BILINGUALISM AND SOCIAL COGNITION IN YOUNG ADULTS

By

Yifan Wang

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ABSTRACT

Research on bilingual advantages has been found to extend beyond benefits in executive functions to benefits in higher levels of social cognition. The relationship between bilingualism and social cognition is complex, making it difficult to agree on whether and how bilingualism affects social cognitive abilities. However, this field continues to be explored, driven by debate and discussion, making it enter a promising period. This thesis contributes to our understanding of the effect of bilingualism on social cognitive abilities from two aspects, namely perspective-taking and social-emotional ability.

Chapter 1 introduces the effects of bilingualism, perspective-taking, and social-emotional skills. Chapter 2 reports the attempt to replicate a visuospatial perspective-taking (VPT) paradigm by Freundlieb et al. (2018). In two experiments, we did not replicate spontaneous co-representation in joint action VPT tasks. The study presented in Chapter 3 investigates whether bilingual young adults outperform their monolingual peers in VPT, including Level-1 and Level-2 VPT, independent of the effects of executive function and cross-cultural differences. The results showed that EF skills, but not individual differences in bilingualism or culture, predict VPT performance in young adults. Chapter 4 presents an individual differences study suggesting that multilingualism is negatively associated with prosocial behaviour, mediated by empathic concern. The final chapter summarises the findings, outlines the limitations of this thesis, discusses some implications for future studies, and provides a conclusion.

The thesis does not find any evidence for a bilingual advantage in VPT. More generally, it contributes to our understanding of the core mechanisms of VPT. It suggests that these core mechanisms are similar across language experience and culture. In contrast to the lack of evidence for a bilingual advantage in VPT, the findings of this thesis suggest that young adult bilinguals are less distressed and anxious and more emotionally stable, which appears to be related to less prosocial behaviour.

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CHAPTER 1

GENERAL INTRODUCTION

More than 50% of the world's population speaks more than one language. The number of bilinguals will continue to rise due to increased mobility, migration, foreign language education movements and convenient social media (Dewaele et al., 2003; Grosjean, 1982).

There are several advantages to being a bilingual that have been suggested in the literature: Firstly, bilingualism seems to benefit the individual with more advanced cognitive abilities. They are more likely to outperform monolingual peers in attention control, inhibitory control, and mental flexibility, meta-linguistic awareness, creative thinking, and logical thinking (e.g. Bialystok, 2009; De Bot, 2017; Luk & Bialystok, 2013). Moreover, bilingualism can be seen as a factor that increases the likelihood of maintaining high levels of cognitive function into old age (Olsen et al., 2015). Bilingualism is a simple way to reduce the age-related declines for language processing that, in turn, lead to mild cognitive impairment (Olsen et al., 2015). Being bilingual has not only individual, but also social benefits, such as a deeper understanding and knowledge of linguistic ability, leading to greater intercultural understanding, societal interactions and greater financial gains for the country (Altarriba & Morier, 2006). These bilingual advantages have critical implications for education policymaking (Grosjean & Li, 2013).

Social cognition refers to the ability to understand, interpret and respond appropriately in social interactions, which involves the integration of perception, memory, problem-solving, social awareness and comprehension (Fiske & Taylor, 1991). Recently, there has been argument that bilingualism affects social-cognitive ability, such as perspective-taking (Navarro et al., 2022; Navarro & Conway, 2021; Wu & Keysar, 2007), and social-emotional

ability, such as empathy and prosocial behaviour (Dewaele & Li, 2012; Miller et al., 2021). The evidence in this field is mixed. Some research has found that mastering more than one language would benefit social-cognitive or social-emotional abilities, while other research has not always supported a bilingual advantage (perspective-taking: Ryskin et al. 2014; J. J. Wang et al. 2019; empathy: Ghoreyshi Rad et al.; 2020). The primary aim of this thesis is therefore to contribute to the investigation of how bilingualism contributes to social-cognitive and social-emotional abilities.

In addition, we do not know if the potential bilingual advantage is due to social abilities or different perspectives being taken. These bilingual advantages might be caused by the cognitive demands of controlling two languages and the resulting cognitive abilities (Bialystok, 2009; Bialystok et al., 2012). They might also at least partly be due to biculturalism, which forces bilinguals to view the world from different perspectives and requires a high level of mental flexibility (Kharkhurin, 2010). We investigated whether culture, including cultural orientation and acculturation, as well as executive function can explain any enhanced social-cognitive and social-emotional performance by bilingual speakers.

In the present chapter, we will first define the scope of bilingualism in this thesis. This will be followed by an introduction to two areas in which bilingual young adults have been found to have an advantage over monolinguals: social-cognitive and social-emotional ability. Subsequently, two factors that contribute to the bilingualism effect will be discussed: executive function and biculturalism.

Bilingualism

There is no widely accepted definition of bilingualism (Grosjean, 1982). Depending on second language acquisition context and location, a bilingual speaker can be categorised

as a coordinate or a compound bilingual. Coordinate bilingual refers to learning one language exclusively for the first part of their life and learning a second language in later life. Compound bilingual refers to learning two languages simultaneously within the same context and time (Grosjean, 1982). Depending on the age or the stage at which the second language is acquired, a bilingual speaker can be categorised as early or late bilingual (Grosjean, 1982). Depending on the proficiency of the two languages, a speaker can be defined as a balanced bilingual or an unbalanced bilingual (Duncan & De Avila, 1979; Rosselli et al., 2016). Some research definitions limit bilinguals to those whose second language is as proficient as their first language, while others embrace a minimal definition that recognises those not proficient in the second language as bilinguals. As the focus of this paper is on the socio-cognitive consequences of speaking multiple languages, we follow Grosjean and Li (2013)'s definition of bilingualism, which defines bilingualism as using two (or more) languages in current daily life, regardless of second language proficiency, and regardless of when or how the second language was acquired.

There is also no standard way of estimating bi/multilingualism. Most studies treat bilingualism as a categorical variable. But some researchers, especially more recently, claim that categorical group comparison is a relatively insensitive way of studying the effects of bilingualism, and that bilingualism should not be a categorical variable (Carter et al., 2023; Grosjean & Li, 2013). In this thesis we have investigated the bilingual advantage hypothesis both through a comparison of different language groups (Chapters 2 and 3) and treating bilingualism as a continuous variable (Chapters 3 and 4).

Social-cognitive ability: Perspective-taking

Perspective-taking is a crucial ability to represent the knowledge state of a communication partner, which helps individuals infer others' mental states, such as beliefs,

knowledge, and attitudes or approximate another's visual perspective (Apperly, 2011). Perspective-taking is a very crucial skill in social life. It guides our personal and social communication and interaction through understanding each other's behaviours and knowledge; then, we can adjust our corresponding utterances and actions to achieve highly efficient social interaction (Apperly, 2011; Baron-Cohen et al., 1985).

Chapters 2 and 3 focus on one type of perspective-taking, namely visuospatial perspective-taking (VPT). In the following, we will introduce two important distinctions in VPT: the difference between level-1 and level-2 VPT, and between altercentric and egocentric interference.

Level-1 and Level-2 VPT

Flavell et al. (1981) proposed that perspective-taking has two levels: level-1 and level-2. Level-1 perspective-taking refers to the ability to understand what other people see or perceive. For example, in a situation where some objects are in sight and some are out of sight, which objects are visible to them. It is acquired from 24 months of human age (Moll & Tomasello, 2006), or even as early as 14 months old (Sodian et al., 2007), and it develops quickly during childhood. Level-2 perspective-taking refers to mentally adopting someone else's viewpoint and understanding how the world looks from an imagined perspective. For example, in a situation where you and other people see different content from the same object, what you can see if you stand in the other person's position. Previous research have found that children engaged in level-2 VPT, that is, the understanding that others may see things differently, at 36-month-olds and even can be as early as 2.5 years old (Moll & Meltzoff, 2011). Most researchers prove that children acquire both levels of ability before age four. But these two levels of tasks differ in developmental onsets (Harwood & Farrar, 2006) and response time patterns (Michelon & Zacks, 2006).

The difference between level-1 and level-2 VPT was investigated a study by Kessler and colleagues (Kessler et al., 2014). They had participants sit in front of a computer with 60 or 120 degrees of body rotation while looking straight ahead. In the stimulus pictures, an avatar sits in front of a round table and makes judgments from one of six angles (60, 110, 160 clockwise and anticlockwise). Four grey balls were placed around an occluder, one of which would turn red and become the target. Participants were asked to stand on the avatar's viewpoint and judge whether the ball was visible or not in the level-1 VPT, or whether the ball was on the left- or right-hand sides in the level-2 VPT. The result showed that the two levels are processed differently. Level-1 requires visibility judgments; therefore, it is based on the line sight of others, whereas level-2 involves left/right judgments and visual judgments involve embodied mental self-rotation. Level-2 also requires longer response times than level-1. Indeed, level-2 VPT has been correlated with mentalising and mindreading on the one hand (Hamilton et al., 2009) and requires simulating the body rotation on the other (Kessler et al., 2014). It is therefore regarded as a more complex cognitive process. This is illustrated by the difficulties that autistic children have with level-2 VPT but not with level-1 VPT (Hamilton et al., 2009), and by the phylogenetic differences in which primates and other species were found to be able to complete certain types of level-1 VPT tasks, but not be able to perform any form of level-2 VPT tasks (Tomasello et al., 2005). In summary, level-1 and level-2 VPT involve different processes, while level-1 VPT is based on visibility judgments, level-2 involves judgments and embodied mental self-rotation. Therefore, level-2 requires more effort (RT) than level-1 VPT.

Altercentric and Egocentric bias

Oneself and other people often have different visual perspectives. An altercentric tendency suggests that our own judgments, beliefs, and behaviours have been influenced by

how other people see the world, even though how others see or behave is irrelevant to our tasks (Kampis & Southgate, 2020; Southgate, 2020). An egocentric tendency refers to being influenced by our own perspective when we were asked to judge from the perspective of others (Samson et al., 2010; Surtees et al., 2012). People with a low egocentric bias and a high altercentric bias are usually defined as good perspective takers. This is because they can inhibit egocentric intentions when judging from other people's perspectives; and they still care about other people's perspectives when judging from their own perspective (Samson et al., 2010; Surtees et al., 2012).

Samson et al. (2010) designed a paradigm that can identify both egocentric and altercentric interference of VPT. They created a level-1 VPT task, in which participants have to judge the number of discs visible on the walls of a 3D room. Surtees et al. (2012) modify the paradigm of Samson et al. (2010) to a level-2 VPT judgments, asking participants to make self and other judgments about numbers. Some numbers (e.g., "6" and "9") look different when viewed from the opposite angle, while others (e.g., "0" and "8") look the same.

In both tasks, egocentric bias is tested by asking participants to make judgement from the other perspective. Participants are required to take the perspective of an avatar to judge how many dots (level-1) the avatar can see, or which number ("6" or "9") the avatar can perceive (level-2). Participants are slower and make more errors in judging the avatar's perspective when the perceptual results between them and the avatar are different, such as seeing a different number of dots in the level-1 task, or seeing a "6" when the avatar sees a "9" in the level-2 task. This demonstrates that level-1 and level-2 VPT require cognitive control and are subject to egocentric interference (Samson et al., 2010; Surtees et al., 2016).

Altercentric bias is tested by asking participants to judge from their own perspective. Participants calculate a different perspective when they do not have to, even though this

requires extra cognitive effort. In the level-1 task, previous studies show that participants are slower in reaction time and make more errors when the avatar see a different number of dots, proving that level-1 VPT requires cognitive control to suppress altercentric interference. On the other hand, there is no "altercentric" effect in level-2 VPT, as evidenced by the fact that participants had no particular difficulty to judge when they saw a "6" while the avatar saw a "9". This suggests that level-2 VPT is not automatic (Surtees et al., 2016; Surtees et al., 2012).

Social-emotional ability: Empathy

Perspective taking overlaps to some extent with the concept of empathy, that is "the ability to understand or feel what someone else is experiencing from their frame of reference, that is, the ability to put yourself in the shoes of someone else" (Bellet & Maloney, 1991). To date, there have been numerous studies that have examined empathy and perspective-taking.

Empathy and perspective-taking were considered as two distinct but tightly related concepts (Harwood & Farrar, 2006; Stietz et al., 2019). In some research, the concept of empathy has been defined to include perspective-taking. For instance, Zaki and Ochsner (2012) defined empathy as being composed of two components, namely a cognitive component, also called perspective-taking, that is the tendency to perceive different viewpoints beyond one’s own, and an affective component, that is the tendency to feel concerned and compassion for others. Davis (1983) subdivided empathy into four scales: perspective-taking, fantasy, empathic concern, and personal distress. Zaki and Ochsner (2012) categorized empathy into three subscales: cognitive empathy, which is the ability to represent the perspective or state of mind of another person, next to affective empathy and prosocial concern.

In the present thesis, we adopt the stance that perspective-taking is a cognitive component of empathy and is different from affective empathy as another component of empathy. We investigate perspective-taking (cognitive empathy) in Chapters 2 and 3; and empathy, including cognitive and affective empathy, in Chapter 4.

Factor 1: Executive Function

Many studies have shown that bilinguals outperform monolinguals on executive function tasks (Bialystok, 2009; Bialystok et al., 2012). In accordance with Green and Abutalebi (2013), bilinguals have two language systems that are constantly active and competing with one another. In turn, bilinguals must constantly monitor, select, and suppress one language. This constant need to monitor, select and suppress languages requires bilinguals to use executive functions more frequently and effectively than monolinguals. In other words, executive function skills of bilinguals may become more developed and efficient than monolinguals (Green & Abutalebi, 2013). Importantly, executive function, especially inhibition and switching, have closely been associated with perspective-taking processes. This thesis therefore investigates performance of bilingual speakers in perspective-taking, with executive function as a potential confounding variable. Thus, we will mainly discuss inhibition and switching in this thesis.

There is a debate about whether the widely reported finding that bilinguals outperform monolinguals on executive function tasks is genuine. Reviews either support a bilingual advantage (Grundy, 2020), while others concluded that there is no bilingual advantage once publication bias has been considered (Donnelly et al., 2019; Lehtonen et al., 2018). There are two patterns of results that support a bilingual advantage (Hilchey & Klein, 2011). The first pattern of result is that bilinguals show smaller interference effects in cognitive control tasks than monolingual, indicating that bilinguals spend less effort in cognitive control. The second

pattern is that bilinguals are generally faster in response time than monolinguals due to a general advantage in attentional control.

The bilingual advantage has been shown in tasks related to conflict perspectives and conflict resolution. For instance, Zhou and Krott (2016) tested bilingual young adults on three non-verbal conflict tasks: Flanker task, Spatial Stroop task and Simon tasks. Participants were instructed to respond with left versus right buttons to indicate a) the direction of an arrow presented either on the same side or the opposite side of the response button in Spatial Stroop task (Lu & Proctor, 1994); b) to the direction of a centrally positioned arrow in Flanker task (Eriksen & Eriksen, 1974); c) to a task-relevant feature (e.g. colour) of a lateralised stimuli in Simon task (Simon & Rudell, 1967). They found that bilinguals, compared to monolinguals, had reduced response times in the more demanding incongruent conditions, suggesting a bilingual advantage in inhibitory control.

A bilingual advantage has also been shown in tasks that require participants to switch between different rules or points of view and thus tasks that involve switching interference. The most common task is the colour shape task, which involves switching between colour and shape rules (Prior & MacWhinney, 2010). In research with young adults, some studies found that bilinguals have smaller switching costs compared to monolinguals (Christoffels et al., 2015; Prior & Gollan, 2011; Stasenko et al., 2017), while others did not find a bilingual advantage in switching (Paap et al., 2017).

Factor 2: Biculturalism

Bicultural can be defined as an individual with three traits: (1) participating in and being exposed to two cultures, (2) adapting attitudes, values, etc. to two cultures as well as switching between the two cultures, (3) integrating two cultures into one behaviour principle (Grosjean, 2015; Grosjean & Li, 2013).

The term "bicultural" and "bilingual" often appear together. Many studies of bilingualism assume that the concept of language already comprises cultural differences, which is a misconception. The pioneering paper by Soffietti (1960) clearly defines that bilingualism and biculturalism are two different but related concepts. An individual can be bicultural-bilingual, bicultural-monolingual, monocultural-bilingual or monocultural-monolingual. Bicultural-bilingual refers to people maintaining two cultures as well as keeping using their two languages. Bicultural-monolingual is immigrant who gives up speaking their native language but maintains their native customs and culture. Monocultural-bilingual is individual who acquires a second language or foreign language but retains only the cultural behaviour of their community. Monocultural-monolingual is people who only speaks their native language and lives in their native culture community (Soffietti, 1960).

Though some claim biculturalism means that both cultures are acquired at the same age and that the two cultures equally well known. But, just like balanced bilingualism is quite rare, it is very rare for a person to maintain two cultures perfectly balanced. Most bicultural people have one dominant culture, which they have acquired earlier, immersed themselves in more often and spent more time with, while the other culture is less dominant. In this thesis, we have assumed that biculturalism is self-identified, regardless of how a person becomes bicultural or how well they know the two cultures.

Summary

The principal aim of the current study was to investigate the effect of bilingualism on social cognition with relation to two aspects: social-cognitive ability (i.e. perspective-taking), and social-emotional ability (i.e. empathy). The thesis consists of 5 chapters: an introductory chapter (Chapter 1, the present chapter), three empirical chapters and a closing discussion chapter (Chapter 5).

The first two empirical chapters directly aim at understanding the effect of bilingualism on perspective-taking, including altercentric and egocentric perspective-taking. Chapter 2 is an exploratory study. It tries to replicate the joint action VPT paradigm of Freundlieb et al. (2018) and exploratorily compare performance of bilingual and monolingual speakers in this paradigm. Since we were not able to replicate the altercentric perspective-taking effect in this paradigm, we used different paradigms in the remainder of the thesis. Chapter 3 investigates bilingual differences in VPT by controlling executive function and cross-cultural differences. An investigation is undertaken to explore the relative contributions of cultural orientation and integration within culture networks to the bilingual perspective-taking advantage.

Chapter 4 investigates how multilingualism influences different aspects of empathy, such as empathic concern and personal distress. It asks whether multilinguals are more likely to engage in prosocial behaviour and whether this is due to heightened empathy.

In closing, Chapter 5 will bring together the results from the empirical chapters and draw general conclusions based on the findings. In addition, we will discuss and address potential limitations of the thesis and provide further suggestions towards a better understanding of bilingualism and its effects on cognitive and socio-emotional outcomes.

CHAPTER 2

REPLICATION OF SPONTANEOUS VISUOSPATIAL PERSPECTIVE-TAKING IN JOINT ACTION

Abstract

Visuospatial perspective-taking is an essential cognitive ability that enables people to comprehend and connect with others successfully in a wide range of social interactions. (Apperly, 2011; Baron-Cohen et al., 1985). People have been found to spontaneously adopt the perspective of others during social interactions. Freundlieb et al. (2016, 2017, 2018) found spontaneous visuospatial perspective-taking (VPT) effects in a series of joint action experiments. They implemented a non-communicative binary choice design in which a participant shared a common goal with another person. This chapter reports an exploratory study with two experiments. Experiment 1 was a gender categorization task and Experiment 2 was a word categorization task. We attempted to replicate the joint action visuospatial perspective-taking paradigm of Freundlieb et al. (2018), and exploratively compared the performance of bilinguals and monolinguals in this paradigm.

The two experiments failed to replicate the spontaneous VPT effects. The results suggest that young adults' spontaneous sensitivity to others' VPT is sensitive to context and other potential factors, which need to be further explored in future studies.

Introduction

Visuospatial perspective-taking (VPT) is a process of visualizing what can be seen and how a scenery looks from a spatial orientation that is different from the individual's own. VPT requires the mental transformation of one's own point of view to fit another. It is an essential cognitive ability that enables people to comprehend and connect with others successfully in a wide range of social interactions (Apperly, 2011; Baron-Cohen et al., 1985). It has been found that people spontaneously adopt the perspective of other people during social interaction. That is, people take perspectives without being (explicitly) prompted to do so (Freundlieb et al., 2016, 2017, 2018; O'Grady et al., 2020; Surtees et al., 2012). Freundlieb et al. (2016, 2017, 2018) found spontaneous VPT effects in a series of joint action experiments. They implemented a non-language joint action design where a participant shares a common goal with another person. The present study is an exploratory study. It tried to replicate the joint action visuospatial perspective-taking paradigm of Freundlieb et al. (2018) and exploratively compare bilinguals and monolinguals performance in this paradigm.

Joint action VPT tasks

The VPT paradigms of Freundlieb and co-workers are joint action design. In recent decades, increasing attention has been paid to the cognitive mechanisms that facilitate people to achieve desired common goals through collective action. Joint action refers to the ability of two or more individuals to coordinate their behaviour towards a common goal or outcome. This can involve a range of behaviours, from simple tasks like carrying a table together, to more complex activities like playing music or engaging in team sports. Joint action requires individuals to understand each other's intentions, anticipate each other's actions, and adapt their behaviour in response to the actions of others (Vesper et al., 2017). Before the joint

action task, partners prepare by developing representations of each other's tasks and the relationship between them. This enables them to anticipate each other's actions, which can facilitate coordination. When performing joint actions, people achieve co-representation and coordination in a series of processes: first, they monitor whether the joint outcomes are the same as planned. Then, they predict the partner's action. Next, they communicate task-relevant information, and finally, co-actor's predictions are coupled (Azaad et al., 2021; Sebanz & Knoblich, 2021; Török et al., 2021).

Non-language vs language joint action VPT task

There are various joint action VPT tasks. Freundlieb et al.'s (2016, 2017, 2018) joint action VPT paradigm is one of the binary choice sharing tasks. In this kind of task, task is generally divided between two participants, each of participants reacting to only one type of stimulus or target. Participants take turns performing their respective parts of the joint task. For instance, the table tennis game played by two people. Another widely used VPT task is the referential communication task (Apperly et al., 2010; Keysar et al., 2003). The task typically involves two participants who are required to work together to complete a task. One participant is designated as the "actor" and the other played as the "observer". The actor is given a specific goal, such as moving a particular object from one location to another, and the observer is asked to monitor the actor's actions and provide guidance as needed. For example, the observer may be asked to guide the actor to move the small red ball from a block to another block while viewing the scene from a different perspective. The communicate reference task involved language fluency and proficiency factors, which is highly likely to vary across bilingual and monolingual participants. Freundlieb et al.'s paradigm, as a non-language design, is more suitable for our next step investigation on bilinguals and monolinguals difference in VPT.

Advantage and disadvantage of joint action VPT tasks

Joint action tasks have advantages and disadvantages as well. Compared to non-joint action VPT tasks, the joint action VPT tasks are more related to the interaction context. The natural design with a common goal rather than a very explicit requirement as a co-representation cue can help to test pure VPT ability (Azaad et al., 2021, Vesper et al., 2017). But the disadvantage of joint action design is that many context factors may affect the joint interaction, such as difference between paired participants (or between participants and the confederate) in aspects such as emotion, personality identity, gender, etc (Perez-Zapata et al., 2016). Some of these factor differences cannot be controlled.

Freundlieb Paradigm

Freundlieb and colleagues investigated the underlying factors and constraints that shape the acquisition of other people's VPT in social reciprocation and tested whether VPT is a spontaneous process. Freundlieb et al. (2016) implemented a novel paradigm in which a participant and a confederate seated at a 90° angle to each other and play a straightforward stimuli-response compatibility task. In order to establish diverse compatibility relationships, the confederate's sitting position changed between the left and right side of the table during the experiment. In the compatible condition, the perception of the participant is consistent with the spatial orientation of their confederate, whereas in the incompatible condition they are inconsistent. For example, when the confederate was seated at a 90° angle to the left of the participant. When a black disc presented on the screen, participants need to press the left button when it is at the top of the screen and to press the right button when it is at the bottom of the screen in the compatible condition; and to press the right button when the disc appeared at the top and the left button when the disc appeared at the bottom. In five experiments, participants presented a spatial compatibility interference when the confederate

was perceived as an intentionally active agent. This study confirmed that people spontaneously adopt others' VPT in the absence of a request and in a communicative context. Furthermore, this study showed that the active agent alongside people in joint action is a crucial factor in people's VPT adaptation.

Freundlieb et al. (2017) conducted two experiments to further investigate the mechanisms of spontaneous VPT. Specifically, they tested whether knowing another person's visual access would affect an individual' perspective-taking by conducting two spatial compatibility tasks. During these tasks, the visual access of the confederate was manipulated using a pair of glasses with adjustable shutters. When the shutter is on, the confederate can see the stimuli; when the shutter is off, the confederate cannot see the stimuli. The results showed that participants represented their task partner's VPT only when the partner had unobstructed visual access to the stimulus, independent of whether they were performing the same or a different task. The results suggested that spontaneous VPT is indeed affected by knowledge about the other's visual access.

Freundlieb et al. (2016; 2017) had demonstrated people's capacity to adopt others' VPT in a shared physical context. Freundlieb et al. (2018) investigated whether spontaneous VPT also occurs in mental activities. They conducted three spontaneous visuospatial word-reading categorization experiments. As in the previous studies, a participant and a confederate seated at a 90° angle to each other. From the participant's orientation, the stimuli were always vertical presented, while from the confederate perspective, the stimuli could be the right way up (congruent condition) or upside down (incongruent condition) according to their sitting position. They were instructed to press the button if the presented words belonged to their assigned word category. The results showed participants responded faster in the congruent condition than in the incongruent condition, which indicates that participants automatically adopted the confederate's viewpoint. This perspective sharing was present even

when the confederate was passive by just sitting without doing the task. However, the effect disappeared when the confederate was unable to see the stimuli. These findings demonstrate that people share others' perspectives also in mental activities like joint reading, but again this is affected by the task partner's visual accessibility of the stimuli.

To sum up, based on Freundlieb et al. (2016, 2017, 2018), spontaneous VPT happens in joint action whenever the partner is visually accessible to the stimuli, independent of the confederate's active or passive participation, feedback or no feedback, same hand or different hand. The co-representation effect in this paradigm was thus very robust. In addition, the paradigm has some further advantages for the present purpose. It has a clear distinction between self and other and an implicit cue, namely the common goal between the participant and the confederate to complete the task as fast and accurately as possible. It has been found that an explicit cue enhances participants to take perspectives spontaneously (Azaad et al., 2021). Thus, if the spontaneous VPT appears in the implicit cue design, it would be more robust evidence that VPT is a spontaneous process. Furthermore, this paradigm does not require compulsory verbal communication between participant and confederate. Language proficiency tends to be lower in bilingual participants, especially in second language learners. This could potentially moderate the VPT effect. The paradigm is thus very suitable for a bilingualism study.

Context differences in spontaneously VPT

Freundlieb and co-workers' findings revealed that people can spontaneously co-represent others' perspectives in social situations are in line with the mere-appearance hypothesis. The mere-appearance hypothesis indicates that the human mind is highly sensitive to other people's VPT. Therefore, the mere presence of another person can elicit spontaneous perspective-taking of others (Ward et al., 2019, 2020). This hypothesis indicated

that people spontaneously took the perspective of the other person even though the other person was completely passive. The effect was not influenced by whether the other person gazed at the stimuli or not, but the effect was reduced when the person stimuli was replaced with objects stimuli (Ward et al., 2019, 2020). Even more, individuals can represent a partner's task even when they are not in the same room (Atmaca et al., 2011). These studies suggest that people can spontaneously adopts another person's point of view or visuospatial perspective without conscious effort, and that this ability can have a range of positive social outcomes, including reduced stereotyping and increased empathy.

While research of Freundlieb and co-workers indicated human take others' perspectives spontaneously. Some studies found contexts, like how others engage with stimuli and how others process a stimulus, influence whether an individual takes others' VPT or not. Some research implies that spontaneous VPT is attuned to other person's task. In particular, VPT tends to be affected by how others engage with the task in studies where participants make judgments. For example, in Freundlieb et al. (2018), VPT appears to depend on whether the participants' partner is processing the stimulus. When the partner wore glass that blocked their line of sight, co-representation disappeared. In addition, Freundlieb et al. (2016) used a paradigm in which participants performed a disc location judgment task with a confederate, co-representation was elicited when the confederate was actively involved, whereas co-representation disappeared when the confederate was passively involved.

Furthermore, spontaneous level-2 VPT was affected by what task the other person processes. Elekes et al. (2016) assigned participants to complete a number recognition task, while assigned a confederate sitting opposite participants performing the same task or a colour matching n-back task. When both of them conducted the same number recognition task, participants were slower and made more errors to asymmetric numbers, which would be

more difficult from the perspective of the other, indicating that confederate's perspective influenced participants' response. However, when the confederate's task was different with the participant, the interference did not occur. These results suggested that people adopted other's perspective specifically when they cooperated in a task contains perspective-dependent features.

To sum up, even though the VPT' spontaneousness (main congruency effect) is reliable, it is quite sensitive to contextual differences, for instance, the engagement of participants and their partners.

Bilingualism advantage in VPT

Bilingual speakers outperform their monolingual peers in various perspective-taking tasks such as False-belief tasks (Rubio-Fernández, 2017), Spatial Reasoning tasks (Greenberg et al., 2013), and Referential communication tasks (Navarro & Conway, 2021; Wu & Keysar, 2007). Bilingual participants were more accurate than monolingual participants at representing from their partner's perspective. Bilinguals were also more likely to take the other person's perspective than monolinguals. We therefore explored differences in bilinguals and monolinguals performance in the present paradigm. We expected that bilinguals would be more likely to spontaneously take the other's perspective, indicating that they are more attuned to taking the other's perspective.

Current study

The present study aimed to replicate the spontaneous VPT effect, that is, the significant congruency interference effect of Freundlieb et al.'s (2016, 2017, 2018) paradigm. This paradigm was chosen for three reasons: Firstly, the joint action design with a real person as the confederate presents a real social interaction situation. Secondly, Freundlieb et al.'s

paradigm is a non-linguistic design and therefore more appropriate for our next step to investigate bilingual and monolingual differences in spontaneous VPT. This is because bilingual and monolingual participants are likely to differ in the fluency and proficiency of the language (English) used in the experiment. Those who are better at English may be better at processing the stimuli of the linguistic VPT task. Thirdly, Freundlieb et al.'s paradigm has consistently shown high effect sizes across different experiments (Freundlieb et al., 2016, 2017, 2018). We conducted two experiments. Experiment 1 was designed to replicate the congruency interference effect of the VPT with a non-verbal task that would not disadvantage bilingual speakers, namely a gender judgement task. Experiment 2 was designed to replicate the congruency interference effect of the VPT using the same task as in Freundlieb et al. (2018), namely a word categorization task. If participants spontaneously adopted the confederate's perspective, they would also find it more difficult to recognize the stimulus in the incongruent condition than in the congruent condition. Therefore, it was predicted that participants would take longer to respond and make more errors in the incongruent condition than in the congruent condition. We also explored the possibility that bilinguals are more attuned to taking the other's perspective in the VPT (Rubio-Fernández, 2017, Greenberg et al., 2013, Navarro & Conway, 2021; Wu & Keysar, 2007), which would be evident in a larger incongruency effect compared to monolinguals.

Experiment 1

We modified Freundlieb's paradigm (Freundlieb et al., 2018) from a word categorization task to a gender recognition task. While the original experiment used stimulus words from two categories, namely animals and vegetables / fruits, Experiment 1 used facial picture stimuli. The pictures were divided into two categories, namely male and female.

If this experiment replicates the results of Freundlieb et al.'s experiment, participants should be faster and more accurate in categorizing stimuli in the congruent condition where the confederate's perspective and the picture orientation match than in the incongruent condition where they do not match. A significant congruency interference effect thus indicates that a participant noticed the state of the confederate. If the confederate has difficulty in the joint task which is due to the upside-down stimuli, participants should spontaneously represent this difficulty and be less accurate and slower to respond.

Methods

Participants

A power analysis was conducted using G*Power version 3.1.9.7 (Faul et al., 2007) for a paired samples t-test, based on the results of Freundlieb et al. (2018) (N = 16), who compared performance in the congruent condition with that in the incongruent condition. The effect size in Freundlieb et al.'s (2018) study was 0.569, considered to be large using Cohen's (1988) criteria. With a significance criterion of $\alpha = 0.05$ and power = 0.8, the minimum sample size needed with this effect size is N = 27 for a two-tailed paired sample t-test. 39 Native British English monolinguals (mean age = 19 years, SD age = 4.84 years, four males), all students from the University of Birmingham, participated in this experiment for course credits. They all had normal or corrected-to-normal vision. None knew the purpose of the study. One participant was removed because the confederate did not change her seat during the interval.

The study was approved by the Research Ethics Committee of the University of Birmingham, United Kingdom (ERN_09-719).

Stimuli

Pictures of faces of Eastern-Asian females, Eastern-Asian males, European females, and European males, 30 in each group, were collected from freely available sources of the Internet. Only the face with hairline and ears was shown. In addition, the picture size and the light were unified across the pictures. Smiling faces, bearded faces etc., which may indicate additional information like mood and gender, were excluded. Figure 2.1 presents an example stimulus picture. All these stimuli can be found in the Appendix (Supplementary: Picture stimuli in Experiment 1).

To eliminate any carry-over effect, we randomly divided the 30 stimuli of each of the four categories into halves, creating eight sub-lists (Eastern-Asian female 1, Eastern-Asian female 2, Eastern-Asian male 1, Eastern-Asian male 2, European female 1, European female 2, European male one and European male 2) with each containing 15 items. We then combined the sub-lists into two lists (lists A and B) so that each had 15 items of each sub-list. Using two lists enabled the presentation of distinct stimuli in each of the two experimental conditions (congruent and incongruent, see the panel A of Figure 2.1). In addition, each stimulus in list A and B was repeated four times. That means lists A and B contained each 240 trials (4 categories*15 items*4 repetitions) and every participant saw 480 trials in total across the two experimental conditions.

Design and Procedure

It took twenty minutes to complete this experiment. Participants performed the task together with a young adult who acted as a confederate (one out of a group of 4, all male). The participants were informed that the confederate was a participant just like them. The task was to indicate the gender of a stimulus displayed on a flat computer screen, which was placed horizontally on a low desk (72 cm high). In the experimental introduction stage, the

participant and the confederate were assigned to one of the two categories (male vs female). They were instructed to press the reaction button only when they saw a picture from their own category. This turned the task into a go/no-go task. Participants were instructed to press the button with their most frequently used hand and to respond as quickly as possible when stimuli appeared. Responses were recorded by two button boxes (Cedrus RB-834 response pad), which were placed on participants' laps under the table to avoid that they were able to see each other's responses. To avoid participants hearing the click sound, both confederate and participants wore earplugs and headphones. The distance from eyes to the screen was approximately 70 cm, for both the participant and the confederate. The experimenter's and participant's instructions can be found in the Appendix (Supplementary: Experimenter Instruction for Experiment 1, Supplementary: Participant Instruction for Experiment 1).

In each trial, participants firstly saw a fixation cross lasting for 350ms. Then the screen turned black for 100ms. Subsequently, a stimulus was presented for 1200ms. The trial sequence is shown in panel B of Figure 2.1. Stimuli within lists A and B were presented in random order.

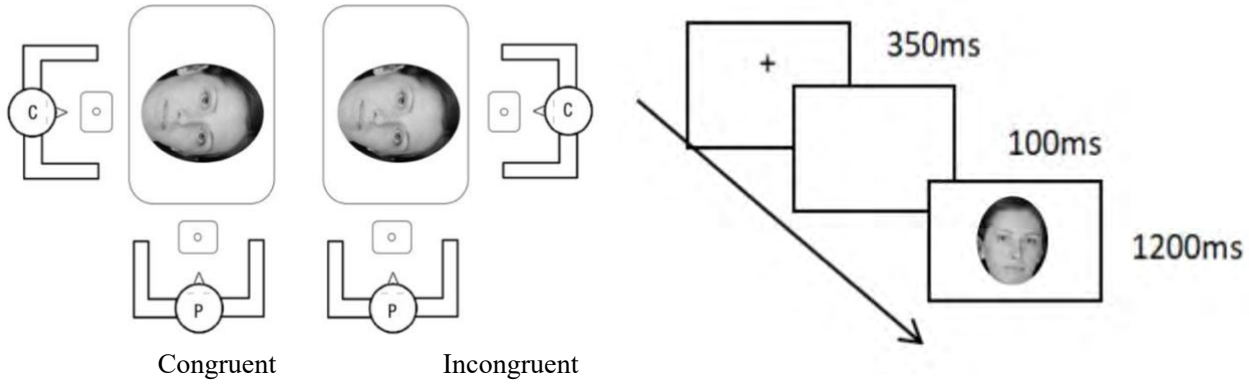
In order to build up the different congruency relationship, the participants were always seated on the narrow side of the rectangular table at 90° clockwise, while the confederate was instructed to sit at one long side of the table and switch to the other long side of the table during the interval. To familiarise participants with the task, each half of the experiment was preceded by four practice trials. In the congruent condition, the confederate sat to the left-hand side of the participant, in which stimuli were oriented the right way up to the confederate; in the incongruent condition, the confederate sat to the right hand side of the participant, so the stimuli were presented upside down to the confederate. Compared to the congruent condition, the incongruent condition is more difficult to identify for the confederate, meaning they should take more time to respond and make more errors. If

participants spontaneously adopted the confederate's perspective (as shown in previous studies), they would also find it more difficult to recognize stimuli in the incongruent condition than in the congruent condition. Therefore, it was predicted that participants would take longer to respond and make more errors in the incongruent condition than in the congruent condition.

The order of congruency conditions (congruent vs incongruent), the task category (male vs female), and the list sequence (list A vs list B) were counterbalanced across participants.

Figure 2.1

Setup for Experiment 1



Note. From left to right, A: The participant (P) sat at a 90° angle to the confederate (C). An example of a trial in the congruent condition is shown on the left, and an example of a trial in the incongruent condition is shown on the right; B: trial sequence of the experiment.

Data Preparation and Analysis

We collected participants' response times (RT) and accuracy. For the accuracy analysis, we excluded practice trials, leaving 18,240 trials. For the RT analysis, we additionally excluded errors trials, including failure to press the button in their own trials

when they should have pressed it, and pressing the button during their confederate's trials when they should not have pressed it (11.42%). Following Freundlieb et al. (2018), we further excluded responses for which the RT was less than 250ms and more than two standard deviations above or below each participant's condition mean (2.31%), leaving 7,661 (86.27%) trials included in the RT analysis.

All data were analysed in R (R Core Team, 2021) with generalised linear mixed-effects models using the lme4 package (Bates et al., 2015). For accuracy analysis, we fitted a binomial distribution to the accuracy data, and categorized accuracy data (correct: 0; incorrect: 1). For RT analysis, we transform data using the log function to get more normal distributed data (Feng et al., 2014).

In both RT and accuracy models, we fitted the fixed effects of congruency (congruent vs incongruent) as well as of the controlled covariate variables, including task list (list A vs list B), task type (male vs female), list sequence (listAB vs listBA) and condition order (Congrunt - Inconcongruent vs Inconcongruent - Congruent). All fixed variables were factorized and deviation coded. All fixed effects were included as main effects and were coded with contrast coding. Random intercepts for both subjects and stimuli were included. In addition, appropriate by-subject and by-stimulus random slopes were included according to our experimental design. When a model did not converge with the maximum structure, we simplified the model by first removing the random slopes interactions (by-stimulus before by-subject), then the random slopes main effects (by-stimulus before by-subject), then the fixed interaction effects, then the fixed main effects, until the model converged (Barr et al., 2013). The drop1 function from the lmerTest package (Kuznetsova et al., 2017) was used to arrive at the best fitted model. We also used the vif function from the car package (Fox & Weisberg, 2019) to check for collinearity between predictors. All vifs were around 1, meaning there was

a very low degree of collinearity among variables. The fitted models were used to determine the statistical significance of a given main effect.

Results

Table 2.1 shows the summary of the results. The analysis of RTs revealed no main effect of congruency, indicating that congruent (M = 600 ms, SD = 123 ms, SE = 1.99) and incongruent conditions (M = 598 ms, SD = 130 ms, SE = 2.10) were responded to equally fast. We did find a main effect of List, though; items in list A (M = 608 ms, SD = 128 ms, SE= 2.08) took longer to respond to than items in list B (M = 590 ms, SD = 125 ms, SE = 2.00), which indicated that list A was more difficult than list B.

Similar to RTs, an analysis of accuracy revealed no main effect of congruency, with equally accurate responses to congruent (M = 88.3%, SD = 3.22%, SE = 0.003) and incongruent conditions (M = 88.9%, SD = 3.15%, SE = 0.003). There was a significant main effect of List Sequence; the accurate rate of listBA (M = 89.6%, SD = 3.05%, SE = 0.003) was higher than that of listAB (M = 87.6%, SD = 3.30%, SE = 0.003).

Table 2.1

Summary of the Best-fitted Models for Experiment 1

Log_RT					
Predictors	***Estimates***	***std. Error***	***CI***	***Statistic***	***p***
(Intercept)	6.38	0.02	6.35 – 6.42	396.33	<0.001
Congruency	0	0.01	-0.03 – 0.02	-0.14	0.89
List	-0.03	0.01	-0.06 – -0.01	-2.42	0.015
Accuracy					
Predictors	***Odds Ratios***	***std. Error***	***CI***	***Statistic***	***p***
(Intercept)	13.79	1.85	10.60 – 17.95	19.52	<0.001
Congruency	1	0.07	0.87 – 1.15	-0.01	0.995
ListSeq	1.34	0.2	1.00 – 1.79	1.99	0.047

Discussion

Against our expectation, the gender categorization task showed no difference between congruent and incongruent conditions. This indicated participants did not spontaneously compute their confederate's perspective. This might be because it is not easy to control the race and other facial details in the stimuli since we found participants were slower in List A than in List B, and a bit less accurate in List sequence AB than in List sequence BA.

Therefore, we conducted a second experiment in which we used the same stimuli as Freundlieb et al. (2018), namely words instead of faces. In addition, we expect bilingual participants to show a particular large effect. In order to maximise the chance of finding evidence for spontaneous perspective-taking, we tested mainly bilingual participants in the second experiment.

Experiment 2

Experiment 2 adapted the same design as that of Freundlieb et al. (Freundlieb et al., 2018). While the original experiment used Hungarian words, we used English words. If our Experiment 2 replicated the results of the previous experiment, participants should be faster and more accurate in the congruent condition where the confederate's perspective and the word orientation match, than in the incongruent condition, where they do not match.

In addition, we did an exploratory comparison of the performance of bilinguals and monolinguals in this paradigm. We assumed that bilingual participants would show a larger congruency interference effect than monolinguals if bilinguals are better at taking the other's perspective.

Method

Participants

We estimated a minimum sample size with an a priori power calculation for an F test, within-between repeated measures ANOVA, using G power version 3.1.0.6 (Faul et al., 2007). We assumed a medium effect size (Cohen's f = 0.25), alpha level of 0.05, and power of 0.8. This analysis indicated that we needed minimally 34 participants, including 17 bilinguals and 17 monolinguals. We recruited 20 first year undergraduate Chinese bilinguals (mean age=24.4 years, SD age=2.03 years, three males) and 8 first year undergraduate native British monolinguals (mean age=23.4 years, SD age=4.97 years, two males) who reported normal or corrected-to-normal vision. All were naïve to the purpose of this experiment. They received credits for their participation.

The study was approved by the Research Ethics Committee of the University of Birmingham, United Kingdom (ERN_09-719).

Stimuli

Stimuli included two categories, a) animals and b) fruits and vegetables. Each contained 40 items that were controlled in frequency (based on The British National Corpus (BNC) and Celex Corpus), length in letters, and number of syllables. In addition, 12 eastern-Asian overseas students were recruited to rate their familiarity with these words using a nine-point Likert scale to ensure the two lists were equally difficult for non-native speakers. The stimulus characteristics are listed in Table 2.2. See Supplementary Table 2.1 in the Appendix for the full set of word stimuli.

Table 2.2

Stimuli Characteristics

		List one (n=40)		List two (n=40)		*F*	*p-value*
		M	**SD**	**M**	**SD**		
Length in letters		6.05	1.47	6.03	1.54	0.01	0.94
Frequency	BNC	532.16	513.37	535.43	529.88	0.00	0.98
	CELEX	117.33	149.21	106.23	129.76	0.13	0.72
	Questionnaire	7.60	1.27	7.63	1.27	0.01	0.91
Syllable		2.03	0.66	2.05	0.68	0.03	0.87

We randomly split the two categories into two halves. This resulted in 4 sub-lists (animals 1, animals 2, fruits and vegetables 1, fruits and vegetables 2), each containing 20 items. We then combined the sub-lists into two lists (lists A and B) so that each had 20 items of each sub-list. Having two lists, allowed to present different words in the two conditions of the experiment (congruent and incongruent, see the panel A of Figure 2.2). In addition, each stimulus in lists A and B were repeated four times. That means the lists contained 160 trials each (2 categories*20 items*4 repetitions) and each participant saw 320 trials in total. Stimuli within lists A and B were presented in random order.

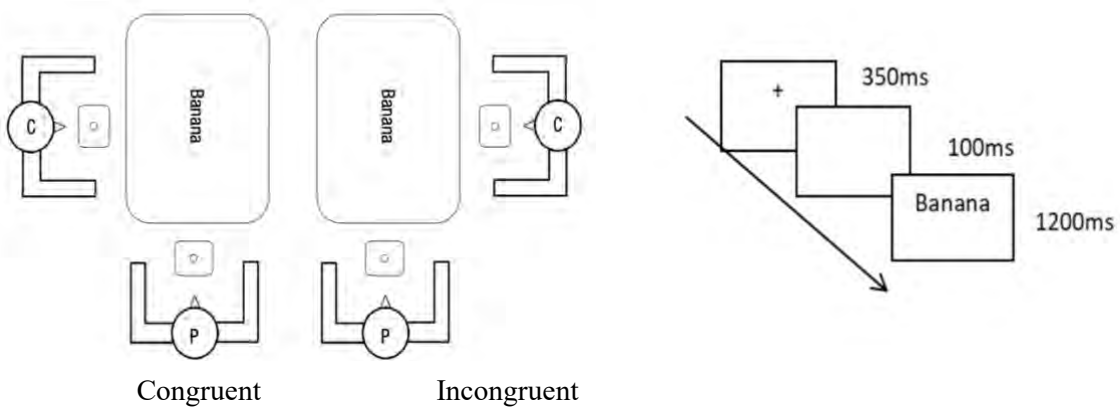
Procedure

The procedure was identical to that of Experiment 1, except that participants were asked to categorize the word stimuli into animal or fruit & vegetable, instead of responding to the gender of the faces (see Figure 2.2). The participant's instructions for Experiment 2 can be found in the Appendix (Supplementary: Participant instruction for Experiment 2).

To minimize the influence of language ability, participants were given 5 minutes to familiarise themselves with the full set of the word stimuli together with corresponding cartoon pictures before the experiment.

Figure 2.2

Setup for Experiment 2



Note. From left to right, A: The participant (P) sat at a 90° angle to the confederate (C). An example of a trial in the congruent condition is shown on the left, and an example of a trial in the incongruent condition is shown on the right. B: trial sequence of the experiment.

Data Preparation and Analysis

We recorded RTs and accuracy of participants. For the accuracy analysis, we excluded practice trials, meaning that 8,960 trials were included in the analysis. For the RT analysis, we additionally excluded error trials, including failure to press the button in their own trials when they should have pressed it, and pressing the button during their confederate's trials when they should not have pressed it (6.07%). Following Freundlieb et al. (2018), we further excluded responses for which the response time was less than 250ms and more than two standard deviations above or below each participant's condition mean (2.28%), leaving 3,993 (91.65%) trials included in the response time analysis.

The analysis procedure was the same as in Experiment 1, using generalised linear mixed-effects models in R, except in this analysis, we transformed data using the inverse

function to get more normal distributed data (Lo & Andrews, 2015). The fixed effects were congruency (congruent vs incongruent), as well as the covariates task list (list A vs list B), task type (animals vs fruits and vegetables), list sequence (listAB vs listBA) and condition order (congruent-inconcongruent vs incongruent-congruent). All fixed effects were included as main effects and were coded with contrast coding. Random intercepts for subjects and stimuli, as well as by-subject and by-stimulus random slopes were included.

For the exploratory comparison between bilingual and monolingual performance in this paradigm, we factorised the bilingualism variable and coded it for deviation. Bilingual was coded as -0.5 and monolingual as 0.5. The bilingualism variable was included as a fixed effect in the mixed effects model.

Results

Table 2.2 shows a summary of the results. In RT analysis, there was no effect of congruency, meaning incongruent (M = 611 ms, SD = 144 ms, SE=3.22) and congruent trials (M = 603 ms, SD = 135 ms, SE=3.02) were responded to equally fast.

In the accuracy analysis, there was no main effect of congruency, meaning congruent (M = 93.6%, SD = 0.245, SE = 0.004) and incongruent (M = 94.3%, SD = 0.232, SE = 0.003) trials did not differ in terms of accuracy[1].

[1] The incongruency between the small Congruency variation in the descriptive data and the minimal magnitude in the model could be attributed to the addition of Congruency as a random within-subject slope. When removing the random effect, the Odds Ratio reduced to 1.10, SE = 0.11, CI = 0.91 – 1.32, z = 0.97, p = 0.332. Additionally, a t-test conducted on congruency (congruent vs incongruent) also indicated no significant difference in congruency (t (54) = 0.505, p = 0.616). Consequently, the results indicated no notable distinction between the congruent and incongruent conditions in accuracy.

Table 2.3

Summary of the Best-fitting Models for Experiment 2

Inverse RT					
Predictors	***Estimates***	***std. Error***	***CI***	***Statistic***	***p***
(Intercept)	-1.7	0.04	-1.79 – -1.62	-40.13	<0.001
Congruency	0.02	0.02	-0.02 – 0.06	1.03	0.305
ACC					
Predictors	***Odds Ratios***	***std. Error***	***CI***	***Statistic***	***p***
(Intercept)	33.55	7.87	21.18 – 53.13	14.98	<0.001
Congruency	1.28	0.17	0.98 – 1.66	1.79	0.074

Exploratory Comparation between Bilinguals and Monolinguals

Analysis of RTs revealed a main effect of bilingualism, but not of congruency. Bilinguals (M = 636 ms, SD = 148 ms, SE = 2.80) responded more slowly than monolinguals (M = 541 ms, SD=87.8 ms, SE=2.52). There was no bilingualism x congruency interaction, indicating that bilinguals and monolinguals did not differ in terms of congruency effect on response speed.

The accuracy analysis revealed a main effect of bilingualism, but not of congruency. Bilinguals (M = 92.2%, SD = 0.268, SE = 0.003) were less accurate than monolinguals (M = 98.2%, SD = 0.131, SE = 0.003). There was also no bilingualism x congruency interaction. Thus, bilinguals and monolinguals did not differ in terms of congruency effect on accuracy.

Table 2.4

Summary of the Exploratory Models for Experiment 2

Inverse_RT					
Predictors	***Estimates***	***std. Error***	***CI***	***Statistic***	***p***
(Intercept)	-1.76	0.04	-1.84 – -1.68	-44.67	<0.001
Bilingualism	-0.26	0.07	-0.40 – -0.11	-3.41	0.001
Congruency	0.02	0.02	-0.02 – 0.06	1.02	0.307
ACC					

Predictors	*Odds Ratios*	*std. Error*	*CI*	*Statistic*	*p*
(Intercept)	48.45	10.21	32.06 – 73.22	18.42	<0.001
Bilingualism	5.26	1.77	2.72 – 10.16	4.93	<0.001
Congruency	1.22	0.15	0.96 – 1.56	1.62	0.106

Discussion

The results of Experiment 2 did not replicate the previous experiment (Freundlieb et al., 2018) because we failed to find the congruency main effect. This indicated participants did not spontaneously take their confederate's perspective during this task.

However, we did find a significant difference between bilinguals and monolinguals. Bilinguals was slower and less accurate than monolinguals. This met our expectation because most of our participants had English as their second language and were in their first year in the UK. Therefore, even though they had time to familiarise themselves with the word stimuli before the experiment, it is still normal that they took longer time to process and recognize these words than native English speakers.

There was no significant interaction between bilingualism and congruency, However, the fact that Experiment 2 also failed to find a congruency main effect makes it impossible to form strong conclusions based on the absence of this interaction.

General Discussion

We conducted two experiments to replicate the spontaneous perspective-taking effect (in other words, significant congruency interference effect) in Freundlieb et al.'s (2018) VPT paradigm. Experiment 1 was modified to a gender category task by changing the original word stimuli to facial picture stimuli in order to avoid any effects of language proficiency for bilingual participants. Since Experiment 1 did not show any signs of spontaneous perspective-taking, Experiment 2 was kept very close to the original experiment, being an

English word category task, where the original Hungarian word stimuli were changed into English word stimuli. In Experiment 2, we recruited mainly bilinguals, but also a small number of monolinguals, to explore whether bilinguals are more attuned to taking the other's perspective in VPT. In other words, we investigated whether bilingual participants had a larger congruency effect than monolinguals.

The results of Experiment 1 and Experiment 2 did not replicate the previously found significant difference between congruent and incongruent conditions (Freundlieb et al., 2018). Our participants did not spontaneously take the confederate's perspective. An exploratory comparison between monolingual and bilingual participants in Experiment 2 did not show any signs of a bilingual difference in congruency interference. However, the fact that we tested very few monolingual participants and the fact that Experiment 2 failed to find a congruency main effect makes it impossible to form strong conclusions about group differences. However, we found a main effect of bilingualism: bilinguals were slower and less accurate than monolinguals. Since Experiment 2 has a strong language component, this result is likely due to our bilingual participants being less proficient in English than our monolinguals.

One reason for our failure to replicate the main effect of congruency may be that the task is not sufficiently sensitive to congruency interference effects. Given that this paradigm has never been replicated in any publication, this is certainly possible. Some evidence comes from a study by Yu & Han (2019) who modified Freundlieb et al.'s paradigm by replacing stimulus words with a name list of home devices. Different from the previous experiment with a physical person (i.e. the confederate), they created a collaborative physical context on the computer screen by presenting the cartoon figure of other users, the cartoon figure of the self, and stimulus words. Just like our study, they also failed to replicate the congruency interference effect. They assumed that the simplicity of their experimental environment might

have led participants to pay more attention to stimulus words. Meanwhile, the stimulus words could have been too salient and can be recognised straight away, without the need to adopt someone else's perspective (e.g., TV). In addition, the representation of these salient words may have been facilitated by the execution of the participants' memory strategy rather than the VPT. However, Yu & Han's results, together with our results, might also indicate that the sensitivity to congruency interference effects in Freundlieb et al.'s task is not reliable.

Another possibility is a methodological difference between the original design and our design. In Freundlieb et al.'s (2018) design, the monitor was adjusted at a height of about 25 cm from the floor, with a button box placed on participants' lap. While in our design, the monitor was adjusted at a height of 72 cm from the floor, and participants placed the button box on their lap, under the desk. Thus, in our case, participants' visual access to confederate's hands was blocked by the table. This design prevented participants to perceive other's state via monitoring the button press context. Also in our experiments, participants and the confederate wore ear plugs, which prevented them from perceiving the confederate's responses via the auditory context. Therefore, in our design, it was more difficult for participants to perceive whether the confederate was doing the task with them or just sitting there and starring at the screen. Though some previous study had shown that the mere presence of another person can promote spontaneous VPT (Ward et al., 2019, 2020), some other research also found spontaneous VPT is sensitive to another's task. Specifically, perspective-taking relies on how others are engaged in the task. For instance, in Freundlieb et al. (2018), whether perspective taking occurs depends on whether or not the confederate is processing the stimuli. When the confederate wore a pair of blocked-vision glasses, consistency conditions did not affect participants' responses. Furthermore, another study by Freundlieb et al. (2016), using a similar paradigm, found that an actively performed confederate could elicit participants' spontaneous VPT, whereas a passively performed

confederate could not elicit participants' spontaneous VPT. In our study, the covered hand and wearing ear plugs might have hidden that the confederate was engaged in processing the stimulus. Therefore, participants might have been less likely to spontaneously take the partner's perspective.

Another possibility is that the effect was weakened by the type of confederate. When interacting with people from the same cultural background, mindreading is generally faster and more accurate compared to when interacting people from different cultural background (Perez-Zapata et al., 2016). Slightly different from Freundlieb's studies, we had a small number of different confederates in Experiment 1. Those varied in culture and ethnic background. When the confederate and participant were not matched in their culture, ethnic background and gender, the participant might have been more likely to focus more on the "self" rather than monitor the "other". This might have led to a weakened congruency interference effect overall.

A further possibility is the conflict between VPT and participants' strategy. It is possible that participants form a certain type of task representation at the beginning of the task, but as the task continues, they will modify it to save cognitive efforts. For instance, participants form a co-representation intention when they listen to the task introduction and rules, but during the task they build up a strategy and can complete the task by using less cognitive efforts. Therefore, participants do not continue to monitor the response of their coordinates. In this situation, the participants' response would not be influenced by their coordinates (Wenke et al., 2011).

This study has limitations. Firstly, the sample size of participants in the second experiment, particularly the British monolingual group, is small. The small sample could increase validity and reduce the statistical power. This reduces the chance to detect true effects or potential differences if they exist (Andrade, 2020). Secondly, our self-selected

sample of university students studying psychology, which may lack diversity, may not accurately represent the wider population of young adults (Hanel & Vione, 2016). Also, psychology students may be familiar with common experimental procedures and may unintentionally change their behaviour to match their understanding of the purpose of the study (Khatamian Far, 2018). This is known as respondent bias and can affect the validity of the experiment. Thirdly, the study is also potentially limited by the predominance of female participants. Gender has been identified as a significant factor in VPT experimental tasks (Eisenberg & Lennon, 1983; Samuel et al., 2023), with females generally displaying more empathy and better embodiment skills compared to males (Kessler et al., 2014; Kessler & Wang, 2012); while males displayed better spatial rotation skills compared to females (Lauer & Lourenco, 2019; Lin et al., 2023). However, this study did not consider gender as a factor, which may reduce the generalisability of these findings to the general population. Fourthly, some of the details of the experimental design differed from the original design, including the desk height, screen distance from the eyes, the number of different confederates, and the fact that participants in our study could not see or hear the other person responding to any stimuli. These discrepancies may have led to the failure of replication.

Our failure to replicate the findings of Freundlieb et al. (2018) casts doubt on previous experiments that have found substantial effects consistent with spontaneous VPT, although for the reasons discussed above, it is possible that methodological and contextual differences between the original paradigm and our sitting may have made spontaneous VPT effects harder to identify in the current experiment. For future replication studies, it is important to ensure that the original findings are robust and stable. In addition, the question of the cognitive process of co-representations is closely related to the present study and efforts can be made to investigate this in depth. Future replications can replicate this paradigm but make changes based on the above issues.

CHAPTER 3

EXECUTIVE FUNCTIONS, NOT BILINGUALISM OR CULTURAL DIFFERENCE, PREDICT VISUOSPATIAL PERSPECTIVE-TAKING IN YOUNG ADULTS

Abstract

It has been found that bilingual speakers outperform monolingual speakers in tasks which involve taking others' perspectives (Rubio-Fernández, 2017; Greenberg et al., 2013; Navarro & Conway, 2021; Wu & Keysar, 2010). However, factors that drive this advantage have remained unclear. Potential factors include executive function (EF), cultural orientation and acculturation. This study aimed to confirm that bilingualism leads to better performance in visuospatial perspective-taking (VPT) tasks in young adults and whether culture, including orientation and acculturation, and EF can explain any enhanced perspective-taking performance by bilingual speakers.

63 Chinese and 61 European bilingual adults (all speaking English as L2), as well as 60 native British English monolingual adults conducted level-1 VPT (judging what others can see) and level-2 VPT (judging how others can see something) tasks as well as EF tasks (flanker and colour-shape tasks). They also filled in Cultural Orientation Scale, the Vancouver Index of Acculturation, and Language and Social Background questionnaires.

Contrary to previous studies, a group comparison did not show a bilingual advantage or an Eastern culture advantage in suppressing egocentric perspective interference, neither for level-1 or level-2 perspective-taking. Hierarchical regression revealed that EF skills but not individual differences in bilingualism and culture predict VPT performance in young adults. These results therefore support the idea of core similarities in VPT mechanisms across language experience and culture. They also suggest that the bilingual perspective-taking advantage found in children does not seem to extend to young adults.

Introduction

Bilingual speakers have been shown to outperform their monolingual peers in various perspective-taking tasks such as False-belief tasks (Rubio-Fernández, 2017), Spatial Reasoning tasks (Greenberg et al., 2013) and Referential communication task (Navarro & Conway, 2021; Wu & Keysar, 2007). Two potential factors might explain this advantage: (1) executive function differences and (2) cross-cultural differences.

Perspective taking has been shown to be affected by executive function abilities such as inhibition and switching. Inhibition allows individuals to filter out distracting information, focus on relevant cues and overcome perceptual biases that may interfere with accurate perspective-taking (Qureshi et al., 2020). And switching allows individuals to consider multiple viewpoints and integrate information from different perspectives (Long et al., 2018; Wardlow, 2013). Both are therefore important facilitating cognitive mechanisms for VPT.

Importantly, bilinguals have often been found to have superior executive function skills compared to monolinguals (Green & Abutalebi, 2013, Bialystok, 2009; Bialystok et al., 2012). It has been argued that this is due to their usage of two languages, which requires that bilinguals constantly monitor, select and suppress one of their languages. This means that bilinguals exercise executive functions skills, including switching, inhibition, and working memory more frequently than monolinguals. In other words, the bilingual advantage in inhibition and switching might lead to be better perspective taking.

The bilingual advantage in VPT may also be related, at least in part, to their biculturalism. Compared to monolinguals, bilinguals are more likely to be exposed to customs, ideas and perspectives from different cultures during language learning and use. Thus bilinguals do not only speak two languages that they need to control, they are also bicultural (Grosjean, 2015; Soffietti, 1960). Being bicultural has forced them to see the world from different perspectives and requires a high level of mental flexibility (Kharkhurin, 2010).

This high level of mental flexibility, which is an important cognitive mechanism for VPT, may lead bilinguals to be better at VPT.

Furthermore, mental flexibility might be modulated by cultural orientation and acculturation. In terms of cultural orientation, it has been found that collectivist cultural orientation, which is usually associated with Eastern cultures, makes it easier for people to automatically adopt another person's point of view than individualist cultural orientation, which is usually associated with Western cultures (Kessler et al., 2014; Wu & Keysar, 2007). Thus, bilinguals with an Eastern heritage culture and a Western host culture might perform better on VPT tasks than bilinguals with two Western cultures, and both groups might perform better than monolinguals from a Western culture. Also, an individual's acculturation strategy, that is the extent to which an individual identifies and recognizes his or her host and heritage cultures (Berry, 1997; Berry et al., 2006), might also influence bilinguals' performance in VPT tasks. Thus, we would expect bilinguals with an integrated acculturation strategy to perform better on VPT than those with an unbalanced.

The present study tests VPT mechanisms across language experience and culture, and whether the bilingual perspective-taking advantage found in children extends to young adults. We investigated whether bilingual young adults outperform their monolingual peers in VPT, including level-1 and level-2 VPT, independent of executive function and cross-cultural differences. We also assessed the potential relationships of VPT with bilingualism, cross-cultural differences, including cultural orientation and acculturation strategy, as well as executive function.

Visuospatial Perspective-taking (VPT)

Perspective-taking (PT) is a complex and multifaceted socio-cognitive mechanism, which is a crucial capacity to represent the mental state of another person, which helps

individuals infer others' mental states such as beliefs, knowledge, attitudes or approximate another's visual perspective. PT allows us to adjust our corresponding utterances and actions to achieve highly efficient social interaction (Apperly, 2011; Baron-Cohen et al., 1985; Bellet & Maloney, 1991). One aspect of PT is visuospatial perspective-taking (VPT), which refers to the ability to imagine and mentally manipulate objects or scenes from different viewpoints or perspectives, such as self and other. It involves the ability to mentally transform images, understand spatial relationships, and navigate through environments using mental imagery (Flavell, 1977). VPT is divided into two levels (Flavell et al., 1981). Level-1 VPT refers to comprehending what others can perceive, for instance, which objects are visible to others; level-2 VPT refers to mentally standing in others' place and understanding how the world looks from others' orientation, for instance, what you can see from another person's perspective. Compared to level-1-VPT, level 2-VPT involves a deliberate spatial rotation simulation that increases cognitive effort by incongruent perception (Surtees et al., 2016). The present study explored factors important for both level-1 and level-2 VPT.

Bilingualism in VPT

Bilingual adults speakers have been shown to outperform their monolingual peers in various perspective-taking tasks such as False-belief tasks (Rubio-Fernández, 2017) and Referential communication tasks (Navarro et al., 2022; Navarro & Conway, 2021; Wu & Keysar, 2007). This advantage has been especially robust and evident in bilingual children (Greenberg et al., 2013; Schroeder, 2018). Studies of bilingual advantage on VPT in adults are rare and do not always support a bilingual advantage (Ryskin et al., 2014; Wang et al., 2019). In the present study, we investigated whether bilingual young adults outperform their monolingual peers in VPT, both level-1 and level-2 VPT.

Culture Orientation in VPT

A superior perspective-taking performance of bilinguals may also stem from cross-cultural differences. Previous studies have shown that cultural differences and experiences can impact perspective-taking performance (Kessler, et al., 2014; Wu & Keysar, 2007). Wu and Keysar (2007) asked twenty Mandarin native speakers born and raised in China but living in the United States for 2 to 9 months as well as twenty American native English speakers to participate in a referential communication task, also called the director task. The eye-tracking data showed that American participants fixated more frequently on egocentric distractors and were slower in making decisions than Chinese participants. Wu and Keysar concluded that the interdependent cultural concept of Chinese participants led them to focus more intensely on the perspective of the communication partner and minimised their egocentric view. A fine-grained time-course analyses of Wu and Keysar's (2007) finding shows that both groups of participants first focused on egocentric distractors, but Chinese participants were quicker in suppressing this egocentric tendency (Wu et al., 2013).

Kessler et al. (2014) provided further evidence for a shared PT process in different cultures. They utilised a level-1 and a level-2 VPT task. Chinese and British adult groups judged the position of an object relevant to a person. The results revealed that in the level-1 VPT task, both groups detected equally well whether an object can be seen by tracing the person's sightline. In the level-2 VPT task, both groups initially took their own position to determine the person's position, but the Chinese group was faster than the British group.

One possible explanation for these findings is that, compared to people grow up in individualistic cultural society, people grow up in collectivistic cultural society tend to define themselves as part of a group and give priority to ingroup goals (Triandis, 1996, 2001). It is suggested that the concept of self/other is modulated by the cultural background from which individuals arise. Markus and Kitayama (1991) argued that most Western cultures emphasise

the importance of self-orientation, which promotes the construction of independence. Most Eastern cultures, on the other hand, emphasise community benefits and pay more attention to others, facilitating the interdependence construction. In interpersonal contexts, individuals with an interdependence construction would be more concerned with the needs of others than with their own.

According to Triandis (1996, 2001) and the framework by Markus and Kitayama (1991), cultural orientation affects the degree of egocentric bias. East Asian and Western participants share the same PT processes (Wu et al., 2013; Kessler et al., 2014), but participants from collectivist cultures tend to be better at suppressing their egocentric bias. We would therefore hypothesise that East Asians are prone to less or no egocentric bias in PT, as the perspectives of others are very likely to be privileged over their own perspectives. Conversely, we would expect that Westerns who are self-concentrated should be more attuned to their own perspectives when the task requires them to take others' perspectives. Put simply, members of individualist cultures such as British and American cultures are expected to show a larger egocentric bias, whereas members of collectivist cultures such as the Chinese culture are expected to suppress their egocentric bias more strongly.

Wu and Keysar (2007) explain the superior performance of Chinese over Western participants as a cultural difference. But the Chinese participants in their study were highly likely bilingual, while the American participants were probably rather monolingual. Since bilingual adults have shown a tendency to be less egocentric than monolingual adults (Rubio-Fernández & Glucksberg, 2012), Chinese participants might have had a performance advantage due to their cultural orientation or their bilingualism.

Interestingly, some research without a confounding factor of bilingualism failed to find the advantage of interdependent/Eastern participants in suppressing their egocentric tendency over independent/Western participants. Bradford et al. (2018) explored similarities

and differences between the Westerns (individualism) and Chinese (collectivism) in terms of ToM processes. Native English speakers were recruited and tested in the UK, whereas native Chinese speakers conducted the task in mainland China. Both groups performed a computer-programmed false belief task. The results showed that both native English and native Chinese participants responded faster in the self-oriented condition than in the other-oriented condition. The groups did not differ in task performance, despite differences in collectivism scores.

Similar results were found in a study by Wang et al. (2019) who used a computer-based director task and a level-1 VPT task (Samson et al., 2010). These two tasks captured both an egocentric tendency, which refers to congruency interference when making judgments from the other-orientation, and an altercentric tendency, which refers to congruency interference when making judgments from the self-orientation. The data of thirty-one Taiwanese (East Asian) and thirty-one British (Western) participants were collected in their home country. Altercentric and egocentric interference was tested in both tasks. The results showed remarkable cross-cultural similarity in PT. East Asian (interdependent) and Western (independent) participants displayed similar egocentric and even similar altercentric biases on both tasks. Since there were no significant cross-cultural differences, interdependent/collective and independent/individuals appear to share a common core and potentially general mechanism for ToM.

These two studies assumed that all participants with an Eastern background are collectivist and those with a Western background are individualist. However, this is an erroneous assumption. For instance, the Western countries of Poland and Portugal are collectivist, while the Eastern countries Singapore and South Korea are individualistic (Krassner et al., 2017). Also, there might be individual differences in cultural orientation (Lomas et al., 2023). It is therefore important to test participants' cultural orientation rather

than assume it due their cultural origin. In the present study, the Culture Orientation Scale (Triandis & Gelfand, 1998) was implied to assess individualism and collectivism traits of participants.

Acculturation in VPT

Also, a cross-cultural difference in VPT might stem from varying degree of acculturation, which refers to how participants with two cultures identify with their heritage and host cultures. Researches have shown that those who seek to integrate and identify strongly with both their cultures appear to be best adapted to the new environment, while those who marginalise and identify weakly with both their cultures are least well adapted, and those who have an unbalanced identification with heritage and host culture are at an intermediate level of adaptation (Berry, 1997; Berry et al., 2006; Tadmor et al., 2012; C. Ward, 1996). Thus, in order to achieve better communication and adaptation, individuals who identify with both of their two cultures might be more likely to pay attention to others' perspectives in social interaction, which might lead them to perform better in VPT.

It is known that people are more likely to interact and cooperate with those close to them than strangers and are better at representing mental states of those close to them (Aron et al., 1991; Aron & Aron, 1986). Cultural identification, therefore, likely trains perspective-taking behaviour and ability. Perez-Zapata et al. (2016a) carried out a culture story task by recruiting native Australia and native Chilean speakers to read short stories with cultural backgrounds. The results demonstrated that participants were faster and more accurate in intracultural conditions (e.g., an Australian reads an Australian culture story) than in cross-culture conditions (e.g., an Australian reads a Chilean culture story). This reflects the effect of cultural integration on mind reading. Also, the degree with which bilinguals orient towards their two cultures can be relevant, as shown for creative thinking (Tadmor et al., 2012) and

cognitive flexibility (Spiegler & Leyendecker, 2017). Therefore, we investigated whether those who highly integrate and identify with both their heritage culture and home culture are better at VPT.

Executive Function in VPT

VPT requires to distinguish between knowledge that is held by somebody else from knowledge that is held by oneself. Executive functions, including working memory, inhibition and switching mediate the degree to which adults adopt perspectives. Because self and other perspectives are competing processes, VPT is especially closely associated with inhibition and switching. To successfully representing other's perspective, the impulse to represent one's own perspective may need to be inhibited. Or, put in other words, inhibition enables individuals to filter out distracting information and focus on relevant cues, switch between different perspectives, and overcome perceptual biases that can interfere with accurate perspective-taking (Qureshi et al., 2020). Similarly, switching enables individuals to consider multiple viewpoints and integrate information from different perspectives (Long et al., 2018; Wardlow, 2013).

Furthermore, executive function varies across cultures (Xie, 2019), and among bilinguals (Lehtonen et al., 2018). Bilinguals and balanced biculturals tend to have better executive function than monolinguals and unbalanced biculturals. Therefore, executive function is a potential confounding or mediating variable in the relationship between bilingualism and VPT, as well as in the relationship between acculturation and VPT. In the present study, inhibition and switching skills were therefore tested as controlled variables.

Current Study

To sum up, previous studies explained the superior performance of Eastern over Western participants as a cultural advantage without considering the influence of bilingualism. The appearance of differences between Eastern and Western participants might have resulted from a bilingual advantage. Therefore, the present study investigated the role of bilingualism in speakers' perspective-taking ability. We also investigated whether those who highly identify with and integrate heritage and host cultures are better at VPT. To our knowledge, this experiment is the first to disentangle the effect of acculturation and bilingualism on VPT.

Our research questions were as follows:

(1) Does bilingualism lead to better performance in VPT tasks, independent of executive function and cross-cultural differences?

(2) Can EF predict PT performance among bilingual and monolingual young adults?

(3) Does the degree of cultural orientation towards participants' two cultures predict performance in VPT tasks, independently of bilingualism? In other words, does a collective background (Eastern culture) lead to better performance in VPT than an individualist background (Western culture). And does a more highly and balanced identification with both heritage and host culture lead to better VPT performance than an unbalanced identification?

To allow a direct measure of cultural differences (Western vs Eastern) and bilingualism (monolingual vs bilingual), the present study tested three groups of participants: British monolinguals (B-Mono), European bilinguals (EU-Bil) and East Asian bilinguals (EA-Bil), with EU-Bil participants incorporating two Western cultures and EA-Bil participants incorporating a combination of an Eastern and a Western culture. To assess VPT abilities when being asked to perceive a situation from their own perspective (self-perspective/altercentric) and somebody else (other-perspective/egocentric), participants

completed a self-perspective and other-perspective level-1 VPT task (Samson et al., 2010) as well as a self-perspective and other-perspective level-2 VPT task (Surtees et al., 2016). These two VPT tasks were chosen for three reasons. Firstly, both tasks can capture both egocentric and altercentric interference, which are two important indices for assessing an individual's performance in VPT. Better performance in VPT from a social interaction perspective is characterised by less egocentric and more altercentric behaviour. A tendency to be less egocentric indicates that an individual is less likely to be distracted by their own perspective when they should or need to take the perspective of others. A stronger tendency towards altercentric bias suggests that an individual can spontaneously take the other's perspective even when the other's performance is irrelevant to the task. Secondly, the two non-linguistic VPT tasks are appropriate for examining variations in VPT performance between bilingual and monolingual individuals. This is because bilingual and monolingual participants may have different levels of fluency and proficiency in the experimental language (English). Those who are better at English may be better at processing the stimuli of the linguistic VPT task. Thirdly, incorporating both level-1 and level-2 visual perceptual tasks with a consistent design would enable a systematic examination of visual perceptual performance.

Furthermore, we anticipated that EA-Bils would be more collectivist as a group, while we expected EU-Bils to be more individualist as a group. The present study used the Culture Orientation Scale (Triandis & Gelfand, 1998) to assess individualism and collectivism traits of participants and the self-reported Vancouver Index of Acculturation (Ryder et al., 2000) to measure acculturation, that is participants' identification with their heritage and host culture. To measure the language status of the participants (bilingualism versus monolingualism), the Language and Social Background Questionnaire (LSBQ) was utilised. To address any potential executive function effect, we included measures of inhibition and switching abilities

in form of the Flanker task (Zhou & Krott, 2018) and the colour-shape task (Stasenko et al., 2017). We predicted that both abilities facilitate VPT (Long et al., 2018).

Our assumption was that bilingualism would influence perspective-taking ability. We anticipated bilinguals to be less egocentric and more altercentric compared to monolinguals. This means that bilinguals should be less affected by their own perspective than monolinguals when judging others' perspective, while bilinguals should be more affected by others' perspective than monolinguals when judging from their own perspective. Also, we expected that collective culture orientation leads to better performance in VPT tasks than individualist culture orientation. Thus, we expected that EA-Bil to be less egocentric and more altercentric than B-Mono and EU-Bil.

In addition to an analysis of differences between the three groups, we also investigated the effects of bilingualism, cultural orientation, acculturation and executive function on VPT by treating the predictor variables as continuous variables.

Methods

Participants

A power analysis was performed using G*Power version 3.1.9.7 (Faul et al., 2007) for a one-way ANOVA with group as a three-level independent variable, namely EA-Bil, EU-Bil and NB-Mono. Since there are no previous studies with a three-group comparison and the congruency index as dependent variable used here, we assumed a mean effect size of f = 0.25. For $\alpha = 0.05$ and power = 0.8, the minimum sample size is 159 participants (e.g. 53 participants per group). 184 young adults aged between 17 and 35 (141 female, mean age =20.5 years, SD= 2.8) were given course credits or payment in return for their participation. Of those, 63 were East-Asian bilinguals (EA-Bil), 61 were European bilinguals (EU-Bil) and 60 were British English monolinguals who had grown up in the United Kingdom (B-Mono). Additional demographic details of the sample, such as type of heritage culture, are available in the Appendix in Supplementary Table 3.1. All participants had normal or corrected-to-normal vision.

The study was approved by the Research Ethics Committee of the University of Birmingham, United Kingdom (ERN_09-719).

Measures

Three questionnaires were used in this study: the Language and Social Background Questionnaire (LSBQ; Anderson et al., 2018), the Culture Orientation Scale (COS; Triandis & Gelfand, 1998) and The Vancouver Index of Acculturation (VIA; Ryder et al., 2000). Besides, four perspective-taking tasks were administered: level-1 VPT self-perspective (Samson et al., 2010), level-1 VPT other-perspective (Samson et al., 2010), level-2 VPT self-perspective (Surtees et al., 2016) and level-2 VPT other-perspective (Surtees et al., 2016).

Also, two executive function tasks were conducted: Flanker task (Zhou and Krott, 2018) and Colour-shape task (Stasenko et al., 2017).

Language and Social Background Questionnaire

We administered the LSBQ (Anderson et al., 2018), a questionnaire designed to test participants' social background, language history, language use in the community and language switching. It assesses participants' socioeconomic status (SES) and degree of bilingualism. Participants' socioeconomic status was determined by their parents' education levels. Participants rated both parents' education level on a five-point Likert scale ranging from 1 ("No high school diploma") to 5 ("Graduate or professional degree"). The SES index was the average of the parents' education scores. Degree of bilingualism was measured with means of the "Composite Factor Score", using the LSBQ calculator (Anderson et al., 2018). A higher score indicates a higher degree of bilingualism, and a very low score indicates monolingualism. The questionnaire has shown good reliability and validity (Anderson et al., 2018).

Culture Orientation

The Culture Orientation Scale (Triandis & Gelfand, 1998) is a 16-item questionnaire to measure the inclination to think, feel or act in a culturally determined way. The items are split into four subscales, each containing four items: Horizontal Individualism (HI) (e.g., "I'd rather depend on myself than others"), Horizontal Collectivism (HC) (e.g., "If a co-worker gets a prize, I would feel proud"), Vertical Individualism (VI) (e.g., "It is important that I do my job better than others"), and Vertical Collectivism (VC) (e.g., "Parents and children must stay together as much as possible"). Items were presented in a mixed order. All items are on a 9-point Likert scale, ranging from "never or definitely no" to "always or definitely yes". A

higher score represents a higher orientation tendency towards collectivism or individualism. The scale has shown good reliability and validity (Triandis, 2001). In our data sample, Cronbach's alpha for the entire scale was 0.68, with 0.72 for the collectivism dimension and 0.68 for the individualism dimension.

Acculturation

The Vancouver Index of Acculturation (VIA) (Ryder et al., 2000) is a self-report questionnaire contains 20-item. It is designed to assess degree of identification with heritage culture as well as host (majority) culture. It measures several aspects relevant to orientation, including values, social activities, marriage, entertainment, social activities, etc. (e.g., "I often participate in my heritage culture traditions"). Each item is rated on a scale of 1 to 9, ranging from "strongly disagree" to "strongly agree". The heritage culture items and host culture items were presented in turn. A higher score represented higher identification with the heritage or host culture. The questionnaire has been verified with good reliability and validity (Testa et al., 2019). In the present sample, Cronbach's alpha for the entire scale was 0.81 overall, and 0.85 for the heritage dimension and 0.88 for the host dimension.

Level-1 VPT Task

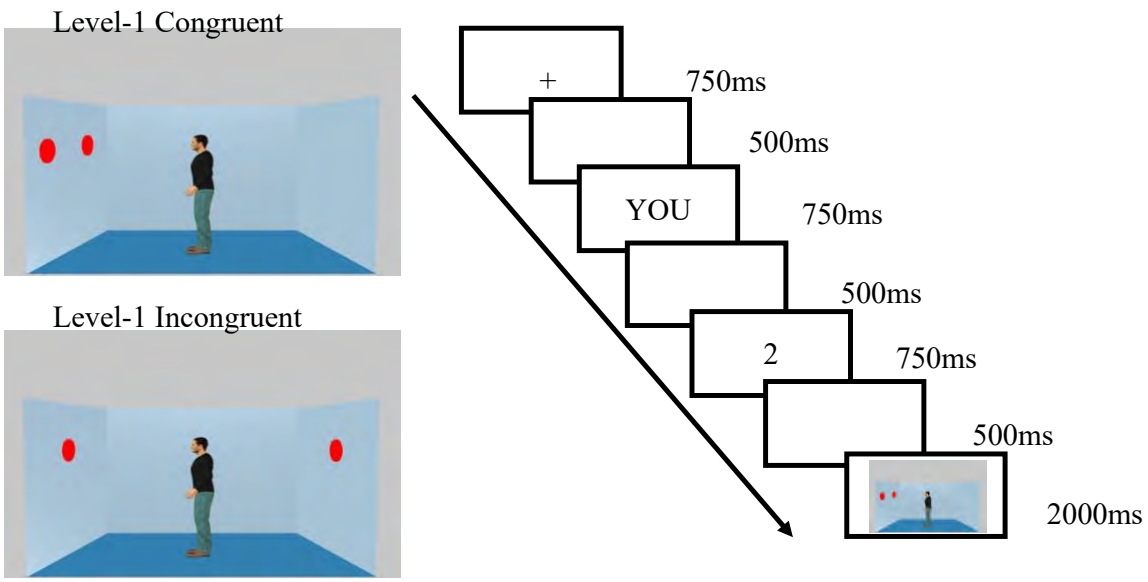
The procedure and materials of the level-1 VPT task were identical to those of Samson et al. (2010). Figure 3.1 shows example stimuli and an example stimulus sequence. In this task, the stimuli were pictures showing a view inside a room with the left, back and right walls visible. Red dots displayed on the left or/and right wall. A three-dimensional animation human avatar was placed in the room's centre facing the wall on the left or the wall on the right. In the congruent condition, the dots were presented only on the well that the avatar faced, so that the participant and the avatar saw the same number of dots. In the

incongruent condition, the dots were presented on both the left and right walls, so that the participant and the avatar saw different numbers of dots. 50% of the trials were congruent, the other 50% incongruent. In addition, avatars matched the gender (male, female) and ethnicity background of the participants. Thus EA-Bil participants were paired with an East Asian avatar, while EU-Bil and B-Mono participants were paired with a Western avatar. This resulted in four different versions of the task.

We separated self and other perspective into separate tests. In the self-perspective task, participants were instructed to judge from their own perspective. If they spontaneously adopted the other's perspective, an altercentric interference would be observed. In the other-perspective task, participants were instructed to judge from the avatar's perspective. If they spontaneously took the avatar's perspective, an altercentric interference would be observed. The altercentric and egocentric interferences were calculated as the difference between the congruent and incongruent conditions generated by the red dot level-1 VPT tasks.

Figure 3.1

Example Stimuli of Level-1 Congruent and Incongruent Conditions (left panel) and Example Trial Sequence (right panel) of the VPT task



Each trial began with a fixation cross, lasted 750 ms and was followed by a 500 ms blank. After that the participants were told whether to focus on their own perspective or the avatar's perspective. Thus, depending on the session design, the word "YOU" (self-perspective) or "HE"/ "SHE" (other-perspective) was presented for 750ms. After a further 500ms interval, an integer between "0-3" was presented for 750ms, indicating the content from the specific perspective for verification. Finally, the stimulus picture was presented. Participants had to press one of the mouse buttons to judge whether the previous number corresponded to the number of red dots in the picture. Participants had maximally 2000ms to respond, after which the next trial started. For example, in the trial sequence in Figure 3.1 (right panel), the information indicated that the participants would see two red dots in the following picture. Participants should have pressed "yes" in this example because from their own perspective, they indeed could see two red dots. For both self-perspective and other-perspective conditions, there were 48 matching ("yes" response) trials, including 24 congruent trials (self and other perspective were the same) and 24 incongruent trials (self and other perspective were different), and 48 mismatching ("no" response) trials, as well as 8 practice trials, and 4 fillers which has no dots in the picture. Trials were divided into two blocks. The order of the trials in each block was pseudo-randomised, and the block presentation sequence was counterbalanced across participants.

The level-1 PT task had a 3 (groups: EA-Bil, EU-Bil and B-Mono) * 2 (perspective: self and other) * 2 (congruency: congruent and incongruent) mixed design, with group as between-participant factor; and perspective and congruency as within-participant factors. The self-perspective tested altercentric bias, while the other-perspective tested egocentric bias.

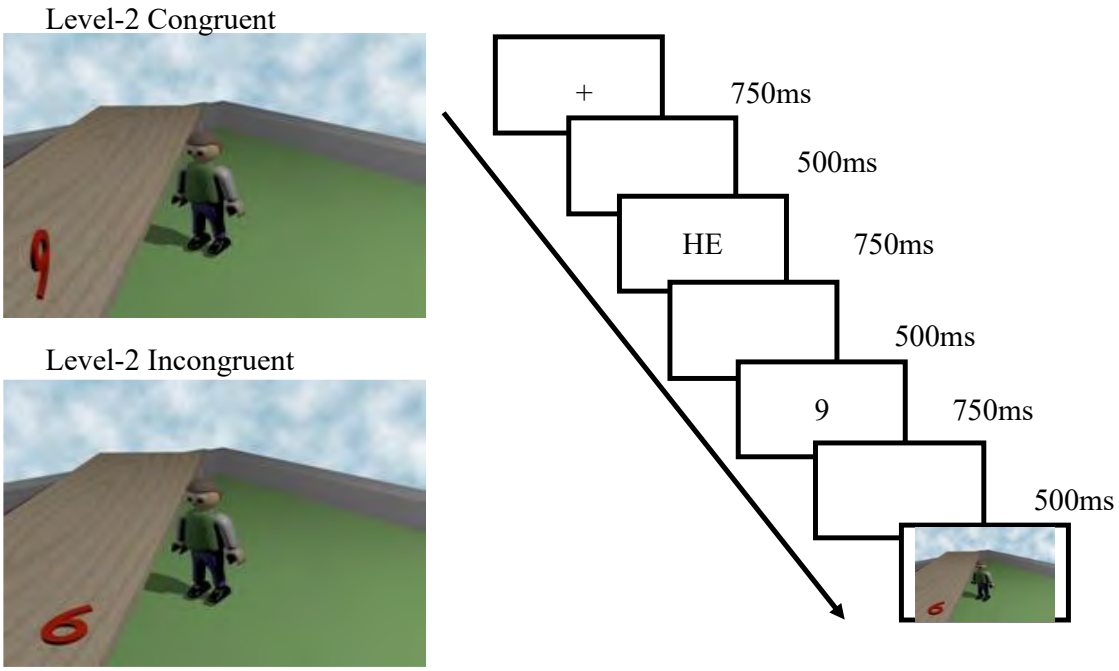
Level-2 VPT Task

The procedure and material of the level-2 VPT task were identical to the blocked design of Surtees et al. (2016). Figure 3.2 shows example stimuli and an example stimulus sequence. In this task, all pictorial stimuli showed a cartoon avatar standing next to a table. The avatar was facing randomly to the left or right side of the table or wall. The number "6" or "9" was placed on the table or stuck to the wall, meaning that the number was seen either lying flat or standing upright. Importantly, if the stimulus contained an upright number, the perspectives of the avatar and the participant were the same (congruent condition), while if the stimulus contained a flat-lying number, the avatar's perspective was different from that of the participant (incongruent condition). In the congruent condition, it would be easier for the participant to make a judgement than in the incongruent condition if they spontaneously take both perspectives into account. Therefore, it was predicted that participants would take more time to respond and make more errors in the incongruent condition than in the congruent condition. Because the cartoon character did not have a gender or any racial features, their gender did not need to be matched with that of the participant.

We split self and other perspectives into separate tests. In the self-perspective task, participants were instructed to judge from their own perspective. If they spontaneously adopted the avatar's perspective, an altercentric interference would be observed. In the other perspective task, participants were instructed to judge from their own perspective. If they spontaneously took the avatar's perspective, an altercentric interference would be observed. The altercentric and egocentric interferences were calculated as the difference in errors and RT between the congruent and incongruent conditions (incongruent minus congruent).

Figure 3.2

Example Stimuli of Level-2 Congruent and Incongruent Conditions (left panel) and an Example Trial Sequence (right panel)



Each trial started with a fixation cross for 750ms, followed by a 500ms break. Then, for the self-perspective test, the cue "YOU" was presented for 750ms; for the other-perspective test, the cue "HE" was presented for 750ms. This cue indicated whether the participant had to make a decision from their own perspective, which tested the altercentric bias, or from the avatar's perspective, which tested the egocentric bias. After a further 500ms break, the number "6" or "9" was presented for 750ms. Finally, participants saw the pictorial stimulus and indicated using a keyboard whether the cues matched the picture ("d" key) or not ("k" key). For both the self-perspective and other-perspective tests, the cues matched the stimulus' content in half of the trials, and did not in the other half. Apart from 10 practice trials and 48 mismatching trials, there were 48 matching ("yes" response) trials, including 24 congruent trials and 24 incongruent trials, distributed over two blocks. Each test contained in total 24 congruent trials and 24 incongruent trials. The order of the trials within a block was

pseudo-randomised and the block presentation sequence was counterbalanced across participants.

Like the level-1 VPT task, this task had a 3 (group: EA-Bil, EU-Bil and B-Mono) * 2 (perspective: self and other) * 2 (congruency: congruent and incongruent) mixed design: cultural group was a between-participant variable; and perspective and congruency were within-participant variables.

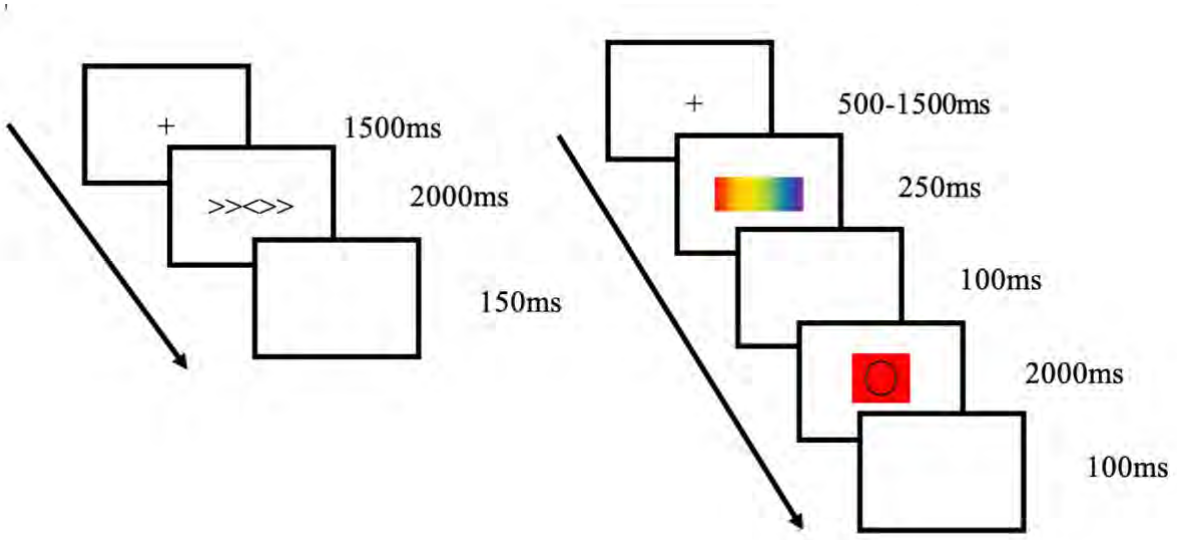
Flanker Task (Inhibition)

We adopted the procedure by Zhou and Krott (2018) for the Erikson Flanker paradigm (Eriksen & Eriksen, 1974). Figure 3.3 shows example stimuli and an example stimulus sequence. Stimuli were rows of five arrows, with a target arrow and two distractor arrows on each side. Each arrow had a visual angle of about 0.55 degrees and the distance between the arrows was about 0.06 degrees.

At the beginning of each trial, a fixation cross was presented for 1500ms, then the stimulus appeared. Once a response was made or after a timeout of 2000ms, the stimulus disappeared. Stimuli were followed by an inter-trial interval of 150ms. Participants were asked to judge the direction of the central arrow by pressing a left or right button on a Cedrus RB-834 response pad. In congruent trials, the central arrow and the distracting arrows were directed in the same direction, whereas in incongruent trials they were directed in opposite directions. To increase the task's difficulty, 75% of the trials were congruent and 25% were incongruent. 24 practice trials were followed by five blocks of 96 trials, totally including 360 congruent trials and 120 incongruent trials. The sequence of stimuli was randomised.

Figure 3.3

An Example Trial Sequences of the Flanker task (left panel) and An Example Trial Sequence of the Colour-Shape Task (right panel)



Colour-shape Task (Switching)

The Colour-Shape Task was designed on the basis of Stasenko et al. (2017). Figure 3.3 shows example stimuli and an example stimulus sequence. Participants were required to judge from either the colour dimension or the shape dimension. Each dimension had two conditions: Red or Green for the colour dimension; Triangle or Circle for the shape dimension. Participants needed to make judgement according to the cue. If the cue was a colour bar, participants had to judge whether the colour of the stimulus was red or green by pressing the right or left button. When the cue was a series of different shapes, participants had to judge whether the shape of the stimulus was a triangle or a circle by pressing the right or left button. Responses were recorded with a Cedrus RB-834 response pad.

At the beginning of each trial, a fixation cross appeared for 500-1500ms. Then a colour or shape cue appeared for 250ms. After a blank screen of 100ms, a central fixation cross occurred for 1000-2000ms, replaced by the stimulus until a button was pressed or until 2000ms. Finally, a blank screen of 100ms followed. Apart from 24 practice trials and 16

fillers, each participant responded to 96 consistent and 96 inconsistent trials, randomly presented in 4 blocks.

Procedure

All data were collected in a quiet laboratory at the University of Birmingham. Tasks were divided into two one-hour sessions, with 2 to 5 days between sessions. In session one, participants first filled in the three questionnaires: the LSBQ, the COS, and the VIA. They then completed the Flanker task, followed by two self-perspective VPT tasks: a level-1 VPT task and a level-2 VPT task. In session two, participants started with two other-perspective VPT tasks: again, a level-1 VPT task and a level-2 VPT task. Then they completed the colour-shape task. In each session, the order of task levels (level-1 vs level-2) was counterbalanced across participants. Self-perspective VPT tasks were always completed in the first session, and other-perspective VPT tasks were always completed in the second session. This is because it's possible that participant spontaneous adopting the non-relevant perspective mainly because the mixed self-perspective and other-perspective trials in same block design. This design requires consistent monitoring of both perspectives in the case of perspective shifts, which can elicit spontaneous VPT. In the present study, we therefore modified the paradigm so that the self- and other-perspective judgements were presented in two separate sessions, with an interval of 2-3 days between them. After modification, VPT can be detected independent of task and attention switching effects (Samson et al., 2010; Surtees et al., 2016).

Data Pre-processing

Bilingualism Index

The bilingualism index was determined with the LSBQ bilingualism score calculator

(Anderson et al., 2018). This index categorises participants into monolingual, bilingual, or ambiguous. A higher score indicates bilingualism, and a very low score indicates monolingualism. More concretely, a score below -3.13 indicates monolingualism, while a score above 1.23 indicates bilingualism, and any score in between is classified as ambiguous. The bilingualism score is based on various measures. Some participants had missing data, especially for "religion", "praying", "partner", and "work", which did not correspond to the participants' current condition. For example, some participants did not have any religion and did not pray. None of the relevant measures, though, had more than 15% missing data. We filled in the missing data by using the "mice" package in R (Buuren & Groothuis-Oudshoorn, 2011). But note that the bilingualism score of one EA-Bil with missing data of more than 60% was excluded from the analyses.

Collectivism and Individualism Indexes

Collectivism and Individualism indexes were generated from the COS by averaging the answers of the four items from each dimension. We found that the two individualism subscales HI and VI were positively correlated, $r=0.21$, $p<0.01$. So were the two collectivism subscales HC and VC, $r=0.33$, $p<0.001$. We therefore averaged HC and VC scores to calculate a collectivism index and averaged HI and VI scores to calculate an individualism index. A higher index represented higher collectivist or individualist orientation, respectively.

Acculturation Index

The acculturation index was generated from the VIA questionnaire. Among the EA-Bil sample, over 92% participants indicated Chinese as their heritage culture, 3.17% Korean, 1.59% Japanese and 1.59% Singaporean. Among the EU-Bil sample, most participants indicated Romanian (13.11%), French (13.11%), Spanish (13.11%), Polish (13.11%) and

Italian (11.48%) as their heritage culture. Among the B-Mono sample, 25% indicated Irish and Welsh as their heritage culture. These and additional demographic details are available in the Appendix in Supplementary Table 3.1. Heritage and host culture indexes were determined by averaging scores to the ten items of each dimension. For bicultural participants, the heritage culture index represented how much participants oriented themselves towards their heritage culture, and the host culture index represented how much participants oriented themselves towards British culture and values. 24 B-Mono participants stated that they only had a heritage but no host culture. We therefore coded their host culture score as "0". All participants identified highly with at least one culture. Thus, the acculturation index was calculated as the absolute value of the difference between heritage and home culture index. It therefore represented the extent to which participants identified with both cultures, with a lower score representing balanced recognition of two cultures, in other words integration of two cultures, and a higher score reflecting a tendency towards unbalanced recognition, in other words a tendency to identify closely with only one of their two cultures.

VPT Tasks

The outliers were detected by plotting boxplots (Howitt & Cramer, 2008; Wilcox, 2012). We further excluded responses for which the RT was greater than 3 SD (Miller, 1991; Ratcliff, 1993). The findings remained consistent whether selecting 2.5 SD or 3 SD. We chose to exclude RTs more than 3 SDs above the participant's mean to reserve more data points.

For level-1 VPT self-perspective, we removed RTs < 300ms (3.50%) and two participants (one EU-Bil and one NB-Mono) whose accuracy rates were lower than three SDs below the mean of all participants (1.05%). We also excluded incorrect response trials (6.45%) and RTs than 3 SDs above the mean of a participant (0.91%).

For level-2 VPT self-perspective, we removed RTs < 300ms (0.18%) and six participants (two EA-Bils, three EU-Bils and one NB-Mono) whose accuracy rates were lower than three SDs below the mean for all participants (3.78%). We also excluded incorrect response trials (6.76%) and RTs longer than 3 SDs above the mean of a participant (1.32%).

For level-1 VPT other-perspective, we removed RT < 300ms (3.07%) and three participants (one EU-Bil and two NB-Bils) whose accuracy rates were lower than three SD below the mean of all participants (1.43%). We also excluded incorrect response trials (5.47%) and RTs longer than 3 SDs above the mean of a participant (0.78%).

For level-2 VPT other-perspective, we removed RTs < 300ms (0.10%) and five participants (one EA-Bil, one EU-Bil and three NB-Monos) whose accuracy rates were lower than three SDs below the mean of all participants (2.71%). We also excluded incorrect response trials (7.10%) and RTs longer than 3 SDs above the mean of a participant (1.14%).

Flanker Task (Inhibition)

For the flanker task, we removed RTs < 300ms (1.12%) and four participants (three EU-Bils and one NB-Mono) whose accuracy rates were lower than three SDs below the mean of all participants (2.12%). We also removed incorrect response trials (1.63%) and RTs longer than three SDs above the mean of a participant (1.35%).

Colour-Shape Task (Switching)

For the Colour-shape task, we removed RTs < 300ms (6.07%) and six participants (three EA-Bils, two EU-Bils and two NB-Monos) whose accuracy rates were lower than three SDs below the mean of all participants (2.94%). We also excluded incorrect responses trials (5.41%) and RTs longer than three SDs above the mean of a participant (1.61%).

Results

Analytic Strategy

Analyses were conducted in four steps. In step 1, we confirmed task effects. We performed mixed effects model analyses for RTs and accuracy for the two VPT tasks, the Flanker task and the Colour-shape task. The aim was to check whether we replicated the main effect of congruency in VPT and Flanker task paradigms, as well as the main effect of switching in colour shape task.

In step 2, we created composite scores for egocentric interference, altercentric interference, inhibition interference and switching interference as a preparation for the analyses in steps 3 to 4, which focused on our research questions.

In step 3, we conducted group comparisons for level-1 and level-2 egocentric and altercentric interference in VPT.

In step 4, we conducted correlation analyses and hierarchical regressions to investigate individual differences in factors determining VPT.

Step 1: Confirmation of Task Effects

We first checked whether we replicated common effects in the VPT, Flanker and Colour-shape tasks. In VPT tasks, we expected participants to respond faster and more accurately in self-perspective trials than in other-perspective trials, in level-1 than in level-2 trials, and in congruent condition than in incongruent condition. Thus, we expected to see a significant congruency effect in both level-1 and level-2 other-perspective conditions (i.e., egocentric interference); and we might find a significant congruency effect in level-1 self-perspective, but not in the level-2 self-perspective tasks (i.e., altercentric interference) (Surtees et al., 2016; Surtees et al., 2012).

In the Flanker task, we expected participants to respond faster and more accurately in congruent trials than in incongruent trials. Finally, in the Colour-shape task, we expected participants to respond faster and more accurate in the stay trials than the switch trials.

Linear Mixed Effect Model Analyses of VPT Tasks

We fitted a linear mixed effects model to RTs and a generalised linear mixed effects model to error rates through the use of the lme4 package (Bates et al., 2015) in R version 4.2.2 (R Core Team, 2021). Response time data were transformed using the inverse function to obtain more normally distributed data (Lo & Andrews, 2015). The fixed effects for the models were the main effects of task level (level-1, level-2), perspective (self, other) and congruency (congruent, incongruent) as well as their interactions. The three variables were factorized and deviation coded. To exclude the speed-up effect, the number of trials was scaled and added as a fixed effect.

We included random intercepts for subjects and stimuli, and random slopes by-subjects and by-stimulus. The maximum models for RTs and accuracy rates included intercepts from both random effects, slopes for within-subject factors (1+tasklevel*perspective*congruency | subject) and slopes for within-stimulus factors (1+perspective | trial). When the model did not converge with the maximum random effects structure, we simplified the model by firstly removing random slopes, then random intercept, then fixed interaction effects, then fixed main effects until the model converged (Barr et al., 2013). The drop1 function from the lmerTest package (Kuznetsova et al., 2017) was used to identify the best fitting model. The best-fitted model were presented in the Appendix.

A particular main effect or interaction was obtained by comparison between the model with the effect and the model without the effect by ANOVA (Winter, 2019). Simple

effects in interaction were checked by using the emmeans function in the emmeans package (Winter, 2019).

The results are shown in Table 3.1 and Figure 3.4. Participants were significantly faster in the level-1 task than in the level-2 task. Participants also responded significantly faster and more accurately in the self-oriented condition than in the other-oriented condition. Finally, participants responded faster and more accurately in the congruent condition than in the incongruent condition.

Importantly, we found a significant two-way interaction effect between perspective and congruency, rather than a three-way interaction of perspective x congruency x task level, for both response times ($\chi2 = 10.38$, $p = .001$) and accuracy ($\chi2 = 142.25$, $p < .001$). Post hoc analyses showed that congruent and incongruent conditions significantly differed in the other perspective (i.e. egocentric interference) for both response times ($z = 5.99$, $p < .001$) and accuracy ($z = 6.76$, $p < .001$). Participants responded faster and more accurately in the congruent condition than in the incongruent condition. This replicated what had been found for previous versions of these two tasks. No significant difference between the congruent and incongruent conditions in self-perspective (i.e., altercentric interference) were found for either response times ($z = 1.049$, $p = .290$) or accuracy ($z = 1.35$, $p = .177$). Thus, we were unable to replicate the congruency effect in level-1 self-VPT (Samson et al., 2010; Surtees et al., 2016).

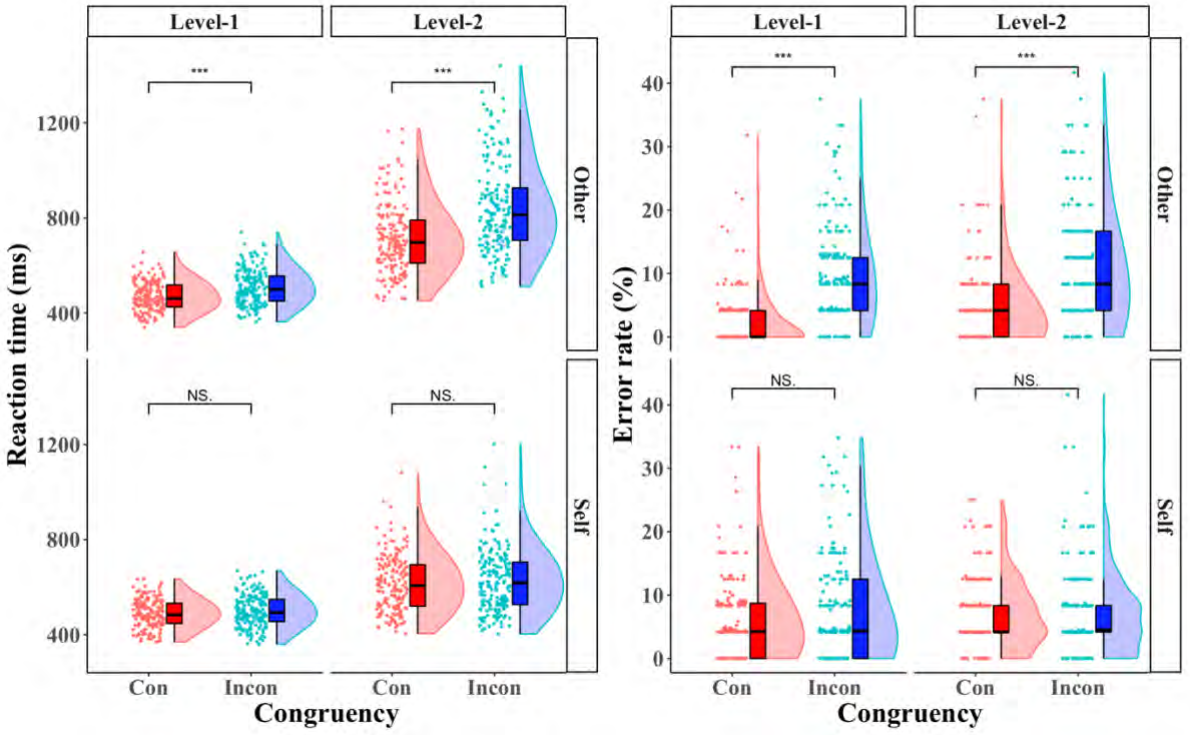
Table 3.1

Results for the Fixed Mixed Effect Model for Response Times and Error Rates in VPT Tasks

	β	***SE***	***χ2***	***df***	***p***
(a) response time					
Tasklevel	0.54	0.03	88.01	1	< .001
Perspective	0.15	0.02	26.82	1	< .001
Congruency	0.12	0.03	12.46	1	< .001
Tasklevel*Perspective	0.39	0.04	45.36	1	< .001
Tasklevel*Congruency	0.01	0.06	0.01	1	.919
Perspective*Congruency	0.15	0.04	10.38	1	.001
Tasklevel*Perspective*Congruency	0.12	0.09	1.82	1	.177
(b) error					
Tasklevel	0.74	0.15	2.16	1	.142
Perspective	1.24	0.06	18.96	1	< .001
Congruency	0.43	0.09	14.47	1	< .001
Tasklevel*Perspective	0.75	0.07	8.79	1	.003
Tasklevel*Congruency	1.58	0.63	1.285	1	.257
Perspective*Congruency	0.32	0.03	142.25	1	<.001
Tasklevel*Perspective*Congruency	1.44	0.28	3.41	1	.065

Figure 3.4

Comparisons of Responses times (left) and Error Rates (right) for Congruent and Incongruent Conditions in Self-perspective and Other-perspective Level-1 and Level-2 VPT tasks



Note. The difference between incongruent and congruent trials indicates the egocentric and altercentric interference in VPT task. * $p < .05$. ** $p < .01$. *** $p < .001$. *NS* = nonsignificant.

Linear Mixed Effect Model Analyses of Flanker and Colour-shape Tasks

For the Flanker task, a linear mixed effects model for reaction times and a generalised linear mixed effects model for accuracy were conducted. Response time data were transformed using the inverse function to obtain more normally distributed data (Lo & Andrews, 2015). The fixed effect of the models was congruency (congruent, incongruent), which was factorised and deviation coded. Participants and trials were added as random effects. The interaction of congruency by participant was added as a random slope. Trial

numbers were scaled and added as a fixed factor to exclude a speed-up effect. The main effect of congruency interference was calculated by comparing models with and without congruency (Winter, 2019). For the Colour-shape task, the data analysis strategy was the same as for the Flanker task, the only difference being that the switching interference effect (stay versus switch) instead of the congruency effect was investigated.

The results of Flanker task (see Table 3.2 and Figure 3.5) highlighted a significant difference between the congruent and incongruent conditions for both response times and error rates. Participants responded significantly faster and more accurately in the congruent condition than in the incongruent condition. This replicated previous findings (Zhou & Krott, 2018).

The results of the Colour-shape task (see Table 3.2 and Figure 3.6) revealed a significant difference between the stay and switch conditions for both response times and error rates. Participants responded significantly faster and more accurately in the stay condition than in the switch condition. These results replicated previous studies (Stasenko et al., 2017).

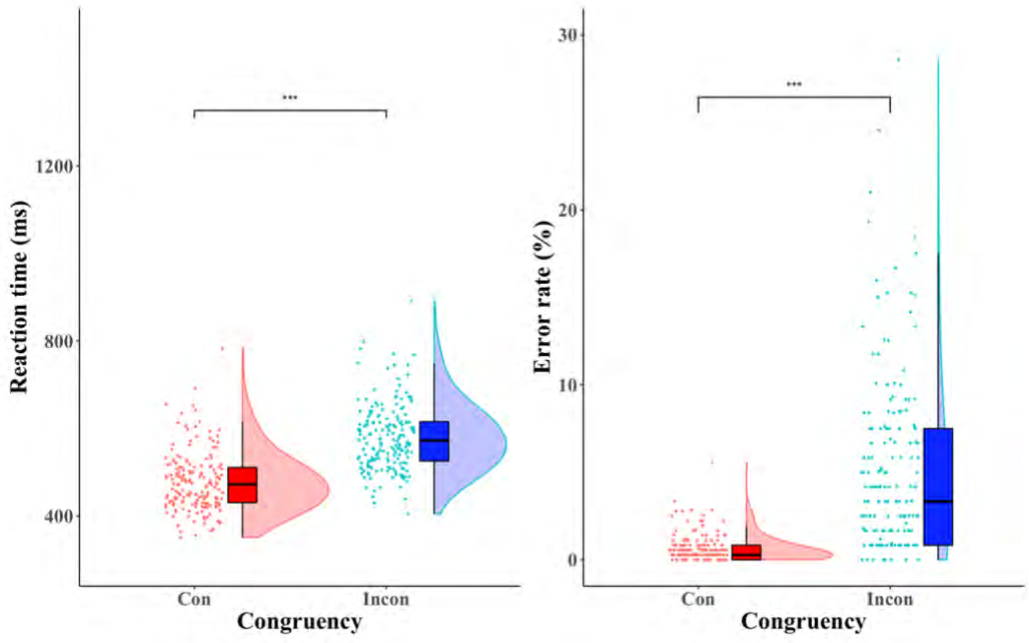
Table 3.2

Results for the Maximum Models and Main effects for Response Times and Accuracy in Flanker Task and Colour-shape Task

	β	*SE*	*χ2*	*df*	*p*
(a) Flanker task-response time					
Congruency	0.4	0.01	21.34	1	< .001
(b) Flanker task-error rate					
Congruency	0.12	0.01	21.99	1	< .001
(c) Colour-shape task-response time					
Switching	0.07	0.01	71.97	1	< .001
(d) Colour-shape task-error rate					
Switching	0.52	0.03	94.27	1	< .001

Figure 3.5

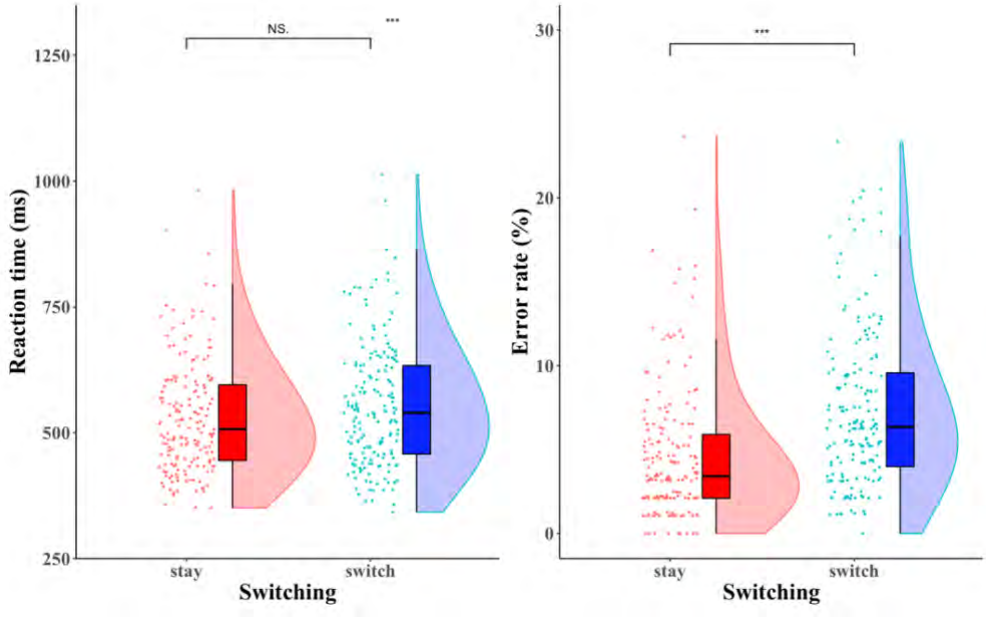
Group Comparisons of Responses Times (left) and Accuracy (right) for Congruent and Incongruent Conditions in Flanker Task



Note. The difference between incongruent and congruent trials indicates the inhibition interference in Flanker task. * $p < .05$. ** $p < .01$. *** $p < .001$. *NS* = nonsignificant.

Figure 3.6

Group Comparisons of Responses times (left) and Accuracy (right) for Switch and Stay Differences in Colour-shape Task



Note. The difference between switching and non-switching trials indicates additional processes due to switching. * $p < .05$. ** $p < .01$. *** $p < .001$. *NS* = nonsignificant.

Summary

The results of the replication confirmed significant egocentric interference, inhibition interference and switching interference. We did not find a significant altercentric interference. Therefore, in the following analyses we focused on egocentric, inhibition and switching interference.

Step 2: Dimensionality Reduction of Dependent Variables

The principle of aggregation stresses that the sum score of a serious of multiple measurements is a more stable and representative estimator than any single measurement (Rushton et al., 1983). Thus, at step 2, we created composite scores for dependent variables to

increase reliability of our results and to simplify our analyses. More specially, we created composite scores for the egocentric interference in VPT task, inhibition in the Flanker task and switching interference in the colour-shape task.

Egocentric Interference in VPT Task

In case of the VPT tasks, we were interested in egocentric interference, that is the influence of a participant's own perspective on their ability to verify what the avatar sees. We compared the performance between trials where stimuli were congruent from different perspectives and where stimuli were incongruent from different perspectives, in other-perspective level-1 and level-2 tasks.

To get a simplified measure of performance per index, a measure of tasks' egocentric interference was calculated in three steps. In first step, we built up a composite score for each condition (congruent vs incongruent) by standardizing the RT and accuracy rate scores, and then summed up the inverted standardized RT score and standardized accuracy score (Bruyer & Brysbaert, 2011). A higher value of the composite score indicated better performance. In the second step, we built up a regression model by regressing the incongruent condition on the congruent condition. In the last step, the residuals of the model were taken as the egocentric index (DeGutis et al., 2013). In this measure, the higher index reflects a better performance in VPT task, that is less interference from an egocentric perspective, thus, less egocentric bias. The index we created increases as interference decreases. This is because the index we created combining INVERSED RTs and accuracy, then the index is the residuals of regressions of incongruent condition on congruent condition. Whereas interference has typically been calculated as the RT of the incongruent condition minus the congruent condition (Bruyer & Brysbaert, 2011; DeGutis et al., 2013).

$$Interference = Resid(lm((-Z_{RT} + Z_{acc})_{Incon} \sim (-Z_{RT} + Z_{acc})_{Con}))$$

Inhibition Interference in Flanker Task

The same approach as that for egocentric interference in VPT task was applied to calculate inhibition interference in the flanker task, which refers to inhibit impulses and to react in a reasonable way, which helps to accomplish the task. To generate a composite score for inhibitory control, RTs and accuracy scores for the congruent and incongruent conditions were standardized and summed with reversed signs for RTs. Next, residuals were calculated by regressing the congruent condition onto the incongruent condition and by calculating the inhibitory index as residuals from the regression model. This meant that a higher inhibitory index indicated better performance, thus a smaller inhibition cost.

Switching Interference in Colour-Shape Task

The same approach as above was applied to calculate a switching index. This is measured by comparing the performance between stay trials and switch trials. To generate a composite score for cognitive switching, response time and accuracy values for the stay and switch conditions were standardized and summed with reversed signs for response time. This way, higher values of the switching composite values indicated better performance. Next, we regressed the stay condition onto the switch condition and calculated the switching index as residuals from the regression model. Thus, a higher switching index corresponded to better performance and a smaller switching cost.

Step 3: Experimental Results – Group Comparisons

At step 3, we investigated whether the three participant groups differed in egocentric interference[2]. Table 3.3 summarises the descriptive statistics and group differences based on one-way ANOVAs (groups: EA-Bil, EU-Bil and B-Mono) for age, SES, bilingualism, collectivism, individualism, acculturation, inhibition, switching, and level-1 and level-2 egocentric VPT indexes.

Table 3.3

EA-Bil, EU-Bil and B-Mono Group Comparison

	EA-Bil		**EU-Bil**		**B-Mono**		**Statistical analyses**	***p***
	N	***M (SD)***	***N***	***M (SD)***	***N***	***M (SD)***		
Age**	63	20.8 (3.71)	61	20.3 (2.66)	60	19.2 (1.26)	$F(2, 181) = 5.84$	< .01**
SES	58	3.65 (0.96)	58	3.91 (1.11)	58	3.79 (1.12)	$F(2, 171) = 0.91$	0.403
Bilingualism***	62	12.9 (4.44)	61	9.81 (4.33)	60	-5.60 (1.79)	$F(2, 180) = 425.80$	< .001***
Collectivism***	63	5.83 (0.96)	61	6.51 (0.87)	60	6.87 (0.91)	$F(2, 181) = 20.37$	< .001***
Individualism	63	6.00 (1.06)	61	6.20 (1.05)	60	6.10 (0.98)	$F(2, 181) = 0.59$	0.555
Acculturation	63	1.81 (1.27)	61	1.45 (1.17)	60	4.19 (3.09)	$F(2, 181) = 32.59$	< .001***
Inhibition*	63	0.17 (0.99)	58	0.07 (0.75)	59	-0.25 (1.07)	$F(2, 177) = 3.19$	.044*
Switching	60	0.07 (0.74)	59	-0.01 (0.96)	59	-0.07 (0.84)	$F(2, 175) = 0.42$	0.658
Level-1-ego	61	0.13 (1.11)	59	-0.05 (1.37)	58	-0.09 (1.27)	$F(2, 175) = 0.55$	0.576
Level-2-ego	60	0.13 (0.89)	60	0.03 (1.20)	57	-0.16 (1.42)	$F(2, 174) = 0.89$	0.414

Note. Overall p values indicate significant level (* $p < .05$. ** $p < .01$. *** $p < .001$).

The three groups of participants differed significantly in terms of age, bilingualism, collectivism and inhibition index. In terms of age, the EA-Bils were older than the EU-Bils and B-Monos ($t = 3.37$, $p < .01$). In terms of bilingualism, both bilingual groups (EA-Bils and

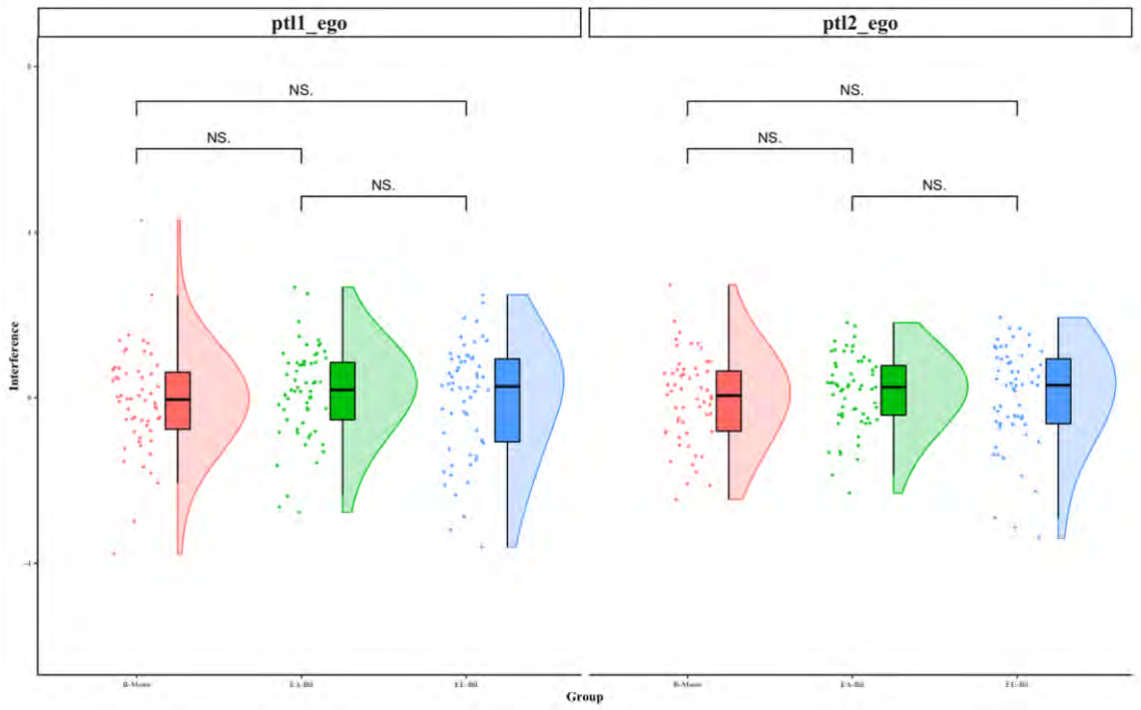
[2] Additional data analysis concerning the comparison of the raw RTs and error rates between three groups can be found in the appendix.

EU-Bils) scored higher than B-Monos (EA-Bils vs B-Monos: $t = 27.32$, $p < .001$; EU-Bils vs B-Monos: $t = 22.67$, $p < .001$), which is consistent with the LSBQ design that the scores of the bilinguals are higher than 1.23 and the ones of the monolinguals are lower than -3.13. However, EA-Bils scored higher than EU-Bils ($t = 4.58$, $p < .001$), indicating a higher level of bilingualism for the East-Asian than the European group. In terms of collectivism, EU-Bils and B-Monos scored higher than EA-Bils (EA-Bils vs EU-Bils: $t = 4.14$, $p < .001$; EA-Bils vs B-Monos: $t = 6.26$, $p < .001$), indicating that the European groups were more collectivist than the East-Asian group. This goes against our expectation that EA-Bils would be the most collectivist. In terms of inhibition, EA-Bils had a higher inhibition index than B-Monos ($t = 2.43$, $p< .05$), while EU-Bil group was not different from the other two groups, thus, suggesting that EA-Bils spent less effort on inhibition than B-Monos. In terms of acculturation, B-Monos scored higher than EA-Bils ($t = 6.50$, $p < .001$) and EU-Bils ($t = 7.43$, $p < .001$) while the two bilingual groups did not differ, meaning that monolingual group was less integrated into two cultures than both bilingual groups. There was no difference among the three groups in terms of switching ability, socioeconomic status or individualism.

Importantly, comparing the groups in terms of their VPT, we found that the groups did not differ in terms of egocentric bias (see Figure 3.7), neither in level-1 VPT nor in the level-2 VPT.

Figure 3.7

Group Comparison of Egocentric Index in Level-1 and Level-2 VPT Tasks



Note. * $p < .05$. ** $p < .01$. *** $p < .001$. *NS* = nonsignificant.

Step 4: Correlation and Regression Analyses

We then conducted individual difference analyses in form of correlation and regression analyses. We did this for two reasons. First, with the group of monolingual participants scoring higher in collectivism than the East Asian bilingual group, our participant groups did not differ as we had expected. An individual differences approach provides an alternative way of treating the data that does not make assumptions about the cultural orientation of particular groups. Second, bilingualism is not a categorical variable (Grosjean & Li, 2013) and a group comparison is a relatively insensitive way of studying the effects of bilingualism and culture. Individual differences, such as executive functions, cultural orientation and acculturation, may also influence perspective-taking performance. We first investigated whether continuous measures of bilingualism, acculturation, individualism,

collectivism, and executive functions, as well as the control variables age and SES were related to perspective-taking skills. We then conducted hierarchical regression analyses to examine how bilingualism influences perspective-taking independently of executive functions and cultural factors, controlling for age and SES.

Table 3.4 shows the correlations coefficients of the relationships between level-1 and level-2 egocentric biases with age, SES, and the indexes of inhibition, switching, collectivism, individualism, acculturation and bilingualism. We found significant relationships only for the switching index, which was positively correlated with level-1 and level-2 egocentric indexes. In other words, participants who were better switchers, showed a smaller egocentric cost when judging someone else's perspective. The egocentric bias did not correlate with bilingualism, collectivism, individualism, acculturation, or inhibition indexes. Results of the full correlation matrix, also for the three participant groups separately, can be found in the Appendix in Supplementary Tables 3.3 and 3.4.

Table 3.4

Correlation Coefficients for Relationships of Bilingualism, Collectivism, Individualism, Acculturation, Inhibition and Switching Indexes with Level-1 and Level-2 Egocentric Indexes

Variables	PT-1-Ego	PT-2-Ego
Age	-0.06	-0.06
SES	0.1	0.13
Inhibition	0.08	0.1
Switching	0.16*	0.29***
Collectivism	0.06	-0.08
Individualism	0.14	0.02
Acculturation	-0.01	-0.07
Bilingualism	0.05	0.11

Note. * $p < .05$. ** $p < .01$. *** $p < .001$.

Regression Analyses

We next investigated whether bilingualism was associated with egocentric bias in VPT independently of a relationship with executive function and culture difference. We conducted hierarchical multiple regression analyses for both level-1 and level-2 egocentric biases with age and SES as control variables, executive function (inhibition and switching) and cross-cultural difference (individualism, collectivism and acculturation) as theoretical control variables, and bilingualism as predictors of interest. All continuous variables were standardized to make sure different variables could be compared on a similar scale. We conducted analyses in R version 4.2.2 (R Core Team, 2021) using the lm function from the lme4 package (Bates et al., 2015). Variables were entered in four steps. We first controlled for age and SES (in step 1), then for inhibition and switching (in step 2) and for individualism, collectivism, acculturation (in step 3). After that we added the bilingualism index to test for an additional contribution (in step 4) (Agresti & Kateri, 2021). We also used the vif function from the car package (Fox & Weisberg, 2018) to check for collinearity between predictors. All vifs for all regressions were around 1, meaning the degree of collinearity among variables was very low.

In terms of the model for level-1 egocentric bias, age and SES accounted for 0.8% in step 1. In step 2, a further 4.7% was explained by the executive function predictors. Switching was a significant predictor ($\beta = 0.27$, $p < .01$). Together, all variables entered in step 2 explained 5.5% of the overall variance in level-1 egocentric bias (F (2, 155) = 3.82, $p < .05$). In step 3, a further 1.5% was explained by the predictors of culture. But none of the culture factors were individually significant, and model comparison revealed that the overall addition of cultural factors did not improve model fit compared with the previous step. In step 4, a further 1.8% was explained by bilingualism. But the effect of bilingualism was not

significant, and model comparison showed no improvement in model fit compared with step 3.

In terms of level-2 egocentric bias model, age and SES accounted for 2.6% in step 1. In step 2, a further 9.7% in level-2 egocentric bias was explained by the executive function predictors. Switching was a significant predictor ($\beta = 0.35$, $p < .001$). All variables entered in step 2 together explained 12.3% of the overall variance in level-2 egocentric bias (F (2, 154) = 8.45, $p < .001$). In step 3, a further 1.7% was explained by culture. But none of the culture factors were individually significant, and model comparison revealed that the overall addition of cultural factors did not improve model fit compared with the previous step. In step 4, a further 0.9% was explained by bilingualism. But the effect of bilingualism was not significant, and model comparison showed no improvement in model fit compared with step 3.

To summarise, participants with smaller switching costs showed less egocentric interference in the level-1 and level-2 egocentric task. Neither bilingualism nor culture predicted egocentric interference suppression.

Table 3.5

Summary of the Linear-effects Model for the Level-1 and Level-2 Egocentric Indexes

Predictors	*β*	*SE*	*t*	R^2	R^2 Change	Model comparison
Level-1 egocentric bias						
Step 1 (control)				0.008	0.008	
Age	-0.05	0.11	-0.44			
SES	0.11	0.1	1.09			
Step 2 (executive function)				0.055	0.047	$F(2, 155)=3.82$*
Age	-0.06	0.11	-0.59			
SES	0.09	0.1	0.9			
Switching	0.27	0.1	2.73**			
Inhibition	0.03	0.1	0.35			
Step 3 (culture)				0.07	0.015	$F(3, 152)=0.83$
Age	-0.06	0.11	-0.55			
SES	0.06	0.1	0.64			
Switching	0.27	0.1	2.69**			
Inhibition	0.02	0.1	0.24			
Individualism	0.14	0.1	1.45			
Collectivism	0.05	0.1	0.44			
Acculturation	-0.02	0.1	-0.23			
Step 4 (bilingualism)				0.088	0.018	$F(1, 151)=2.89$
Age	-0.09	0.11	-0.83			
SES	0.08	0.1	0.81			
Switching	0.25	0.1	2.5*			
Inhibition	0.01	0.1	0.05			
Individualism	0.14	0.1	1.46			
Collectivism	0.1	0.11	0.96			
Acculturation	0.05	0.11	0.44			
Bilingualism	0.2	0.12	1.7			
Level-2 egocentric bias						
Step 1 (control)				0.026	0.026	
Age	-0.13	0.1	-1.24			
SES	0.17	0.09	1.8			
Step 2 (executive function)				0.123	0.097	$F(2, 154)=8.45$***
Age	-0.16	0.1	-1.68			
SES	0.14	0.09	1.55			
Switching	0.35	0.09	3.86***			
Inhibition	0.13	0.09	1.39			
Step 3 (culture)				0.14	0.017	$F(3, 151)=1.02$

Predictors	***β***	***SE***	***t***	***R²***	***R²* Change**	**Model comparison**
Age	-0.19	0.1	-1.95.			
SES	0.14	0.09	1.53			
Switching	0.36	0.09	3.95***			
Inhibition	0.1	0.1	1.03			
Individualism	0.02	0.09	0.22			
Collectivism	-0.15	0.1	-1.59			
Acculturation	-0.04	0.1	-0.39			
Step 4 (bilingualism)				0.149	0.009	$F(1, 150)=1.51$
Age	-0.22	0.1	-2.14*			
SES	0.15	0.09	1.63			
Switching	0.35	0.09	3.77***			
Inhibition	0.09	0.1	0.94			
Individualism	0.02	0.09	0.21			
Collectivism	-0.11	0.1	-1.13			
Acculturation	0.01	0.1	0.11			
Bilingualism	0.13	0.11	1.23			

Note. Sample size for level-1 VPT is 160 and level-2 VPT is 159. * $p < .05$. ** $p < .01$. *** $p < .001$.

From the regression analyses above, switching was the only significant predictor of both level-1 and level-2 egocentric bias. Although bilingualism and acculturation were not directly correlated with egocentric bias, we wondered whether bilingualism and acculturation might indirectly affect egocentric bias via switching. However, bilingualism was not correlated with either switching ability or VPT (see Supplementary Table 3.2). Thus, the hypothesis that bilingualism is indirectly related to VPT via switching was rejected. Similarly, acculturation was not correlated with either switching skills or VPT either. Therefore, the hypothesis that acculturation might be indirectly related to VPT via switching was rejected as well.

Discussion

Previous studies had shown that bilinguals outperformed monolinguals in inhibiting egocentric bias in VPT (Rubio-Fernández, 2017; Wu & Keysar, 2007). However, this bilingual advantage in VPT performance might be related to an executive function advantage (Long et al., 2018; Qureshi et al., 2020) or associated with cultural differences (Kessler et al., 2014; Wu & Keysar, 2007). We investigated whether bilingualism leads to better performance in VPT tasks independent of executive function skills or cultural differences. We examined whether bilinguals whose culture orientation is more collective or those who strongly identify with both heritage and host culture, would show stronger advantages in VPT. To address these questions, we tested young adults from three backgrounds, namely East-Asian bilinguals, European bilinguals and British monolinguals, on two VPT tasks, assessing both level-1 and level-2 VPT. Both tasks are capable of detecting both egocentric and altercentric tendencies.

Comparing the three participant groups on their VPT performance did not reveal any effects of bilingualism or culture: the three groups showed similar levels of egocentrism in both tasks. In addition, neither group displayed altercentric interference on any of the task. These findings were supported by individual differences analyses. They confirmed that neither bilingualism, collectivism, individualism, or acculturation predicted the suppression of egocentric interference in VPT. In contrast, switching ability predicted both level-1 and level-2 VPT egocentric interference, with better switching ability being related to better suppression of egocentric interference. Thus, our results showed that executive function, but not bilingualism or cultural differences, predicts VPT performance. These findings are crutial for approaches to cultural and bilingual differences in VPT in a number of ways, which we will discuss in the following.

Bilingual and Monolingual VPT Performance Did Not Differ

Our finding does not support the assumption that bilingualism can improve perspective-taking abilities in young adults. The bilingual advantage hypothesis suggests that bilinguals should be better at various cognitive tasks, such as interpreting and using an interlocutor's perspective online (Bialystok & Viswanathan, 2009). Our results revealed that both bilingual groups performed similarly to the monolingual group in VPT tasks. Also, the degree of bilingualism did not predict VPT performance. This null effect is in line with some previous studies which also report no bilingual advantage on VPT tasks (Ryskin et al., 2014; Wang et al., 2019). We can think of three possible explanations for this result.

First, different VPT tasks might reveal different bilingualism performances. Tasks varied across previous studies. For instance, studies using the false belief task found mixed results; some found a young adult bilingual advantage (Rubio-Fernández, 2017), while others did not (Bradford et al., 2018). Studies using the referential communication task also found mixed results; some found a young adult bilingual advantage (Navarro et al., 2022; Navarro & Conway, 2021; Wu & Keysar, 2007), while others did not (Wang et al., 2019). Our study used the level-1 dot and level-2 number VPT tasks. Wang et al. (2019) tested different participants, but used the same level-1 dot VPT task as we did, and they also did not find a bilingual advantage. We can therefore conclude with some certainty that bilinguals do not show advantages in the tasks used in the present studies.

Second, the bilingual perspective-taking advantage found quite robustly in children may not extend to young adults. Review papers have suggested that the bilingual advantage in children is quite strong (Greenberg et al., 2013; Schroeder, 2018)Diaz, 2022). While in young adults, the effect was not always present. In young adults, a bilingual advantage in executive functions has often failed to be found, and it has been argued that this is because young adults' executive function skills are mature and young adults are at their peak

performance, leaving less chance to detect the influence of bilingualism. (Poarch & Krott, 2019).

Third, monolingual and bilingual participants may differ in other ways besides their language experience. It is therefore important to take these potential influencing factors into account. The East-Asian bilinguals were significantly older than both European bilinguals and monolinguals. Age can predict egocentric and altercentric performance in level-1 and level-2 VPT (Martin et al., 2019). However, Supplementary Table 3.2 shows that age was not significantly correlated with egocentric interference in our sample, neither for the participants as a whole nor for the individual groups. In addition, age did not explain variance for egocentric interference. Therefore, age differences between groups should not be taken as the cause for the absence of a bilingual advantage. Furthermore, SES is usually considered as a potential confounding factor in bilingualism research (Rivera Mindt et al., 2008). However, all our participants were students at the University of Birmingham, and tresults of the SES analysis showed no group difference, implying that SES is also unlikely to account for the lack of a bilingual group advantage.

In summary, the most likely explanation for the lack of a bilingual advantage in VPT is that individuals' VPT abilities have reached their peak in young adults, so that the bilingual perspective-taking advantage found quite robustly in children may not extend to young adults. Interestingly, we failed to observe a benefit for bilinguals in switching but observed a small bilingual advantage in inhibition. These mixed results are consistent with previous findings (Paap et al., 2015; Zhou & Krott, 2016) and indicate that, even though there is a difference in basic cognitive functioning between bilinguals and monolinguals, this may not translate into consistent advantages in higher-level cognition, especially in young adults.

Cultural Differences Did Not Predict VPT Performance

The current study shows for the first time that people from collectivist cultures experience as much egocentric bias as people from individualist cultures, in both level-1 and level-2 VPT tasks. This finding is in line with the results by Wang et al. (2019) and Bradford et al. (2018), but appears to be inconsistent with those of Wu and co-workers (Wu et al., 2013; Wu & Keysar, 2007). A possible explanation is that Wu and co-workers used a referential communication task, while we used the VPT task. However, Wang and co-workers did not find that culture factors influence VPT performance in either the referential communication task or level-1 dot VPT task, meaning that the type of task cannot fully explain the differences. Furthermore, our finding confirmed the null result by Wang and co-workers and extended it to a level-2 number VPT task. This findings indicate that the early egocentric tendency detected by Wu and his coworkers (2013) for Eastern participants may not always be corrected in time and can affect behavioural responses also in this type of participants.

Importantly, though, and against our expectations, East-Asian bilinguals who took part in our study were not more collectivist than European bilinguals or British monolinguals. Instead, they were less collectivist than the other two groups. East-Asian bilinguals also did not differ from the other two groups in terms of individualism. This result does not align with the argument of stronger collectivist traits in East-Asian participants than in Western participants (Markus & Kitayama, 1991; Triandis & Gelfand, 1998). We can think of three possible reasons for our finding.

First, the East-Asian participants in our study left their country to go abroad. They might not be typical East-Asian people, but instead might be more focussed on their own than Eastern Asian individuals who chose to stay home. This is supported by the finding that Chinese students who choose to study overseas are from a higher social status, with a higher

level of international perspective (Wang & Crawford, 2021). Also, it has been found that the sense of self of international students is affected by cultural differences in overseas experience (Tavares, 2021). Being immersed in an individualist culture as in the U.K. might also contribute to East-Asian individuals become less collectivist. In our study, we tested participants' acculturation scores, being able to test whether the lower collectivism score of East-Asian bilinguals was due to their attitudes toward their two cultures. The heritage culture score represented how much they identified with their heritage culture, while the host culture score represented how much they identified with the host culture. It might be that even though Eastern cultures as a group tend to be collectivist, East-Asians, in particular those who took part in our study, were more detached from their heritage Eastern culture and identified more closely with the host (Western) culture. This might lead them to be as individualistic and less collectivist than individuals from Western cultures (here British monolinguals and European bilinguals). However, the group comparison revealed that the East-Asian bilinguals and European bilinguals did not differ in acculturation scores, meaning they identified very similarly with their two cultures. Therefore, the finding of East-Asian bilinguals being less collectivist than the other two groups was unlikely be caused by a reduced identification with their heritage culture.

Second, another possible explanation is that the assumption of Eastern cultures being more collectivist and less individualist than Western cultures might be wrong. Lomas et al. (2023) examined this assumption in the 2020 Gallup World Poll, which involved more than one hundred thousand participants in one hundred and sixteen countries. The results showed that, contrary to expectations, Easterners were more self-centred than Westerners. Thus, the East seems more individualistic and the West less individualistic than expected.

Third, the concepts of individualism and collectivism might be more complex than anticipated and the Culture Orientation Scale might not reflect the type of collectivism and

individualism that is relevant for VPT. While our findings using the Culture Orientation Scale (Triandis & Gelfand, 1998) suggest Eastern culture is less collectivist, Lomas and his colleagues using their own measure (Lomas et al., 2023) found Eastern culture to be more individualist. Moreover, Bradford et al. (2018) tested participants' culture orientation using the AICS questionnaire, developed by Shulruf and his colleagues (Shulruf et al., 2007) and they found that a Chinese group scored higher in terms of collectivism than a Western group and the two groups scored similarly in terms of individualism. To sum up, the results are not consistent across the different studies that have used different types of questionnaires. Therefore, we need to be cautious in interpreting the current results. How we measure cultural orientation can make a difference and a different measure of cultural orientation might significantly predict VPT.

Furthermore, our results are inconsistent with the culture orientation framework of Triandis (1996) and Markus and Kitayama (1991). They argue that collectivism and the interdependent self leads to less egocentric bias and more altercentric tendency. We found that East-Asian bilinguals scored lower in terms of collectivism than the two European groups. Therefore, we should see a higher egocentric interference in East-Asian bilinguals than in the other two groups. But we did not find this. To sum up, while our participant groups differed in terms of collectivism, these differences and therefore cultural orientation did not influence task performance.

The reason why culture and bilingualism did not predict VPT performance might be because VPT ability becomes more stable and more similar across participants in adulthood (Surtees & Apperly, 2012). Interestingly, none of our factors reflecting differences in experience and socialisation predicted VPT. This is different from infancy, childhood and adolescence, where it is quite common to observe various factors influence VPT, such as neural, cognitive, psychological, and social factors (Devine & Lecce, 2021). This is in line

with Kessler et al.'s (2014) proposition that all adults share basic processes involved in calculating VPT.

Switching Index Predicts Egocentric Bias

According to Kessler et al. (2014) and Wu et al. (2013), when participants are asked to take another person's perspective, they all start with an egocentric perspective, but then suppress this and switch to the other's perspective. We found that switching ability predicted egocentric interference suppression in both level-1 and level-2 VPT, while inhibition ability predicted neither. Since it is generally assumed that inhibition is part of switching, it does not seem to be the inhibition aspect of switching that is predictive of egocentric interference. Instead, it might be cognitive flexibility, that is the skill to switch smoothly between one rule to the other or one perspective to the other that is important in egocentric suppression in VPT. Thus, we did not find inhibitory control predicts VPT performance.

The egocentric effect derived from calculating the interference between congruent and incongruent conditions in the "other" VPT tasks is aligned with the independent measure of switching derived from calculating the interference between switching and non-switching conditions. This may cast doubts on whether the "other" VPT tasks involve "switching" since they always follow the sessions of "self" VPT tasks. However, the measure of egocentrism was obtained through the interference of Other-Incongruent and Other-Congruent trials. Both trial types likely require a "switch" from the preceding "self" trials, hence, it is improbable that the variation between them is due to the need for switching.

No Significant Altercentric Interference

Altercentric interference is spontaneous perspective computation that illustrated by interference from another's VPT when reporting one's own. In VPT tasks, we expected to find

a significant congruency effect in the level-1 self-perspective condition, but not in the level-2 self-perspective condition (i.e., in altercentric interference) (Surtees et al., 2016). However, in our experiment, we found no evidence of altercentric interference, neither in level-1 nor in level-2 VPT. Supplementary Figure 3.2 shows that the lack of this effect is consistent across participants groups. Thus, we did not replicate the congruency difference in level-1 self-VPT. We are not the only one failing to replicate the expected altercentric bias. Other studies have found that altercentric bias can be decreased or avoided if participants retain their own perspective (Capozzi et al., 2014; Gardner et al., 2018; O'Grady et al., 2020).

The absence of a self-perspective congruency effect during VPT might contribute to an on-going debate whether VPT arises automatically (Furlanetto et al., 2016; Surtees et al., 2012), spontaneously (Freundlieb et al., 2017, 2018; Samson et al., 2010; Surtees et al., 2016), or neither. According to previous studies (O'Grady et al., 2020; Holland et al., 2021), if a self-perspective congruency effect was observed in explicit tasks, VPT is likely to arise unintentionally and spontaneously. If a self-perspective congruency effect was observed in implicit tasks, VPT is likely to arise automatically and cannot be inhibited. A self- and other-perspective mixed design (i.e., mixing self- and other-perspectives in a single task) was taken as explicit VPT task, while a self- and other-perspective blocked design (self-perspective task and other-perspective task are tested in two separate tasks and on separate days) was taken as more implicit VPT task (Samson et al., 2010; Surtees et al., 2016). Our experiment is a blocked design and therefore an implicit VPT task. The absence of self-perspective congruency effect in our study therefore indicates VPT is not an automatic process. Attention systems might need to prompt participants to represent other's perspectives (O'Grady et al., 2020). However, although the effect of altercentric interference is significantly influenced by attentional and intentional factors, a meta-analysis of perspective-taking in the dot/disc task found that studies generally find congruency interference in both explicit and implicit cueing

conditions, although the effect size is smaller in the explicit cueing condition (Holland et al., 2021).

Another potential reason for the absence of altercentric interference might be that altercentric effects were over-ridden by participants' strategic control. In our experiment, participants were constantly instructed to make judgments from their own perspective. It is possible that the participants started to reframe the task in order to reduce the cognitive effort. Rather than explicitly attributing "perspective" to themselves, participants may have only identified the number of dots visible in the picture stimuli in level-1 VPT and the number on the desk or wall in level-2 VPT. In other words, it is possible that participants choose not to consider the other's perspective, meaning that self-perspective congruency effects could not be observed.

Correlation between Level-1 and Level-2 VPT Tasks

Performance of the three participant groups in the level-1 and level-2 VPT employed in the current study was remarkably similar. All groups were affected by their own perspective when making other-perspective oriented judgements. All groups also failed to show automatic calculation of others' perspectives in self-perspective oriented judgements.

However, there was no significant correlation between the degrees of egocentric bias in the two tasks (See Supplementary Table 3.2). This finding rather suggests that they are distinct processes (Flavell et al., 1981), reflecting the respective requirements and characteristics of what participants perceive versus how they perceive it. In addition, egocentric tendencies are possibly related to different contexts. They are likely to appear depending on situational requirements for processing.

It is common to find that perspective-taking tasks are not correlated with each other. Qureshi and co-workers found that the director task and the level-1 VPT task were not

correlated, but were independently correlated with different inhibitory tasks. The director task performance was related with conflict inhibition while VPT was more correlated with switching inhibition (Qureshi et al., 2020). Wang and her collaborators also found no correlation between the performance on the director task and on the level-1 VPT task (Wang et al., 2019). De Lillo and Ferguson found that level-1 and level-2 VPTs were highly correlated (De Lillo & Ferguson, 2023). Their task setting, manipulation and interference calculation methods are different from ours. In their study, level-1 and level-2 tasks used the same avatar setting, whereas in our study the two levels of tasks used different paradigm settings. Furthermore, in their study, the egocentric index was calculated from the logarithmic reaction times for both level-1 and level-2 judgments. The index in our study was the composite of reaction time and accuracy. What is more, other factors besides cognitive demands may influence the differences in performance between level-1 and level-2. Further work is necessary to explore other factors affecting adult VPT and explaining individual differences in social cognition.

Limitation

Our study has some limitations. Firstly, our self-selected sample from university students following a Psychology degree is not necessarily a reflection of the general population of young adults (Hanel & Vione, 2016). Also, psychology students may be familiar with common experimental procedures and may unintentionally change their behaviour to match their understanding of the purpose of the study (Khatamian Far, 2018).

Another restriction of this study is the predominance of female participants. Gender has been revealed to be one of the influencing factors in VPT experimental tasks (Eisenberg & Lennon, 1983; Samuel et al., 2023). For instance, Kessler et al. (2012, 2014) discovered that adult females exhibit a stronger effect of manipulating body posture when making

left/right judgments from alternative perspectives in VPT tasks as compared to males. These results suggest that females outperformed males in embodiment. Females tended to be more empathetic while males were more inclined towards systemizing. However, it is possible that females may have less flexibility in spatial rotation of bodily representations. Relatively, males exhibited superior performance in mental rotation and spatial perception tasks, such as car parking skills and direction estimation (Lauer et al., 2019; Lin et al., 2023). To sum up, it should be noted that gender was not considered as a factor in this study, which may limit the depth of understanding of observed effects.

In addition, the scenarios in both level-1 and level-2 paradigms do not meet the demands of a real-life communication scenario. In real life, communicators are often required to track the perspectives of multiple interlocutors. It is possible that one would find different results in social interaction situations where participants need to spontaneously track others' perspectives in communications. Future studies should look at cross-language and cross-cultural differences in VPT, involving more realistic communication and interactions.

Conclusion

The aim of the present study was to explore a bilingual advantage in level-1 and level-2 VPT independent of executive function and cultural differences. We compared VPT abilities in three groups: East Asian bilinguals, European bilinguals, and British monolinguals. We also conducted individual differences analyses. Results from both the level-1 and level-2 VPT tasks revealed a similar egocentric bias for all three groups and no altercentric bias in any of the groups. While the groups did not show the expected differences in cultural orientation, individual differences analyses confirmed the results and showed that only switching ability predicted egocentric interference, at both level-1 and level-2 VPT. These results therefore support the idea of core similarities in VPT mechanisms across

language experience and culture. They also suggest that the bilingual advantage in perspective-taking found in children does not appear to apply to young adults.. The VPT ability of young adults appears to be less affected be socialisation, including culture and bilingualism, than that of children.

CHAPTER 4

MULTILINGUALISM IS NEGATIVELY ASSOCIATED WITH PROSOCIAL BEHAVIOUR IN YOUNG ADULTS, MEDIATED BY EMPATHIC CONCERN

Abstract

Multilingual speakers have been found to demonstrate increased empathy (Dewaele & Li, 2012) compared to monolinguals (but see Ghoreyshi Rad et al. (2020)). Also, empathy is closely related to prosocial behaviour (Davis, 1983). The present study tested whether multilingualism, especially frequency of language use and language proficiency, promotes prosocial behaviour and, if so, whether this is mediated by empathy.

126 monolinguals, 126 bilinguals, and 50 participants knowing three to five languages filled in the Language and Social Background Questionnaire (Anderson et al., 2018), the Prosocialness Scale (Caprara et al., 2005) and the Interpersonal Reactivity Index (Davis, 1983) (measuring empathy), plus the Culture Orientation Scale (Triandis & Gelfand, 1998) and a Socioeconomic Status (SES) questionnaire to control for confounds. We measured multilingualism as self-reported language use frequency and proficiency across languages.

Analyses of the four empathy subscales (Perspective taking, Fantasy Score, Empathic Concern, Personal Distress) showed that multilingualism negatively predicted empathic concern and personal distress. In addition, multilingualism predicted prosocial behaviour indirectly (and negatively) via empathic concern.

These results suggest that being multilingual does not associate with higher but lower prosocial behaviour than being monolingual, and that this is due to lower empathic concern. The negative relationship with empathic concern might be due to multilinguals being more emotionally stable than monolinguals and being less impacted by emotional distraction. Furthermore, multilinguals scoring lower in terms of personal distress confirmed that bilinguals are less anxious than monolinguals.

Introduction

As many studies have shown, the bilingual advantage goes beyond executive control. Indeed, bilingualism was found to be associated with perspective-taking (Rubio-Fernández, 2017; Greenberg et al., 2013; Navarro & Conway, 2021; Wu & Keysar, 2010), creativity (Kharkhurin, 2010), diversified thinking (Hommel et al., 2011) and personality (Dewaele & Wei, 2013). It has also been shown to increase empathy (Dewaele & Li, 2012). In this study, we investigated how multilingualism influences different dimensions of empathy such as perspective taking, empathic concern, etc. Furthermore, empathy is closely related to prosocial behaviour (Yin & Wang, 2022), that is voluntary behaviour intended to benefit another, such as offering the seat on the bus to a disabled person or making a donation to a charitable organisation (Eisenberg et al., 2007). But to date no study has investigated the potential relationship between multilingualism and prosocial behaviour. An understanding of what promotes empathy and prosocial behaviour is important because by understanding and sharing the emotions of others, individuals can cultivate a greater sense of compassion and actively contribute to the welfare of others and society. We therefore investigated whether multilinguals are more likely to engage in prosocial behaviour and whether this is due to heightened empathy.

Multilingualism and Empathy

Empathy is the ability to put oneself in another's shoes. It is the ability to understand or perceive what others are experiencing from their frame of reference (Preston & Waal, 2001; Riess, 2017). Empathy is an essential social skill. It helps people to share their feelings, experience, desires, etc., and promotes prosocial behaviour (Riess, 2017). It also facilitates us to feel valued, loved and cared for. Empathy leads to a connection to others, and being connected to others is good for our mental well-being (Saeri et al., 2018).

Research has suggested a relationship between multilingualism and empathy. Dewaele & Li (2012) conducted a worldwide online questionnaire study, recruiting 2158 participants from 204 different nationalities. They explored the relationship between multilingualism and empathy, using the Empathy Quotient (Baron-Cohen & Wheelwright, 2004). They found that aspects of multilingualism, including language proficiency and frequency of multilingual use were highly correlated, and that the latter were weakly but significantly correlated with cognitive empathy. In contrast, other aspects of bilingualism such as the number of languages known by a multilingual and their linguistic history were not related. Similarly, Javor (2017) investigated a bilingual advantage in empathy and theory of mind, testing 240 Hungarian-Serbian bilinguals and Hungarian monolinguals. Empathy was tested by Davis' Interpersonal Reactivity Index (Davis, 1983). Bilinguals outperformed monolinguals in both theory of mind and empathy. Also, percentage of second language usage positively correlated with the empathy score, and early bilinguals were more empathic than later bilinguals. Tarighat & Krott (2021) confirmed the bilingual advantage on the perspective taking dimension of the Interpersonal Reactivity Index (Davis, 1983) with a sample of monolingual and bilingual speakers in Iran, but found that bilingualism only enhanced perspective taking in males, not females. While these studies suggest a multilingual advantage in perspective taking, especially a positive relationship with multilingual proficiency and frequency of language use, Ghoreyshi Rad et al. (2020) failed to find a bilingual empathy advantage in a sample of Azari-Persian bilinguals and Persian monolinguals. They investigated participants' performance in social cognition (mindreading), motivation, inhibitory control and empathy by using the reading the mind in eyes test (Baron-Cohen et al., 2001) and an executive function index (Ahmadi et al., 2017). Results showed bilinguals outperformed monolinguals in social cognition and inhibitory control, but not in motivation and cognitive empathy.

Empathy is closely related to other concepts such as emotional intelligence and emotional perception (Lewis et al., 2010). Emotional intelligence is the ability to listen to, understand and feel other's feeling and to express emotions in an efficient way (Ioannidou & Konstantikaki, 2008). Emotional intelligence is partly measured with questions that are very similar to those measuring empathy: "Seeing things from another person's position is often difficult for me" (Petrides & Furnham, 2003). Alqarni & Dewaele (2020) found a bilingual advantage for emotional intelligence and emotional perception. They recruited 205 Arabic-English bilinguals, 71 Arabic monolinguals and 333 English monolinguals adults for an online trait emotional intelligence questionnaire and emotion perception task. Compared to the monolingual groups, Arabic-English bilinguals had a significant but small emotional advantage, in both emotion perception and intelligence. In contrast, Dewaele (2021) failed to find a multilingualism advantage in trait emotional intelligence. He re-analysed the data of three previous studies with in total 1278 participants to explore the association between multilingualism and trait emotional intelligence. He found multilinguals failed to outperform monolinguals, indicating bilingualism effect in emotional intelligence was susceptible and weak. The inconsistencies could be due to differences in measurement and instructions. They concluded that differences in results across studies could be caused by variations in the underlying concepts, methods, or measurement techniques applied. It is also noteworthy to point out that the effect size of the bilingualism advantage in Alqarni and Dewaele's study (2020) was small.

Empathy is also an aspect of personality (Johnson et al., 1983). The multicultural personality questionnaire (van der Zee et al., 2013) contains a cultural empathy subscale, which measures the capacity to empathize in diverse cultural context and includes item such as "Sympathizes with others", "Pays attention to the emotions of others". Dewaele & Stavans (2014) found multilinguals scored higher on the cultural empathy subscale when recruiting

193 Israeli, aged between 13 to 72. Participants with an immigrant parent, rather than locally born parent(s), with a high level of multilingual language use, and with advanced knowledge of more languages scored higher on cultural empathy, open-mindedness, and social initiative than monolinguals. However, not all studies have found a significant correlation between multilingualism and cultural empathy (Korzilius et al., 2011).

In sum, previous studies found either no or a small multilingual advantage in empathy. In addition, different aspects of the multilingual advantage, namely language use frequency and language proficiency, were found to correlate differently with empathy, with frequency of language use being more closely related to empathy (Dewaele & Li, 2012; Javor, 2017). Therefore, we considered independent relationships with frequency of language use and language proficiency. We expected that enhanced multilingualism, especially frequency of language use, leads to higher levels of empathy.

Interpersonal Reactivity Index

The present study examined the correlation between multilingualism and various aspects of the empathy by using the Interpersonal Reactivity Index (IRI) (Davis, 1983). The IRI consists of four dimensions: (1) Perspective-taking (PT) assesses an individual's ability to transition to another person's position and adopt their perspective; (2) Empathic concern (EC) assesses other-centred sympathy and caring for others; (3) Fantasy (FS) assesses the trend towards imaginative engagement with the emotions and behaviour of characters in stories and films, (4) Personal Distress (PD) assesses an individual’s feelings of anxiety and discomfort in stressful social interaction. PT, EC and FS, are positively related with each other, while PT and PD show an inverse relationship (Davis, 1983). We choose this measure for two reasons: firstly, IRI distinguishes between different components of empathy, providing a comprehensive measurement of this complex construct. The differentiation between the four

subscales increases the precision and utility of the IRI in understanding empathy. Secondly, the IRI has been extensively used in various research fields, including psychology, psychiatry, education, and sociology (Diotaiuti et al., 2021), and across various cultures, having been translated to several languages, such as Spanish (Pérez-Albéniz et al., 2003), Chinese (Siu & Shek, 2005), Dutch (De Corte et al., 2007). It has presented a high degree of internal consistency, reliability, and construct validity across various populations and cultural contexts. This evidence supports the IRI's reliability as a measurement tool.

Multilingualism and Prosocial Behaviour

Prosociality is a core element in the success of an individual's social adaptation and it promotes cooperation and collaboration in society (Fehr & Fischbacher, 2003). Prosocial behaviour is voluntary behaviour intended to benefit others. As such, it can be distinguished from empathic concern, which refers to the affective sympathy to another's experience, and perspective taking, which refers to cognitive responses such as the ability to take another's perspective, which might or might not lead to actions for the benefit of others (Eisenberg et al., 2007). In general, prosocial behaviours refers to behaviours that help others, such as offering a seat on the bus to the disables or donate to charity. It keeps the community functioning smoothly and harmoniously. It is therefore important to study how prosocial behaviour might be promoted.

Research on the correlation between bilingualism and prosociality is rare and mainly focuses on infants and children and their judgement of behaviour rather than their own behaviour. Bilingual infants, compared to monolingual infants, have been found to be more sensitive to morally relevant social behaviour, including prosocial and antisocial behaviour (Singh, 2020). Furthermore, children's level of bilingualism, including frequency and proficiency, was found to be significantly correlated with better prosocial skills. For instance,

preschool bilingual children showed better emotion recognition and prosocial skills (Sun et al., 2021).

In young adults, a bilingual prosociality advantage has not yet been explored directly, but Miller et al. (2021) examined bilinguals' prosocial sentiment and behaviour after offense taking. The results revealed that bilingual language proficiency affected the willingness to engage in prosocial behaviour. Speakers of high proficiency increased prosocial sentiment, while low proficiency led to no change in prosocial sentiment. In addition, bilingual young adults have shown some advancement in aspects related to prosociality. For instance, bilinguals have been found to be more open-minded and to show increased social initiative (Dewaele & Botes, 2020), that is the tendency to become actively involved in social situations and to take the initiative in interpersonal setting. We would therefore expect to see a potential correlation between bilingualism and prosocial behaviour.

The potential relationship between bilingualism and prosocial behaviour is likely to be mediated by empathy. Research has consistently shown a positive correlation between empathy and prosocial behaviour. Empathy is considered one of the most important motivations for prosocial behaviours (Davis, 1983; Yin & Wang, 2022). Empathy induction substantially promotes prosocial behaviour in young adults (Mayer et al., 2018). And a high level of empathy can increase altruistic responses and facilitate prosocial moral reasoning. (Einolf, 2008). People who are more empathetic also tend to engage in more prosocial acts. These include sharing resources, volunteering and providing emotional support (Eisenberg & Miller, 1987; Lewis et al., 2010; Schroeder & Graziano, 2015). Empathy motivates prosocial behaviour by increasing people's concern for the welfare of others and their willingness to take action to help them. Among the four sub-components of empathy, that is perspective taking (cognitive empathy), empathic concern (affective empathy), fantasy and personal distress, perspective taking (Knight et al., 2015; Spataro et al., 2020) and empathic concern

(Davis & Carlo, 2020; Longobardi et al., 2019) have been identified as important predictors of prosocial behaviour.

In conclusion, bilingual infants and children have been found to be sensitive to prosocial behaviour, while young adult bilinguals potentially have a prosocial bilingualism advantage. This relationship is likely mediated by empathy, especially perspective taking and empathic concern.

Culture Orientation, Socioeconomic States and Age

While the main focus of this study was to explore how empathy and prosocial behaviour are related to bilingualism, we controlled for other factors that are closely related to bilingualism and that can lead to differences in empathy, such as culture, socioeconomic status and age.

Cultures differ in their general orientation, namely whether they are high or low in terms of individualism and collectivism. People from highly collectivistic cultures tend to be concerned and feel compassion for others because their sense of happiness is more likely to be linked to that of others, while it is thought that people from strongly individualistic cultures are more likely to be self-directed in their well-being (Markus & Kitayama, 1991). Because empathy is related to the degree to which individuals view and construct themselves as an interdependent part of their social groups and is therefore related to cultural orientation, higher levels of collectivism and lower levels of individualism have been found to be associated with higher levels of empathy (Chopik et al., 2017; Duan et al., 2008; Zheng et al., 2021).

Other factors that affect empathy are age and socioeconomic status. Elderly individuals and those with high socioeconomic status (SES) typically report higher levels of both empathy and prosocial behaviour (Andreoni et al., 2021; Dewaele & Li, 2012; Jiménez-

Moya et al., 2021; Kamas & Preston, 2021; O'Brien et al., 2013). When studying effects of bilingualism on empathy and prosocial behaviour, it is therefore important to control for these factors.

Current study

The present study had two aims. First, it aimed to verify the multilingual advantage in empathy, by investigating different dimensions of empathy: perspective taking, fantasy, empathic concern, and personal distress. Given previous findings, we expected participants with higher levels of multilingualism to score higher on empathy, particularly in terms of perspective taking, empathic concern and fantasy. And we might find negative effects on personal distress.

Second, while empathy is closely related to prosocial behaviour, there is yet no direct evidence that multilingualism enhances prosociality in adults. We therefore investigated whether multilingualism is related to enhanced self-reported prosocial behaviour and whether this relationship is mediated by empathy. We expected participants with higher levels of multilingualism, especially those using their languages more frequently and those with higher language proficiency, to score higher on prosocial behaviour. We expected this relationship to be mediated by differences in empathy. Furthermore, because both empathy and prosocial behaviour are related to individual differences in collectivism, individualism, age and SES, we controlled for these variables in our analyses.

Methods

Participants

A power analysis was performed using Monte Carlo power simulation (Schoemann et al., 2017) for a mediation analysis. Based on data from (Yin & Wang, 2022), the correlation between empathy and prosocial behaviour is around 0.5. The correlation between empathy and bilingualism is around 0.2 (Dewaele & Li, 2012), bilingualism SD = 8 (Dewaele & Li, 2012), empathy SD = 0.65 (Javor, 2016), prosocial behaviour = 0.6 (Yin & Wang, 2022). With a significance criterion of $\alpha = 0.05$ and power = 0.8, the minimum sample size needed with this effect size is N = 210. 356 participants took part in an online study through the University of Birmingham research participation scheme for course credits. There were no exclusion criteria for enrolment. After removing incomplete and inadequate data (e.g., participants with missing data of more than 50%), 302 participants were left for analysis. Based on their responses on the language and social background questionnaire (for details see below), 262 participants were male, 36 females, and 4 preferred not to say. The average age was 19.1 years (SD=1.2), with a range from 17 to 30 years. In terms of origin, most participants reported to be born in the United Kingdom (n=224), followed by China (n=22), Poland (n=6), United Arab Emirates (n=5), Pakistan (n=5), Romania (n=4) and very small groups of other nationalities. Of these participants, 126 indicated they were monolingual (41.7%), 126 bilingual (41.7%), 37 trilingual (12.3%), and 13 indicted to speak four or five languages (4.3%). English was the most frequent first language (n=260), followed by Chinese Mandarin (n=17), Chinese Cantonese (n=4), Arabic (n=2), Estonian (n=2), Urdu (n=2) and 15 other languages. English was also the most frequent second language (n=39), followed by Spanish (n=25), French (n=16), Urdu (n=16), Punjabi (n=13), German (n=12), Polish (n=6), Welsh (n=5) and 44 other languages. French was the most frequent third language (n=10),

followed by Spanish (n=7), German (n=6), Hindi (n=3), Chinese Mandarin (n=3), Russian (n=3) and 18 other languages.

Measures

Five questionnaires were used in this study: the Language and Social Background Questionnaire (LSBQ; Anderson et al., 2018), the Prosocialness Scale for Adults (PSA; Caprara et al., 2005), the Interpersonal Reactivity Index (IRI; Davis, 1980), and the Cultural Orientation Scale (COS; Triandis & Gelfand, 1998). Besides those, a questionnaire assessing Socioeconomic Status (SES) was created.

Language and Social Background Questionnaire (LSBQ)

We administered the LSBQ (Anderson et al., 2018), a measure of participants' social background, language history, language use in community and language switching in daily life.

Following the calculation of multilingualism in Dewaele & Li (2012), the degree of multilingualism was measured on three dimensions: the number of languages acquired, language proficiency, and frequency of language use. The number of languages ranged from 1 to 5. The language proficiency score was calculated by summing up the proficiency scores for speaking, understanding, reading and writing for all reported languages, all of which ranged from 1 to 10. The proficiency score therefore ranged from 1 to 200. The frequency of use score was calculated by summing up the frequency of use scores for listening, speaking, reading and writing for all reported languages, all of which ranged from 0 to 4. The frequency of use score therefore ranged from 0 to 80.

Interpersonal Reactivity Index (IRI)

The IRI (Davis, 1980) is a 28-item dispositional empathy measurement that composed of four distinct but interrelated dimensions: (1) Perspective Taking Scale (PT), e.g. "I try to look at everybody's side of a disagreement before I make a decision"; (2) Fantasy Scale (FS), e.g. "I really get involved with the feelings of the characters in a novel"; (3) Empathic Concern Scale (EC), e.g. "I often have tender, concerned feelings for people less fortunate than me"; (4) Personal Distress Scale (PD), e.g. "In emergency situations, I feel apprehensive and ill-at-ease". Each of the 4 dimensions contains 7 items, which are presented in a mixed order. Answers are based on a 5-point Likert scale, where "1" means "does not describe me well" to "5" means "describes me very well". Some items are negatively coded. After reverse-scoring these items, independent scores for PT, FS, EC and PD are calculated by averaging the item scores. A high score represents an increased level.

Studies conducted in various countries have found that the IRI (i.e., various versions of it) is high in construct and differentiation validity and a reliable measure of empathy (Bonfils et al., 2017; Chiang et al., 2014; De Corte et al., 2007). The questionnaire showed good reliability in our study. The Cronbach α-coefficient of IRI and the four factors in our sample were: IRI empathy: 0.82, PT: 0.73, FS: 0.75, EC: 0.78, PD: 0.72, respectively.

Prosocialness Scale for Adults (PSA)

The PSA (Caprara et al., 2005) is a 16-item scale that assesses the tendency to engage in prosocial behaviour. It can be applied to people between late adolescence and adulthood. Participants were instructed to rate items on a five-point Likert scale, ranging from 1 ("never/ almost never") to 5 ("always/almost always"). For example, "I share the things that I have with my friends". A PSA score is calculated by averaging scores of all 16 items. A high score reflects a high tendency to perform prosocial actions, while a low score indicates a low

tendency to perform prosocial actions. The scale has presented good reliability and validity with a Cronbach α-coefficient of 0.9.

Cultural Orientation Scale (COS)

The Culture Orientation Scale (Triandis & Gelfand, 1998) is a 16-item scale to assess the inclination to think, feel or act in a culturally determined way. The scale is split into four subscales, each containing four items: Horizontal Individualism (HI) (e.g., "I'd rather depend on myself than others"), Horizontal Collectivism (HC) (e.g., "If a co-worker gets a prize, I would feel proud"), Vertical Individualism (VI) (e.g., "It is important that I do my job better than others"), and Vertical Collectivism (VC) (e.g., "Parents and children must stay together as much as possible"). Items are presented in a mixed order. All statements are rated on a 9-point Likert scale, where "1" means "never or definitely no" and "9" means "always or definitely yes". Each dimension score was calculated by averaging the scores of the four respective items. Furthermore, an individualism score was calculated by averaging HI and VI scores. HI and VI were positively correlated, $r=0.28$, $p<0.001$. Due to a technical error, no answers to the VC items are available. Therefore, the collectivism score was equal to the HC score. A higher score represents a higher orientation tendency towards collectivism or individualism, depending on the scale. The Cronbach α-coefficients of collectivism and individualism in our sample were 0.69 and 0.77, respectively.

Socioeconomic Status (SES)

Socioeconomic status is the social position or class of an individual or group which is often assessed by a composite of education, income and occupation (Winkleby et al., 1992). To measure SES, we designed a simple questionnaire concerning education and occupation. The first question asked about the number of parents/guardians the participant had, in order to

include students who did not come from the stereotypical nuclear family. Participants were then instructed to answer the occupation and education questions about the parents/guardians (up to three) to whom they were most closely related, and were told to enter 'NA' if the questions did not apply to them. The occupation question asked, "What is the occupation of your first/second/third parent/guardian?". Occupation scores were manually coded based on the average UK annual salary level for that occupation. (See Table 4.1). The education question was "What is the highest academic qualification your first/ second/ third parent has received?" The coding scale for education is shown in Table 4.1. An overall SES score was calculated by scaling and averaging the occupation and education scores of the participants' parents/guardians. A high score represented a high level of SES.

Table 4.1

SES Score Calculator

Level	Score
Highest Academic Qualification	
No qualifications	0
GCSEs or equivalent	1
A-levels or equivalent (e.g., International	2
Bachelor's Degree	3
Master's Degree	4
Doctoral Degree	5
Average UK Annual Salary of Occupation	
0-£10 000	0
£10 000-£20 000	1
£20 000-£30 000	2
£30 000-£40 000	3
£40 000-£50 000	4
£50 000-£60 000	5
£60 000-£70 000	6
£70 000-£80 000	7
£80 000-£90 000	8
£90 000-£100 000	9
£100 000-£110 000	10
£110 000-£120 000	11
Above £120 000	12

Procedure

All data were collected online. Participants were instructed to open a Google document which included the consent form and links to all the questionnaires. Participants were asked to complete the consent form and the questionnaires in a fixed order in a quiet space. Completing all the questionnaires required approximately thirty minutes. The study was approved by the STEM Research Ethics Committee of the University of Birmingham (ERN_09-719).

Results

Descriptive data for each variable, including mean, standard deviation and range of scores, as well as correlations between all variables, are presented in Table 4.2. In terms of the four subscales of empathy, perspective taking was positively related to empathic concern but not related to personal distress. Empathic concern and fantasy were positively related. The other intercorrelations were relatively small. Our findings are consistent with previous theories and research (Davis, 1983).

The two dimensions of multilingualism, that is language proficiency and frequency of language use, were highly correlated with each other. Both measures were also significantly positively correlated with individualism, but negatively with empathic concern, personal distress and prosocial behaviour. In the following analyses, in order to avoid type I errors and to reduce collinearity, proficiency and frequency scores were standardized, summed and entered into analyses as a multilingualism score (Agresti & Kateri, 2021).

Table 4.2

Descriptive Data and Sample Correlation of Variables

	M (SD)	**Rang**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1. Age	19.1 (1.18)	17-30											
2. SES	10.3 (4.59)	0-28	-0.05										
3. Collectivism	7.12 (1.08)	3.75-9	-0.06	0.07									
4. Individualism	6.09 (1.18)	2.25-9	-0.02	-0.14*	-0.15*								
5. PT	2.62 (0.60)	0.86-4	0.07	0.06	0.27***	-0.12*							
6. FS	2.58 (0.74)	0.71-4	0.03	0	0.02	0.04	0.24***						
7. EC	2.97 (0.62)	0.43-4	-0.01	0	0.40***	-0.21***	0.51***	0.35***					
8. PD	2.10 (0.62)	0.43-4	-0.07	-0.15*	-0.02	0.05	-0.06	0.13*	0.22***				
9. Prosocial behaviour	3.89 (0.55)	2-5	0.01	0.13*	0.51***	-0.27***	0.40***	0.13*	0.59***	0.08			
10. Language Number	1.80 (0.86)	1-5	0.08	-0.04	-0.11	0.14*	0.03	0	-0.20***	-0.17**	-0.16**		
11. Proficiency	54.5 (21.7)	16-159	0.09	-0.02	-0.06	0.12*	0.06	0.07	-0.16**	-0.17**	-0.12*	0.86***	
12. Frequency	19.4 (5.64)	10-46	0.08	-0.04	-0.09	0.16**	-0.02	-0.04	-0.26***	-0.14*	-0.12*	0.74***	0.76***

Note. PT = perspective taking scale, FS = fantasy scale, EC = empathic concern scale and PD = personal distress scale. ∗ $p < .05$. ** $p < .01$. *** $p < .001$.

Is multilingualism associated with empathy?

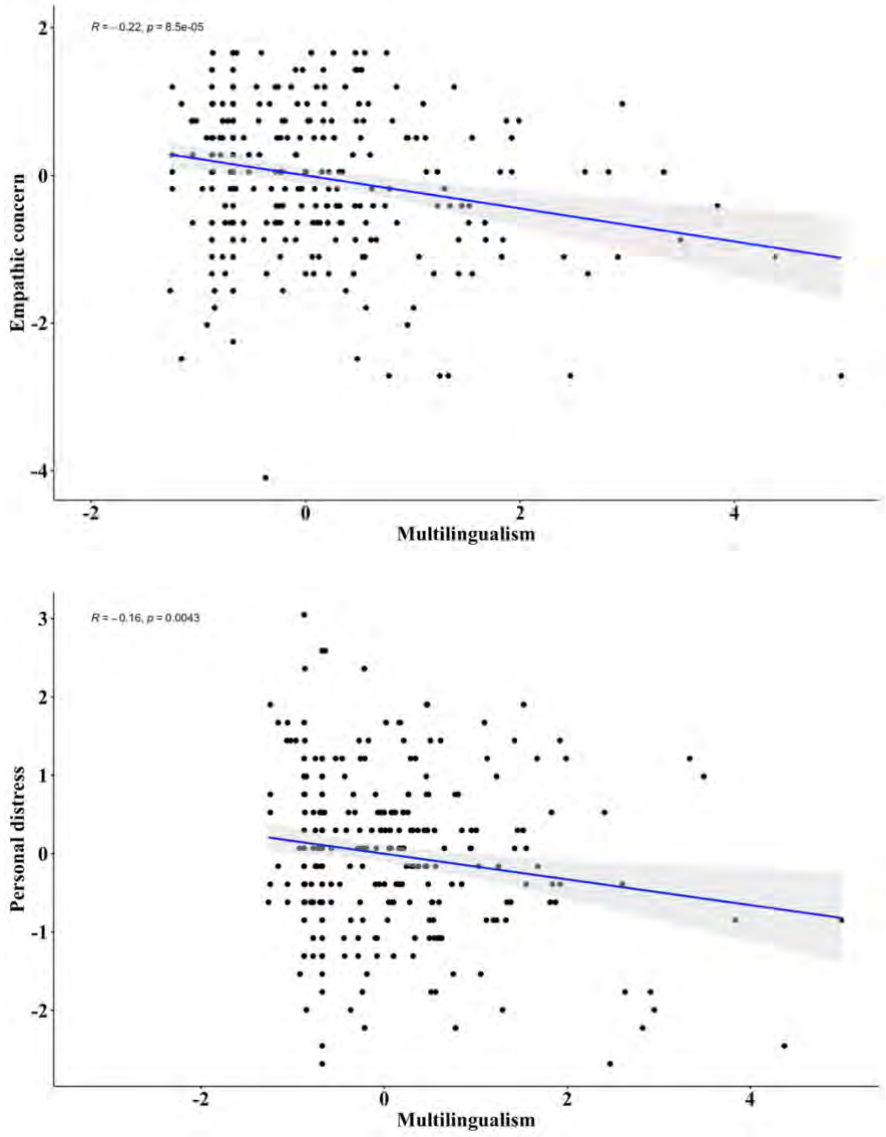
In order to establish whether the level of multilingualism was associated with the level of empathy, we conducted hierarchical multiple regression analyses for the four empathy subscales (perspective taking, fantasy score, empathic concern, personal distress), with the multilingualism score as predictor and age and SES status as controlled demographic variables and cultural orientation (collectivism and individualism) as theoretical controlled variables. We conducted analyses in R version 4.2.2 (R Core Team, 2021) using the lm function from the lme4 package (Bates et al., 2015). Variables were entered in three steps in order to first control for age and SES (in step 1) and then control for the theoretical control variables collectivism and individualism (in step 2). After that we added the multilingualism score to test for an additional contribution (step 3) (Agresti & Kateri, 2021). We also used the *vif* function from the car package (Fox & Weisberg, 2018) to check for collinearity between predictors. All *vifs* for all regressions were around 1, meaning the degree of collinearity among variables was very low. Results are presented in Table 4.3. We found significant predictors for perspective taking, empathic concern and personal distress, which we report hereafter. The fantasy score was not predicted by any of the variables.

Multilingualism was a significant predictor, but only for empathic concern (next to collectivism and individualism) and personal distress (next to SES)[3]. Note that multilingualism predicted both measures negatively, meaning that participants with a higher level of multilingualism were less likely to show empathic concern and to experience personal distress. These relationships are show in Figure 4.1.

[3] : If we exclude participants whose score is 2.5SD above the median, i.e. highly multilingual, the EC effect is still robust ($r = 0.17$, $p < .01$) in language frequency of language use but the PD effect disappears. Since we don't have any reason to believe that they are not suitable datapoint. We chose to keep them in our dataset.

Figure 4.1

Correlations of Multilingualism with Empathic Concern and Personal Distress (standardized scores)



We also found typical results for some of the co-variates, especially for collectivism, which was a significant positive predictor of perspective taking and empathic concern. Thus, more collectivist participants were more likely to take others' perspectives and showed more empathic concern. In contrast, participants who were more individualist showed less empathic concern. Furthermore, personal distress was predicted by SES, with participants from a higher socioeconomic status being less likely to experience personal distress.

Table 4.3

Summary of Hierarchical Regression Analysis for Variables Predicting Perspective Taking, Empathic Concern and Personal Distress

Perspective Taking								
Predictors	***Estimates***	***SE***	***CI***	***Statistic z***	***Cumulative R2 / R2 adjusted***	***R2 Change***	***F test***	***Comparison with preceding model***
Step 1								
(Intercept)	0	0.06	-0.11 – 0.11	0				
Age	0.07	0.06	-0.04 – 0.18	1.2	0.009 / 0.002	0.009 / 0.002	F(2, 299)=1.332	
SES	0.07	0.06	-0.05 – 0.18	1.16				
Step 2								
(Intercept)	0	0.06	-0.11 – 0.11	0				
Age	0.08	0.06	-0.03 – 0.19	1.48				
SES	0.04	0.06	-0.07 – 0.15	0.67	0.086 / 0.074	0.077 / 0.072	F(4, 297)=6.996***	F(1,2)=12.556***
Collectivism	**0.26**	**0.06**	**0.15 – 0.37**	**4.6*****				
Individualism	-0.07	0.06	-0.19 – 0.04	-1.32				
Step 3								
(Intercept)	0	0.06	-0.11 – 0.11	0				
Age	0.08	0.06	-0.03 – 0.19	1.39				
SES	0.04	0.06	-0.07 – 0.15	0.67				
Collectivism	**0.26**	**0.06**	**0.15 – 0.37**	**4.64*****	0.089 / 0.074	0.003/0.000	F(5, 296)=5.756***	F(1,2)=0.817
Individualism	-0.08	0.06	-0.19 – 0.03	-1.43				
Multilingualism	0.05	0.06	-0.06 – 0.16	0.9				
Empathic Concern								
Step 1								
(Intercept)	0	0.06	-0.11 – 0.11	0				
Age	-0.01	0.06	-0.12 – 0.10	-0.17	0.000 / -0.007	0.000 / -0.007	F(2, 299)=0.018	
SES	0	0.06	-0.11 – 0.12	0.07				
Step 2								
(Intercept)	0	0.05	-0.10 – 0.10	0				
Age	0.01	0.05	-0.10 – 0.11	0.14				

Predictors	*Estimates*	*SE*	*CI*	*Statistic z*	*Cumulative R2 / R2 adjusted*	*R2 Change*	*F test*	*Comparison with preceding model*
SES	-0.05	0.05	-0.15 – 0.06	-0.85	0.183 / 0.172	0.183 / 0.179	F(4, 297)=16.600***	F(1,2)=33.187***
Collectivism	**0.38**	**0.05**	**0.27 – 0.48**	**7.08*** **				
Individualism	**-0.16**	**0.05**	**-0.27 – -0.06**	**-3** **				
Step 3								
(Intercept)	0	0.05	-0.10 – 0.10	0				
Age	0.02	0.05	-0.08 – 0.12	0.44				
SES	-0.05	0.05	-0.15 – 0.06	-0.88	0.213 / 0.200	0.030 / 0.028	F(5, 296)=16.06***	F(1,2)=11.532**
Collectivism	**0.37**	**0.05**	**0.26 – 0.47**	**7*** **				
Individualism	**-0.14**	**0.05**	**-0.24 – -0.03**	**-2.56***				
Multilingualism	**-0.18**	**0.05**	**-0.28 – -0.07**	**-3.4*** **				
Personal Distress								
Step 1								
(Intercept)	0	0.06	-0.11 – 0.11	0	0.028 / 0.021	0.028 / 0.021	F(2, 299)=4.243*	
Age	-0.08	0.06	-0.19 – 0.04	-1.33				
SES	**-0.15**	**0.06**	**-0.26 – -0.04**	**-2.65** **				
Step 2								
(Intercept)	0	0.06	-0.11 – 0.11	0				
Age	-0.08	0.06	-0.19 – 0.04	-1.32				
SES	**-0.15**	**0.06**	**-0.26 – -0.03**	**-2.52***	0.029 / 0.016	0.001/ -0.005	F(4, 297)=2.194.	F(1,2)=0.170
Collectivism	-0.01	0.06	-0.12 – 0.11	-0.13				
Individualism	0.03	0.06	-0.08 – 0.15	0.54				
Step 3								
(Intercept)	0	0.06	-0.11 – 0.11	0				
Age	-0.06	0.06	-0.17 – 0.05	-1.07				
SES	**-0.15**	**0.06**	**-0.26 – -0.03**	**-2.57***				
Collectivism	-0.02	0.06	-0.13 – 0.10	-0.3	0.058 / 0.042	0.029 / 0.026	F(5, 296)=3.623**	**F(1,2)=9.099** **
Individualism	0.06	0.06	-0.06 – 0.17	0.96				
Multilingualism	**-0.17**	**0.06**	**-0.29 – -0.06**	**-3.02** **				

Note. ∗ $p < .05$. ** $p < .01$. *** $p < .001$.

Does multilingualism promote prosocial behaviour and, if so, is this relationship mediated by empathic concern or personal distress?

We conducted mediation analyses based on Hayes' process (Hayes, 2013). The mediation analyses using a path analyses framework were performed in R. We used the sem and parameterEstimates functions from the lavaan package (Rosseel, 2012).

For empathic concern, three path models were built for the mediation analysis. We first modelled multilingualism to predict empathic concern as path a. Then empathic concern was modelled to predict prosocial behaviour as path b. Multilingualism was modelled to predict prosocial behaviour as path c. Additionally, collectivism and individualism were included in these models as controlled variables. To estimate the indirect effect, we used the product of coefficients method (MacKinnon & Dwyer, 1993) and the percentile bootstrapping method (Hayes, 2013). The indirect index was calculated by multiplying path coefficient of multilingualism in path a with empathic concern in path b.

The following three parameters were used to assess the appropriateness of the model: (1) the comparative fit index (CFI): It ranges from 0 to 1. A value greater than 0.90 indicates an acceptable fit and a value greater than 0.95 indicates a good fit (Bentler & Bonett, 1980); (2) Root-Mean-Square Error of Approximation (RMSEA): It ranges from 0 to 1. A value between 0.05 and 0.8 indicates an acceptable fit of the model and a value less than 0.05 indicates a good fit (Browne & Cudeck, 1992); (3) Standardized Root Mean Square Residual (SRMR): It ranges from 0 to 1. A good fit is generally considered to be less than 0.08 (Hu & Bentler, 1999). In the present study, the hypothesized model fit the data well, CFI = 1, RMSEA = 0, SRMR = 0.

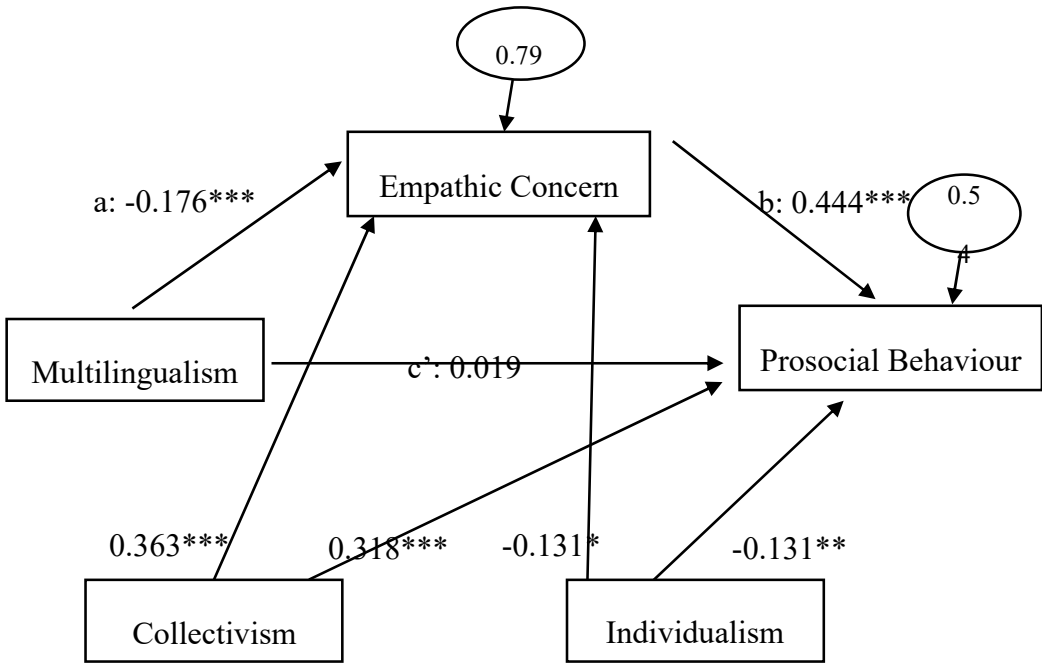
Figure 4.2 and Table 4.4 presents that there was a significant and negative relationship between multilingualism and empathic concern, β = -0.176, p < .001, 95% CI [-0.275, -0.066]. There was also a positive and significant correlation between empathic

concern and prosocial behaviour, $\beta = 0.444$, $p < .001$, 95% CI [0.290, 0.594]. There was no direct correlation between multilingualism and prosocial behaviour. But when empathic concern was entered into the model as mediator, there was a negative and significant indirect relation between them, $\beta = -0.078$, $p < .01$, 95% CI [-0.131, -0.025], with bootstrapping for 1000 samples, and high and low values of the CI do not cross 0. Therefore, we can conclude that the mediation of the relationship between multilingualism and prosocial behaviour by empathic concern is significant. Thus, individuals who use more languages were less likely to report prosocial behaviour, but this was due to them having less empathic concern.

Mediation analyses with the two multilingualism aspects frequency and proficiency separately revealed only one and only an indirect relationship of multilingualism with prosocial behaviour: Language usage frequency predicted prosocial behaviour indirectly via Empathic Concern. More details can be found in Appendix Table 4.1 in the Appendix.

Figure 4.2

Mediation Analysis for the Relation between Multilingualism and Prosocial Behaviour via Empathic Concern



Note. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4.4

Standardized Robust Maximum Likelihood Parameter Estimates for Mediation Model of Empathic Concern

Model parameter	*Estimate*	*SE*	*z*	*ci.lower*	*ci.upper*
EC ~					
Multilingualism	-0.176	0.051	-3.472***	-0.275	-0.066
Collectivism	0.363	0.059	6.192***	0.256	0.488
Individualism	-0.131	0.054	-2.409*	-0.241	-0.021
PSA ~					
Collectivism	0.318	0.067	4.732***	0.186	0.444
Individualism	-0.131	0.05	-2.59**	-0.228	-0.03
EC	0.444	0.08	5.575***	0.29	0.594
Multilingualism	0.019	0.042	0.454	-0.062	0.107
Path					
Multilingualism indirect	-0.078	0.026	-2.961**	-0.131	-0.025
Multilingualism direct	0.019	0.042	0.454	-0.062	0.107

Note. * $p < .05$. ** $p < .01$. *** $p < .001$.

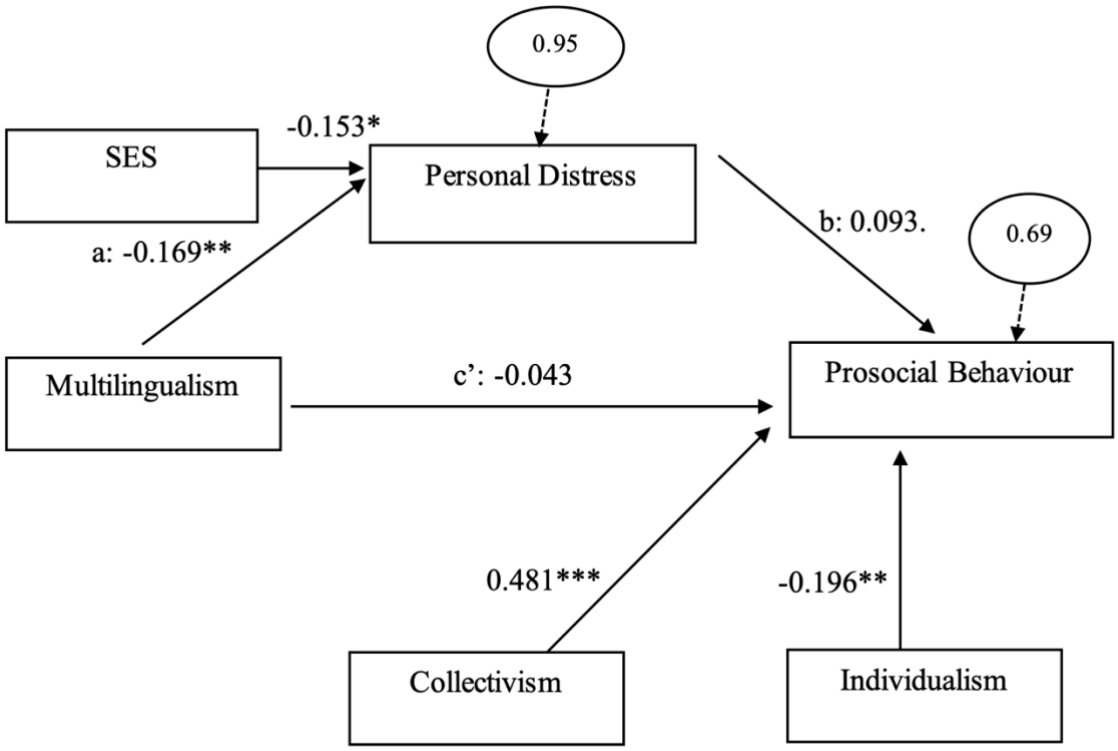
For personal distress, three path models were built for the mediation analysis based on correlation and regression. We first modelled multilingualism and the controlled variable SES to predict personal distress as path a. Then personal distress together with the theoretical controlled variables collectivism and individualism were modelled to predict prosocial behaviour as path b. Multilingualism was modelled to predict prosocial behaviour as path c. The hypothesized model fit the data well, CFI = 0.994, RMSEA = 0.029, SRMR = 0.022.

Figure 4.3 and Table 4.5 showed that there was a significant and negative relationship between multilingualism and personal distress, $\beta = -0.169$, $p < .01$, 95% CI [-0.289, -0.03]. There was a marginal positive and significant relation between personal distress and prosocial behaviour, $\beta = 0.093$, $p = 0.057$, 95% CI [-0.002, 0.189]. The mediation analysis results revealed that there was no direct or indirect correlation between multilingualism and

prosocial behaviour (see Table 4.5). Consequently, we can conclude that personal distress did not mediate the relationship between multilingualism and prosocial behaviour.

Figure 4.3

Mediation Analysis for the Relation between Multilingualism and Prosocial Behaviour via Personal Distress



Note. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4.5

Standardized Robust Maximum Likelihood Parameter Estimates for Mediation Model of Personal Distress

Model parameter	*Estimate*	*SE*	*z*	*ci.lower*	*ci.upper*
PD ~					
Multilingualism	-0.169	0.066	-2.56**	-0.289	-0.03
SES	-0.153	0.061	-2.521*	-0.272	-0.036
PSA ~					
Collectivism	0.481	0.061	7.877***	0.362	0.602
Individualism	-0.196	0.062	-3.146**	-0.32	-0.078
PD	0.093	0.049	1.9.	-0.002	0.189
Multilingualism	-0.043	0.049	-0.874	-0.132	0.064
Path					
Multilingualism indirect	-0.016	0.01	-1.496	-0.039	0.002
Multilingualism direct	-0.043	0.049	-0.873	-0.132	0.064

Note. * $p < .05$. ** $p < .01$. *** $p < .001$

Discussion

The "bilingual advantage" has been found to extend beyond executive control to perspective-taking (Rubio-Fernández, 2017; Greenberg et al., 2013; Navarro & Conway, 2021; Wu & Keysar, 2010), creativity (Kharkhurin, 2010), diversified thinking (Hommel et al., 2011) and personality (Dewaele & Wei, 2013). It has also been shown to increase empathy (Dewaele & Li, 2012). The present questionnaire study investigated whether multilingualism influences different dimensions of empathy such as empathic concern and personal distress. Furthermore, since empathy is closely related to prosocial behaviour (Yin & Wang, 2022), we explored for the first time whether multilingualism promotes prosocial behaviour and whether empathy mediates this relationship. In line with our expectations, our results show that participants with higher levels of multilingualism tend to score lower on personal distress; whereas, contrary to our expectations, participants with higher levels of multilingualism tend to score lower on empathic concern. Meanwhile, multilingualism was not related to the sub-components of perspective taking and fantasy. Also, multilingualism was not directly related to prosocial behaviour but indirectly via empathic concern.

Our first hypothesis was partly confirmed as multilingualism was negatively related to personal distress. Based on previous studies, a higher level of personal distress is associated with a higher level of social disfunction. The strongest relations in this subscale have been found with shyness, social anxiety, and extraversion. Individuals with a high level of personal distress tend to be more shy, anxious and less extroverted than those with lower levels (Davis, 1983; Dewaele & Wei, 2013). In the present study, the negative relationship between multilingualism and personal distress suggests that individuals with a higher level of multilingualism are less likely to feel distressed and anxious compared to individuals with a lower level of multilingualism, including monolinguals. However, multilingualism was not

related to either the perspective taking or the fantasy subscale. Thus, multilingualism does not seem to be related to all aspects of empathy.

Against our assumption, multilingualism was associated negatively with empathic concern, meaning that participants with a higher degree of multilingualism reported a lower level of empathic concern than participants with a lower level, including monolinguals. One possible explanation for these findings is that the relationship between empathy and multilingualism in young adults is nuanced. Previous findings on the relationship between multilingualism and empathy have been mixed, reporting either no relationship (Dewaele, 2021; Ghoreyshi Rad et al., 2020; Korzilius et al., 2011) or a positive relationship (Alqarni & Dewaele, 2020; Dewaele & Li, 2012; Dewaele & Stavans, 2014). And group comparisons between monolinguals and bilinguals have shown that bilinguals scored higher than monolinguals, but the effect sizes were relatively small. It seems that a relationship between multilingualism and empathy might depend on the type of the bilingual population, with some types of bilinguals even showing a lack of empathic concern, as found in the present study.

Another possible explanation is that the age of second language acquisition influences empathy motivation and performance. Our finding is partly consistent with the study conducted by Javor (2017) who found that late language acquisition (after age 6) can have a negative impact on the four subscales of empathy. The bilingualism score, which was calculated as the sum of the age at which the second language was acquired and the frequency of daily use of the second language, correlated negatively with perspective taking, fantasy, empathic concern and personal distress. In contrast, in the group of early bilinguals, the bilingualism score correlated positively with empathy. These results suggest that the age of acquisition influences the relationship between bilingualism and empathy. We explored whether the age of second language acquisition had a similar effect on outcome measures in

our study. We split our participants into early and late bilinguals depending on whether they had acquired a second language up to or after age 6. This led to 62.3% (n=109) early bilinguals and 37.7% (n=66) late bilinguals. But neither group showed any significant correlations of multilingualism measures with any of the empathy sub-scales (see Appendix, Supplementary Table 4.2), even though almost all of the relationships (apart from the relationship between proficiency and empathic concern), had a negative direction just like the significant correlation with the group as a whole. The lack of significant relationships is difficult to interpret, but it rather suggests that age of acquisition is not an influential moderator of the multilingualism-empathy relationship.

Another possible explanation for our negative relationship between multilingualism and empathic concern is that multilinguals are more emotionally stable. Though previous studies have found that bilinguals tend to be more empathic than monolinguals, there is also evidence that bilinguals are more emotionally stable and less impacted by emotional distraction than monolinguals (Barker & Bialystok, 2019; Dewaele & Stavans, 2014). Barker & Bialystok (2019) found young adult bilinguals were more accurate in an emotion n-back task, which indicated bilingual's task performance was less affected by the emotional distraction than that monolingual performance. Also, bilinguals were found to be more tolerant of ambiguity and less anxious than monolinguals (Dewaele & Wei, 2013). Therefore, it is possible that compared with monolingual peers, multilinguals are more emotionally stable, less likely to show empathic concern to others, and less likely to suffer from personal distress. In addition, multilinguals' emotional stability and less empathic concern might also be related to the positive relationship between multilingualism and individualism in our study. We found that participants with higher multilingualism scores were more independent and self-reliant than those with lower multilingualism scores. Also, empathic concern and personal distress are often grouped as "affective empathy", also known as "warm empathy",

while perspective taking and fantasy are often grouped as "cognitive empath", also known as "cold empathy" (Y. Wang et al., 2020; Zaki & Ochsner, 2012). Our results showed a negative correlation between multilingualism and "warm empathy", meaning that the higher the level of multilingualism, the less warm the individual. All in all, these results mean that at least in our sample, multilingualism was related to a "cold", calm, stable and independent personality.

Our second hypothesis was partly confirmed. Multilingualism was not related to prosocial behaviour directly, but multilingualism had an indirect influence on prosocial behaviour via empathic concern, even though the relationship was negative. Thus, participants with high levels of multilingualism did not score higher, but lower on prosocial behaviour than participants with low levels of multilingualism, including monolingual participants.

A possible reason for the negative relationship between multilingualism and prosocial behaviour, as well as between multilingualism and empathy, could be the population under study. Multilingualism results from a complex combination of individual personal characteristics and social community factors, such as family circumstances. Similarly, empathy and prosocial behaviour can also be influenced by social environmental factors. It is therefore difficult to disentangle the factors that might influence empathy and prosocial behaviour from language skills and proficiency.

Furthermore, the participants in our study came from the University of Birmingham, whose student population is very diverse in terms of ethnicity and culture, and in particular includes many first and second-generation immigrants. First-generation immigrants have a lower emotional fit with the typical emotional patterns of the host culture, while second-generation immigrants have a higher fit (De Leersnyder, 2017). Previous research on biculturalism has provided compelling evidence for the role of acculturation on emotional experience (De Leersnyder, 2017; De Leersnyder et al., 2011). People’s emotional patterns

may change depending on their level of acculturation. Since emotional experience and emotional patterns are linked to empathy (Lewis et al., 2010), acculturation might influence empathy as well.

In summary, based on our participant sample, people with high levels of multilingualism appear to be more individualistic, emotionally calm, relaxed and less anxious. However, individual differences in participants' language and social background, as well as situational framing, can result in different empathy motivations and prosocial behaviour. The unexpected results point to some important considerations, including that multilingualism may be a outcome of a complicated combination of individual differences, such as personality traits, cognitive functioning and social factors (such as family and cultural context). Future research should disentangle these potential factors.

As for the controlled variables in this study, collectivism was positively related to empathy and prosocial behaviour, while individualism was negatively related. This fits the assumption that individuals with strong collectivistic personality traits tend to feel sympathy for others because their well-being is highly correlated with the well-being of others, while individuals with strong individualistic personality traits are thought to be more self-focused (Markus & Kitayama, 1991). We also found that SES was negatively associated with personal distress. People were less likely to be anxious and stressed if they had a higher socioeconomic status. This finding provides further evidence that low socioeconomic status is correlated with poor mental health (Lam et al., 2019; Reiss et al., 2019). Finally, age made no difference in this study. This is probably due to the small age range of our participants.

Limitation

Our study has some limitations. Firstly, our self-selected sample from university students following a Psychology degree is not necessarily a reflection of the general

population of young adults. Another limitation is the gender bias in the participant sample. Most of the participants were female because they were recruited from the School of Psychology at the University of Birmingham, where the majority of students are female. It has been established that females display higher levels of empathy and a greater tendency towards prosocial behaviour than males in self-reported measures. For example, Chopik et al. (2017) conducted a study on empathy and its four subcomponents using the IRI (Davis, 1983) in a sample of 104,365 participants from 63 countries. They found that females scored higher than males in perspective taking, empathic concern and total empathy score. Tarighat and Krott (2021) explored perspective-taking as one of the subcomponents of empathy in a sample of 108 males and 108 females from Iran, employing the IRI (Davis, 1983). Female monolinguals reported higher scores in perspective-taking compared with male monolinguals. Tremblay et al. (2021) found that females presented increased levels of empathy when viewing a painful facial expression, whereas this was not the case for males. Abdullahi & Kumar (2016) investigated gender differences in prosocial behaviour by administering the Prosocial Personality Battery (PSB) to 30 males and 30 females. The results of the study suggested that females exhibited a greater ability to comprehend other viewpoints and displayed a higher level of concern for social morality compared to males. Espinosa & Kovářík, (2015) examined previous studies on gender differences in prosocial behaviour and found that social framing increased prosocial behaviour in females but not in males, although there was no gender difference at the 'neutral' baseline. In summary, this study, in which the majority of participants were female, did not adequately represent young adult males, limiting the generalisability of these findings to the male population.

One more restriction of this study is the use of self-report measures of multilingualism, empathy and prosociality, which are subjective. For instance, although self-report assessments of empathy (IRI, Davis, 1980) are widely available and reliable tools for

measuring empathy, they have exhibited a lack of consistent adequate validity evidence with behavioural assessments Kuperman et al. (2023). Murphy and Lilienfeld (2019) have argued that self-reports assess motivation rather than ability. In addition, they have argued that, given human's intrinsic metacognitive limitations, no self-report questionnaire can be constructed to validly detect empathy in a way that relates minimally to largely irrelevant personality variables, such as narcissism (Murphy & Lilienfeld, 2019). Thus, for future studies, combining self-report and behavioural assessments would make the results more convincing.

Conclusion

To conclude, we found that a higher level of multilingualism, or more precisely, a higher usage frequency of more than one language, does not lead to higher but lower prosocial behaviour than a lower level of multilingualism (including monolingualism), and that this was due to lower empathic concern. The negative relationship with empathy stands in contrast to previous findings and might be due to multilinguals being more emotionally stable than monolinguals and being less impacted by emotional distraction. Furthermore, multilingualism being negatively related to personal distress confirmed that bilinguals tend to be less anxious than monolinguals.

CHAPTER 5

GENERAL DISCUSSION

The relationship between bilingualism and social cognition is complicated, making it difficult to determine whether bilingualism influences individual social cognition abilities and in what ways. In addition, we do not know if a bilingual advantage in this area is due to social abilities or different perspectives being taken. Current debates and discussions in this area suggest that one of the explanations could be the advanced cognitive skills resulting from the cognitive demands of mastering two languages (Bialystok, 2009; Bialystok et al., 2012). They might also at least partly be due to biculturalism, which forces bilinguals to view the world from different perspectives and requires a high level of mental flexibility (Kharkhurin, 2010). This thesis aimed to contribute to our understanding of the effect of bilingualism on individuals' social cognitive abilities with relation to two aspects: (1) bilingualism and social-cognitive ability (i.e. perspective-taking ability) (Chapter 2 and 3), and (2) bilingualism and social-emotional ability (i.e. empathy) (Chapter 4). In this final Chapter, I will first summarize the findings in the following sequence:

- Bilingualism and perspective-taking ability
- Bilingualism and empathy
- Spontaneous process of visuospatial perspective-taking (VPT)

I will then outline the limitation of this thesis, discuss implications for future studies and address a conclusion.

Bilingualism and Perspective-taking Ability

Chapter 2 exploratively compared the performance of bilinguals and monolinguals in the joint action visuospatial perspective-taking paradigm of Freundlieb et al. (2018). The

results showed no evidence of a bilingual difference in congruency interference. However, the fact that we tested very few monolingual participants and that we did not find a main effect of congruency makes it impossible to draw strong conclusions about group differences.

Chapter 3 addressed whether bilingual young adults outperform their monolingual peers in visuospatial perspective-taking (VPT), independently of executive function and cross-cultural differences. Under the assumption that understanding more than one language cultivates some low-level executive function which benefits an individual's performance in high-level perceptual taking, there are studies supporting that bilingual speakers outperform monolinguals on tasks that require taking the perspectives of others (Rubio-Fernández, 2017; Greenberg et al., 2013; Navarro & Conway, 2021; Wu & Keysar, 2010) (but see Ryskin et al., 2014; J. J. Wang et al., 2019). We tested this hypothesis using level-1 and level-2 VPT tasks, which test egocentric and altercentric interference in a single paradigm. The results showed that bilingual and monolingual speakers performed similarly in egocentric interference. This suggests that speaking an additional language does not promote VPT. In addition, results showed that congruency interference for monolingual and bilingual speakers was similarly affected by cultural orientation and cultural integration. This suggested that cross-cultural differences do not affect speakers' performance on VPT. Furthermore, switching ability was the only significant predictor of egocentric interference on both level-1 and level-2 VPT, with better switching ability being associated with better suppression of egocentric interference. These results imply that executive function, not bilingualism or cultural differences, predicts VPT performance.

These finding provided further evidence that VPT mechanisms are similar across different language experience and culture. Based on our study, The advantage of bilingual perspective taking in children does not seem to be the case in young adults (Paap et al., 2015; Zhou & Krott, 2016).

Bilingualism and Social-emotional Ability

The finding of similar performance in VPT across monolinguals and bilinguals (Chapters 2 and 3) may not generalise to other basic social cognitive mechanisms such as socio-emotional ability. Chapter 4 presented an individual differences study that uncovered the correlation between multilingualism and socio-emotional skills. We examined four components of empathy, namely perspective-taking, empathic concern, fantasy and personal distress, as well as prosocial behaviour, which is closely related to empathy. We controlled in our analyses for cultural orientation, age and socioeconomic status. Results revealed that personal distress was negatively correlated with multilingualism, which suggested that multilingual speakers with a higher level of multilingualism are less likely to feel distressed and anxious compared to individuals with a lower level of bilingualism, including monolinguals. The effect on empathic concern, however, was different than initially expected. Rather than finding that multilingual speakers were more likely to show greater empathic concern, this study found the reverse relationship. In addition, our results suggest that empathic concern mediates a negative relationship between multilingualism and prosocial behaviour, with higher a level of multilingualism being related speakers to a lower level of prosocial behaviour. Although this finding was unexpected, it could be interpreted as bilinguals are more emotionally stable and less impacted by emotional distraction than monolinguals (Barker & Bialystok, 2019; Dewaele & Stavans, 2014).

This finding helped to extend existing knowledge on empathy and prosocial behaviour in multilingual young adults. Interestingly, bilingual's social-emotional outperformance than monolinguals in children and adolescents appears not to extend to young adults, whose social cognition reached its peak (Devine & Lecce, 2021). The difference between bilinguals and monolinguals in social-emotional skills remains unclear and inconsistent, based on the current literature. Future studies exploring this area should

reconcile the individual difference of multilingual speakers and identify lifespan differences in social-emotional skills.

The Visuospatial Perspective-taking Debate

The experiments in Chapter 2 and 3 contribute to the debate about the underlying processes of VPT, that is whether VPT arises automatically (Furlanetto et al., 2016; Surtees et al., 2012), spontaneously (Furlanetto et al., 2016; Surtees et al., 2012), or neither. Previous studies argued that if a self-perspective consistency effect was observed in explicit tasks, VPT is likely to arise unintentionally and spontaneously. However, if a self-perspective consistency effect was observed in implicit tasks, VPT is likely to arise automatically and cannot be inhibited (O'Grady et al., 2020).

In Chapter 2, we tested the joint action VPT tasks designed by Freundlieb et al. (2016, 2017, 2018). Participants were instructed to perform a binary choice sharing task with a confederate. The task was to make a judgement from one's own perspective. This is an implicit task, with no explicit cue to remind participants to take another person's perspective. The aim of the task is to see whether an individual will spontaneously take another person's perspective. Freundlieb et al. (2016, 2017, 2018) found consistent congruency interference across their studies, with participants responding slower and less accurately when the task was more difficult from the confederate's perspective. These results showed that participants automatically took the VPT of their task partners. Their findings are compatible with the mere appearance hypothesis, which argues that the human mental activity is remarkably sensitive to the VPT of others, and the mere presence of another person can lead to spontaneous co-representation (Ward et al., 2019, 2020). However, we did not replicate the congruency effect in Chapter 2 using two adapted tasks: a gender categorisation task and a word categorisation task, indicting VPT might not be a spontaneous process.

In Chapter 3, we tested a level-1 VPT task designed by Samson et al. (2010) and a level-2 VPT task designed by Surtees et al. (2016). These two tasks measured both a direct (other-perspective) and an indirect (self-perspective) perspective-taking in one single paradigm. The self-perspective task is an explicit task, in which a cue is presented to indicate which perspective the participant should judge from. Previous studies found a significant congruency effect in the level-1 self-perspective condition but not in the level-2 self-perspective condition (Surtees et al., 2016), suggesting that individuals can spontaneously adjust the perspective of others in level-1 task. However, Chapter 3 found no altercentric interference in neither the first nor second level tasks.

Our failure to replicate altercentric effects across three tasks in Chapters 2 and 3 is surprising given previous experiments that found substantial effects in line with spontaneous VPT (Freundlieb et al., 2017, 2018; Samson et al., 2010; Surtees et al., 2016). It suggests that VPT tasks are sensitive to methodological and context differences, such as how others engage with stimuli and how others process a stimulus, influencing whether an individual takes others' VPT or not. As we discussed in Chapter 2 and 3, our designs slightly differed from the original task designs, which may increase the difficult to identify altercentric effects in the this thesis.

Another possible reason for the lack of altercentric interference could be that altercentric effects were overridden by participants' strategic control. For instance, in our level-1 and level-2 VPT tasks in Chapter 3, participants were constantly instructed to make judgments from their own perspective. It is possible that the participants started to reframe the task in order to reduce the cognitive effort. Rather than explicitly attributing "perspective" to themselves, participants may have only identified the number of dots visible in the picture stimuli in level-1 VPT and the number on the desk or wall in level-2 VPT. In other words, it

is possible that participants choose not to consider the other's perspective, meaning that self-perspective congruency effects could not be observed.

In summary, it is yet unknown what influenced VPT and future studies should focus on investigating this further. Also, future work on VPT co-representation should consider conflicting findings regarding contexts, methodology and task design (Holland et al., 2021).

Limitations

There are some limitations to be considered in this thesis. Participants were young adults, aged between 17-35 years old, who are considered to be at the climax of their cognitive abilities (Poarch & Krott, 2019). Social cognition is likely to change with the ageing process. The social cognition abilities in children and young adult varies (Devine & Lecce, 2021). Therefore, the findings from this study cannot be generalised into other age groups.

Furthermore, all of our participants were university students studying psychology, which did not successfully reflect the general population of young adults in different social and educational backgrounds. Additionally, it should be noted that the samples used in all experiments were predominantly female. The gender bias in our sample size is attributable to the recruitment of participants from the School of Psychology at the University of Birmingham, where the majority of students are female. Previous research has demonstrated that females tend to outperform males in social interaction skills, such as perspective-taking, empathy, and prosocial behaviour, not only in self-report measures but also in experimental tasks. We noted that our predominantly female sample does not seem to be able to explain the results in chapters 2 and 4, while it is unclear whether it did so in chapter 3. Nevertheless, since our experiments did not adequately represent young adult males, the generalisability of my findings to males remains limited.

Another limitation of the study is the use of self-report measures of multilingualism, empathy and prosociality, which are subjective. For instance, although self-report assessments of empathy (IRI, Davis, 1980) are widely available and reliable tools for measuring empathy, they have exhibited a lack of consistent adequate validity evidence with behavioural assessments Kuperman et al. (2023). Murphy and Lilienfeld (2019) have argued that self-reports assess motivation rather than ability. In addition, they have argued that, given human's intrinsic metacognitive limitations, no self-report questionnaire can be constructed to validly detect empathy in a way that relates minimally to largely irrelevant personality variables, such as narcissism (Murphy & Lilienfeld, 2019). Thus, for future study, combining self-report and behavioural assessments would make the results more convincing.

Conclusions

This thesis provided evidence that bilingualism had no effect on VPT of young adults and also showed mixed effects in social-emotional skills comparing with other studies. Bilingualism effects seem to be subtle and can be masked by individual differences in participants, methodology, or noise created by the experimental design. To help future researchers in better understanding the bilingualism effect, we present below some suggestions for further research directions. These include strict control of variables, careful experimental designs, appropriate analysis strategies and extension into neural response investigation.

Strict Control of Variables

Language experience is a diverse variable, including the age of acquisition, language use frequency, level of proficiency, etc. Cultural difference is another diverse variable, including cultural orientation, acculturation, immigration, etc. Given the diversity of bilingual

backgrounds, finding inconsistent bilingual effects in social cognition performance is maybe unsurprising. Differences between languages and cultures affect cognitive behavioural performance. Indeed, Chapter 4 showed that the frequency of language use, but not language proficiency, influences prosocial behaviour. Therefore, controlling for participants' language and cultural backgrounds is crucial in bilingualism studies. One way to identify possible complications caused by the characteristics of the participants would be to further investigate the potential influencing factors and to control for them in the study design.

Careful Experimental Design

The strength of a bilingual advantage seems to vary across an individual's lifespan (Bialystok et al., 2004). Bilinguals show superior cognitive ability in children and elders, while this effect is less pronounced in young adults (Hilchey & Klein, 2011). One possible explanation is that young adults are at the peak of their cognitive development. Thus, tasks easily fail to capture differences between groups due to ceiling effects. Since our study focused on young adults, it is important for future studies to design and choose a more appropriate and reliable paradigm or measure in order to observe the effects of bilingualism.

Appropriate Analysis Programme

An analysis programme should be chosen based on the characteristics of the sample participants. If the population of participants is diverse, categorical analysis is inappropriate to capture effects. In this case, an individual differences approach is more appropriate. This approach has been found to be convenient in controlling for potential influencing factors such as frequency of language use (Deweale & Li, 2012; Javor, 2017), language proficiency (Deweale & Li, 2012; Miller et al., 2021), and age of second language acquisition (Javor, 2017). In line with this argument, all experiments in this thesis defined bilingualism as a continuous variable and used methods taking individual difference into account.

Beyond Behaviour Data

Our study investigated behavioural responses in young adults. Many studies have found differences in neural responses while behavioural responses were similar. For instance, it is possible that bilingualism and cross-cultural differences led to neural differences rather than behavioural performance differences in VPT (Kobayashi et al., 2006). For instance, in an fMRI study, Dang et al. (2020) recruited sixteen American English-speaking monolinguals and sixteen Japanese-English bilinguals to participate in second-order false-belief story tasks. Results showed that both American and Japanese groups presented significant neural over-activation in the medial prefrontal cortex and anterior cingulate cortex when engaged in ToM tasks. However, Japanese group showed significantly less activity in the temporoparietal junction compared to American group, even though there were no significant differences between the two groups in behavioural responses. Based on these findings, Kobayashi et al. (2006) suggested that there may be cultural differences in the underlying neural mechanisms of ToM. Compared to the American participants, the Japanese participants had a lower sense of self and other distinction, as they emphasised more the collectivist orientation in social interaction. Further research exploring neural responses in VPT tasks can help to understand how bilingual ToM mechanisms develop, function, and are implied in daily life.

Additionally, we should test the mechanisms of bilingualism on socio-emotional and perspective-taking in a longitudinal manner to evaluate whether a bilingual advantage is exaggerated over time, maintained or whether it disappears. A longitudinal design is fundamental for the understanding of the developmental course of bilingualism and for the differentiation between those who develop socio-emotional advantages that lead them to better academic abilities and those who do not. This should allow us to locate the differences in the cognitive mechanisms between monolingual, bilingual and multilingual (as shown in Chapter 4 where multilingualism was negatively correlated with prosocial behaviour but mediated by empathic concern). Our findings are introductions to how empathic concern can

develop with bilingualism, a longitudinal approach can be used as a measure to help us to understand the wider impact of bilingualism on socio-cognitive and emotional abilities.

Overall, this thesis has provided evidence that young adult bilinguals' performance is equivalent to that of monolinguals in VPT. But young adult bilinguals are also less distressed and anxious and more emotionally stable. Due to our limited scope of the target population of bilinguals, the generalisability of the findings of this present thesis to other populations remains to be open. Furthermore, given the variety of factors involved in the phenomenon of bilingualism, research should explore how specific aspects of the bilingual experience can affect social cognition and social-emotional skills. In conclusion, the current study provides an important contribution to the understanding of how bilingualism and multilingualism affect socio-emotional and socio-cognitive abilities.

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Supplementary: Experimenter Instruction for Experiment 1

Before experiment

1. Welcome and Introduction

   a) Welcome to my experiment. I'm ***, the experimenter. This is ***. He will do the gender category experiment with you as a partner.

   b) Would you like to have some water?

2. Questionnaires

   Before the experiment, would you please first fill in some questionnaires (paper and computer)? If you have any questions, please feel at ease to ask me.

3. Instructions

   a) Great! Please sit here. And this is the instruction for the experiment. Please have a look.

   b) (after a while) Do you have any questions about the instruction?

   You will first do a practice session. After that is the experiment. The experiment has two parts—A and B.

4. Male and female button box

   a) (Participant), you should respond to male/female.

      (***), you respond to female/male, please.

   b) There are labels on your button. Male or female, begin and repeat. You should use them during the experiment. The male and female button is the most frequently used button. The begin button is only used when you begin a new session. The repeat button only is used when you think you need to do the practice again.

   c) Please put the button box on the lap underneath the table and respond as fast and accurately as possible.

d) Are you a right-hand or left-hand user? If right, please use your right hand to press the button. If left, use your left hand, please.

5. Earplugs

You should wear earplugs and earphones during the experiment. These are new.

6. Head movement

Please don't move your head wildly during the experiment.

During experiment

7. Change seat

Now, wait a moment. Let *** change the seat.

After experiment

8. Goodbye

This is the end of the experiment. Thanks very much.

Supplementary: Participant Instruction for Experiment 1

Dear Participants,

Thanks for joining my experiment!

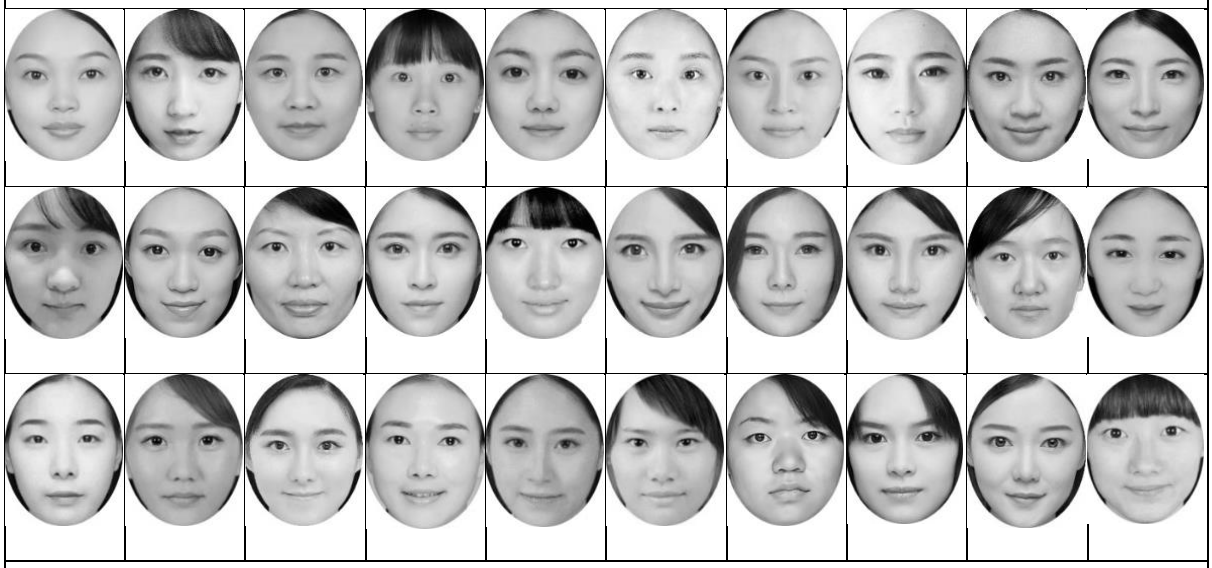
In this experiment, you will perform a gender categorization task with face pictures displayed on a computer screen. The image stimuli always are male or female faces. You only need to respond to one gender category (male/female). The experimenter will tell you which category you should respond to. Press the button only to the faces from your own category and not to those from the other category.

You will first do a practice session with feedback. For the real experiment, there won't be any feedback. The experiment has two parts, each taking about 7 mins.

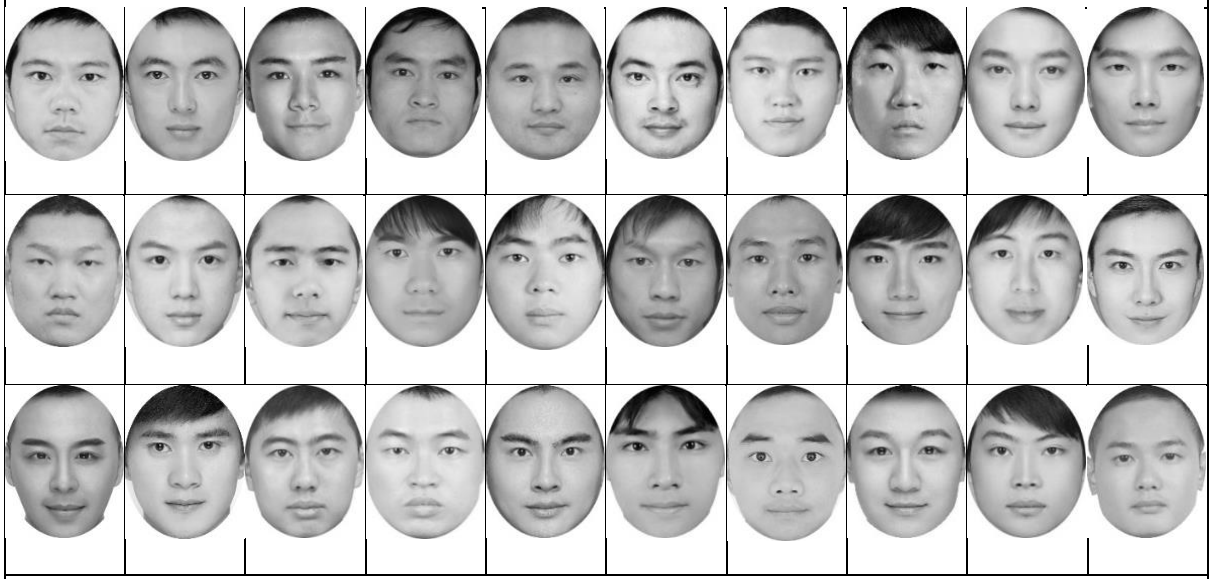
If you have any questions, please ask the experimenter (Yifan WANG).

Supplementary: Picture stimuli in Experiment 1

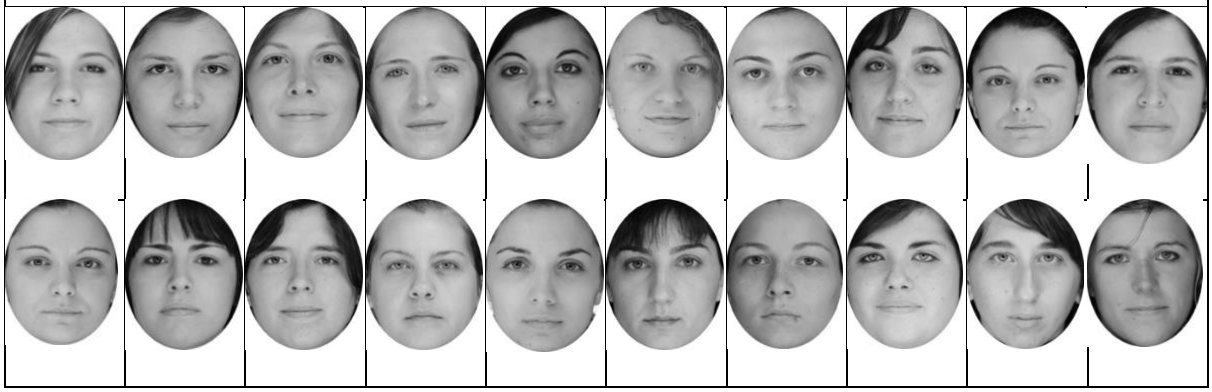
Eastern Female

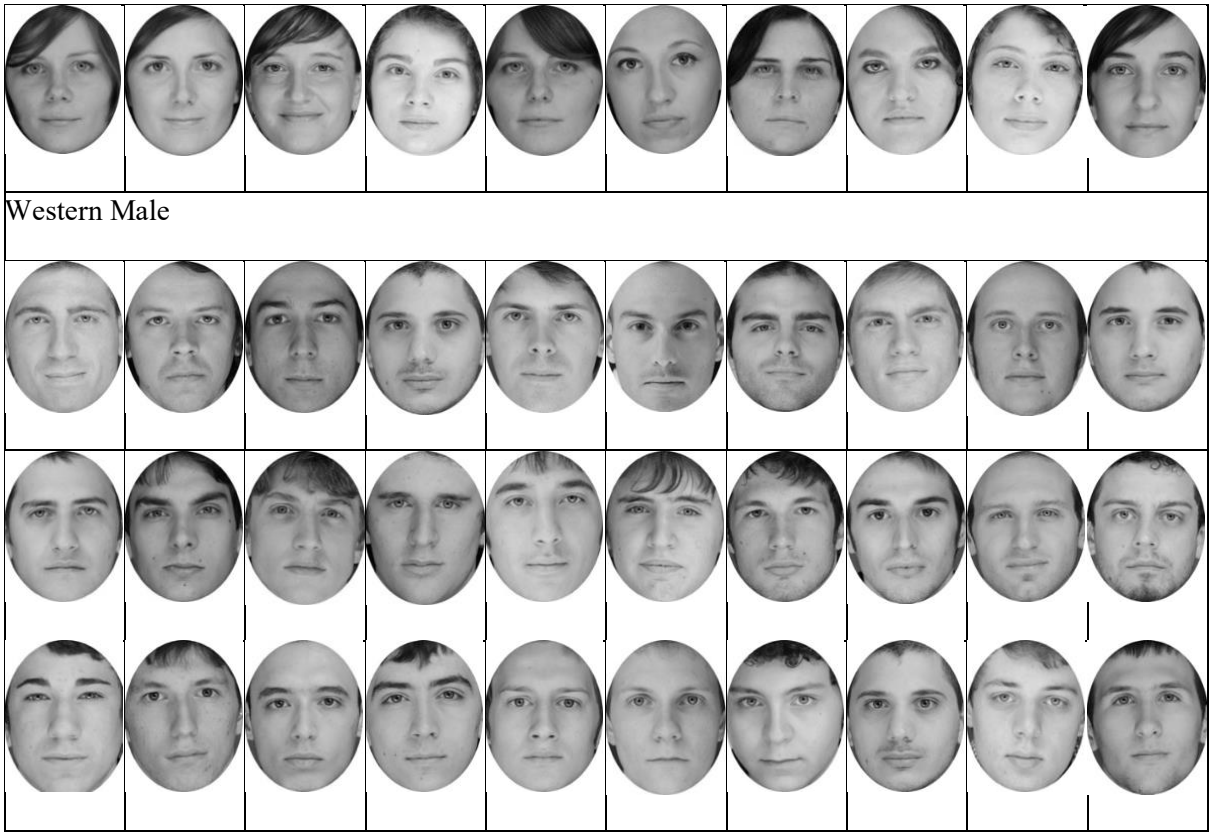


Eastern Male



Western Female





Western Male

Supplementary: Participant instruction for Experiment 2

Dear Participants,

Thanks for joining my experiment!

In this experiment, you will perform a word categorization task with English words being displayed on a computer screen. The word stimuli always belong to (a) animals or (b) fruits and vegetables. You only need to respond to one word category (animals/fruits and vegetables). The experimenter will tell you to which you should respond. Press the button only to the word from your own category and not to that from the other category.

You will first do a practice session with feedback. For the real experiment, there won't be any feedback. The experiment has two parts, each taking about 7 mins.

If you have any questions, please ask the experimenter (Yifan WANG).

Supplementary Table 2.1

Word stimuli in Experiment 2

	Length	BNC	CELEX	Questionnaire	Syllable
veg&fruit-1					
strawberry	10	371	50	8.85	3
broccoli	8	222	16	7.77	3
cucumber	8	324	54	8.08	3
tomato	6	1162	122	9.00	3
apple	5	2570	310	9.00	2
cherry	6	1190	104	9.00	2
carrot	6	639	44	8.77	2
lemon	5	914.5	233	8.69	2
mango	5	511	15	8.69	2
ginger	6	609	90	7.00	2
pepper	6	280	119	8.00	2
okra	4	30	1	5.00	2
cabbage	7	269	142	7.92	2
lettuce	7	197	114	6.85	2
beetroot	8	57	27	5.15	2
celery	6	110	48	3.77	3
grape	5	461	37	8.62	1
pear	4	385	43	8.62	1
plum	4	198	50	7.08	1
lime	4	188	148	6.00	1
veg&fruit-2					
blueberry	9	11	7	8.77	3
coconut	7	350	40	8.08	3
pineapple	9	272	39	8.08	3
banana	6	948	72	9.00	3
potato	6	851	204	8.92	3
orange	6	2582	519	9.00	2
onion	5	717	169	8.85	2
melon	5	526	38	8.69	2
olive	5	896	198	8.00	2
garlic	6	784	115	5.00	2
chilly	6	370	11	8.31	2
radish	6	23	11	4.92	2
mushroom	8	381	87	8.31	2
pumpkin	7	205	30	7.23	2
spinach	7	131	74	5.69	2
papaya	6	17	1	4.31	3
peach	5	836	53	8.92	1
bean	4	669	67	8.77	1

corn	4	222	433	7.54	1
leek	4	128	5	5.80	1
animal-1					
butterfly	9	623	88	8.69	3
crocodile	9	247	69	7.31	3
kangaroo	8	109	34	7.46	3
koala	5	15	7	7.31	3
squirrel	8	227	63	7.54	2
chicken	7	2027	534	7.92	2
puppy	5	460	87	7.85	2
lion	4	1194	288	8.85	2
giraffe	7	71	22	6.85	2
peacock	7	469	50	6.31	2
spider	6	648	71	8.62	2
turtle	6	253	39	7.77	2
parrot	6	375	53	6.08	2
rabbit	6	1393	189	8.15	2
pigeon	6	394	67	6.38	2
panda	5	175	15	9.00	2
dove	4	298	53	7.08	1
duck	4	709	187	8.67	1
frog	4	488	63	8.69	1
crab	4	323	97	6.54	1
animal-2					
elephant	8	892	216	8.62	3
mosquito	8	238	43	7.85	3
flamingo	8	79	9	6.23	3
octopus	7	170	26	5.77	3
sparrow	7	185	47	6.00	2
turkey	6	2047	231	8.00	2
kitty	5	291	912	8.00	2
tiger	5	870	155	8.69	2
seagull	7	63	18	7.15	2
penguin	7	467	60	7.54	2
dolphin	7	763	24	8.23	2
lobster	7	244	36	8.00	2
camel	5	358	146	7.69	2
monkey	6	552	156	8.77	2
dragon	6	860	131	8.70	2
donkey	6	499	161	7.00	2
shark	5	314	245	7.69	1
wolf	4	804	115	8.77	1
worm	4	582	125	7.31	1
crow	4	321	70	6.15	1

Supplementary: Pictures of the Word Stimuli in Experiment 2

Animals



octopus



sparrow



parrot



crow



flamingo



peacock



pigeon



crab



giraffe



donkey



dove



seagull



crocodile



koala



worm



kangaroo



squirrel



penguin



camel



shark



turtle



mosquito



puppy



chicken



lobster



turkey



kitten



rabbit



dolphin



elephant



spider



duck



butterfly



tiger



frog



dragon



monkey



wolf



lion



panda

Fruits and vegetables



celery



papaya



radish



okra



garlic



beetroot



spinach



lime



lettuce



leek



ginger



plum



pumpkin



corn



broccoli



cabbage



olive



pepper



coconut



cucumber



pineapple



chilly



mushroom



pear



grape



mango



lemon



melon



bean



carrot



blueberry



onion



strawberry



peach



potato



apple



cherry



orange



banana



tomato

Supplementary Table 3.1

Participant Demographics

	EA-Bil $N = 63$	EU-Bil $N = 61$	B-Mono $N = 60$
	(Count, percentage)	(Count, percentage)	(Count, percentage)
First Language	Chinese (53, 84.13%) English (7, 11.11%) Korean (2, 3.17%) Indonesian (1, 1.59%)	English (17, 27.87%) Spanish (8, 13.11%) Italian (7, 11.48%) Romanian (7, 11.48%) French (4, 6.56%) Polish (2, 3.28%) Bulgarian (2, 3.28%) Czech (2, 3.28%) Hungarian (2, 3.28%) Slovak (2, 3.28%) Estonian (1, 1.64%) Finnish (1, 1.64%) German (1, 1.64%) Greek (1, 1.64%) Norwegian (1, 1.64%) Portuguese (1, 1.64%) Punjabi (1, 1.64%)	English (60, 100%)
First 15 years in heritage country	yes (62, 98.41%) no (1, 1.59%)	yes (50, 81.97%) no (11, 18.03%)	yes (100%) no
Home culture different from second language	same (63, 100%) \	same (60, 98.36%) 1 (1.64%)	same (59, 98.33%) 1 (1.67%)
Heritage Culture	Chinese (58, 92.06%) Korean (2,3.17%) Japanese (1,1.59%) Indonesian (1,1.59%) Singaporean (1,1.59%)	Romanian (8, 13.11%) French (8, 13.11%) Spanish (8, 13.11%) Polish (8, 13.11%) Italian (7, 11.48%) Indian (2, 3.28%) Hungarian (2, 3.28%) Slovak (2, 3.28%) Bulgarian (2, 3.28%) Czech (2, 3.28%) Serbian (2, 3.28%) German (2, 3.28%) Estonian (2, 3.28%) Portuguese (2, 3.28%) Norwegian (1, 1.64%) Greek (1, 1.64%) Finnish (1, 1.64%) Jamaican (1, 1.64%)	Native British (24, 40%) Irish (10, 16.67%) Welsh (4, 6.67%) Danish (3, 5%) Indian (3, 5%) Chinese (2, 3.33%) Italian (2, 3.33%) Jamaican (2, 3.33%) Bulgarian (1, 1.67%) Caribbean (1, 1.67%) Dutch (1, 1.67%) German (1, 1.67%) Ireland (1, 1.67%) Jewish (1, 1.67%) Nigerian (1, 1.67%) Romanian (1, 1.67%) Russian (1, 1.67%) Scottish (1, 1.67%)

Supplementary: Fitted models for outputs from the visual perspective-taking task

The maximal model for both response time and error rate didn't converge. The fitted model for response time included all fixed effects (tasklevel, perspective, congruency) and their interaction, as well as intercepts for both random effects (subject and stimulus) and slopes for tasklevel | subject, perspective | subject, congruency | subject, perspective | stimulus.

The fitted model for error rate contained all fixed effects (tasklevel, perspective, congruency) and their interaction, as well as intercepts for both random effects (subject and stimulus) and slopes for congruency | subject.

Supplementary: Cross-group difference of RTs and error rates

We fitted a linear mixed effects model to RTs and a generalised linear mixed effects model to error rates using the lme4 package (Bates et al., 2015) in R (version 4.2.2, R Core Team, 2021). Before model fitting, response time data were transformed using the inverse function to obtain more normally distributed data (Lo & Andrews, 2015). As fixed effects, we added the main effects of group (EA-Bils, EU-Bils, NB-Monos), task level (level-1, level-2), perspective (self, other) and congruency (congruent, incongruent) as well as their interactions. The four variables were factorized and deviation coded. To account for a speed-up effect, the number of trials was scaled and added as a fixed effect. We also added the maximum random effects structure. When this model did not converge, we simplified the model by firstly removing random slopes, then random intercept, then fixed interaction effects, then fixed main effects until the model converged (Barr et al., 2013). The drop1 function from the lmerTest package (Kuznetsova et al., 2017) was used to identify the best fitting model. A particular main effect or interaction was obtained by comparing the model with the factor or interaction and the model without the factor or interaction by ANOVA

(Winter, 2019). Simple effects in interactions were checked by using the emmeans function in the emmeans package (Winter, 2019).

The best-fitting model for response time was

lmer(inv_rt~Group *Tasklevel *Perspective *Congruency + scale(Trial,scale=TRUE) +(1+Tasklevel +Perspective +Congruency |Subject)+(1+Perspective |Image).

The best-fitting model for accuracy was

glmer(acc~Group +Tasklevel +Perspective +Congruency + Group:Tasklevel + Group:Perspective + Tasklevel:Perspective + Group:Congruency + Tasklevel:Congruency + Perspective:Congruency + Tasklevel:Perspective:Congruency + scale(Trial,scale=TRUE) +(1 |Subject)+(1 |Image).

The results were shown in Supplementary Table 3.2.

Supplementary Table 3.2

Results for the Fixed Mixed Effect Model for Response Times and Error Rates in VPT Tasks

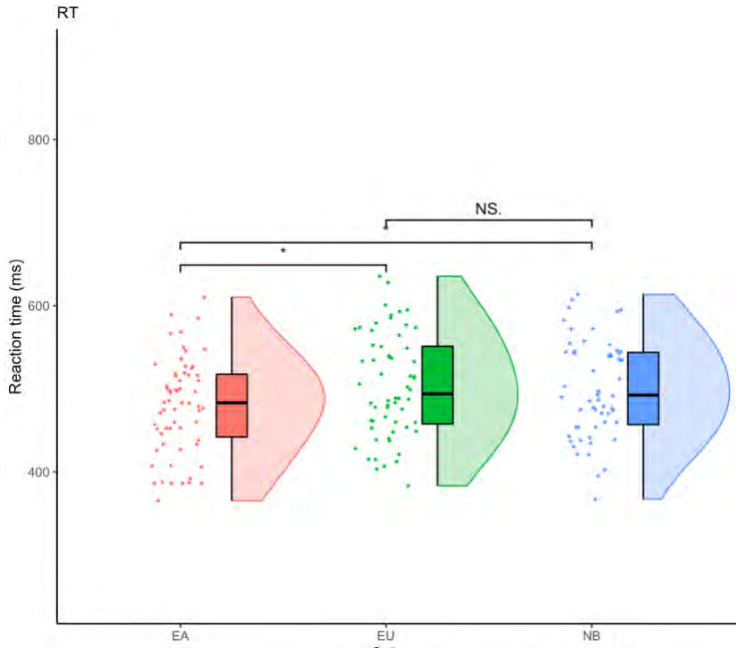
inverse_rt					
Predictors	***Estimates***	***std. Error***	***CI***	***Statistic***	***p***
(Intercept)	-1.86	0.02	-1.90 – -1.81	-80.82	**<0.001**
Group	0.01	0.04	-0.06 – 0.08	0.17	0.864
Tasklevel	**0.55**	**0.03**	**0.48 – 0.61**	**15.88**	**<0.001**
Perspective	**0.15**	**0.02**	**0.10 – 0.19**	**6**	**<0.001**
Congruency	**0.12**	**0.03**	**0.06 – 0.18**	**3.81**	**<0.001**
Trial	**0**	**0**	**-0.00 – -0.00**	**-6.72**	**<0.001**
Group × Tasklevel	-0.06	0.03	-0.12 – 0.00	-1.86	0.063
Group × Perspective	**0.05**	**0.03**	**0.00 – 0.11**	**1.97**	**0.048**
Tasklevel × Perspective	**0.39**	**0.04**	**0.31 – 0.47**	**9.16**	**<0.001**
Group × Congruency	-0.02	0.01	-0.04 – 0.00	-1.77	0.076
Tasklevel × Congruency	0.01	0.06	-0.12 – 0.13	0.1	0.922
Perspective × Congruency	**0.15**	**0.04**	**0.06 – 0.23**	**3.49**	**<0.001**
Group × Tasklevel × Perspective	**0.17**	**0.02**	**0.13 – 0.20**	**9.01**	**<0.001**
Group × Tasklevel × Congruency	0	0.02	-0.03 – 0.04	0.2	0.84
Group × Perspective × Congruency	-0.02	0.02	-0.06 – 0.01	-1.35	0.177
Tasklevel × Perspective × Congruency	0.12	0.08	-0.05 – 0.28	1.38	0.168
Group × Tasklevel × Perspective × Congruency	0.05	0.04	-0.02 – 0.12	1.43	0.153
Accuracy					
Predictors	***Odds Ratios***	***std. Error***	***CI***	***Statistic***	***p***
(Intercept)	20.31	2.27	16.32 – 25.27	26.99	**<0.001**
Group	0.9	0.11	0.71 – 1.13	-0.94	0.349
Tasklevel	0.75	0.15	0.51 – 1.10	-1.47	0.142
Perspective	1.23	0.06	1.12 – 1.36	4.28	**<0.001**
Congruency	0.43	0.09	0.29 – 0.64	-4.25	**<0.001**
Trial	1.13	0.03	1.08 – 1.18	5.38	**<0.001**
Group × Tasklevel	1.08	0.1	0.90 – 1.30	0.84	0.399
Group × Perspective	0.89	0.09	0.74 – 1.08	-1.17	0.243
Tasklevel × Perspective	0.75	0.07	0.62 – 0.91	-2.94	**0.003**
Group × Congruency	0.91	0.09	0.75 – 1.10	-0.99	0.324
Tasklevel × Congruency	1.58	0.63	0.73 – 3.43	1.16	0.248
Perspective × Congruency	0.32	0.03	0.26 – 0.39	-11.76	**<0.001**
Tasklevel × Perspective × Congruency	1.46	0.28	1.00 – 2.13	1.94	**0.053**

The RT results showed no significant main effect of group. However, a significant group by perspective interaction ($\chi2 = 3.431$, $p = .05$) as well as a group by task level by perspective interaction was found ($\chi2 = 81.118$, $p < .001$). To investigate the group by perspective interaction, we separated the data based on perspective, generating datasets for self and other, and subsequently analysed the performance of the three groups for these datasets. We did not find a significant difference between the groups in either self-perspective task ($\chi2 = 4.659$, $p = .097$) or other-perspective task ($\chi2 = 3.075$, $p = .215$). To investigate the group by task level by perspective interaction, we separated the data based on task level and perspective, generating datasets for level-1 self, level-1 other, level-2 self, and level-2 other, and subsequently analysed the performance of the three groups for these datasets. We found a significant group difference, but only for level-1 self-perspective task ($\chi2 = 6.02$, $p = .049$), with EA-Bils showing significantly faster performance than the other two groups (EA vs EU, $z = 2.19$, $p < .05$, EA vs NB, $z = 2.16$, $p< .0.5$; EA = 481ms, EU = 505ms, NB= 501ms) (see Supplementary Figure 3.1). In line with prior research, it was discovered that participants from East Asian responded faster than participants from Western in the level-1 self-perspective task (Klaus et al., 2014; Wang et al., 2019), but not in the other VPT tasks.

There were no noteworthy variations in accuracy between the groups and no significant interactions with the group. Thus, all three groups performed with similar accuracy in all VPT tasks.

Supplementary Figure 3.1

Group Comparisons of Responses times for EA-Bil, EU-Bil and B-Mono in Level-1 Self-perspective VPT tasks



Supplementary Table 3.3

Correlation Matrix for Combined Groups

	VPT-1-ego	VPT-2-ego	Age	SES	Bilingualism	Collectivism	Individualism	Acculturation	Inhibition
VPT-1-ego									
VPT-2-ego	0.14.								
Age	-0.06	-0.06							
SES	0.1	0.13	0.14						
Bilingualism	0.05	0.11	0.26***	-0.03					
Collectivism	0.06	-0.08	-0.17*	0.07	-0.37****				
Individualism	0.14	0.02	-0.02	0.09	-0.03	0.03			
Acculturation	-0.01	-0.07	-0.14	-0.15*	-0.44****	0.18*	-0.03		
Inhibition	0.08	0.1	0.06	-0.03	0.17*	-0.13	0.08	0.01	
Switching	0.16*	0.29***	0.11	0.12	0.11	0.04	0.02	-0.01	0

Note. Symbols indicate significant level (* $p < .05$. ** $p < .01$. *** $p < .001$).

Supplementary Table 3.4

Correlation Matrix for EA-Bil, EU-Bil and B-Mono

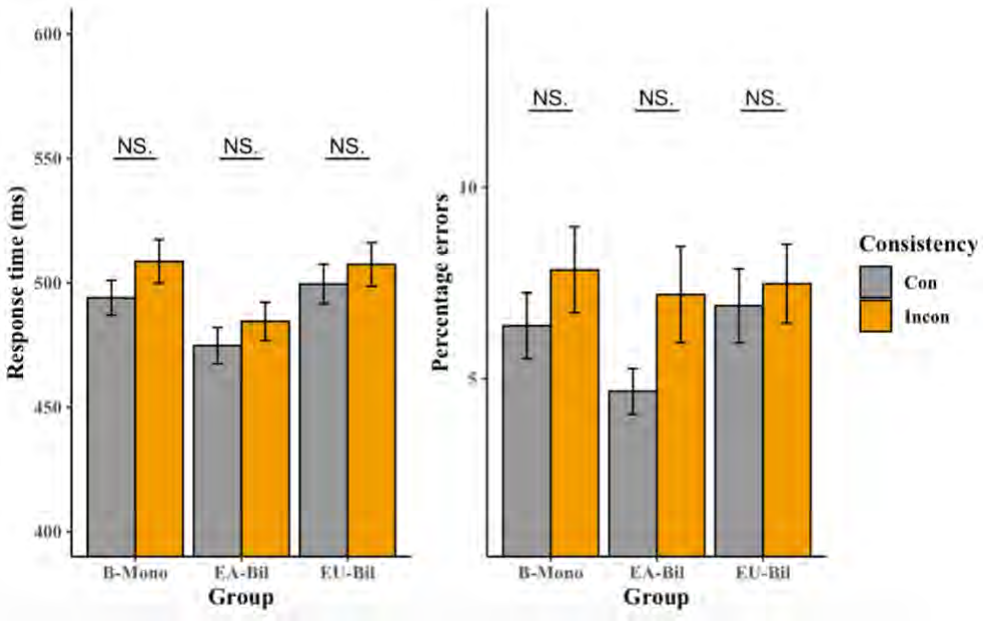
	VPT-1-ego	VPT-2-ego	Age	SES	Bilingualism	Collectivism	Individualism	Acculturation	Inhibition
EA-Bil									
VPT-1-ego									
VPT-2-ego	0.12								
Age	-0.12	0							
SES	0.24	0.14	0.19						
Bilingualism	-0.19	0.14	0.11	-0.2					
Collectivism	0.16	-0.16	-0.19	0	-0.22				
Individualism	0.1	0.07	0.01	0.19	-0.05	0.08			
Acculturation	-0.14	-0.18	-0.07	-0.22	0.16	0.24	0.12		
Inhibition	-0.04	0.21	-0.01	0	0.16	0	0.08	0.08	
Switching	0.28*	0.21	0.16	0.08	0.27*	0.06	0.24	0.07	0.03
EU-Bil									
VPT-1-ego									
VPT-2-ego	-0.02								
Age	-0.12	-0.18							
SES	0.17	0.25	0.2						
Bilingualism	0.11	0.09	0.05	0.03					
Collectivism	0.15	0.09	0.02	0.31*	0.02				
Individualism	0.27*	-0.07	-0.05	0.22	-0.1	-0.18			
Acculturation	0.09	-0.36**	0.04	-0.15	0.14	0	0.05		
Inhibition	0.30*	0.14	0.04	0.16	-0.11	-0.02	0.05	-0.22	
Switching	-0.02	0.30*	0.13	0.15	0.09	0.18	-0.16	-0.01	0.03
B-Mono									
VPT-1-ego									
VPT-2-ego	0.29*								
Age	0.08	-0.16							
SES	-0.05	0.03	0.05						
Bilingualism	0.1	-0.12	0.13	0.16					
Collectivism	0	-0.09	-0.02	-0.14	-0.06				
Individualism	0.03	0.08	-0.01	-0.16	0.09	0.15			
Acculturation	0.05	0.13	-0.07	-0.2	-0.19	-0.02	-0.15		
Inhibition	-0.02	-0.03	0.07	-0.15	-0.22	-0.17	0.11	0.12	
Switching	0.27*	0.32*	-0.11	0.12	-0.22	-0.03	0.01	-0.05	-0.07

Note. Symbols indicate significant level (* $p < .05$. ** $p < .01$. *** $p < .001$).

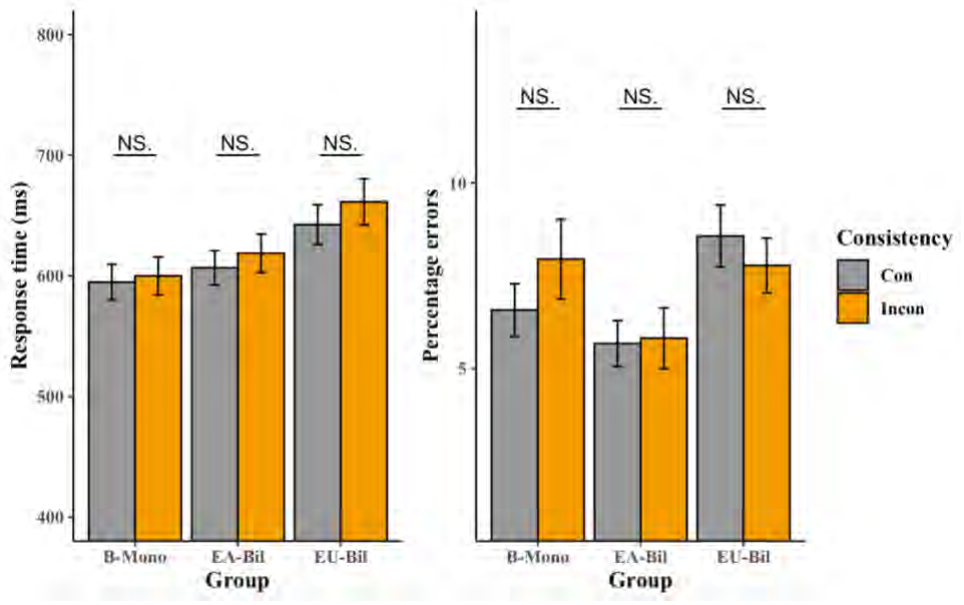
Supplementary Figure 3.2

Group Comparisons of Responses times (left) and Percentage Errors (right) for Congruent and Incongruent Conditions in Other-perspective Level-1 and Level-2 VPT tasks (altercentric bias)

VPT-1-Alter



VPT-2-Alter



Note. The difference between incongruent and congruent trials reflects the interference from the distracting objects. * $p < .05$. ** $p < .01$. *** $p < .001$. *NS* = nonsignificant.

Supplementary Table 4.1

Standardized Robust Maximum Likelihood Parameter Estimates for Mediation Model of Empathic Concern with Frequency and Proficiency as Predictors in Separate Models

Model parameter	*Estimate*	*SE*	*z*	*ci.lower*	*ci.upper*
Frequency					
EC ~					
Multilingualism	-0.208	0.053	-3.955***	-0.315	-0.108
Collectivism	0.359	0.057	6.32***	0.238	0.469
Individualism	-0.124	0.055	-2.273*	-0.232	-0.009
PSA ~					
Collectivism	0.318	0.067	4.769***	0.189	0.454
Individualism	-0.134	0.05	-2.702**	-0.235	-0.042
EC	0.453	0.078	5.791***	0.3	0.598
Frequency	0.053	0.042	1.263	-0.024	0.135
Path					
Frequency indirect	-0.094	0.028	-3.303**	-0.155	-0.045
Frequency direct	0.053	0.042	1.263	-0.024	0.135
Frequency total	-0.041	0.048	-0.858	-0.136	0.057
Proficiency					
EC ~					
Multilingualism	-0.122	0.059	-2.076*	-0.231	0.006
Collectivism	0.368	0.059	6.248***	0.248	0.483
Individualism	-0.141	0.056	-2.543*	-0.25	-0.027
PSA ~					
Collectivism	0.319	0.067	4.779***	0.189	0.457
Individualism	-0.127	0.051	-2.508*	-0.229	-0.032
EC	0.437	0.077	5.672***	0.282	0.579
Proficiency	-0.016	0.04	-0.401	-0.093	0.065
Path					
Proficiency indirect	-0.053	0.028	-1.901.	-0.11	0.003
Proficiency direct	-0.016	0.04	-0.401	-0.093	0.065
Proficiency total	-0.069	0.047	-1.484	-0.155	0.031

Supplementary Table 4.2

Correlation Matrix of Early and Late Bilinguals Performance

	1	2	3	4	5	6	7	8	9	10
Early Bilinguals										
1. Age										
2. SES	0.13									
3. Collectivism	-0.23	-0.17								
4. Individualism	-0.11	-0.09	0.06							
5. PT	0.09	0.18	0.18	-0.02						
6. FS	-0.1	0.09	0.13	0.14	0.28*					
7. EC	-0.23	-0.08	0.49****	-0.24	0.38**	0.28*				
8. PD	-0.30*	-0.27*	0.13	0	0.09	-0.01	0.41**			
9. PSA	-0.18	0.02	0.52****	-0.31*	0.49****	0.28*	0.68****	0.1		
10. L2_Proficency	0.08	0.24	0.08	0.02	0.18	0.15	-0.15	-0.19	0.11	
11. L2_Frequency	0.01	0.13	-0.06	0.08	0.17	0.01	-0.12	-0.01	-0.04	0.71****
Late Bilinguals										
1. Age										
2. SES	-0.21									
3. Collectivism	-0.28	0.27								
4. Individualism	0.04	-0.02	-0.1							
5. PT	-0.11	0.17	0.38**	0.13						
6. FS	-0.01	-0.21	-0.1	0.14	0.2					
7. EC	-0.12	0.08	0.35*	-0.02	0.66****	0.39**				
8. PD	0.11	-0.41**	-0.07	-0.12	-0.04	0.23	0.27			
9. PSA	-0.04	0.17	0.65****	0.08	0.45**	-0.09	0.41**	0.15		
10. L2_Proficency	0.13	-0.22	-0.30*	0.46**	0.15	0.25	0.04	-0.03	-0.23	
11. L2_Frequency	0.23	-0.06	-0.2	0.43**	-0.08	-0.03	-0.23	-0.09	-0.04	0.53***