicks & Cook, 2006; Scullin et al., 2010, 2013). Our results contribute to the existing literature on PM by dissociating the processes involved and identifying specific conditions affecting each component process. Thus, beyond the focality of the cue (McDaniel et al., 2015), in our studies, we observed that the characteristics of the ongoing activity, such as the linguistic complexity or the language in which it was performed, influenced the cost of monitoring the PM intention (Anderson et al., 2019). These findings suggest the need to take these factors into consideration when measuring PM ability.

Finally, in light of the findings of the current work and those of previous studies in the field, we stress the notion that language should be understood as “more than words” (for an extended review on this notion, see Marian, 2023). Language has been shown to be a powerful tool that modulates our attention, memories, and reasoning and, consequently, influences how we perceive the world and integrates the information that surrounds us (Arndt & Beato, 2017; Bialystok et al., 2020; Chabal & Marian, 2015; Del Maschio et al., 2022; D'Souza et al., 2021). Therefore, people who speak more than one language have as many ways to perceive the world as languages they know. Moreover, the ways in which they carry out activities in daily life is influenced by the language through which they engage in these activities. Thus, research on bilingualism advances our current knowledge about how languages leave a unique imprint on our brains and behaviours. This work has extended this notion of the power of language by showing how prior bilingual experience and linguistic context (L1 and L2) influence the recall of future intentions.

FINAL CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

The ability to recall future intentions is extremely valuable in all spheres of life. Nobody wants to forget something important, such as a medical appointment or a work call—not to mention forgetting activities that could directly endanger your health, such as taking your medication or turning off the gas. Moreover, this ability is also needed for the maintenance of our social relationships, for example, in asking how a friend did on an exam, congratulating a relative on a birthday, or going on a date. Hence, it is crucial to know how we might improve PM and mitigate the factors that could impair it. An extensive body of literature has suggested that the processes underlying PM can be modulated by various factors, such as task demands (Anderson et al., 2019) or individual differences (Cejudo et al., 2019, 2022; Wang et al., 2013). However, the influence of languages on PM has not been previously studied. Thus, the empirical work of this thesis focused on investigating the role of bilingualism in the cognitive and neural mechanisms that underlie PM.

Overall, the observed outcomes of our experimental series are consistent with the hypothesis that being bilingual could induce variations in prospective processing. In general, we observed that bilinguals had better PM performance than monolinguals when the task was performed in the course of a linguistically complex ongoing activity. Enhanced brain activity was also observed, especially in the more demanding conditions, as a reflection of neural adaptations in the cognitive processes of PM. This pattern of brain activity signalled the ability of bilinguals to adjust their monitoring strategies to the demands of the task conditions. Thus, by comparing participants' performance under different monitoring conditions of the task, we were able to highlight the importance of bilingual experience as a modulator of these effects. Specifically, bilinguals immersed in (or exposed to) linguistic contexts where both languages were used in coordination exhibited better ability to adapt their cognitive strategies and processing to the PM tasks. However, the pattern of differences due to bilingualism in our data varied across the different types of PM tasks utilised, suggesting that these effects were task-dependent. For example, greater behavioural differences between monolinguals and bilinguals were found in the more linguistically complex task.

In addition, we observed impaired PM performance when participants worked in their L2, suggesting that L2 processing taxed their cognitive resources used to deal with the prospective intention. Similarly, the neural PM markers also diminished when bilinguals carried out the PM in the L2 context. Thus, we can say that bilinguals' performance in their L2 is closer to that of monolinguals. Finally, we conclude that the effect of bilingualism could selectively influence the prospective and retrospective processes involved in PM. Thus, language-switching practice modulates PM cue detection processes, but not those processes associated with the retrieval of the intention. Future research should be directed to investigate factors that are based on the linguistic experience impact memory. More generally, the findings of this thesis increased our understanding of executive control processes in bilinguals (Beatty-Martínez et al., 2020; De Bruin, 2019) and of the ways in which the processes underlying PM work (Peper & Hunter Ball, 2023).

We consider this dissertation to be an exciting starting point from which to continue exploring the different ways in which bilingualism in particular, and languages in general, change our thoughts and the way in which we remember and project intentions into the future. Whereas the present studies were based on EEG recordings and ERP analyses as methodological tools to unravel the cognitive processes modulated by bilingualism during PM recall, future research should consider the use of other neuroimaging techniques, such as positron emission tomography (PET) or functional magnetic resonance imaging (fMRI), which may provide useful data for understanding the brain networks recruited during prospective and retrospective processing in PM and the ways in which bilingualism selectively impacts specific brain networks. Similarly, the use of transcranial direct current stimulation (tDCS) might provide causal evidence of the impact of bilingual and second language processing in the neural circuits underlying the recall of intentions. Beyond the use of new techniques, it would also be relevant to extend these findings to other memory effects, such as the language-dependency effect (Marian & Kaushanskaya, 2007; Marsh et al., 2015). In the present experiments, we have mainly focused on the functional variables (type of cue and ongoing task) with the potential to affect the prospective components of PM, and their interaction with language use. Further research should also be directed to understanding the impact of language on the retrospective components of PM. Thus, manipulating the congruency between the linguistic context of PM encoding and retrieval and other variables affecting retrieval could yield important findings regarding the practical implications of this research.

CAPÍTULO 9.
RESUMEN Y CONCLUSIONES

Conocer idiomas nos abre la puerta a nuevos mundos y experiencias. Nos conecta con gente diversa y nos permite desarrollar proyectos a nivel internacional (tanto personales como profesionales). Sin embargo, el poder del bilingüismo va más allá de los beneficios sociales que todos/as podemos fácilmente imaginar. El aprendizaje de idiomas ha demostrado ser una herramienta altamente eficaz para modular nuestra mente, y con ello, nuestro comportamiento. Contrariamente a la creencia inicial de que un bilingüe es la suma de dos monolingües (Grosjean, 1989), la clave para entender cómo el uso de varios idiomas acaba influyendo en nuestro cerebro es el fenómeno de la co-activación de lenguas y la necesidad de controlar dicha activación (Kroll et al., 2015). Cuando una persona conoce varios idiomas estos son activados paralelamente durante la comprensión o producción (¡Incluso en situaciones donde solo se está utilizando uno de ellos!), así, es necesario emplear un mecanismo de control de lenguas que permita seleccionar el idioma adecuado en cada momento y reducir la activación del no deseado (Green, 1998; Kroll et al., 2008; Macizo, 2016).

Esta constante necesidad de controlar ambas lenguas da lugar a cambios estructurales y funcionales en el cerebro bilingüe (Abutalebi et al., 2012; Gold et al., 2013). Sin embargo, estos cambios no solo afectan a las redes cerebrales encargadas del control de lenguas, sino que también se extienden a otros sistemas neuronales relacionados con el control cognitivo de manera general (Anderson et al., 2018; Sulpizio et al., 2020). De este modo, durante las últimas décadas numerosos estudios se han centrado en explorar los efectos del bilingüismo en tareas no verbales, señalando la existencia de costes y beneficios a nivel cognitivo (Giezen et al., 2015; Noort et al., 2019; Marian & Spivey 2003; Morales et al., 2013, 2015).

No obstante, definir el bilingüismo es una cuestión compleja dada la variedad de factores que subyacen a este concepto. Así, muchas son las dudas que surgen cuando tratamos de caracterizar a una persona bilingüe: ¿Debo haber nacido y haber sido criado expuesto a las dos lenguas para ser considerado bilingüe o puedo aprender el idioma en la edad adulta y seguir siendo considerado bilingüe? En este último caso, ¿son bilingües solo quienes hablan dos lenguas con fluidez y sin acento? Entonces, ¿qué hay de quienes utilizan ambos idiomas en sus tareas cotidianas, aunque no lo hagan con tanta fluidez o tengan un fuerte acento? Estas cuestiones hacen ver que no existe una definición única que se ajuste a la variabilidad del espectro de la experiencia bilingüe (Costa, 2020). La edad de adquisición, la exposición, el uso del idioma, la frecuencia con la que se cambia entre ellos o el dominio son sólo algunos de los factores que definen a un bilingüe.

Curiosamente, el hecho de que en nuestro cerebro coexistan distintas lenguas tiene importantes repercusiones en nuestra forma de ver el mundo e interactuar con él. Podemos decir que el bilingüismo actúa como una lente que modula nuestras experiencias y cambia nuestra perspectiva en función de la lengua a través de la cual "estamos viendo". De hecho, existe un amplio abanico de estudios que han investigado cómo el idioma en el que realizamos ciertas actividades (ej., nuestro primer o segundo idioma) repercute en el procesamiento y ejecución de diversas tareas relacionadas con la toma de decisiones (Brouwer, 2021), la atención visual (Chabal & Marian, 2015), la percepción (Chen et al., 2022) o incluso con la memoria (Arndt & Beato, 2017; Marian et al., 2021).

Como vemos, dados los diferentes cambios a nivel cerebral que conlleva ser bilingüe, existe un interés creciente en estudiar cómo el bilingüismo impacta en los procesos cognitivos generales, así como en comprender cómo el idioma que utiliza una persona bilingüe afecta al desarrollo de sus actividades cotidianas. Sin embargo, hasta el momento, no hay estudios que hayan explorado los efectos del bilingüismo en una tarea tan esencial como es el recuerdo de intenciones futuras. La habilidad que nos permite recordar este tipo de intenciones es conocida como Memoria Prospectiva (MP) y se encuentra involucrada en la mayoría de tareas de nuestro día a día. Veamos un ejemplo: imagina que estás trabajando y recibes un mensaje de tu pareja pidiéndote que compres pan para la cena. Para recordarlo en tu "post-it mental" escribes "¡comprar pan!". Más tarde, inicias el camino a casa mientras escuchas tu podcast favorito. Sin embargo, durante el trayecto a casa debes prestar atención al entorno para localizar la panadería y llevar a cabo la intención previamente creada: comprar pan. La dificultad de este tipo de recuerdos radica en que debemos prestar atención al contexto para detectar cuándo es el momento adecuado para llevar a cabo la intención (es decir, cuándo veas la panadería) y pasar de la actividad principal (escuchar el podcast) a la intención previamente creada (comprar pan).

La idea central de esta investigación se basa en la asunción de que existen semejanzas entre este proceso de recuerdo de intenciones futuras y los procesos que los bilingües ponen en marcha cuando tienen que seleccionar el idioma adecuado en base a claves contextuales. Y es que, una persona bilingüe que vive en un contexto donde ambos idiomas son usados frecuentemente debe prestar atención al entorno para seleccionar el idioma adecuado en función de la situación (ej., el lugar en el que está, la persona con la que habla o el tema sobre el que está conversando). Esto les lleva a estar entrenados/as en procesos como observar el entorno en busca de pistas que indiquen qué idioma usar, detectar señales o pistas y cambiar de un idioma a otro cuando es requerido. Como adelantábamos, todos estos procesos se asemejan a los involucrados en la ejecución de tareas prospectivas (Scullin et al., 2015), lo cual nos lleva a pensar que las personas que conocen y usan dos idiomas podrían enfrentar este tipo de tareas de manera diferente a aquellos que únicamente manejan una lengua. Sin embargo, estos efectos del bilingüismo en el recuerdo de intenciones futuras podrían estar modulados por las demandas cognitivas impuestas por la tarea de MP, las cuales variarán en función de características como la naturaleza de las claves prospectivas (esto es, los eventos que indican el momento de ejecutar la intención) o el contexto lingüístico en el que se debe recordar la intención (ej., primer o segundo idioma).

Para estudiar este tipo de memoria en el laboratorio es común utilizar el paradigma de tarea basada en eventos (Einstein & McDaniel, 2005; Einstein et al., 1995). Este procedimiento consiste en pedirle a los/as participantes que completen una tarea continua (ej., una tarea de decisión léxica). Además, se les indica que deben recordar una tarea adicional, por ejemplo, pulsar una tecla específica cuando la imagen de una pelota aparece (clave prospectiva). Así, los/as participantes realizan la tarea continua pero, cuando la clave previamente codificada aparece, deben parar la actividad principal y realizar la intención prospectiva, en este caso pulsar la tecla. Es importante puntualizar que la aparición de la clave prospectiva se da en un porcentaje muy pequeño del total de ensayos (ej., un 10%). Para una representación gráfica ver Figura 12.

Figura 12. Procedimiento clásico de una tarea MP basada en eventos.

De acuerdo con la Teoría Multiprocesos (McDaniel y Einstein, 2000), los procesos involucrados para recuperar la intención prospectiva pueden variar en función de la naturaleza de las claves prospectivas. Por un lado, hay claves que dan lugar a una "recuperación espontánea de la intención" sin la necesidad de involucrar procesos de monitorización (Einstein y McDaniel, 2005; Scullin et al., 2015). Estas son conocidas como claves focales y su procesamiento es similar al requerido para procesar la tarea continua. Por otro lado, existen claves no focales cuyo procesamiento requiere de recursos adicionales a los empleados para durante la tarea continua. Así, las claves no focales, en comparación con las focales, son mas demandantes a nivel cognitivo, lo que se traduce en una mayor dificultad y un peor desempeño (Cona et al., 2014; McDaniel et al., 2015).

Por este motivo, en la mayoría de los experimentos que conforman esta tesis se manipularon el tipo de claves utilizadas. Esta manipulación es especialmente interesante a nivel teórico puesto que permitió observar las habilidades de los bilingües para adaptarse a las demandas de la tarea.

Adicionalmente, en parte de los experimentos llevados a cabo, implementamos medidas electrofisiológicas (ej., EEG) para observar cómo el bilingüismo modula los correlatos neurales del recuerdo de intenciones futuras. Tradicionalmente, en la literatura de MP se han explorado diversos componentes asociados al procesamiento de tareas prospectivas (West, 2011).

Por un lado, el componente N300 y positividad frontal han sido asociados a la detección de la señal prospectiva, así como a los procesos necesarios para cambiar de la tarea continua a la intención prospectiva (West & Ross-Munroe, 2002; Bissiachi et al., 2009). Por otro lado, los componentes P3b y ondas frontales lentas (entre otros) se han relacionado con procesos de recuperación de la intención durante el transcurso de la actividad continua y tras la aparición de la señal prospectiva (Hockey & Cutmore, 2021; Polich, 2007; West et al., 2003). En general, el uso de la técnica de EEG nos permitió disociar los efectos sobre los procesos prospectivos y retrospectivos de MP derivados de la experiencia bilingüe y de procesar la tarea en un segundo idioma.

OBJETIVOS Y RESULTADOS

En resumen, el propósito central de este trabajo fue estudiar los efectos del bilingüismo en Memoria Prospectiva. Para ello nos centramos en abordar dos objetivos generales: 1) Explorar cómo diversas experiencias lingüísticas influían en el procesamiento de tareas de MP; 2) Investigar cómo el contexto lingüístico en el que se realiza una tarea de MP (primer o segundo idioma) influía en los procesos de monitorización, detección de señales y cambio entre tipo de tareas. Para abordar dichos objetivos se diseñaron un total de cuatro experimentos, los cuales se encuentran publicados (Experimentos 1-3) o enviados para su publicación (Experimento 4). A continuación, pasamos a describirlos brevemente y señalar los principales hallazgos derivados de ellos.

En el Experimento 1 estudiamos el papel de las diversas experiencias bilingües en el procesamiento y la ejecución de tareas de MP. Para ello, comparamos el desempeño de participantes monolingües, bilingües tardíos y bilingües tempranos en una tarea prospectiva donde se manipuló la demanda de monitorización incluyendo claves focales y no focales. Simultáneamente, mientras los participantes completaban la tarea registramos su actividad cerebral. Curiosamente, fueron los datos de actividad cerebral los que claramente evidenciaron la mayor habilidad de los bilingües tempranos para adaptar las estrategias de monitorización en función de las demandas de las tareas. Concretamente, en los componentes N300 y P3b, se observó que los bilingües tempranos ponían en marcha en mayor medida procesos de detección de las señales prospectivas y de actualización de la intención futura en el transcurso de la tarea continua. A nivel comportamental, esto se reflejó en mayores tiempos de respuesta para los bilingües tempranos, en comparación con los bilingües tardíos y monolingües cuyos resultados (tanto comportamentales como de actividad cerebral) no difirieron.

Sin embargo, las evidencias más claras de un beneficio en MP derivado del conocimiento de idiomas fueron arrojadas por los hallazgos del Experimento 2. En este estudio, presentamos a nuestros participantes (monolingües y bilingües) una tarea de MP que debían completar en su primer idioma. Los participantes tenían que leer textos breves, los cuales siempre requerían actualizar una inferencia, y responder a una pregunta de comprensión después de cada uno de ellos. Además, se les pidió recordar una intención prospectiva. Así, cuando aparecían algunas claves previamente memorizadas (ej., la palabra collar o bicicleta), los participantes debían llevar a cabo la intención prospectiva (ej., pulsar una determinada tecla). Esta tarea fue diseñada para recrear la dificultad de un entorno lingüísticamente exigente, similar a aquellos a los que suelen estar expuestos los bilingües. Los resultados mostraron una clara ventaja de los/as participantes bilingües en el recuerdo de intenciones futuras. Específicamente, mostraron una mayor comprensión durante la lectura de los textos, así como mayor recuerdo de la intención prospectiva. Este patrón de resultados sugirió que las personas bilingües son más eficientes involucrando los procesos de monitorización, actualización y cambio requeridos tanto en la revisión del texto como en la ejecución de la tarea prospectiva.

En general, los resultados encontrados en los Experimentos 1 y 2, mostraron los efectos de la experiencia bilingüe en los diversos procesos involucrados en MP. Con el objetivo de profundizar en estos hallazgos y sus implicaciones teóricas, en el Experimento 4 nos propusimos explorar si los efectos de la práctica previa en cambio de idiomas se transferían a una tarea de MP. Para ello, seleccionamos a un grupo de bilingües de un contexto en el que no es frecuente el cambio entre idiomas (bilingües de contexto único). Así, este grupo realizó una practica en cambio de idiomas antes de la ejecución de la tarea de Memoria Prospectiva. Después, comparamos su ejecución en la tarea MP con un grupo de bilingües que tenían las mismas características, pero que no habían realizado dicha práctica en cambio de idiomas. Adicionalmente, registramos la actividad cerebral para explorar los correlatos neurales de los procesos prospectivos y retrospectivos implicados en el MP. Nuestra hipótesis era que los procesos de cambio afectarían a la monitorización y detección de la clave prospectiva mientras que los procesos de actualización y recuperación de la intención de memoria a largo plazo no se verían afectados. En concreto, seleccionamos los componentes N300 y positividad frontal para estudiar el conjunto de procesos relacionados con la detección de la clave prospectiva (Bissiachi et al., 2009, West, 2007), mientras que los componentes P3b y ondas frontales lentas se asumieron como correlatos de los procesos de MP relacionados con el mantenimiento y la recuperación de la intención de la memoria (Polich, 2007; West et al., 2003; Cona et al., 2014; Hockey & Cutmore, 2021). Aunque a nivel comportamental no encontramos efectos relacionados con haber practicado el cambio entre idiomas, el patrón de resultados derivados de la actividad cerebral dio lugar a novedosos e interesantes hallazgos. Así, tal y como esperábamos, nuestro patrón de resultados indicó que la práctica en cambio de idiomas moduló los componentes prospectivos (es decir, N300 y positividad frontal), pero no tuvo efectos en los retrospectivos (estos son, P3b y ondas frontales lentas), apoyando la idea de que el cambio frecuente de idiomas mejora los procesos de monitorización y detección de la clave prospectiva.

El segundo objetivo de esta tesis buscaba determinar cómo el contexto lingüístico (primer o segundo idioma) en el que se realizaba la tarea influía en su ejecución. Los Experimento 2 y 3 mostraron claras evidencias de un peor recuerdo de intenciones futuras derivado de trabajar en el idioma menos dominante.

Por ejemplo, en el Experimento 2 mencionado anteriormente, se les pidió a los/as bilingües que también completaran la tarea prospectiva en su segundo idioma. Los resultados mostraron que, además de una afectación general en la comprensión de los textos, tuvieron un peor recuerdo de intenciones cuando la tarea se hizo en el segundo idioma en comparación con cuando se completó en el idioma nativo. Así, podemos decir que cuando los/as bilingües trabajaron en su segundo idioma su desempeño fue similar al que observamos en monolingües trabajando en su idioma nativo. Específicamente se observó que el efecto de focalidad, esto es, la peor ejecución en la tarea más demandante (no focal) comparada con la tarea menos costosa (focal), se hizo patente para los bilingües en el segundo idioma, pero no en el primero. En conjunto, estos resultados muestran que el hecho de procesar una actividad en nuestro segundo idioma conlleva una sobrecarga cognitiva que deja pocos recursos disponibles para afrontar con éxito la tarea MP, por esto la ejecución se ve especialmente afectada en las tareas que requieren más recursos atencionales.

En esta línea, el Experimento 3 ayudó a definir las conclusiones derivadas de este estudio. En este experimento registramos la actividad cerebral para observar qué ocurre en los mecanismos cerebrales de MP cuando se trabaja en una lengua menos dominante. Con este objetivo, evaluamos a participantes bilingües a los que se les pidió que realizaran una tarea de MP tanto en su primer como en su segundo idioma. No obstante, en esta ocasión se seleccionó como actividad continua una tarea de categorización léxica, la cual era menos compleja a nivel lingüístico en comparación con la utilizada en el Experimento 2 (compresión y revisión de textos). Por otro lado, de modo similar al Experimento 1, seleccionamos los componentes N300 y P3b para observar los efectos a nivel cerebral. Conductualmente observamos un peor desempeño en la tarea continua cuando se realizaba en el segundo idioma, apoyando los resultados previos a este respecto (Experimento 2). Sin embargo, al contrario que en el Experimento 2, no hubo diferencias en el recuerdo de intenciones, indicando que la aparición de estos efectos comportamentales puede depender de las características de la tarea (ej., complejidad lingüística). A pesar de esto, el patrón de actividad cerebral mostró un claro coste del procesamiento del segundo idioma en el componente P3b relacionado con procesos de memoria de trabajo que tienen que ver con la actualización y monitorización de la intención. Esto sugirió que son los procesos retrospectivos de MP los que se ven especialmente afectados cuando se trabaja en un idioma no nativo, mientras que aquellos de naturaleza más prospectiva (reflejados en el N300) no se ven tan influenciados.

CONCLUSIONES FINALES

En términos generales, los hallazgos de esta tesis permiten mejorar nuestra comprensión de los procesos de control ejecutivo en bilingües (De Bruin, 2019; van den Noort et al., 2019), así como ampliar nuestro conocimiento sobre cómo funcionan los procesos subyacentes a la Memoria Prospectiva (Pepper & Hunter Ball, 2023). Los resultados observados en esta serie de experimentos concuerdan con nuestra hipótesis previa de que ser bilingüe puede influir en el procesamiento prospectivo. De este modo, nuestros resultados apoyan el papel del bilingüismo como un factor que modula el funcionamiento de nuestro cerebro y comportamiento (Antoniou, 2019). Aunque, tras los primeros estudios que señalaron la existencia de ventajas cognitivas asociadas al bilingüismo (Bialystok, 2017; Kroll & Bialystok, 2013), este supuesto ha sido puesto en cuestión (De Bruin et al., 2021; Lehtonen et al., 2018; Nichols et al., 2020; Paap, 2019), consideramos que se deben centrar los esfuerzos en clarificar las razones para estos resultados mixtos e identificar las condiciones en que se evidencian los costes y beneficios del bilingüismo a nivel cognitivo. Así, los patrones de datos observados en este trabajo muestran que el bilingüismo no produce un coste o beneficio global en el recuerdo de intenciones futuras, sino que estos efectos van a depender de una combinación de factores extrínsecos (ej., naturaleza de la tarea continua, focalidad de la clave prospectiva) e intrínsecos (ej., tipo de experiencia bilingüe, uso de los idiomas) que modularán cómo los bilingües realizan este tipo de tareas.

Por ejemplo, a través de los estudios que conforman esta tesis, observamos que los bilingües tienen un mejor rendimiento que los monolingües en MP cuando la tarea es lingüísticamente compleja, así como una mayor actividad cerebral que aparece especialmente en las condiciones más exigentes, señalando la capacidad de los bilingües para ajustar sus estrategias de monitorización a las exigencias de la tarea. En este sentido, destacamos la importancia de las diversas experiencias bilingües como moduladoras de estos efectos. En concreto, los bilingües inmersos en (o expuestos a) contextos lingüísticos en los que se utilizan ambas lenguas de forma coordinada, presentaron a nivel neural una mayor capacidad para adaptar las estrategias cognitivas involucradas en el recuerdo futuro. Sin embargo, esta mejor capacidad a nivel neural no se reflejaba en diferencias comportamentales (ausencia de diferencias conductuales en Experimento 4 y coste conductual en Experimento 1). Por tanto, es muy posible que los registros electrofisiológicos sean más sensibles a los efectos asociados al bilingüismo, por lo que la posible controversia en relación a la ventaja bilingüe podría resolverse mediante la utilización de técnicas de registro adecuadas. Además, el patrón de diferencias en nuestros datos debidas al bilingüismo también cambió en función de las características de la tarea prospectiva (ej. la focalidad de la clave o el contexto lingüístico). Así, observamos claras evidencias de un peor recuerdo cuando las personas trabajan en su segunda lengua, lo que sugirió una sobrecarga en los recursos cognitivos de los bilingües para afrontar la intención prospectiva. Por último, a raíz de nuestros resultados sugerimos que el efecto del bilingüismo puede influir selectivamente en los procesos prospectivos y retrospectivos implicados en MP. Los hallazgos sobre el impacto de la práctica en cambio de idiomas en los procesos de detección de señales prospectivas, pero no en los asociados a la recuperación de la intención, indicaron la necesidad de seguir explorando en profundidad cómo ciertos factores asociados a la historia lingüística pueden impactar en los diferentes mecanismos de memoria.

En conjunto, esta tesis supone un punto de partida apasionante para seguir explorando las diferentes formas en las que el bilingüismo en concreto, y el lenguaje en general, modifican nuestro pensamiento y nuestra forma de recordar. Como futuras líneas de investigación, sugerimos desarrollar estudios centrados en estudiar este fenómeno a través de diferentes metodologías y nuevos enfoques.

References

Abutalebi, J., Della Rosa, P. A., Green, D. W., Hernandez, M., Scifo, P., Keim, R., ... & Costa, A. (2012). Bilingualism tunes the anterior cingulate cortex for conflict monitoring. *Cerebral Cortex*, *22*(9), 2076-2086. https://doi.org/10.1093/cercor/bhr287

Adamou, E., & Shen, X. R. (2019). There are no language switching costs when codeswitching is frequent. *International Journal of Bilingualism*, *23*(1), 53-70. https://doi.org/10.1177/1367006917709094

Afsharrad, M., & Sadeghi Benis, A. R. (2017). Differences between monolinguals and bilinguals/males and females in English reading comprehension and reading strategy use. *International Journal of Bilingual Education and Bilingualism*, *20*(1), 34-51. https://doi.org/10.1080/13670050.2015.1037238

Aguerre, N.V., Bajo, M.T. & Gómez-Ariza, C.J. (2021) Dual mechanisms of cognitive control in mindful individuals. *Psychological Research*, *85*(5), 1909–1921. https://doi.org/10.1007/s00426-020-01377-2

Alptekin, C., & Erçetin, G. (2010). The role of L1 and L2 working memory in literal and inferential comprehension in L2 reading. *Journal of Research in Reading*, *33*(2), 206-219. https://doi.org/10.1111/j.1467-9817.2009.01412.x

Altgassen, M., Vetter, N. C., Phillips, L. H., Akgün, C., & Kliegel, M. (2014). Theory of mind and switching predict prospective memory performance in adolescents. *Journal of Experimental Child Psychology*, *127*, 163-175. https://doi.org/10.1016/j.jecp.2014.03.009

Anastasi, J., Rhodes, M., Marquez, S., & Velino, V. (2005). The incidence of false memories in native and non-native speakers. *Memory*, *13*(8), 815-828. https://doi.org/10.1080/09658210444000421

Anderson, F. T., & McDaniel, M. A. (2019). Retrieval in prospective memory: Multiple processes or just delay?. *Quarterly Journal of Experimental Psychology*, *72*(9), 2197-2207. https://doi.org/10.1177/1747021819845622

Anderson, F. T., Strube, M. J., & McDaniel, M. A. (2019). Toward a better understanding of costs in prospective memory: A meta-analytic review. *Psychological Bulletin*, *145*(11), 1053. https://doi.org/10.1037/bul0000208

Anderson, J. A., Chung-Fat-Yim, A., Bellana, B., Luk, G., & Bialystok, E. (2018). Language and cognitive control networks in bilinguals and monolinguals. *Neuropsychologia*, *117*, 352-363. https://doi.org/10.1016/j.neuropsychologia.2018.06.023

Ansaldo, A. I., Ghazi-Saidi, L., & Adrover-Roig, D. (2015). Interference control in elderly bilinguals: Appearances can be misleading. *Journal of Clinical and Experimental Neuropsychology*, *37*(5), 455-470. https://doi.org/10.1080/13803395.2014.990359

Antoniou, K. (2023). The ups and downs of bilingualism: A review of the literature on executive control using event-related potentials. *Psychonomic Bulletin & Review*, 1-40. https://doi.org/10.3758/s13423-023-02245-x

Antoniou, M. (2019). The advantages of bilingualism debate. *Annual Review of Linguistics*, *5*, 395-415. https://doi.org/10.1146/annurev-linguistics-011718-011820

Anwyl-Irvine, A. L., Massonnié, J., Flitton, A., Kirkham, N., & Evershed, J. K. (2020). Gorilla in our midst: An online behavioral experiment builder. *Behavior Research Methods*, *52*(1), 388-407. https://doi.org/10.3758/s13428-019-01237-x

Arndt, J., & Beato, M. S. (2017). The role of language proficiency in producing false memories. *Journal of Memory and Language*, *95*, 146-158. https://doi.org/10.1016/j.jml.2017.03.004

Athanasopoulos, P. (2009). Cognitive representation of colour in bilinguals: The case of Greek blues. *Bilingualism: Language and Cognition*, *12*(1), 83-95. https://doi.org/10.1017/S136672890800388X.

Bailey, C., Venta, A., & Langley, H. (2020). The bilingual [dis] advantage. *Language and Cognition*, *12*(2), 225-281. https://doi.org/10.1017/langcog.2019.43

Ballhausen, N., Schnitzspahn, K.M., Horn, S.S., & Kliegel, M. (2017). The interplay of intention maintenance and cue monitoring in younger and older adults' prospective memory. *Memory & Cognition*, *45*(7), 1113–1125. https://doi.org/10.3758/s13421-017-0720-5

Balota, D. A., Yap, M. J., Hutchison, K. A., Cortese, M. J., Kessler, B., Loftis, B., ... & Treiman, R. (2007). The English lexicon project. *Behavior Research Methods*, *39*, 445-459. https://doi.org/10.3758/BF03193014.

Bartolotti, J., & Marian, V. (2012). Bilingual memory: structure, access, and processing. *Memory, language, and bilingualism: Theoretical and applied approaches*, 7-47, Cambridge University Press.

Baum, S., & Titone, D. (2014). Moving toward a neuroplasticity view of bilingualism, executive control, and aging. *Applied Psycholinguistics*, *35*(5), 857-894. https://doi.org/10.1017/S0142716414000174

Beatty-Martínez, A. L., & Dussias, P. E. (2017). Bilingual experience shapes language processing: Evidence from codeswitching. *Journal of Memory and Language*, *95*, 173-189. https://doi.org/10.1016/j.jml.2017.04.002

Beatty-Martínez, A. L., & Titone, D. A. (2021). The quest for signals in noise: Leveraging experiential variation to identify bilingual phenotypes. *Languages*, *6*(4), 168. https://doi.org/10.3390/languages6040168

Beatty-Martínez, A. L., Navarro-Torres, C. A., Dussias, P. E., Bajo, M. T., Guzzardo Tamargo, R. E., & Kroll, J. F. (2020). Interactional context mediates the consequences of bilingualism for language and cognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *46*(6), 1022. https://psycnet.apa.org/doi/10.1037/xlm0000770

Beatty-Martínez, A. L., Bruni, M. R., Bajo, M. T., & Dussias, P. E. (2021). Brain potentials reveal differential processing of masculine and feminine grammatical gender in native Spanish speakers. *Psychophysiology*, *58*(3), e13737. https://doi.org/10.1111/psyp.13737

Beck, S. M., Ruge, H., Walser, M., & Goschke, T. (2014). The functional neuroanatomy of spontaneous retrieval and strategic monitoring of delayed intentions. *Neuropsychologia*, *52*, 37-50. https://doi.org/10.1016/j.neuropsychologia.2013.10.020

Bergmann, C., Meulman, N., Stowe, L. A., Sprenger, S. A., & Schmid, M. S. (2015). Prolonged L2 immersion engenders little change in morphosyntactic processing of bilingual natives. *Neuroreport*, *26*(17), 1065-1070. doi: 10.1097/WNR.0000000000000469

Bialystok, E. (2001). *Bilingualism in development: Language, literacy, and cognition*. Cambridge University Press.

Bialystok, E. (2017). The bilingual adaptation: How minds accommodate experience. *Psychological Bulletin*, *143*(3), 233. https://doi.org/10.1037/bul0000099

Bialystok, E., & Craik, F. I. (2010). Cognitive and linguistic processing in the bilingual mind. *Current Directions in Psychological Science*, *19*(1), 19-23. DOI:10.1177/0963721409358571

Bialystok, E., & Craik, F. I. (2022). How does bilingualism modify cognitive function? Attention to the mechanism. *Psychonomic Bulletin & Review*, *29*(4), 1246-1269. https://doi.org/10.3758/s13423-022-02057-5

Bialystok, E., Abutalebi, J., Bak, T. H., Burke, D. M., & Kroll, J. F. (2016). Aging in two languages: Implications for public health. *Ageing Research Reviews*, *27*, 56-60. https://doi.org/10.1016/j.arr.2016.03.003

Bialystok, E., Craik, F. I., & Luk, G. (2012). Bilingualism: Consequences for mind and brain. *Trends in Cognitive Sciences*, *16*(4), 240-250. https://doi.org/10.1016/j.tics.2012.03.001

Bialystok, E., Dey, A., Sullivan, M. D., & Sommers, M. S. (2020). Using the DRM paradigm to assess language processing in monolinguals and bilinguals. *Memory & Cognition*, *48*(5), 870-883. https://doi.org/10.3758/s13421-020-01016-6

Bice, K., & Kroll, J. F. (2019). English only? Monolinguals in linguistically diverse contexts have an edge in language learning. *Brain and Language*, *196*, 104644. https://doi.org/10.1016/j.bandl.2019.104644

Bisiacchi, P. S., Schiff, S., Ciccola, A., & Kliegel, M. (2009). The role of dual-task and task-switch in prospective memory: Behavioural data and neural correlates. *Neuropsychologia*, *47*(5), 1362-1373. https://doi.org/10.1016/j.neuropsychologia.2009.01.034

Blanco-Elorrieta, E., & Pylkkänen, L. (2017). Bilingual language switching in the laboratory versus in the wild: The spatiotemporal dynamics of adaptive language control. *Journal of Neuroscience*, *37*(37), 9022-9036. https://doi.org/10.1523/JNEUROSCI.0553-17.2017

Blumenfeld, H. K., & Marian, V. (2007). Constraints on parallel activation in bilingual spoken language processing: Examining proficiency and lexical status using eye-tracking. *Language and Cognitive Processes*, *22*(5), 633-660. https://doi.org/10.1080/01690960601000746

Blumenfeld, H. K., & Marian, V. (2013). Parallel language activation and cognitive control during spoken word recognition in bilinguals. *Journal of Cognitive Psychology*, *25*(5), 547-567. https://doi.org/10.1080/20445911.2013.812093.

Bobb, S. C., Von Holzen, K., Mayor, J., Mani, N., & Carreiras, M. (2020). Co-activation of the L2 during L1 auditory processing: An ERP cross-modal priming study. *Brain and Language*, *203*, 104739. https://doi.org/10.1016/j.bandl.2019.104739

Bonfieni, M., Branigan, H. P., Pickering, M. J., & Sorace, A. (2019). Language experience modulates bilingual language control: The effect of proficiency, age of acquisition, and exposure on language switching. *Acta Psychologica*, *193*, 160-170. https://doi.org/10.1016/j.actpsy.2018.11.004

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review*, *108*(3), 624. https://doi.org/10.1037/0033-295X.108.3.624

Brandimonte, M. A., Ferrante, D., Feresin, C., & Delbello, R. (2001). Dissociating prospective memory from vigilance processes. *Psicológica*, *22*(1), 97-113.

Braver, T. S. (2012). The variable nature of cognitive control: a dual mechanisms framework. *Trends in Cognitive Sciences*, *16*(2), 106-113. https://doi.org/10.1016/j.tics.2011.12.010

Brouwer, S. (2021). The interplay between emotion and modality in the Foreign-Language effect on moral decision making. *Bilingualism: Language and Cognition*, *24*(2), 223-230. https://doi.org/10.1017/S136672892000022X

Brown, S. D., & Heathcote, A. (2008). The simplest complete model of choice response time: Linear ballistic accumulation. *Cognitive Psychology*, *57*(3), 153-178. https://doi.org/10.1016/j.cogpsych.2007.12.002

Burgess, P. W., Quayle, A., & Frith, C. D. (2001). Brain regions involved in prospective memory as determined by positron emission tomography. *Neuropsychologia*, *39*(6), 545-555. https://doi.org/10.1016/S0028-3932(00)00149-4

Calvillo, D. P., & Mills, N. V. (2020). Bilingual witnesses are more susceptible to the misinformation effect in their less proficient language. *Current Psychology*, *39*, 673-680. https://doi.org/10.1007/s12144-018-9787-9

Cejudo, A. B., Gómez-Ariza, C. J., & Bajo, M. T. (2019). The cost of prospective memory in children: The role of cue focality. *Frontiers in Psychology*, *9*, 2738. https://doi.org/10.3389/fpsyg.2018.02738

Cejudo, A. B., López-Rojas, C., Gómez-Ariza, C. J., & Bajo, M. T. (2022). ERP Correlates of Prospective Memory and Cue Focality in Children. *Brain Sciences*, *12*(5), 533. https://doi.org/10.3390/brainsci12050533

Chabal, S., & Marian, V. (2015). Speakers of different languages process the visual world differently. *Journal of Experimental Psychology: General*, *144*(3), 539. https://doi.org/10.1037/xge0000075

Chen, M., Ma, F., Zhang, Z., Li, S., Zhang, M., Yuan, Q., ... & Guo, T. (2021). Language switching training modulates the neural network of non-linguistic cognitive control. *PloS One*, *16*(4), e0247100. https://doi.org/10.1371/journal.pone.0247100

Chen, P., Chung-Fat-Yim, A., & Marian, V. (2022). Cultural experience influences multisensory emotion perception in bilinguals. *Languages*, *7*(1), 12. https://doi.org/10.3390/languages7010012

Chiew, K. S., & Braver, T. S. (2017). Context processing and cognitive control: From gating models to dual mechanisms. *The Wiley Handbook of Cognitive Control*, 143-166. https://doi.org/10.1002/9781118920497.ch9

Christoffels, I. K., Firk, C., & Schiller, N. O. (2007). Bilingual language control: An event-related brain potential study. *Brain research*, *1147*, 192-208. https://doi.org/10.1016/j.brainres.2007.01.137

Chun, E., & Kaan, E. (2019). L2 Prediction during complex sentence processing. *Journal of Cultural Cognitive Science*, 3(2), 203-216. https://doi.org/10.1007/s41809-019-00038-0

Cohen, A. L., & Hicks, J. L. (2017). *Prospective memory: Remembering to remember, remembering to forget*. Springer.

Cohen, A. L., Jaudas, A., & Gollwitzer, P. M. (2008). Number of cues influences the cost of remembering to remember. *Memory & cognition*, *36*, 149-156. https://doi.org/10.3758/MC.36.1.149

Cohen, J. (1969). *Statistical power analysis for the behavioral sciences*. Academic press.

Colzato, L. S., Bajo, M. T., Van den Wildenberg, W., Paolieri, D., Nieuwenhuis, S., La Heij, W., & Hommel, B. (2008). How does bilingualism improve executive control? A comparison of active and reactive inhibition mechanisms. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *34*(2), 302. 10.1037/0278-7393.34.2.302

Cona, G., & Rothen, N. (2019). Neuropsychological and physiological correlates of prospective memory. In *Prospective memory* (pp. 95-115). Routledge.

Cona, G., Bisiacchi, P. S., & Moscovitch, M. (2014). The effects of focal and nonfocal cues on the neural correlates of prospective memory: Insights from ERPs. *Cerebral Cortex*, *24*(10), 2630-2646. https://doi.org/10.1093/cercor/bht116

Cona, G., Bisiacchi, P. S., Sartori, G., & Scarpazza, C. (2016). Effects of cue focality on the neural mechanisms of prospective memory: A meta-analysis of neuroimaging studies. *Scientific Reports*, *6*(1), 25983. https://doi.org/10.1038/srep25983

Cona, G., Scarpazza, C., Sartori, G., Moscovitch, M., & Bisiacchi, P. S. (2015). Neural bases of prospective memory: a meta-analysis and the "Attention to Delayed Intention"(AtoDI) model. *Neuroscience & Biobehavioral Reviews*, *52*, 21-37. https://doi.org/10.1016/j.neubiorev.2015.02.007

Contemori, C., & Tortajada, F. (2020). The use of social–communicative cues to interpret ambiguous pronouns: Bilingual adults differ from monolinguals. *Applied Psycholinguistics*, *41*(1), 51-77. doi:10.1017/S0142716419000407

Cook, G. I., Marsh, R. L., & Hicks, J. L. (2005). Associating a time-based prospective memory task with an expected context can improve or impair intention completion. *Applied Cognitive Psychology*, *19*(3), 345-360. https://doi.org/10.1002/acp.1082

Costa, A. (2020). *The Bilingual Brain: And what it tells us about the science of language*. Penguin UK.

Costa, A., & Santesteban, M. (2004). Lexical access in bilingual speech production: Evidence from language switching in highly proficient bilinguals and L2 learners. *Journal of Memory and Language*, *50*(4), 491-511. https://doi.org/10.1016/j.jml.2004.02.002

Costa, A., Corey, J. D., Hayakawa, S., Aparici, M., Vives, M. L., & Keysar, B. (2019). The role of intentions and outcomes in the foreign language effect on moral judgements. *Quarterly Journal of Experimental Psychology*, *72*(1), 8-17. https://doi.org/10.1177/1747021817738409

Costa, A., Foucart, A., Hayakawa, S., Aparici, M., Apesteguia, J., Heafner, J., & Keysar, B. (2014). Your morals depend on language. *PloS One*, 9(4), e94842. https://doi.org/10.1371/journal.pone.0094842

Costa, A., Hernández, M., & Sebastián-Gallés, N. (2008). Bilingualism aids conflict resolution: Evidence from the ANT task. *Cognition*, *106*(1), 59-86. https://doi.org/10.1016/j.cognition.2006.12.013

Costa, A., Hernández, M., Costa-Faidella, J., & Sebastián-Gallés, N. (2009). On the bilingual advantage in conflict processing: Now you see it, now you don't. *Cognition*, *113*(2), 135-149. https://doi.org/10.1016/j.cognition.2009.08.001

Costa, A., Miozzo, M., & Caramazza, A. (1999). Lexical selection in bilinguals: Do words in the bilingual's two lexicons compete for selection?. *Journal of Memory and Language*, *41*(3), 365-397. https://doi.org/10.1006/jmla.1999.2651

Cousens, R., Cutmore, T., Wang, Y., Wilson, J., Chan, R. C., & Shum, D. H. (2015). Effects of perceptual and semantic cues on ERP modulations associated with prospective memory. *International Journal of Psychophysiology*, *98*(1), 151-156. https://doi.org/10.1016/j.ijpsycho.2015.07.012

Cox, S. R., Bak, T. H., Allerhand, M., Redmond, P., Starr, J. M., Deary, I. J., & MacPherson, S. E. (2016). Bilingualism, social cognition and executive functions: A tale of chickens and eggs. *Neuropsychologia*, *91*, 299-306. https://doi.org/10.1016/j.neuropsychologia.2016.08.029

Cruz, G., Miyakoshi, M., Makeig, S., Kilborn, K., & Evans, J. (2016). ERPs and their brain sources in perceptual and conceptual prospective memory tasks: Commonalities and differences between the two tasks. *Neuropsychologia*, *91*, 173-185. https://doi.org/10.1016/j.neuropsychologia.2016.08.005.

Czernochowski, D., Horn, S., & Bayen, U. J. (2012). Does frequency matter? ERP and behavioral correlates of monitoring for rare and frequent prospective memory targets. *Neuropsychologia*, *50*(1), 67-76. https://doi.org/10.1016/j.neuropsychologia.2011.10.023

D'Souza, D., Brady, D., Haensel, J. X., & D'Souza, H. (2021). Early bilingual experience is associated with change detection ability in adults. *Scientific Reports*, *11*(1), 1-9. https://doi.org/10.1038/s41598-021-81545-5

Dash, T., Berroir, P., Ghazi-Saidi, L., Adrover-Roig, D., & Ansaldo, A. I. (2021). A new look at the question of the bilingual advantage: Dual mechanisms of cognitive control. *Linguistic Approaches to Bilingualism*, *11*(4), 520-550. https://doi.org/10.1075/lab.18036.das

Davies, I. R., & Corbett, G. G. (1997). A cross-cultural study of colour grouping: Evidence for weak linguistic relativity. *British Journal of Psychology*, *88*(3), 493-517. https://doi.org/10.1111/j.2044-8295.1997.tb02653.x

De Bruin, A. (2019). Not all bilinguals are the same: A call for more detailed assessments and descriptions of bilingual experiences. *Behavioral Sciences*, *9*(3), 33. https://doi.org/10.3390/bs9030033

De Bruin, A., Dick, A. S., & Carreiras, M. (2021). Clear theories are needed to interpret differences: Perspectives on the bilingual advantage debate. *Neurobiology of Language*, *2*(4), 433-451. https://doi.org/10.1162/nol_a_00038

De Bruin, A., Roelofs, A., Dijkstra, T., & FitzPatrick, I. (2014). Domain-general inhibition areas of the brain are involved in language switching: FMRI evidence from trilingual speakers. *NeuroImage*, *90*, 348-359. https://doi.org/10.1016/j.neuroimage.2013.12.049

Declerck, M., & Koch, I. (2022). The concept of inhibition in bilingual control. *Psychological Review*. https://doi.org/10.1037/rev0000367

Declerck, M., & Philipp, A. M. (2015). A review of control processes and their locus in language switching. *Psychonomic Bulletin & Review*, *22*, 1630-1645. https://doi.org/10.3758/s13423-015-0836-1

Declerck, M., Grainger, J., Koch, I., & Philipp, A. M. (2017). Is language control just a form of executive control? Evidence for overlapping processes in language switching and task switching. *Journal of Memory and Language*, *95*, 138-145. https://doi.org/10.1016/j.jml.2017.03.005

Del Maschio, N., Crespi, F., Peressotti, F., Abutalebi, J., & Sulpizio, S. (2022). Decision-making depends on language: A meta-analysis of the Foreign Language Effect. *Bilingualism: Language and Cognition*, *25*(4), 617-630. https://doi.org/10.1017/S1366728921001012

Delcenserie, A., & Genesee, F. (2017). The effects of age of acquisition on verbal memory in bilinguals. *International Journal of Bilingualism*, *21*(5), 600-616. https://doi.org/10.1177/1367006916639158

Delorme, A., & Makeig, S. (2004). EEGLAB : an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis, *134*, 9–21. https://doi.org/10.1016/j.jneumeth.2003.10.009

DeLuca, V., Rothman, J., Bialystok, E., & Pliatsikas, C. (2020). Duration and extent of bilingual experience modulate neurocognitive outcomes. *NeuroImage*, *204*, 116222. https://doi.org/10.1016/j.neuroimage.2019.116222

Desideri, L., & Bonifacci, P. (2018). Verbal and nonverbal anticipatory mechanisms in bilinguals. *Journal of Psycholinguistic Research*, *47*, 719-739. https://doi.org/10.1007/s10936-017-9556-1

Dijkstra, T., & Kroll, J. F. (2005). Bilingual visual word recognition and lexical access. *Handbook of Bilingualism: Psycholinguistic Approaches*, *178*, 201. Oxford University Press.

Dolgoarshinnaia, A., & Martin-Luengo, B. (2021). False Memories in Native and Foreign Languages. *Frontiers in Psychology*, *12*, 716336. https://doi.org/10.3389/fpsyg.2021.716336

Donchin, E., & Fabiani, M. (1991). The use of event-related brain potentials in the study of memory: Is P300 a measure of event distinctiveness?. *Psychol. Facul. Public.* 7, 58–77. doi: 10.1111/sltb.12055

Donnelly, S., Brooks, P. J., & Homer, B. D. (2019). Is there a bilingual advantage on interference-control tasks? A multiverse meta-analysis of global reaction time and interference cost. *Psychonomic Bulletin & Review*, *26*, 1122-1147. https://doi.org/10.3758/s13423-019-01567-z

Droop, M., & Verhoeven, L. (2003). Language proficiency and reading ability in first- and second-language learners. *Reading Research Quarterly*, *38*(1), 78-103. https://doi.org/10.1598/RRQ.38.1.4

Eimer, M. (1996). The N2pc component as an indicator of attentional selectivity. *Electroencephalography and Clinical Neurophysiology*, *99*(3), 225-234. https://doi.org/10.1016/0013-4694(96)95711-9

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*(4), 717. https://doi.org/10.1037/0278-7393.16.4.717

Einstein, G. O., & McDaniel, M. A. (2005). Prospective memory: Multiple retrieval processes. *Current Directions in Psychological Science*, *14*(6), 286-290. https://doi.org/10.1111/j.0963-7214.2005.00382.x

Einstein, G. O., McDaniel, M. A., Thomas, R., Mayfield, S., Shank, H., Morrisette, N., & Breneiser, J. (2005). Multiple processes in prospective memory retrieval: factors determining monitoring versus spontaneous retrieval. *Journal of Experimental Psychology: General*, *134*(3), 327. https://doi.org/10.1037/0096-3445.134.3.327

Ellis, J. (1996). Prospective memory or the realization of delayed intentions: A conceptual framework for research. *Prospective Memory: Theory and Applications*, 1-22.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175-191. https://doi.org/10.3758/BF0319314

Filippi, R., Leech, R., Thomas, M. S., Green, D. W., & Dick, F. (2012). A bilingual advantage in controlling language interference during sentence comprehension. *Bilingualism: Language and Cognition*, *15*(4), 858-872. doi:10.1017/S1366728911000708

Folstein, J. R., & Van Petten, C. (2008). Influence of cognitive control and mismatch on the N2 component of the ERP: A review. *Psychophysiology*, *45*(1), 152-170. https://doi.org/10.1111/j.1469-8986.2007.00602.x.

Foucart, A., Romero-Rivas, C., Gort, B. L., & Costa, A. (2016). Discourse comprehension in L2: Making sense of what is not explicitly said. *Brain and Language*, 163, 32-41. https://doi.org/10.1016/j.bandl.2016.09.001

Geva, E., & Siegel, L. S. (2000). Orthographic and cognitive factors in the concurrent development of basic reading skills in two languages. *Reading and Writing*, *12*(1), 1-30.

Giezen, M. R., Blumenfeld, H. K., Shook, A., Marian, V., & Emmorey, K. (2015). Parallel language activation and inhibitory control in bimodal bilinguals. *Cognition*, *141*, 9-25. https://doi.org/10.1016/j.cognition.2015.04.009

Gold, B. T., Kim, C., Johnson, N. F., Kryscio, R. J., & Smith, C. D. (2013). Lifelong bilingualism maintains neural efficiency for cognitive control in aging. *Journal of Neuroscience*, *33*(2), 387-396. https://doi.org/10.1523/JNEUROSCI.3837-12.2013

Grady, C. L., Luk, G., Craik, F. I., & Bialystok, E. (2015). Brain network activity in monolingual and bilingual older adults. *Neuropsychologia*, *66*, 170-181. https://doi.org/10.1016/j.neuropsychologia.2014.10.042

Green, D. W. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition*, *1*(2), 67-81.

Green, D. W., & Abutalebi, J. (2013). Language control in bilinguals: The adaptive control hypothesis. *Journal of Cognitive Psychology*, *25*(5), 515-530. https://doi.org/10.1080/20445911.2013.796377

Greve, W., Koch, M., Rasche, V., & Kersten, K. (2021). Extending the scope of the 'cognitive advantage'hypothesis: multilingual individuals show higher flexibility of goal adjustment. *Journal of Multilingual and Multicultural Development*, 1-17. https://doi.org/10.1080/01434632.2021.1922420

Grosjean, F. (2021). *Life as a bilingual: Knowing and using two or more languages*. Cambridge University Press.

Grundy, J. G., & Bialystok, E. (2018). Monolinguals and bilinguals disengage attention differently following conflict and errors: Evidence from ERPs. *Brain and Cognition*, *128*, 28-36. https://doi.org/10.1016/j.bandc.2018.11.006

Grundy, J. G., & Timmer, K. (2016). Cognitive mechanisms underlying performance differences between monolinguals and bilinguals. *Cognitive control and consequences of multilingualism*, *2*, 375-396. John Benjamins Publishing Company. https://doi.org/10.1075/bpa.2.16gru

Grundy, J. G., Anderson, J. A., & Bialystok, E. (2017). Bilinguals have more complex EEG brain signals in occipital regions than monolinguals. *NeuroImage*, *159*, 280–288. https://doi.org/10.1016/j.neuroimage.2017.07.063

Guasch, M., Boada, R., Ferré, P., & Sánchez-Casas, R. (2013). NIM: A Web-based Swiss army knife to select stimuli for psycholinguistic studies. *Behavior Research Methods*, *45*, 765-771. https://doi.org/10.3758/s13428-012-0296-8.

Gullifer, J. W., & Titone, D. (2020). Characterizing the social diversity of bilingualism using language entropy. *Bilingualism: Language and Cognition*, *23*(2), 283-294. https://doi.org/10.1017/S1366728919000026

Gullifer, J. W., & Titone, D. (2021). Bilingualism: A neurocognitive exercise in managing uncertainty. *Neurobiology of Language*, *2*(4), 464-486. https://doi.org/10.1162/nol_a_00044

Gullifer, J. W., Chai, X. J., Whitford, V., Pivneva, I., Baum, S., Klein, D., & Titone, D. (2018). Bilingual experience and resting-state brain connectivity: Impacts of L2 age of acquisition and social diversity of language use on control networks. *Neuropsychologia*, *117*, 123-134. https://doi.org/10.1016/j.neuropsychologia.2018.04.037

Guynn, M. J. (2003). A two-process model of strategic monitoring in event-based prospective memory: Activation/retrieval mode and checking. *International Journal of Psychology*, *38*(4), 245-256. https://doi.org/10.1080/00207590344000178

Guynn, M. J. (2008). Theory of monitoring in prospective memory: Instantiating a retrieval mode and periodic target checking. In *International Conference on Prospective Memory, 2, Jul, 2005, Zurich, Switzerland; Portions of this research were presented at the aforementioned conference.*. Taylor & Francis Group/Lawrence Erlbaum Associates.

Hammer, K. (2017). They speak what language to whom?!: Acculturation and language use for communicative domains in bilinguals. *Language & Communication*, *56*, 42-54. https://doi.org/10.1016/j.langcom.2017.04.004

Han, F. (2012). Comprehension monitoring in reading English as a foreign language. *New Zealand Studies in Applied Linguistics*, *18*(1), 38-51.

Han, X., Wei, L., & Filippi, R. (2022). Modulating effects of interactional contexts on bilinguals' cognitive control: Evidence for the Adaptive Control Hypothesis. *International Journal of Bilingualism*, 13670069221102011. https://doi.org/10.1177/13670069221102011

Harris, J. E. (1984). Remembering to do things: A forgotten topic. In J. E. Harris & P. E. Morris (Eds.), *Everyday Memory Actions and Absentmindedness*. London: Academic.

Harrison, T. L., Mullet, H. G., Whiffen, K. N., Ousterhout, H., & Einstein, G. O. (2014). Prospective memory: Effects of divided attention on spontaneous retrieval. *Memory & Cognition*, *42*, 212-224. https://doi.org/10.3758/s13421-013-0357-y

Hartanto, A., & Yang, H. (2016). Disparate bilingual experiences modulate task-switching advantages: A diffusion-model analysis of the effects of interactional context on switch costs. *Cognition*, *150*, 10-19. https://doi.org/10.1016/j.cognition.2016.01.016

Hartanto, A., & Yang, H. (2019). Does early active bilingualism enhance inhibitory control and monitoring? A propensity-matching analysis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *45*(2), 360-378. https://doi.org/10.1037/xlm0000581

Hartanto, A., & Yang, H. (2020). The role of bilingual interactional contexts in predicting interindividual variability in executive functions: A latent variable analysis. *Journal of Experimental Psychology: General*, *149*(4), 609. https://doi.org/10.1037/xge0000672

Hayakawa, S., & Keysar, B. (2018). Using a foreign language reduces mental imagery. *Cognition*, *173*, 8-15. https://doi.org/10.1016/j.cognition.2017.12.010

Hayakawa, S., & Keysar, B. (2018). Using a foreign language reduces mental imagery. *Cognition*, 173, 8-15. https://doi.org/10.1016/j.cognition.2017.12.010

Hayakawa, S., Costa, A., Foucart, A., & Keysar, B. (2016). Using a foreign language changes our choices. *Trends in Cognitive Sciences*, *20*(11), 791-793. https://doi.org/10.1016/j.tics.2016.08.004

Hayakawa, S., Pan, Y., & Marian, V. (2021). Considering Preventative Care in a Native vs. Non-native Language: A Foreign Language Effect. *Brain Sciences*, *11*(10), 1309. https://doi.org/10.3390/brainsci11101309

Hayakawa, S., Pan, Y., & Marian, V. (2022). Language changes medical judgments and beliefs. *International Journal of Bilingualism*, *26*(1), 104-121. https://doi.org/10.1177/13670069211022851

Hayakawa, S., Tannenbaum, D., Costa, A., Corey, J. D., & Keysar, B. (2017). Thinking more or feeling less? Explaining the foreign-language effect on moral judgment. *Psychological Science*, *28*(10), 1387-1397. http://www.psychologicalscience.org/ps

He, H., Li, J., Xiao, Q., Jiang, S., Yang, Y., & Zhi, S. (2019). Language and color perception: Evidence from Mongolian and Chinese speakers. *Frontiers in Psychology*, *10*, 551. https://doi.org/10.3389/fpsyg.2019.00551.

Heathcote, A., & Matzke, D. (2022). Winner takes all! What are race models, and why and how should psychologists use them?. *Current Directions in Psychological Science*, *31*(5), 383-394. https://doi.org/10.1177/09637214221095852

Heathcote, A., Loft, S., & Remington, R. W. (2015). Slow down and remember to remember! A delay theory of prospective memory costs. *Psychological Review*, *122*(2), 376. https://doi.org/10.1037/a0038952

Henry, J. D., MacLeod, M. S., Phillips, L. H., & Crawford, J. R. (2004). A meta-analytic review of prospective memory and aging. *Psychology and Aging*, *19*(1), 27. https://doi.org/10.1037/0882-7974.19.1.27

Hering, A., Wild-Wall, N., Falkenstein, M., Gajewski, P. D., Zinke, K., Altgassen, M., & Kliegel, M. (2020). Beyond prospective memory retrieval: Encoding and remembering of intentions across the lifespan. *International Journal of Psychophysiology*, *147*, 44-59. https://doi.org/10.1016/j.ijpsycho.2019.11.003

Hering, A., Wild-Wall, N., Gajewski, P. D., Falkenstein, M., Kliegel, M., & Zinke, K. (2016). The role of cue detection for prospective memory development across the lifespan. *Neuropsychologia*, *93*, 289-300. https://doi.org/10.1016/j.neuropsychologia.2016.11.008

Hernández, A. E., & Meschyan, G. (2006). Executive function is necessary to enhance lexical processing in a less proficient L2: Evidence from fMRI during picture naming. *Bilingualism: Language and Cognition*, *9*(2), 177-188. https://doi.org/10.1017/S1366728906002525

Hernández, M., Costa, A., Fuentes, L. J., Vivas, A. B., & Sebastián-Gallés, N. (2010). The impact of bilingualism on the executive control and orienting networks of attention. *Bilingualism: Language and Cognition*, *13*(3), 315-325. https://doi.org/10.1017/S1366728909990010

Hernández, M., Martin, C. D., Barceló, F., & Costa, A. (2013). Where is the bilingual advantage in task-switching?. *Journal of Memory and Language*, *69*(3), 257-276. https://doi.org/10.1016/j.jml.2013.06.004

Hilchey, M. D., & Klein, R. M. (2011). Are there bilingual advantages on nonlinguistic interference tasks? Implications for the plasticity of executive control processes. *Psychonomic Bulletin & Review*, *18*(4), 625-658. https://doi.org/10.3758/s13423-011-0116-7

Hilchey, M. D., Saint-Aubin, J., & Klein, R. M. (2015). Does bilingual exercise enhance cognitive fitness in traditional non-linguistic executive processing tasks. *The Cambridge Handbook of Bilingual Processing*, 586-613.

Hockey, A., & Cutmore, T. (2021). Inhibitory control in prospective memory: An event related potential comparison of task-switch and dual task processing. *Neuropsychologia*, *158*, 107906. https://doi.org/10.1016/j.neuropsychologia.2021.107906

Hofweber, J., Marinis, T., & Treffers-Daller, J. (2016). Effects of dense code-switching on executive control. *Linguistic Approaches to Bilingualism*, *6*(5), 648-668. https://doi.org/10.1075/lab.15052.hof

Hohwy, J. (2013). *The predictive mind*. Oxford University Press.

Holmes, K. J., & Wolff, P. (2010). Simulation from schematics: dorsal stream processing and the perception of implied motion. In *Proceedings of the annual meeting of the cognitive science society* (Vol. 32, No. 32).

Horiba, Y., & Fukaya, K. (2015). Reading and learning from L2 text: Effects of reading goal, topic familiarity, and language proficiency. *Reading in a Foreign Language*, *27*, 22–46. doi: 10125/66699

Hoshino, N., & Thierry, G. (2011). Language selection in bilingual word production: Electrophysiological evidence for cross-language competition. *Brain Research*, *1371*, 100-109. https://doi.org/10.1016/j.brainres.2010.11.053

Hunter Ball, B., & Bugg, J. M. (2018). Context cue focality influences strategic prospective memory monitoring. *Psychonomic Bulletin and Review*, *25*(4), 1405–1415. https://doi.org/10.3758/s13423-018-1442-9

Iniesta, A., Paolieri, D., Serrano, F., & Bajo, M. T. (2021). Bilingual writing coactivation: Lexical and sublexical processing in a word dictation task. *Bilingualism: Language and Cognition*, *24*(5), 902-917. https://doi.org/10.1017/S1366728921000274

Ito, A., Corley, M., & Pickering, M. J. (2018). A cognitive load delays predictive eye movements similarly during L1 and L2 comprehension. *Bilingualism: Language and Cognition*, *21*(2), 251-264. https://doi.org/10.1017/S1366728917000050

Jäger, T., & Kliegel, M. (2008). Time-based and event-based prospective memory across adulthood: Underlying mechanisms and differential costs on the ongoing task. *The Journal of General Psychology*, *135*(1), 4-22. https://doi.org/10.3200/GENP.135.1.4-22

Jiao, L., Grundy, J. G., Liu, C., & Chen, B. (2020). Language context modulates executive control in bilinguals: Evidence from language production. *Neuropsychologia*, *142*, 107441. https://doi.org/10.1016/j.neuropsychologia.2020.107441

Jiao, L., Liu, C., Liang, L., Plummer, P., Perfetti, C. A., & Chen, B. (2019a). The contributions of language control to executive functions: From the perspective of bilingual comprehension. *Quarterly Journal of Experimental Psychology*, *72*(8), 1984-1997. https://doi.org/10.1177%2F1367006917709097

Jiao, L., Liu, C., Wang, R., & Chen, B. (2019b). Working memory demand of a task modulates bilingual advantage in executive functions. *International Journal of Bilingualism*, *23*(1), 102-117. https://doi.org/10.1177/1367006917709097

Kaan, E., Kheder, S., Kreidler, A., Tomić, A., & Valdes Kroff, J. R. (2020). Processing code-switches in the presence of others: An ERP study. *Frontiers in Psychology*, *11*, 1288. https://doi.org/10.3389/fpsyg.2020.01288

Kaan, E., Kirkham, J., & Wijnen, F. (2016). Prediction and integration in native and second-language processing of elliptical structures. *Bilingualism: Language and Cognition*, *19*(1), 1-18. https://doi.org/10.1017/S1366728914000844

Kang, C., Fu, Y., Wu, J., Ma, F., Lu, C., & Guo, T. (2017). Short-term language switching training tunes the neural correlates of cognitive control in bilingual language production. *Human Brain Mapping*, *38*(12), 5859-5870. https://doi.org/10.1002/hbm.23765

Kapa, L. L., & Colombo, J. (2013). Attentional control in early and later bilingual children. *Cognitive development*, *28*(3), 233-246. https://doi.org/10.1016/j.cogdev.2013.01.011

Kaushanskaya, M., & Prior, A. (2015). Variability in the effects of bilingualism on cognition: It is not just about cognition, it is also about bilingualism. *Bilingualism: Language and Cognition*, *18*(1), 27-28. doi:10.1017/S1366728914000510

KawasakiI-Miyaji, Y., Inoue, T., & Yama, H. (2003). Cross-linguistic false recognition: How do Japanese-dominant bilinguals process two languages: Japanese and English?. *Psychologia*, *46*(4), 255-267. https://doi.org/10.2117/psysoc.2003.255

Khodos, I., Moskovsky, C., & Paolini, S. (2021). Bilinguals' and monolinguals' performance on a non-verbal cognitive control task: How bilingual language experience contributes to cognitive performance by reducing mixing and switching costs. *International Journal of Bilingualism*, *25*(1), 189-204. https://doi.org/10.1177/136700692094640

Kidder, D. P., Park, D. C., Hertzog, C., & Morrell, R. W. (1997). Prospective memory and aging: The effects of working memory and prospective memory task load. *Aging, Neuropsychology, and Cognition*, *4*(2), 93-112. https://doi.org/10.1080/13825589708256639

Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. New York: Cambridge University Press.

Kliegel, M., Altgassen, M., Hering, A., & Rose, N. S. (2011). A process-model based approach to prospective memory impairment in Parkinson's disease. *Neuropsychologia*, *49*(8), 2166-2177. https://doi.org/10.1016/j.neuropsychologia.2011.01.024

Kliegel, M., Jäger, T., & Phillips, L. H. (2008). Adult age differences in event-based prospective memory: A meta-analysis on the role of focal versus nonfocal cues. *Psychology and Aging*, *23*(1), 203. https://doi.org/10.1037/0882-7974.23.1.203

Kliegel, M., Martin, M., McDaniel, M., & Einstein, G. (2004). Importance effects on performance in event-based prospective memory tasks. *Memory*, *12*(5), 553-561. https://doi.org/10.1080/09658210344000099

Kousaie, S., & Phillips, N. A. (2012). Conflict monitoring and resolution: Are two languages better than one? Evidence from reaction time and event-related brain potentials. *Brain Research*, *1446*, 71–90. https://doi.org/10.1016/j.brainres.2012.01.052

Kousaie, S., & Phillips, N. A. (2017). A behavioural and electrophysiological investigation of the effect of bilingualism on aging and cognitive control. *Neuropsychologia*, *94*, 23-35. https://doi.org/10.1016/j.neuropsychologia.2016.11.013

Kremin, L. V., & Byers-Heinlein, K. (2021). Why not both? Rethinking categorical and continuous approaches to bilingualism. *International Journal of Bilingualism*, *25*(6), 1560-1575. 10.1177/13670069211031986

Kretschmer-Trendowicz, A., & Altgassen, M. (2016). Event-based prospective memory across the lifespan: Do all age groups benefit from salient prospective memory cues?. *Cognitive Development*, *39*, 103-112. https://doi.org/10.1016/j.cogdev.2016.04.005

Kroll, J. F., & Bialystok, E. (2013). Understanding the consequences of bilingualism for language processing and cognition. *Journal of Cognitive Psychology*, *25*(5), 497-514. https://doi.org/10.1080/20445911.2013.799170

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, *33*(2), 149-174. https://doi.org/10.1006/jmla.1994.1008

Kroll, J. F., Bobb, S. C., Misra, M., & Guo, T. (2008). Language selection in bilingual speech: Evidence for inhibitory processes. *Acta Psychologica*, *128*(3), 416-430. https://doi.org/10.1016/j.actpsy.2008.02.001

Kroll, J. F., Chan, A., Cheng, A., & Scontras, G. (2023). How to frame bilingualism in context: Putting people and places in mind. *Bilingualism: Language and Cognition*, *26*(1), 17-19. https://doi.org/10.1017/S1366728922000074

Kroll, J. F., Dussias, P. E., & Bajo, M. T. (2018). Language use across international contexts: Shaping the minds of L2 speakers. *Annual Review of Applied Linguistics*, *38*, 60-79. https://doi.org/10.1017/S0267190518000119

Kroll, J. F., Dussias, P. E., Bice, K., & Perrotti, L. (2015). Bilingualism, mind, and brain. *Annu. Rev. Linguist.*, *1*(1), 377-394. https://doi.org/10.1146/annurev-linguist-030514-124937

Kroll, J. F., Dussias, P. E., Bogulski, C. A., & Kroff, J. R. V. (2012). Juggling two languages in one mind: What bilinguals tell us about language processing and its consequences for cognition. In *Psychology of learning and motivation* (Vol. 56, pp. 229-262). Academic press. https://doi.org/10.1016/B978-0-12-394393-4.00007-8

Kuipers, J. R., & Thierry, G. (2010). Event-related brain potentials reveal the time-course of language change detection in early bilinguals. *Neuroimage*, *50*(4), 1633-1638. https://doi.org/10.1016/j.neuroimage.2010.01.076

Kvavilashvili, L. (1992). Remembering intentions: A critical review of existing experimental paradigms. *Applied Cognitive Psychology*, *6*(6), 507-524. https://doi.org/10.1002/acp.2350060605

Kvavilashvili, L., Messer, D. J., & Ebdon, P. (2001). Prospective memory in children: the effects of age and task interruption. *Developmental Psychology*, *37*(3), 418. https://doi.org/10.1037/0012-1649.37.3.418

Laera, G., Borghese, F., Hering, A., Kliegel, M., & Mioni, G. (2023). Aging and time-based prospective memory in the laboratory: A meta-analysis on age-related differences and possible explanatory factors. *Memory*, 1-20. https://doi.org/10.1080/09658211.2023.2191901

Lamichhane, B., McDaniel, M. A., Waldum, E. R., & Braver, T. S. (2018). Age-related changes in neural mechanisms of prospective memory. *Cognitive, Affective, & Behavioral Neuroscience*, *18*(5), 982-999.https://doi.org/10.3758/s13415-018-0617-1

Lehtonen, M., Soveri, A., Laine, A., Järvenpää, J., De Bruin, A., & Antfolk, J. (2018). Is bilingualism associated with enhanced executive functioning in adults? A meta-analytic review. *Psychological Bulletin*, *144*(4), 394. https://doi.org/10.1037/bul0000142

Lesaux, N., Koda, K., Siegel, L., & Shanahan, T. (2006). Development of literacy. Developing literacy in second-language learners. Report of the *National Literacy Panel on Language-Minority Children and Youth*. Mahwah: Lawrence Erlbaum Associates, Publishers.

Lewis-Peacock, J. A., Cohen, J. D., & Norman, K. A. (2016). Neural evidence of the strategic choice between working memory and episodic memory in prospective remembering. *Neuropsychologia*, *93*, 280-288. https://doi.org/10.1016/j.neuropsychologia.2016.11.006

Li, M., Koh, P. W., Geva, E., Joshi, R., & Chen, X. (2020). The componential model of reading in bilingual learners. *Journal of Educational Psychology, 112*(8), 1532. https://doi.org/10.1037/edu0000459

Li, Y., Yang, J., Scherf, K. S., & Li, P. (2013). Two faces, two languages: An fMRI study of bilingual picture naming. *Brain and Language*, *127*(3), 452-462. https://doi.org/10.1016/j.bandl.2013.09.005

Libben, M. R., & Titone, D. A. (2009). Bilingual lexical access in context: evidence from eye movements during reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35*(2), 381. https://doi.org/10.1037/a0014875

Linck, J. A., Osthus, P., Koeth, J. T., & Bunting, M. F. (2014). Working memory and second language comprehension and production: A meta-analysis. *Psychonomic Bulletin & Review*, *21*, 861-883. https://doi.org/10.3758/s13423-013-0565-2

Liu, C., Timmer, K., Jiao, L., Yuan, Y., & Wang, R. (2019a). The influence of contextual faces on bilingual language control. *Quarterly Journal of Experimental Psychology*, *72*(9), 2313-2327. https://doi.org/10.1177/1747021819836713

Liu, C., Yang, C. L., Jiao, L., Schwieter, J. W., Sun, X., & Wang, R. (2019b). Training in language switching facilitates bilinguals' monitoring and inhibitory control. *Frontiers in Psychology*, *10*, 1839. https://doi.org/10.3389/fpsyg.2019.01839

Liu, X., Tu, L., Chen, X., Zhong, M., Niu, M., Zhao, L., Zhi, L., & Huang, R. (2020). Dynamic Language Network in Early and Late Cantonese–Mandarin Bilinguals. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01189

López-Rojas, C., Csilinkó, A., Bajo, M. T., & Marful, A. (2023b). ERP and Behavioural Correlates of Prospective Memory in Bilinguals during L1 and L2 Processing. *Brain Sciences*, *13*(2), 365. https://doi.org/10.3390/brainsci13020365

López-Rojas, C., Marful, A., Pérez, A. I., & Bajo, M. T. (2023a). Prospective memory in bilinguals: Recalling future intentions in first and second language contexts. *Bilingualism: Language and Cognition*, 1-16. doi:10.1017/S136672892300010X

López-Rojas, C., Rossi, E., Marful, A., & Bajo, M. T. (2022). Prospective memory in bilinguals and monolinguals: ERP and behavioural correlates of prospective processing in bilinguals. *Brain and Language*, *225*, 105059. https://doi.org/10.1016/j.bandl.2021.105059

Luck, S. J., & Hillyard, S. A. (1994). Electrophysiological correlates of feature analysis during visual search. *Psychophysiology*, *31*(3), 291-308. https://doi.org/10.1111/j.1469-8986.1994.tb02218.x

Luk, G. (2022). Justice and equity for whom? Reframing research on the "bilingual (dis) advantage". *Applied Psycholinguistics*, 1-15. https://doi.org/10.1017/S0142716422000339

Luk, G., & Bialystok, E. (2013). Bilingualism is not a categorical variable: Interaction between language proficiency and usage. *Journal of Cognitive Psychology*, *25*(5), 605-621. https://doi.org/10.1080/20445911.2013.795574

Luk, G., Anderson, J. A., Craik, F. I., Grady, C., & Bialystok, E. (2010). Distinct neural correlates for two types of inhibition in bilinguals: Response inhibition versus interference suppression. *Brain and Cognition*, *74*(3), 347-357. https://doi.org/10.1016/j.bandc.2010.09.004

Luk, G., De Sa, E. R. I. C., & Bialystok, E. (2011). Is there a relation between onset age of bilingualism and enhancement of cognitive control?. *Bilingualism: Language and Cognition*, *14*(4), 588-595. https://doi.org/10.1017/S1366728911000010

Ma, F., Li, S., & Guo, T. (2016). Reactive and proactive control in bilingual word production: An investigation of influential factors. *Journal of Memory and Language*, *86*, 35-59. https://doi.org/10.1016/j.jml.2015.08.004

Macizo, P. (2016). Phonological coactivation in the bilinguals' two languages: Evidence from the color naming task. *Bilingualism: Language and Cognition*, *19*(2), 361-375. https://doi.org/10.1017/S136672891500005X

Macizo, P., Bajo, T., & Martín, M. C. (2010). Inhibitory processes in bilingual language comprehension: Evidence from Spanish–English interlexical homographs. *Journal* *of Memory and Language*, *63*(2), 232-244. https://doi.org/10.1016/j.jml.2010.04.002

Macizo, P., Bajo, T., & Paolieri, D. (2012). Language switching and language competition. *Second Language Research*, *28*(2), 131-149. DOI: 10.1177/0267658311434893

Mahy, C. E., Moses, L. J., & Kliegel, M. (2014). The development of prospective memory in children: An executive framework. *Developmental Review*, *34*(4), 305-326. https://doi.org/10.1016/j.dr.2014.08.001

Maki, R. H., Shields, M., Wheeler, A. E., & Zacchilli, T. L. (2005). Individual Differences in Absolute and Relative Metacomprehension Accuracy. *Journal of Educational psychology*, *97*(4), 723.

Mangels, J. A., Picton, T. W., & Craik, F. I. (2001). Attention and successful episodic encoding: An event-related potential study. *Cognitive Brain Research*, *11*(1), 77-95. https://doi.org/10.1016/S0926-6410(00)00066-5

Marian, V., & Fausey, C. M. (2006). Language-dependent memory in bilingual learning. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*, *20*(8), 1025-1047. https://doi.org/10.1002/acp.1242

Marian, V., & Hayakawa, S. (2021). Measuring bilingualism: The quest for a "bilingualism quotient". *Applied Psycholinguistics*, *42*(2), 527-548. https://doi.org/10.1017/S0142716420000533

Marian, V., & Kaushanskaya, M. (2004). Self-construal and emotion in bicultural bilinguals. *Journal of Memory and Language*, *51*(2), 190-201. https://doi.org/10.1016/j.jml.2004.04.003

Marian, V., & Kaushanskaya, M. (2005). Autobiographical memory and language in bicultural bilinguals. In *ISB4: Proceedings of the 4th International Symposium on Bilingualism, ed. James Cohen, Kara T. McAlister, Kellie Rolstad, and Jeff MacSwan* (pp. 1478-1486).

Marian, V., & Kaushanskaya, M. (2007). Language context guides memory content. *Psychonomic Bulletin & Review*, *14*, 925-933. https://doi.org/10.1111/j.1467-9922.2007.00401.x

Marian, V., & Neisser, U. (2000). Language-dependent recall of autobiographical memories. *Journal of Experimental Psychology: General*, *129*(3), 361. https://doi.org/10.1037/0096-3445.129.3.361

Marian, V., & Spivey, M. (2003a). Competing activation in bilingual language processing: Within-and between-language competition. *Bilingualism: Language and Cognition*, *6*(2), 97-115. https://doi.org/10.1017/S1366728903001068

Marian, V., & Spivey, M. (2003b). Bilingual and monolingual processing of competing lexical items. *Applied Psycholinguistics*, *24*(2), 173-193. doi:10.1017/S0142716403000092

Marian, V., Bartolotti, J., van den Berg, A., & Hayakawa, S. (2021). Costs and Benefits of Native Language Similarity for Non-native Word Learning. *Frontiers in Psychology*, *12*, 651506. https://doi.org/10.3389/fpsyg.2021.651506

Marian, V., Blumenfeld, H. K., & Kaushanskaya, M. (2007). The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing Language Profiles in Bilinguals and Multilinguals. *Journal of Speech, Language, and Hearing Research*, *50*(4), 940–967. https://doi.org/10.1044/1092-4388(2007/067)

Marsh, B. U., Kanaya, T., & Pezdek, K. (2015). The language dependent recall effect influences the number of items recalled in autobiographical memory reports. *Journal of Cognitive Psychology*, *27*(7), 829–843. https://doi.org/10.1080/20445911.2015.1046876

Marsh, R. L., & Hicks, J. L. (1998). Event-based prospective memory and executive control of working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *24*(2), 336. https://doi.org/10.1037/0278-7393.24.2.336

Marsh, R. L., Hancock, T. W., & Hicks, J. L. (2002). The demands of an ongoing activity influence the success of event-based prospective memory. *Psychonomic Bulletin & Review*, *9*, 604-610. https://doi.org/10.3758/BF03196319

Marsh, R. L., Hicks, J. L., & Cook, G. I. (2006). Task interference from prospective memories covaries with contextual associations of fulfilling them. *Memory & Cognition*, *34*, 1037-1045. https://doi.org/10.3758/BF03193250

Marsh, R. L., Hicks, J. L., Cook, G. I., Hansen, J. S., & Pallos, A. L. (2003). Interference to ongoing activities covaries with the characteristics of an event-based intention. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*(5), 861. https://doi.org/10.1037/0278-7393.29.5.861

Martin, C. D., Molnar, M., & Carreiras, M. (2016). The proactive bilingual brain: Using interlocutor identity to generate predictions for language processing. *Scientific Reports*, *6*(1), 26171. https://doi.org/10.1038/srep26171

Martin, C. D., Thierry, G., Kuipers, J. R., Boutonnet, B., Foucart, A., & Costa, A. (2013). Bilinguals reading in their second language do not predict upcoming words as native readers do. *Journal of Memory and Language*, *69*(4), 574-588. https://doi.org/10.1016/j.jml.2013.08.001

Marzecová, A., Asanowicz, D., Kriva, L. U., & Wodniecka, Z. (2013). The effects of bilingualism on efficiency and lateralization of attentional networks. *Bilingualism:*

Language and Cognition, *16*(3), 608-623. https://doi.org/10.1017/S1366728912000569

Matos, P., Pereira, D. R., Albuquerque, P. B., & Santos, F. H. (2020). How does performing demanding activities influence prospective memory? A systematic review. *Advances in Cognitive Psychology*, *16*(3), 268. doi: 10.5709/acp-0302-0

Matsumoto, A., & Stanny, C. J. (2006). Language-dependent access to autobiographical memory in Japanese-English bilinguals and US monolinguals. *Memory*, *14*(3), 378–390. https://doi.org/10.1080/09658210500365763

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: a multiprocess framework. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*, *14*(7), S127-S144. https://doi.org/10.1002/acp.775

McDaniel, M. A., & Einstein, G. O. (2005). Material Appropriate Difficulty: A Framework for Determining When Difficulty Is Desirable for Improving Learning. In A. F. Healy (Ed.), *Experimental cognitive psychology and its applications* (pp. 73–85). American Psychological Association. https://doi.org/10.1037/10895-006

McDaniel, M. A., Umanath, S., Einstein, G. O., & Waldum, E. R. (2015). Dual pathways to prospective remembering. *Frontiers in Human Neuroscience*, *9*, 392. https://doi.org/10.3389/fnhum.2015.00392

McDaniel, M. A., & Einstein, G.O. (2007). *Prospective memory: An overview and synthesis of an emerging field*. Sage Publications.

McDonald, M., & Kaushanskaya, M. (2020). Factors modulating cross-linguistic co-activation in bilinguals. *Journal of Phonetics*, *81*, 100981. https://doi.org/10.1016/j.wocn.2020.100981

McNerney, M.W. (2006). *An evaluation of the relationship between task switching and prospective memory* [Unpublished master's thesis]. University of Notre Dame, Notre Dame, America.

Meier, B., & Zimmermann, T. D. (2015). Loads and loads and loads: The influence of prospective load, retrospective load, and ongoing task load in prospective memory. *Frontiers in Human Neuroscience*, *9*, 322. https://doi.org/10.3389/fnhum.2015.00322

Melby-Lervåg, M., & Lervåg, A. (2014). Reading comprehension and its underlying components in second-language learners: A meta-analysis of studies comparing first- and second-language learners. *Psychological Bulletin*, *140*(2), 409–433. https://doi.org/10.1037/a0033890

Meuter, R. F., & Allport, A. (1999). Bilingual language switching in naming: Asymmetrical costs of language selection. *Journal of Memory and Language*, *40*(1), 25-40.

Michael, E. B., & Gollan, T. H. (2005). Being and becoming bilingual. *Handbook of Bilingualism: Psycholinguistic Approaches*, 389-407.

Mitsugi, S., & Macwhinney, B. (2016). The use of case marking for predictive processing in second language Japanese. *Bilingualism: Language and Cognition*, *19*(1), 19-35. https://doi.org/10.1017/S1366728914000881

Morales, J., Gómez-Ariza, C. J., & Bajo, M. T. (2013). Dual mechanisms of cognitive control in bilinguals and monolinguals. *Journal of Cognitive Psychology*, *25*(5), 531–546. https://doi.org/10.1080/20445911.2013.807812

Morales, J., Yudes, C., Gómez-Ariza, C. J., & Bajo, M. T. (2015). Bilingualism modulates dual mechanisms of cognitive control: Evidence from ERPs. *Neuropsychologia*, *66*, 157–169. https://doi.org/10.1016/j.neuropsychologia.2014.11.014

Moreno, S., Bialystok, E., Wodniecka, Z., & Alain, C. (2010). Conflict resolution in sentence processing by bilinguals. *Journal of Neurolinguistics*, *23*(6), 564-579. https://doi.org/10.1016/j.jneuroling.2010.05.002

Morford, J. P., Wilkinson, E., Villwock, A., Piñar, P., & Kroll, J. F. (2011). When deaf signers read English: Do written words activate their sign translations? *Cognition*, *118*(2),286-292. https://doi.org/10.1016/j.cognition.2010.11.006

Morishima, Y. (2013). Allocation of limited cognitive resources during text comprehension in a second language. *Discourse Processes*, *50*(8), 577-597. https://doi.org/10.1080/0163853X.2013.846964

Morrison, C., Kamal, F., & Taler, V. (2019). The influence of bilingualism on working memory event-related potentials. *Bilingualism: Language and Cognition*, *22*(1), 191-199. https://doi.org/10.1017/S1366728918000391

Möschl, M., Walser, M., Surrey, C., & Miller, R. (2019). Prospective memory under acute stress: The role of (output) monitoring and ongoing-task demands. *Neurobiology of Learning and Memory*, *164*, 107046. https://doi.org/10.1016/j.nlm.2019.107046

Oksanen, K. M., Waldum, E. R., McDaniel, M. A., & Braver, T. S. (2014). Neural mechanisms of time-based prospective memory: evidence for transient monitoring. *PloS One*, *9*(3), e92123. https://doi.org/10.1371/journal.pone.0092123

Oostenveld, R., Fries, P., Maris, E., & Schoffelen, J. M. (2011). FieldTrip: open source software for advanced analysis of MEG, EEG, and invasive electrophysiological data. *Computational Intelligence and Neuroscience*, *2011*. https://doi.org/10.1155/2011/156869

Paap, K. (2019). The bilingual advantage debate: Quantity and quality of the evidence. *The handbook of the Neuroscience of Multilingualism*, 701-735. https://doi.org/10.1002/9781119387725.ch34

PANGEA: Power Analysis for General Anova Designs. Available online: https://jakewestfall.shinyapps.io/pangea/ (accessed on 23 January 2023).

Park, D. C., Hertzog, C., Kidder, D. P., Morrell, R. W., & Mayhorn, C. B. (1997). Effect of age on event-based and time-based prospective memory. *Psychology and Aging*, *12*(2), 314. https://doi.org/10.1037/0882-7974.12.2.314

Patel, S. H., & Azzam, P. N. (2005). Characterization of N200 and P300: selected studies of the event-related potential. *International Journal of Medical Sciences*, *2*(4), 147. doi: 10.7150/ijms.2.147

Peper, P., & Hunter Ball, B. (2022). Strategic monitoring improves prospective memory: A meta-analysis. *Quarterly Journal of Experimental Psychology*, 17470218231161015. https://doi.org/10.1177/17470218231161015

Pérez, A., Cain, K., Castellanos, M. C., & Bajo, T. (2015). Inferential revision in narrative texts: An ERP study. *Memory & Cognition*, *43*(8), 1105-1135. https://doi.org/10.3758/s13421-015-0528-0

Pérez, A., Hansen, L., & Bajo, T. (2019). The nature of first and second language processing: The role of cognitive control and L2 proficiency during text-level comprehension. *Bilingualism: Language and Cognition*, *22*(5), 930-948. https://doi.org/10.1017/S1366728918000846

Pérez, A., Schmidt, E., Kourtzi, Z., & Tsimpli, I. (2020). Multimodal semantic revision during inferential processing: The role of inhibitory control in text and picture comprehension. *Neuropsychologia*, *138*, 107313. https://doi.org/10.1016/j.neuropsychologia.2019.107313

Perfetti, C. A., Stafura, J. Z., & Adlof, S. M. (2013). Reading comprehension and reading comprehension problems: A word-to-text integration perspective. *Unravelling reading comprehension: Behavioral, Neurobiological, and Genetic Components*, 22-32. Baltimore, MD: Paul Brookes Publishing Co.

Perrotti, Lauren. *Grammatical gender processing in L2 speakers of Spanish: Does cognate status help?*. Diss. Pennsylvania State University, 2012.

Polich, J. (2007). Updating P300: An integrative theory of P3a and P3b. *Clinical Neurophysiology*, *118*(10), 2128-2148. https://doi.org/10.1016/j.clinph.2007.04.019

Polinsky, M., & Kagan, O. (2007). Heritage languages: In the 'wild' and in the classroom. *Language and Linguistics Compass*, *1*(5), 368-395. https://doi.org/10.1111/j.1749-818X.2007.00022.x

Prior, A., & Gollan, T. H. (2011). Good language-switchers are good task-switchers: Evidence from Spanish–English and Mandarin–English bilinguals. *Journal of the International Neuropsychological Society*, *17*(4), 682-691. https://doi.org/10.1017/S1355617711000580

Prior, A., & Gollan, T. H. (2013). The elusive link between language control and executive control: A case of limited transfer. *Journal of Cognitive Psychology*, *25*(5), 622-645. https://doi.org/10.1080/20445911.2013.821993

Prior, A., & MacWhinney, B. (2010). A bilingual advantage in task switching. *Bilingualism: Language and Cognition*, *13*(2), 253-262. doi:10.1017/S1366728909990526

Ramírez-Esparza, N., García-Sierra, A., & Jiang, S. (2020). The current standing of bilingualism in today's globalized world: A socio-ecological perspective. *Current Opinion in Psychology*, *32*, 124-128. https://doi.org/10.1016/j.copsyc.2019.06.038

Rendell, P. G., & Craik, F. I. (2000). Virtual week and actual week: Age-related differences in prospective memory. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*, *14*(7), S43-S62. https://doi.org/10.1002/acp.770

Rendell, P. G., & Henry, J. D. (2009). A review of Virtual Week for prospective memory assessment: Clinical implications. *Brain Impairment*, *10*(1), 14-22. https://doi.org/10.1375/brim.10.1.14

Reynolds, M. G., Schlöffel, S., & Peressotti, F. (2016). Asymmetric switch costs in numeral naming and number word reading: Implications for models of bilingual language production. *Frontiers in Psychology*, *6*, 2011. https://doi.org/10.3389/fpsyg.2015.02011

Roediger, H. L., & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*(4), 803.

Roessel, J., Schoel, C., Zimmermann, R., & Stahlberg, D. (2019). Shedding new light on the evaluation of accented speakers: Basic mechanisms behind nonnative listeners' evaluations of nonnative accented job candidates. *Journal of Language and Social Psychology*, *38*(1), 3-32. https://doi.org/10.1177/0261927X17747904

Rösler, F., Heil, M., & Glowalla, U. (1993). Monitoring retrieval from long-term memory by slow event-related brain potentials. *Psychophysiology*, *30*(2), 170-182. https://doi.org/10.1111/j.1469-8986.1993.tb01730.x

Rosselli, M., Loewenstein, D. A., Curiel, R. E., Penate, A., Torres, V. L., Lang, M., Greig, M. T., Barker, W. W., & Duara, R. (2019). Effects of bilingualism on verbal and nonverbal memory measures in mild cognitive impairment. *Journal of the International Neuropsychological Society*, 25(1), 15-28. doi:10.1017/S135561771800070X

Rossi, E. (2023). Bilingualism as a Human Health Capital [Communication]. *The 2023 Speakers Series in the Humanities*, University of Florida (Gainesville), United States.

Rossion, B., & Pourtois, G. (2004). Revisiting Snodgrass and Vanderwart's object pictorial set: the role of surface detail in basic-level object recognition. *Perception*, *33*(2), 217–236. https://doi.org/10.1068/p5117

Rothman, J., Bayram, F., DeLuca, V., Di Pisa, G., Dunabeitia, J. A., Gharibi, K., ... & Wulff, S. (2022). Monolingual comparative normativity in bilingualism research is out of "control": Arguments and alternatives. *Applied Psycholinguistics*, 1-14. https://doi.org/10.1017/S0142716422000315

Rummel, J., & Kvavilashvili, L. (2023). Current theories of prospective memory and new directions for theory development. *Nature Reviews Psychology*, *2*(1), 40-54. https://doi.org/10.1038/s44159-022-00121-4

Rummel, J., Einstein, G. O., & Rampey, H. (2012). Implementation-intention encoding in a prospective memory task enhances spontaneous retrieval of intentions. *Memory*, *20*(8), 803-817. https://doi.org/10.1080/09658211.2012.707214

Rummel, J., Smeekens, B. A., & Kane, M. J. (2017). Dealing with prospective memory demands while performing an ongoing task: Shared processing, increased on-task focus, or both?. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *43*(7), 1047. https://doi.org/10.1037/xlm0000359

Sabourin, L., & Vinerte, S. (2019). Cognitive control among immersed bilinguals: Considering differences in linguistic and non-linguistic processing. *Bilingualism: Language and Cognition*, *22*(3), 590-605. doi:10.1017/S1366728918000524

Sadat, J., Martin, C. D., Magnuson, J. S., Alario, F. X., & Costa, A. (2016). Breaking down the bilingual cost in speech production. *Cognitive Science*, *40*(8), 1911-1940. https://doi.org/10.1111/cogs.12315

Sahlin, B. H., Harding, M. G., & Seamon, J. G. (2005). When do false memories cross language boundaries in English–Spanish bilinguals?. *Memory & Cognition*, *33*, 1414-1421. https://doi.org/10.3758/BF03193374

Salig, L. K., Valdés Kroff, J. R., Slevc, L. R., & Novick, J. M. (2021). Moving from bilingual traits to states: Understanding cognition and language processing through moment-to-moment variation. *Neurobiology of Language*, *2*(4), 487-512. https://doi.org/10.1162/nol_a_00046

Schnitzspahn, K. M., Ihle, A., Henry, J. D., Rendell, P. G., & Kliegel, M. (2011). The age-prospective memory-paradox: An exploration of possible mechanisms. *International Psychogeriatrics*, *23*(4), 583-592. https://doi.org/10.1017/S1041610210001651

Schnitzspahn, K. M., Stahl, C., Zeintl, M., Kaller, C. P., & Kliegel, M. (2013). The role of shifting, updating, and inhibition in prospective memory performance in young and older adults. *Developmental Psychology*, *49*(8), 1544. DOI:10.1037/a0030579

Schrauf, R. W. (2003). A protocol analysis of retrieval in bilingual autobiographical memory. *International Journal of Bilingualism*, *7*(3), 235-256.

Schrauf, R. W., & Rubin, D. C. (2004). The 'language'and 'feel'of bilingual memory: Mnemonic traces. *Estudios de Sociolingüística*, *5*, 21-39. https://doi.org/10.1558/sols.v5i1.21

Schroeder, S. R., & Marian, V. (2012). A bilingual advantage for episodic memory in older adults. *Journal of Cognitive Psychology*, *24*(5), 591-601. https://doi.org/10.1080/20445911.2012.669367

Schroeder, S. R., & Marian, V. (2014). Bilingual episodic memory: How speaking two languages influences remembering. In *Foundations of Bilingual Memory*, 111-132. https://doi.org/10.1007/978-1-4614-9218-4_6

Schwartz, A. I., & Kroll, J. F. (2006). Bilingual lexical activation in sentence context. *Journal of Memory and Language*, *55*(2), 197-212. https://doi.org/10.1016/j.jml.2006.03.004

Scullin, M. K., McDaniel, M. A., & Shelton, J. T. (2013). The Dynamic Multiprocess Framework: Evidence from prospective memory with contextual variability. *Cognitive Psychology*, *67*(1-2), 55-71. https://doi.org/10.1016/j.cogpsych.2013.07.001

Scullin, M. K., McDaniel, M. A., Shelton, J. T., & Lee, J. H. (2010). Focal/nonfocal cue effects in prospective memory: Monitoring difficulty or different retrieval processes?. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *36*(3), 736. https://doi.org/10.1037/a0018971

Scullin, M.K., Mullet, H.G., Einstein, G.O., & McDaniel, M.A. (2015). *Prospective Memory, International Encyclopedia of the Social & Behavioral Sciences* (2nd ed.). Elsevier. doi:10.1016/B978-0-08-097086-8.51055-1

Segalowitz, N., & Frenkiel-Fishman, S. (2005). Attention control and ability level in a complex cognitive skill: Attention shifting and second-language proficiency. *Memory & Cognition*, *33*(4), 644-653. https://doi.org/10.3758/BF03195331

Segalowitz, N., Watson, V., & Segalowitz, S. (1995). Vocabulary skill: Single-case assessment of automaticity of word recognition in a timed lexical decision task. *Second Language Research*, *11*(2), 121-136. https://doi.org/10.1177/026765839501100204

Shelton, J. T., Scullin, M. K., & Hacker, J. Y. (2019). The multiprocess framework: Historical context and the "dynamic" extension. In *Prospective Memory* (pp. 10-26). Routledge.

Shin, J. (2020). A meta-analysis of the relationship between working memory and second language reading comprehension: Does task type matter?. *Applied Psycholinguistics*, *41*(4), 873-900. https://doi.org/10.1017/S0142716420000272

Shook, A., & Marian, V. (2019). Covert co-activation of bilinguals' non-target language: Phonological competition from translations. *Linguistic approaches to bilingualism*, *9*(2), 228-252. https://doi.org/10.1075/lab.17022.sho

Silawi, R., Shalhoub-Awwad, Y., & Prior, A. (2020). Monitoring of Reading Comprehension Across the First, Second, and Third Language: Domain-General or Language-Specific?. *Language Learning*, 70(3), 886-922. https://doi.org/10.1111/lang.12410

Smith, R. E. (2003). The cost of remembering to remember in event-based prospective memory: investigating the capacity demands of delayed intention performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*(3), 347. https://doi.org/10.1037/0278-7393.29.3.347

Smith, R. E., & Bayen, U. J. (2004). A multinomial model of event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *30*(4), 756. https://doi.org/10.1037/0278-7393.30.4.756

Smith, R. E., Hunt, R. R., McVay, J. C., & McConnell, M. D. (2007). The cost of event-based prospective memory: salient target events. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 33(4), 734.https://doi.org/10.1037/0278-7393.33.4.734.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory*, 6(2), 174.

Spiess, M. A., Meier, B., & Roebers, C. M. (2016). Development and longitudinal relationships between children's executive functions, prospective memory, and metacognition. *Cognitive Development*, *38*, 99-113. https://doi.org/10.1016/j.cogdev.2016.02.003

Stankovic, M., Biedermann, B., & Hamamura, T. (2022). Not all bilinguals are the same: A meta-analysis of the moral foreign language effect. *Brain and Language*, *227*, 105082. https://doi.org/10.1016/j.bandl.2022.105082

Starreveld, P. A., De Groot, A. M., Rossmark, B. M., & Van Hell, J. G. (2014). Parallel language activation during word processing in bilinguals: Evidence from word production in sentence context. *Bilingualism: Language and Cognition*, *17*(2), 258-276. https://doi.org/10.1017/S1366728913000308

Strickland, L., Loft, S., Remington, R. W., & Heathcote, A. (2018). Racing to remember: A theory of decision control in event-based prospective memory. *Psychological Review*, *125*(6), 851. https://doi.org/10.1037/rev0000113

Suarez, M., & Beato, M. S. (2021). The role of language proficiency in false memory: a mini review. *Frontiers in Psychology*, *12*, 659434. https://doi.org/10.3389/fpsyg.2021.659434

Sulpizio, S., Del Maschio, N., Del Mauro, G., Fedeli, D., & Abutalebi, J. (2020). Bilingualism as a gradient measure modulates functional connectivity of language and control networks. *NeuroImage*, *205*, 116306. https://doi.org/10.1016/j.neuroimage.2019.116306

Tao, L., Marzecová, A., Taft, M., Asanowicz, D., & Wodniecka, Z. (2011). The efficiency of attentional networks in early and late bilinguals: the role of age of acquisition. *Frontiers in Psychology*, *2*, 123. https://doi.org/10.3389/fpsyg.2011.00123

Tao, L., Wang, G., Zhu, M., & Cai, Q. (2021). Bilingualism and domain-general cognitive functions from a neural perspective: A systematic review. *Neuroscience & Biobehavioral Reviews*, *125*, 264-295. https://doi.org/10.1016/j.neubiorev.2021.02.029

Teubner-Rhodes, S. E., Mishler, A., Corbett, R., Andreu, L., Sanz-Torrent, M., Trueswell, J. C., & Novick, J. M. (2016). The effects of bilingualism on conflict monitoring, cognitive control, and garden-path recovery. *Cognition*, *150*, 213-231. https://doi.org/10.1016/j.cognition.2016.02.011

Thierry, G. (2016). Neurolinguistic relativity: How language flexes human perception and cognition. *Language Learning*, *66*(3), 690-713. https://doi.org/10.1111/lang.12186.

Thierry, G., & Wu, Y. J. (2007). Brain potentials reveal unconscious translation during foreign-language comprehension. *Proceedings of the National Academy of Sciences*, *104*(30), 12530-12535. https://doi.org/10.1073/pnas.0609927104

Thoma, D. (2023). Language-dependent emotions in heritage and second language bilinguals: When physiological reactions deviate from feelings. *International Journal of Bilingualism*. https://doi.org/10.1177/13670069231159840

Timmer, K., Calabria, M., & Costa, A. (2019). Non-linguistic effects of language switching training. *Cognition*, *182*, 14-24. https://doi.org/10.1016/j.cognition.2018.09.001

Timmer, K., Costa, A., & Wodniecka, Z. (2021). The source of attention modulations in bilingual language contexts. *Brain and Language*, *223*, 105040. https://doi.org/10.1016/j.bandl.2021.105040

Titone, D. A., & Tiv, M. (2023). Rethinking multilingual experience through a Systems Framework of Bilingualism. *Bilingualism: Language and Cognition*, *26*(1), 1-16. https://doi.org/10.1017/S1366728921001127

Tomić, A., & Kaan, E. (2022). Oscillatory brain responses to processing code-switches in the presence of others. *Brain and Language*, *231*, 105139. https://doi.org/10.1016/j.bandl.2022.105139

Tomić, A., & Valdés Kroff, J. (2022). Expecting the unexpected: Code-switching as a facilitatory cue in online sentence processing. *Bilingualism: Language and Cognition*, *25*(1), 81-92. https://doi.org/10.1017/S1366728921000237

Torres, J., & Sanz, C. (2015). Is there a cognitive advantage for Spanish heritage bilinguals? A first look. *Heritage Language Journal*, *12*(3), 292-309. https://doi.org/https://doi.org/10.46538/hlj.12.3.4

Torres, J., Pascual, D., & Beusterien, J. (2018). What's next?: Heritage language learners shape new paths in Spanish teaching. *Hispania*, *100*(5), 271-276.

Ushiro, Y., Hosoda, M., Komuro, R., Mori, Y., & Nishi, T. (2022). Quantitative and Qualitative Effects of the Reading Goal on the Monitoring of Global Causal Coherence in L2 Reading. *JACET Journal*, *66*, 113-131. https://doi.org/10.32234/jacetjournal.66.0_113

Van den Noort, M., Struys, E., Bosch, P., Jaswetz, L., Perriard, B., Yeo, S., ... & Lim, S. (2019). Does the bilingual advantage in cognitive control exist and if so, what are its modulating factors? A systematic review. *Behavioral Sciences*, *9*(3), 27. https://doi.org/10.3390/bs9030027

Van Hell, J. G., & Dijkstra, T. (2002). Foreign language knowledge can influence native language performance in exclusively native contexts. *Psychonomic Bulletin & Review*, *9*(4), 780-789. https://doi.org/10.3758/BF03196335

Vecchi, T., & Gatti, D. (2020). *Memory as prediction: From looking back to looking forward*. MIT press.

Vejnović, D., Milin, P., & Zdravković, S. (2010). Effects of proficiency and age of language acquisition on working memory performance in bilinguals. *Psihologija*, *43*(3), 219-232. DOI: 10.2298/PSI1003219V

Verhoef, K., Roelofs, A., & Chwilla, D. J. (2009). Role of inhibition in language switching: Evidence from event-related brain potentials in overt picture naming. *Cognition*, *110*(1), 84-99. https://doi.org/10.1016/j.cognition.2008.10.013

Verreyt, N., Woumans, E. V. Y., Vandelanotte, D., Szmalec, A., & Duyck, W. (2016). The influence of language-switching experience on the bilingual executive control advantage. *Bilingualism: Language and Cognition*, *19*(1), 181-190. https://doi.org/10.1017/S1366728914000352

Waldum, E. R., & McDaniel, M. A. (2016). Why are you late? Investigating the role of time management in time-based prospective memory. *Journal of Experimental Psychology: General*, *145*(8), 1049. https://doi.org/10.1037/xge0000183

Walter, C. (2004). Transfer of reading comprehension skills to L2 is linked to mental representations of text and to L2 working memory. *Applied linguistics*, *25*(3), 315-339. https://doi.org/10.1093/applin/25.3.315

Wang, L., Altgassen, M., Liu, W., Xiong, W., Akgün, C., & Kliegel, M. (2011). Prospective memory across adolescence: the effects of age and cue focality. *Developmental Psychology*, *47*(1), 226. https://doi.org/10.1037/a0021306.

Wang, Y., Cao, X. Y., Cui, J. F., Shum, D. H., & Chan, R. C. (2013). The relation between prospective memory and working memory: Evidence from event-related potential data. *PsyCh Journal*, *2*(2), 113-121. https://doi.org/10.1002/pchj.24

West, R. (2007). The influence of strategic monitoring on the neural correlates of prospective memory. *Memory & Cognition*, *35*, 1034-1046. https://doi.org/10.3758/BF03193476

West, R. (2008). The cognitive neuroscience of prospective memory. In M. Kliegel, M. A. McDaniel, & G. O. Einstein (Eds.), *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives* (pp. 261–282). Taylor & Francis Group/Lawrence Erlbaum Associates.

West, R. (2011). The temporal dynamics of prospective memory: A review of the ERP and prospective memory literature. *Neuropsychologia*, *49*(8), 2233-2245. https://doi.org/10.1016/j.neuropsychologia.2010.12.028

West, R., & Bowry, R. (2005). Effects of aging and working memory demands on prospective memory. *Psychophysiology*, *42*(6), 698-712. https://doi.org/10.1111/j.1469-8986.2005.00361.x

West, R., & Ross-Munroe, K. (2002). Neural correlates of the formation and realization of delayed intentions. *Cognitive, Affective, & Behavioral Neuroscience*, *2*(2), 162-173. https://doi.org/10.3758/CABN.2.2.162

West, R., & Wymbs, N. (2004). Is detecting prospective cues the same as selecting targets? An ERP study. *Cognitive, Affective, & Behavioral Neuroscience*, *4*(3), 354-363. https://doi.org/10.3758/CABN.4.3.354

West, R., Bowry, R., & Krompinger, J. (2006). The effects of working memory demands on the neural correlates of prospective memory. *Neuropsychologia*, *44*(2), 197-207. https://doi.org/10.1016/j.neuropsychologia.2005.05.003

West, R., Herndon, R. W., & Crewdson, S. J. (2001). Neural activity associated with the realization of a delayed intention. *Cognitive Brain Research*, *12*(1), 1-9. https://doi.org/10.1016/S0926-6410(01)00014-3

West, R., Krompinger, J., Bowry, R., & Doll, R. (2004). Neural correlates of conflict monitoring and error processing. *Brain and Cognition*, *54*, 168–170

West, R., McNerney, M. W., & Travers, S. (2007). Gone but not forgotten: The effects of cancelled intentions on the neural correlates of prospective memory. *International Journal of Psychophysiology*, *64*(3), 215-225. https://doi.org/10.1016/j.ijpsycho.2006.09.004

West, R., Wymbs, N., Jakubek, K., & Herndon, R. W. (2003). Effects of intention load and background context on prospective remembering: An event-related brain potential study. *Psychophysiology*, *40*(2), 260–276. https://doi.org/10.1111/1469-8986.00028

Wilkins, A. J., & Baddeley, A. (1978). Remembering to recall in everyday life: an approach to absentmindedness. In *Practical Aspects of Memory* (pp. 27-34). Academic Press.

Wilson, J., Cutmore, T. R., Wang, Y., Chan, R. C., & Shum, D. H. (2013). Effects of cue frequency and repetition on prospective memory: An ERP investigation. *International Journal of Psychophysiology*, *90*(2), 250-257. https://doi.org/10.1016/j.ijpsycho.2013.08.003

Wolff, P., & Holmes, K. J. (2011). Linguistic relativity. *Wiley Interdisciplinary Reviews: Cognitive Science*, *2*(3), 253-265. https://doi.org/10.1002/wcs.104

Woumans, E., Martin, C. D., Vanden Bulcke, C., Van Assche, E., Costa, A., Hartsuiker, R. J., & Duyck, W. (2015). Can faces prime a language?. *Psychological Science*, *26*(9), 1343-1352. https://doi.org/10.1177%2F0956797615589330

Wu, Y. J., & Thierry, G. (2010). Chinese–english bilinguals reading english hear chinese. *Journal of Neuroscience*, *30*(22), 7646-7651. https://doi.org/10.1523/JNEUROSCI.1602-10.2010

Wu, Y. J., & Thierry, G. (2017). Brain potentials predict language selection before speech onset in bilinguals. *Brain and Language*, *171*, 23-30. https://doi.org/10.1016/j.bandl.2017.04.002

Wu, Y. J., & Thierry, G. (2013). Fast modulation of executive function by language context in bilinguals. *Journal of Neuroscience*, *33*(33), 13533-13537.https://doi.org/10.1523/JNEUROSCI.4760-12.2013.

Yahya, M., & Özkan Ceylan, A. (2022). Interactions between language and inhibitory control: Evidence from a combined language switching and Stroop paradigm. *International Journal of Bilingualism*, *26*(6), 675-694. https://doi.org/10.1177/13670069211062554

Yang, Y. F. (2002). Reassessing readers' comprehension monitoring. *Reading in a Foreign Language*, *14*, 18–42. doi: 10125/66584

Zhang, H., Kang, C., Wu, Y., Ma, F., & Guo, T. (2015). Improving proactive control with training on language switching in bilinguals. *NeuroReport*, *26*(6), 354-359. https://doi.org/10.1097/WNR.0000000000000353

Zhang, J., Xue, T., & Zhang, Z. (2021). Salient cues facilitate automatic processes in prospective memory. *NeuroReport*, *32*(10), 864–868. https://doi.org/10.1097/WNR.0000000000001668

Zhang, T., Van Heuven, W. J., & Conklin, K. (2011). Fast automatic translation and morphological decomposition in Chinese-English bilinguals. *Psychological Science*, *22*(10), 1237-1242. 10.1177/0956797611421492

Zöllig, J., Martin, M., & Kliegel, M. (2010). Forming intentions successfully: Differential compensational mechanisms of adolescents and old adults. *Cortex*, *46*, 575–589. https://doi.org/10.1016/j.cortex.2009.09.010

Zuber, S., Kliegel, M., & Ihle, A. (2016). An individual difference perspective on focal versus nonfocal prospective memory. *Memory & Cognition*, *44*, 1192-1203. https://doi.org/10.3758/s13421-016-0628-5

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