AMERICAN PSYCHOLOGICAL ASSOCIATION

Translational Issues in Psychological Science

ISSN: 2332-2136

2023, Vol. 9, No. 4, 444–459
https://doi.org/10.1037/tps0000379

Empathy Interacts with Second Language Proficiency to Modify Executive Control of Attention to Social Information

Schea Fissel Brannick[1], Emily Sebranek[1], Emily Anderson[2], Ileana Ratiu[3], and Arianna N. LaCroix[4]

[1] Speech-Language Pathology Program, Midwestern University
[2] Clinical Neuropsychology Program, Midwestern University
[3] Communication Sciences and Disorders, Arizona State University
[4] Speech, Language and Hearing Sciences, Purdue University

A large body of research suggests that bilinguals show a unique, lifelong relationship between language experience and executive control, but the nature of this relationship is unclear as much of this work has not addressed the role of social functioning. The purpose of this study was to clarify the relationship between language experience and social functioning by first exploring relationships between second language experience and two indices of social functioning: empathy and social cognition. We then explored whether these variables impact executive control of attention to incongruent trials over time. Thirty-eight adults with a range of second language experience completed surveys of language experience, empathy, and social cognition, as well as a traditional Flanker task and a socially modified version of the Flanker task. Reaction times, fixation counts, and blinking counts were measured by trial on each Flanker task. Second language experience did not predict empathy or social cognition, which was contrary to what was predicted. On the Flanker tasks, greater empathy interacted with bilingualism to improve executive control and behavioral responses to incongruent social stimuli, but interacted with worse social cognition to broaden attention to incongruent social stimuli, but with greater inhibitory costs and impaired performance. Highly empathetic bilinguals showed unique temporal patterns of broadening attention to incongruent stimuli early in trials, which then enhanced executive control and behavioral performance in subsequent trials. These findings point to the importance of measuring social variables in bilingual and clinical populations.

What is the significance of this article for the general public?
More empathetic individuals who also spoke a second language were better able to process and use social information to accomplish task goals over time. Greater empathy broadened attention to social information in persons with worse social cognition. Empathy is a skill that can be taught and learned, and empathy-building may represent an important priority for an ever-globalized society and may benefit adults who struggle in social contexts.

Keywords: executive control, social cognition, empathy, attention, Flanker task

Supplemental materials: https://doi.org/10.1037/tps0000379.supp

---

This article was published Online First October 5, 2023.
Schea Fissel Brannick https://orcid.org/0000-0003-1220-4193
Schea Fissel Brannick and Emily Sebranek equally share the first author position, as each contributed essential and substantive ideas, content, and writing efforts to the development and submission of this submission.
Correspondence concerning this article should be addressed to Schea Fissel Brannick, Department of Speech-Language Pathology, Midwestern University, Glendale Campus, 19555 North 59th Avenue, Cactus Wren 302E, Glendale, AZ 85308, United States. Email: sfisse@midwestern.edu

A robust body of work suggests that bilinguals show a unique lifelong relationship between language and cognition that differs from monolinguals (e.g., Perani & Abutalebi, 2015). In general, this literature shows that bilingual adults have better cognitive abilities than monolingual adults (Adesope et al., 2010; Bialystok, 2017). However, several notable works contradict these findings, revealing mixed results, including neutral and indirect relationships between bilinguals' language and cognition (e.g., Paap et al., 2020). Unfortunately, most studies of bilinguals' relationship between language and cognition fail to directly measure bilinguals' social functioning or indirectly measures social functioning using language experience variables. It is critical to directly measure adult bilinguals' social functioning in studies exploring the relationship between cognition and language, as these three areas interdependently influence one another in ways that persist later in life (Bialystok, 2007). The purpose of this study was to shed light on the role social functioning plays in the cognitive and language abilities of adults with diverse language experiences. We operationalized social functioning as social cognition (i.e., the ability to infer and coordinate joint mental states with others) and empathy (i.e., the ability to adapt one's own thoughts and behaviors based on understanding the thoughts, feelings, and states of others; Decety & Lamm, 2006). We then explored how individual differences in these social functioning domains interacted with participants' language proficiency and cognitive abilities on social and nonsocial executive control tasks.

Studies examining bilingualism focus largely on its impact on executive control (Costa et al., 2009). Executive control of attention (Posner & Petersen, 1990; Villard, 2021) includes a set of higher-order neurocognitive processes that direct attentional focus (and thereby cognitive resources) to salient or goal-relevant stimuli. This ability is critical for allowing humans to act (or not act) adaptively within a multisensory world. One of these neurocognitive processes is interference inhibition, which functions to resist processing distracting or uninformative stimuli, while attending to salient or goal-relevant stimuli. Studies exploring the relationship between language and interference inhibition have been studied extensively within the context of the "bilingual advantage." This line of work suggests that the unique, lifelong practice that bilinguals have regulating two languages benefits their domain general executive control in ways that differ from monolinguals (Bialystok, 2017). Indeed, multiple models have been proposed to address these benefits, such as the adaptive control hypothesis (e.g., Green & Abutalebi, 2013). While some have failed to replicate the "bilingual advantage" (Dick et al., 2019; D'Souza et al., 2018; Paap et al., 2014), others have found that a domain general executive control advantage does exist for bilinguals, but varies based on individual factors such as the frequency (Anderson et al., 2018) or context (Beatty-Martínez et al., 2020) of language use, neuroanatomical differences (DeLuca et al., 2019), and socioeconomic status (Naeem et al., 2018) within the often heterogeneous "monolingual" and "bilingual" groups (Westergaard, 2021). Many of these studies have not measured participants' social factors, which are unique to the bilingual experience (Titone & Tiv, 2023), and are related to social cognition and empathy (Dewaele & Wei, 2012). A benefit of bilingualism or multilingualism that is free from social influences is unlikely to fully account for the (general) executive control advantages reported, suggesting that other social variables such as one's social cognition, and empathy may contribute to the purported advantages (Vogeley & Roepstorff, 2009).

Executive control of social information is critical for language learning and later social functioning (Decety & Lamm, 2006). Social information automatically recruits attention and executive control to suppress distracting (nonsocial) information (Palermo & Rhodes, 2007). In this way, executive control frees up cognitive resources that are recruited to process social information, such as a mother's face, which contains high densities of visual information that are important for the development of more advanced language, cognitive, and social skills (Decety, 2010). Thus, social experiences both gait and ground multisensory learning of languages, social functioning, and executive control abilities that continue to reciprocally influence one another in adulthood. As such, measuring adult bilinguals' social functioning, in addition to aspects of their language history, offers a more complete picture of the lifelong influences that dynamically influence executive control. Measuring both executive control of attention to social and nonsocial information may further clarify any potential benefits of bilingualism to this cognitive process.

Studies using eye tracking to measure attention provide some evidence for the interdependence of second language learning, social functioning, and executive control of attention in children (e.g., Byers-Heinlein et al., 2014; Pons et al., 2015; Singh et al., 2019, 2020), suggesting that collectively these variables may lead to functional differences in how bilinguals view and process social information. For example, monolingual children look at speakers' mouths more so than their eyes or other social features during critical periods related to speech sound acquisition. Pons et al. (2015) showed that bilingual, compared to monolingual children, showed a longer developmental period for looking at speakers' mouths, possibly due to the demands to learn the sounds of two languages. Bilingual children also show a more balanced gaze toward adults speaking native and nonnative languages than their monolingual peers who show a preference for looking at native speakers (Byers-Heinlein et al., 2014; Singh et al., 2019). Singh et al. (2020) found that the more equitable gaze patterns of bilingual children predicted their ability to resolve the ambiguity of mispronounced words by speakers of nonnative races, whereas monolingual children struggled to do so. These studies suggest that early language experiences influence executive control of attention to social information and that these patterns are detectable using eye tracking. However, in the adult bilingual literature, attention is often measured behaviorally, which may not be as sensitive to individual differences in social attention as physiologic measures (Erb et al., 2021), such as eye tracking. For example, several preliminary investigations of empathy in bilingual and bicultural children showed similar behavioral performance, but different underlying neurocognitive signatures (e.g., Kobayashi et al., 2006). Measuring eye movements in addition to behavioral responses may help to elucidate these signatures in bilingual adults.

The purpose of this study was to investigate how social functioning (operationalized via social cognition and empathy) interacts with bilingualism (or second language experience) and interference inhibition. To this end, we first sought to determine if participants' social cognition or empathy varied by their language experience, as indexed by survey data. Then, we determined if individual variation in social cognition, empathy, and language experience predicted their performance on two Flanker tasks, which classically measure interference inhibition by requiring continuous visual attention to center stimuli while inhibiting attentional interference from flanking stimuli (Eriksen & Eriksen, 1974). The two Flanker tasks were social and nonsocial in nature; briefly, the social Flanker replaced the classical arrow stimuli with face-gaze stimuli. We included a social Flanker task because we anticipated that bilinguals would show unique patterns of attention to social information, as described above. We hypothesized that adults with more robust second language experiences would show greater social cognition and empathy and that these variables would interact to predict performance on both Flanker tasks. However, we expected smaller predictive effects of language and social functioning on the traditional Flanker task compared to the social Flanker task because the increased perceptual salience of faces should result in greater performance variation.

Method

Participants

Forty-three adult participants provided informed consent to participate in this study, which is part of a larger project exploring how the social experiences of adults with autistic traits interact with social cognition and empathy. Participants were recruited through various community outlets near Midwestern University located in the American Southwest. Most participants were students and faculty of the university. Consistent with sampling procedures in the individual differences approach, a few strict inclusion/exclusion criteria were used: participants had to be older than 18 and score less than 32 on a survey measure of social cognition (Baron-Cohen, Wheelwright, Skinner, et al., 2001; reflecting social cognition that was nonautistic). Participants' language experiences, as well as their social cognition and empathy, were quantified post hoc based on their responses to several survey instruments described below. This information was then used to assign participants to counterbalanced groups for completion of the experimental task. Five participants did not complete the experimental tasks due to experimental error. The final participant set included 38 participants (29 female, nine male, $M_{\text{age}} = 28.29$) without any history of language, cognitive, hearing, or vision impairments.

Procedures

Survey Measures

Participants completed several electronic survey instruments before scheduling their participation in the experimental task. All surveys and questionnaires were disseminated through Research Electronic Data Capture (REDCap), which is a secure, web-based platform used to electronically collect and store survey responses. All participants completed a demographic questionnaire, the LEAP-Q (Marian et al., 2007), the Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, et al., 2001), and the Interpersonal Reactivity Index (IRI; Davis, 1983). Participants' scores from each survey are reported in Table S1 in the online supplemental materials.

The demographic questionnaire collected information about age and gender, as well as socioeconomic status, behavioral (e.g., caffeine consumption), neurological (e.g., TBI, medications), and mental health (e.g., anxiety) factors that could impact attentional performance. The LEAP-Q is a widely used, validated self-report measure of bilingual status that asks about the age of second language acquisition, level of second language use, and level of second language proficiency in speaking and understanding. Second language proficiency was operationalized as the average of their speaking and understanding scores for their nondominant language (L2). Larger scores on these sections of the LEAP-Q indicate higher second language proficiency.

The AQ is a valid and reliable 50-item self-report questionnaire designed to identify social differences in adults with normal intelligence in the domains of social skills, attention switching, attention to detail, communication, and imagination (Baron-Cohen, Wheelwright, Skinner, et al., 2001). For the purposes of this paper, the AQ was used to characterize participants' social cognition. Higher AQ scores reflect worse social cognition.

The IRI is a valid and widely used survey of empathy (Melchers et al., 2015). It measures four dimensions of empathy (Davis, 1983): perspective taking, fantasy, empathetic concern, and personal distress. In this study, we used the IRI to classify participants' overall empathy across all dimensions. Higher scores on the IRI translate to higher levels of empathy.

Experimental Tasks

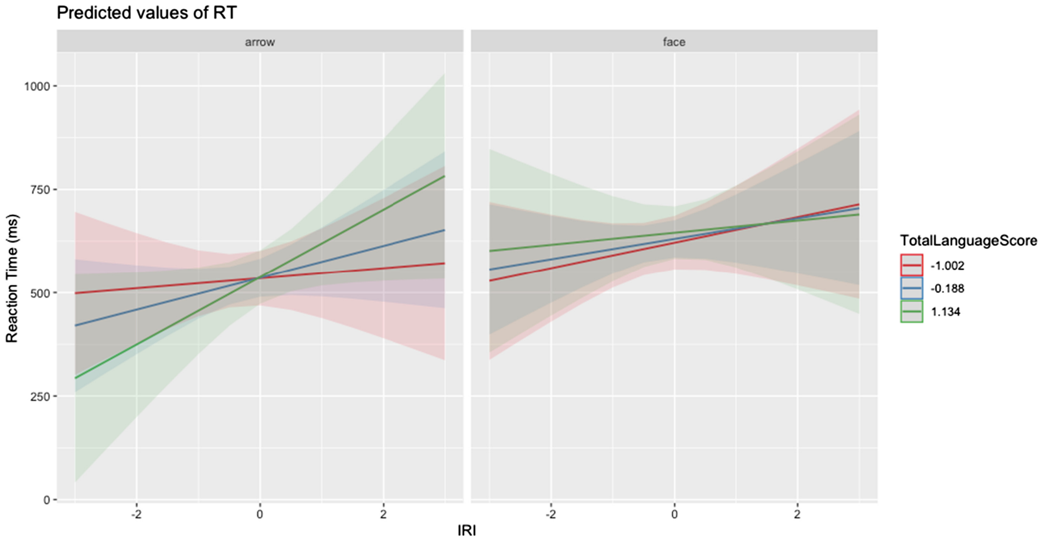
Participants completed two executive control tasks: the traditional (nonsocial) Flanker task and a social version of the Flanker task. While all analyses (described below) used continuous data to characterize participants, participants were initially classified as monolingual (no second language proficiency) or bilingual (any second language proficiency) to counterbalance participants a priori to one of two within-subjects, social-order conditions: Faces then Arrows [FA] or Arrows then Faces [AF]. These classifications were discarded after participants were assigned to either condition and second language proficiency was used as a continuous variable in the analyses. Overall, 10–15 practice trials with feedback preceded each trial block.

Flanker Task. The traditional (nonsocial) Flanker task (Eriksen & Eriksen, 1974) measures interference inhibition. In this task, participants see five arrows and are instructed to indicate the direction the center arrow is flanking via a keyboard button press; if the center arrow pointed left, participants pressed the left key (Z) and if the center arrow pointed right, participants pressed the right key (M). The task advanced when the participant pressed a key. Three trial types were presented: Congruent trials presented all five arrows pointing in the same direction. Incongruent trials presented a center arrow pointing in one direction, with flanking arrows pointing in the opposite direction, which induces interference. Neutral trials presented a center arrow flanked by horizontal lines. Participants completed 135 trials where all conditions were presented equally. Interference inhibition was indexed by dependent variables measured on incongruent trials only, which we expected to vary maximally by individual participant variables.

Social Flanker Task. The social adaptation of the traditional Flanker involved replacing arrow stimuli, with gaze-emotion stimuli. The gaze-emotion stimuli were based on The Reading the Mind in the Eyes task (Baron-Cohen, Wheelwright, Hill, et al., 2001), which presents a face that is cropped just below the eyes and just above the eyebrows (see Figure 1). Since the eyes gaze in various directions, these stimuli are classically used to test one's ability to use visual indicators

Figure 1

Participants Scaled and Centered IRI Performance Is Displayed Along the x*-Axis for the Nonsocial (Arrow) and Social (Face) Tasks*



Note. Participants scaled and centered Total Language Scores (from the LEAP-Q) reflect terciles of second language proficiency, with the green line representing the highest second language proficiency and the red line signaling the lowest second language proficiency. See the online article for the color version of this figure.

of gaze direction and emotion to respond to task goals. As in the traditional Flanker task, participants are asked to indicate which direction the center face is gazing (i.e., center gaze direction). Participants pressed key board buttons corresponding to four gaze directions: left-down (Z), left-up (Q), right-up (P), and right-down (M). Incongruent stimuli consisted of Flankers that were vertically and horizontally opposite (e.g., left-down) from the center gaze direction (e.g., right-up). Congruent trials presented the same gaze direction in target and Flanker stimuli. Neutral trials presented the center gaze direction flanked by eyes-closed stimuli. Participants completed 382 trials where all conditions were presented equally. As in the nonsocial Flanker task, interference inhibition was indexed by dependent variables on incongruent trials only.

Experimental Task Setup

The experimental tasks were programmed using Eprime 3.0 (Psychology Software Tools, 2016) on an Eyelink 1000 Plus eye tracker. The Eyelink 1000 Plus tracks eye movements with an accuracy within 0.01° of the visual angle. The temporal resolution was set to 1,000 Hz. Participants were initially calibrated using a nine-point calibration and validation, to ensure accurate tracking, and used a head–chin rest to stabilize head movements during all trials. The chin rest was positioned 90 cm from the monitor.

Behavioral responses and eye-movement measures were recorded and labeled using Data Viewer software (SR Research Ltd., Mississauga, Ontario, Canada). Reaction time was calculated as the amount of time elapsed (in milliseconds) between the onset of the traditional or social Flanker stimulus and the keyboard press. Faster reaction times on incongruent trials reflect better inhibitory control. The eye movements we measured were fixation counts and blink counts. Fixation counts reflect the number of times that a participant focused on a particular stimulus within the visual display, with each stimulus set as a distinct area of interest. Higher fixation counts suggest greater exploration of the visual scene and greater exploration should be associated with slower reaction times. Blinks are counted when the Eyelink registers that the participant's pupil is occluded because the eyelid is closed. Humans spontaneously blink at rates that are higher and lower than what is needed to lubricate and keep the eyes safe. Studies have found that blinking counts/rate varies by the cognitive demands of different visual tasks. For example, cognitively demanding or high-salience visual tasks that present stimuli continuously result in decreased eye-blinking rates, such as when reading (Ratiu et al., 2022), or when viewing high-salience (e.g., social) stimuli (Shultz et al., 2011). When directing attention to stimuli that always appear in the same location, as in the Flanker task, inhibition of spontaneous eye blinking increases the flow of visual information to demanding/important stimuli, thus mitigating the loss of visual information incurred by a blink. On the traditional Flanker task, faster reaction times should be associated with fewer blinks as this task requires continuous attention to center stimuli, with visual interference inhibition to external, flanking stimuli. On the social Flanker task, we expected greater initial demand (fewer blinks) to social stimuli for all participants as they began the social task. Social stimuli, such as faces capture attention in a mandatory fashion and should exert greater demands on inhibitory resources (inhibition cost), compared to arrows. These increased demands should result in fewer blinks, more fixations, and longer response times. However, we expected this cost to decrease over time associated with participants' improved performance. Improving performance should be indexed by faster reaction times, fewer blinks, and fewer fixations as trials progress.

Statistical Analyses

All analyses and models were developed in R Studio (R Core Team, 2021) using the lme4 package (v1.1-27.1; Bates et al., 2015). The package ggPlot2 (Wickham, 2016) was used to develop all figures. We first developed two simple regression models to test for relationships between second language experience and empathy and the relationship between second language experience and social cognition. Gender, age, and maternal education (a proxy of socioeconomic status) were inputted as covariates in both models.

We then used linear mixed effects regression models (LMER) to test whether second language (L2) proficiency, social cognition (AQ), and empathy (IRI) interacted with task type (nonsocial, social) and trial number (hereafter referred to as time) to predict Flanker task performance on incongruent trials. Continuous indices of L2, AQ, and IRI were used in all analyses, consistent with an individual differences approach. The dependent variables for the LMER models were reaction times on accurate, incongruent trials, and eye movements (blinking, fixations) measured on accurate, incongruent trials. In all models, task order (AF | FA) and participant were specified as the random slope and random intercept, respectively. A maximal random effects structure was employed permitting model convergence (Barr et al., 2013). All continuous independent variables were centered and scaled before analyses. Standardized beta and standard error values were calculated and reported for all LMER models to estimate which effects had the greatest influence on the dependent variables.

Results

Impact of Second Language Proficiency on Empathy and Social Cognition

Empathy

Second language proficiency did not predict empathy, $B(4, 32) = 0.159$, $SE = 0.384$, $t = 0.416$, $p = .680$: participants with higher language proficiency were similarly empathetic ($M = 67.54$, $SD = 11.12$) to those with lower language proficiency ($M = 66.76$, $SD = 10.89$). Maternal education did not predict empathy, $B(4, 32) = -1.045$, $SE = 3.687$, $t = -0.284$, $p = .778$. Gender marginally predicted empathy, $B(4, 32) = -6.803$, $SE = 4.016$, $t = -1.694$, $p = .100$: males showed lower empathy ($M = 62.11$, $SD = 9.23$) than females ($M = 68.76$, $SD = 11.01$), which is consistent with previous research (Baron-Cohen & Wheelwright, 2004). Age also marginally predicted empathy, $B(4, 32) = -0.380$, $SE = 0.193$, $t = -1.989$, $p = .056$: older participants showed lower empathy ($M = 65.88$, $SD = 13.08$) than younger participants ($M = 68.10$, $SD = 9.11$).

Social Cognition

Second language proficiency did not predict social cognition, $B = 0.262$, $SE = 0.223$, $t = -1.173$, $p = .249$: participants with higher language proficiency showed similar levels of social cognition ($M = 19.10$, $SD = 4.45$) to those with lower language proficiency ($M = 15.81$, $SD = 6.30$). Maternal education, $B(4, 32) = 0.684$, $SE = 2.141$, $t = 0.320$; gender, $B(4, 32) =$

-1.473, $SE = 2.337$, $t = -0.630$, $p = .533$; and age, $B(4, 32) = 0.149$, $SE = 0.113$, $t = 1.338$, $p = .190$ also did not predict social cognition.

Executive Control of Attention on the Social and Nonsocial Tasks

The full model results predicting incongruent trial performance from second language proficiency, social cognition, empathy, and their interactions with task (nonsocial, social) and time are presented in Tables S2–S4 in the online supplemental materials, which show many significant interactions. Below, we interpret the significant main effects and two-way interactions, as well as the three-way interactions that maximally influenced the dependent variable (i.e., largest β values) and directly related to our hypotheses (i.e., interactions that involved task and at least one independent variable).

Reaction Time

Second language proficiency, empathy, and social cognition did not predict reaction time on incongruent trials. However, we did observe a significant effect of task ($\beta = 0.160$, $SE = 0.008$, $p < .001$): all participants were slower on the social task than the nonsocial task. Multiple interactions were significant (see Table S2 in the online supplemental materials).

The two-way interaction between task and empathy was significant ($\beta = -0.099$, $SE = 0.038$, $p = .009$): participants with lower empathy were slightly, but significantly faster on the social task compared to the nonsocial task than their more empathetic peers. Time also significantly interacted with task ($\beta = -0.201$, $SE = 0.022$, $p < .001$): participants were initially slower on the social task but showed increasingly faster reaction times as trials progressed, whereas reaction times on the nonsocial task remained relatively stable over time.

The three-way interaction between task, second language proficiency, and empathy was significant ($\beta = -0.254$, $SE = 0.051$, $p < .001$; Figure 1): participants with greater second language proficiency and higher levels of empathy were slightly (46.103 ms) faster on the social task than those with poorer second language proficiency and high levels of empathy. Interestingly, task also interacted with social cognition and empathy ($\beta = -0.232$, $SE = 0.044$, $p < .001$; Figure 2): participants with better social cognition and better empathy were significantly faster on the social task than those with higher empathy but worse social cognition. On the arrow task, highly empathetic participants with better social cognition were significantly faster than highly empathetic participants with worse social cognition.

Blink Count

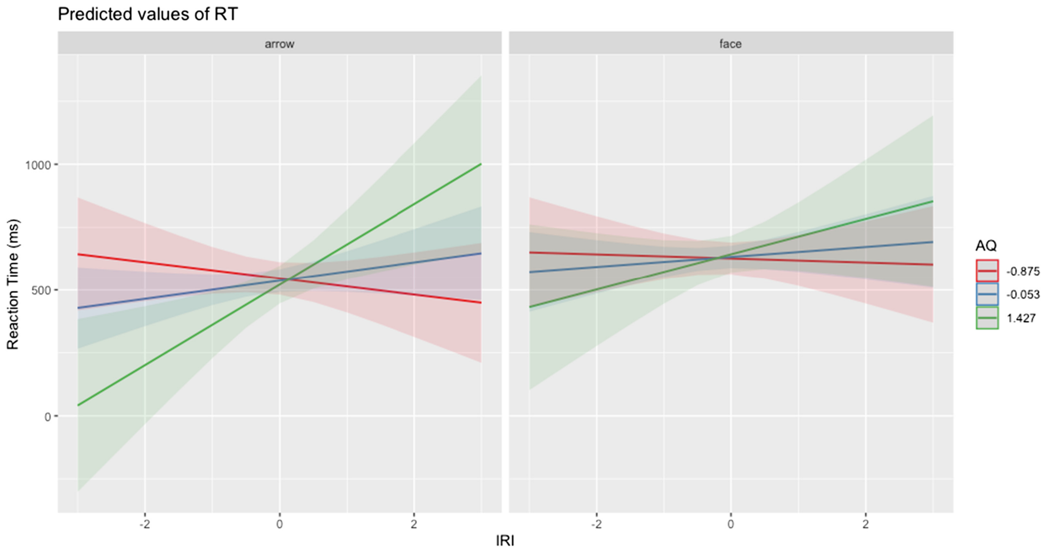
Time, second language proficiency, and social cognition did not independently predict blinking on incongruent trials, but task did ($\beta = 0.023$, $SE = 0.009$, $p = .010$). Although the effect was small, participants blinked more on the social task than the nonsocial task. Empathy also predicted blinking on incongruent trials ($\beta = 0.230$, $SE = 0.098$, $p = .031$): participants with greater empathy blinked more than those with lower empathy. Multiple interactions were also significant (see Table S3 in the online supplemental materials).

The two-way interaction between time and task predicted blink counts on incongruent trials ($\beta = 0.071$, $SE = 0.025$, $p = .004$): All participants blinked slightly more over time on the social versus nonsocial task. The two-way interaction between time and second language proficiency ($\beta = 0.056$, $SE = 0.025$, $p = .025$) was also significant, but small. Participants with greater second language proficiency blinked more in later than earlier incongruent trials. Second language proficiency and empathy interacted to predict blink counts ($\beta = 0.242$, $SE = 0.115$, $p = .044$): Participants with greater second language proficiency and greater empathy blinked more than those with lower second language proficiency and lower empathy. Second language proficiency interacted with social cognition to predict blinks ($\beta = -0.208$, $SE = 0.090$, $p = .027$): those with higher second language proficiency but worse social cognition, blinked less than those with lower second language proficiency and worse social cognition. Alternatively, those with better social cognition and better second language proficiency had higher blink counts compared to those with better social cognition, but lower second language proficiency.

The three-way interaction between task, second language proficiency, and empathy significantly predicted blinking ($\beta = -0.157$, $SE = 0.059$, $p = .008$; Figure 3): On the social task, participants with higher second language proficiency but worse empathy blinked less than

Figure 2

Participants Scaled and Centered IRI Performance Is Displayed Along the x*-Axis for the Nonsocial (Arrow) and Social (Face) Tasks*



Note. Participants scaled and centered AQ performance is displayed in the legend for nonsocial (arrow) and social (face) tasks. Recall that higher AQ scores reflect worse social cognition, whereas lower scores reflect better social cognition. The green line reflects higher AQ scores—worse social cognition. The red line represents lower AQ scores—better social cognition. See the online article for the color version of this figure.

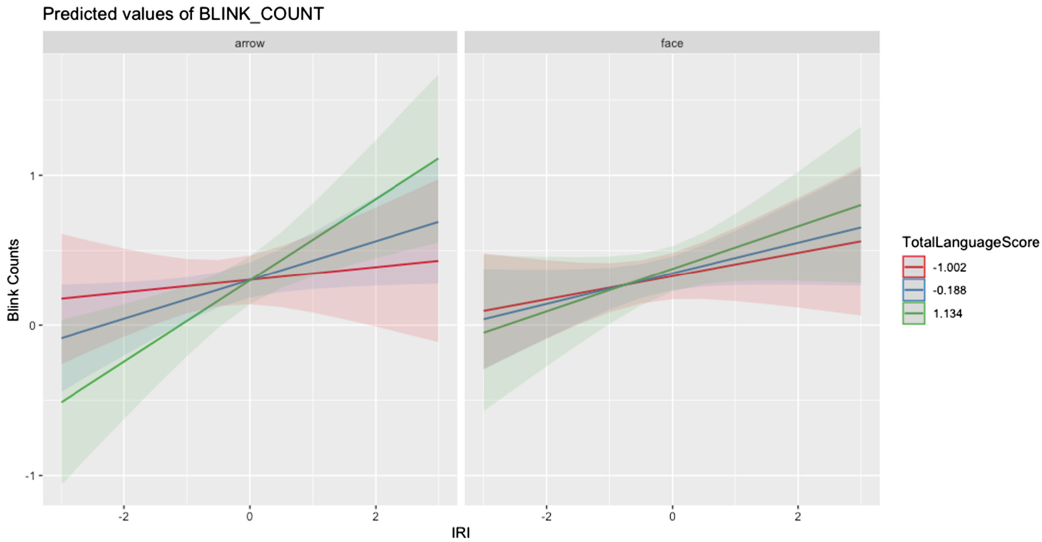
those with higher second language proficiency and greater empathy. A similar trend was observed on the nonsocial task but showed greater variation in blink counts between more empathetic participants with greater second language proficiency and less empathetic participants with higher second language proficiency. The three-way interaction between task, second language proficiency, and social cognition also predicted blinking ($\beta = 0.121$, $SE = 0.042$, $p = .005$; Figure 4): Participants with higher second language proficiency and better social cognition showed blink counts on the social task that were commensurate with the blink counts of participants showing worse social cognition and lower second language proficiency on the nonsocial task. Lastly, the three-way interaction between second language proficiency, empathy, and social cognition predicted blink counts ($\beta = -0.294$, $SE = 0.138$, $p = .038$; Figure 5): Those with the lowest empathy and worst social cognition blinked least of all participants, where those with the greatest empathy and best social cognition blinked the most. Those with the lowest levels of language proficiency were most sensitive to empathy by social cognition interactions: As empathy improved, those with lower levels of second language proficiency and worse social cognition blinked more than those with lower levels of second language proficiency but better social cognition.

Fixation Count

Second language proficiency predicted fixations on incongruent trials ($\beta = -0.221$, $SE = 0.088$, $p = .016$): those with better second language proficiency had fewer fixation counts than those with worse second language proficiency. Task predicted fixations on incongruent trials ($\beta = 0.189$, $SE = 0.009$, $p < .001$): Participants showed more fixations on the social task than on the nonsocial task. Time also predicted fixations on incongruent trials ($\beta = 0.127$, $SE = 0.020$, $p < .001$): the number of fixations increased across time for all participants. Empathy and social cognition did not independently predict fixation counts. Multiple interactions were significant (see Table S4 in the online supplemental materials).

Figure 3

Participants Scaled and Centered IRI Performance Is Displayed Along the x*-Axis for the Nonsocial (Arrow) and Social (Face) Tasks*



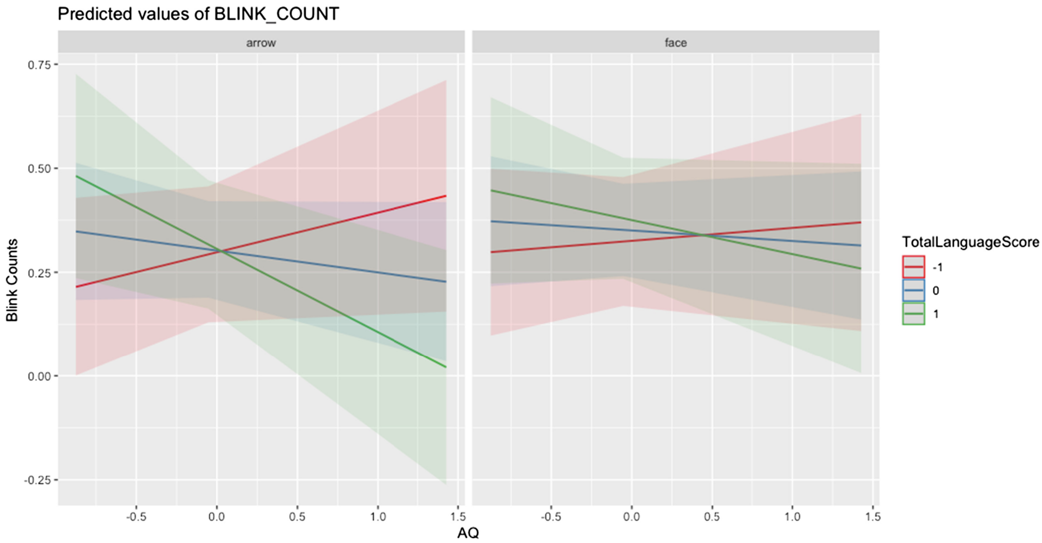
Note. Participants scaled and centered Total Language Scores (from the LEAP-Q) reflect terciles of second language proficiency, with the green line representing the highest second language proficiency and the red line signaling the lowest second language proficiency. See the online article for the color version of this figure.

Time interacted with task to predict fixation counts ($\beta = -0.279$, $SE = 0.024$, $p < .001$): Participants initially showed higher fixation counts on the social task than the nonsocial task, followed by a decline in the number of fixations over time. The opposite pattern was observed on the nonsocial task: Participants showed fewer initial fixations, but a pattern of increasing fixations over time. Language proficiency also interacted with the task ($\beta = 0.180$, $SE = 0.033$, $p < .001$): Participants with higher second language proficiency showed more fixations on the social task, compared to the nonsocial task. However, on the nonsocial task, those with greater second language proficiency showed fewer fixations, whereas those with lower second language proficiency showed more fixations. Social cognition also interacted with the task ($\beta = 0.175$, $SE = 0.034$. $p < .001$): Participants with worse social cognition showed more fixations than those with better social cognition on the social task, but the opposite was true for the nonsocial task (i.e., Participants with worse social cognition showed fewer fixations than those with better social cognition).

The three-way interaction between task, second language proficiency, and empathy predicted fixation counts ($\beta = -0.274$, $SE = 0.057$, $p < .001$; Figure 6): those with higher levels of second language proficiency and greater empathy showed lower fixation counts compared to those with lower levels of second language proficiency and lower empathy on the social task. On the nonsocial task, fixation counts did not vary by empathy, but participants with greater second language proficiency demonstrated the fewest fixations overall. Finally, time interacted with task and social cognition to predict fixation counts ($\beta = -0.128$, $SE = 0.027$, $p < .001$; Figure 7): as noted above on the social task, all participants showed initially higher fixation counts, followed by declining fixation counts over time. However, participants with worse social cognition showed the highest fixation counts compared to those with better social cognition. On the nonsocial task, those with worse social cognition showed higher fixations in later compared to earlier trials, whereas those with better social cognition showed a stable pattern of fixation counts over time.

Figure 4

Participants Scaled and Centered AQ Performance Is Displayed Along the x*-Axis for the Nonsocial (Arrow) and Social (Face) Tasks*



Note. Recall that higher AQ scores reflect worse social cognition, whereas lower scores reflect better social cognition. Participants scaled and centered Total Language Scores (from the LEAP-Q) reflect terciles of second language proficiency, with the green line representing the highest second language proficiency and the red line signaling the lowest second language proficiency. See the online article for the color version of this figure.

Discussion

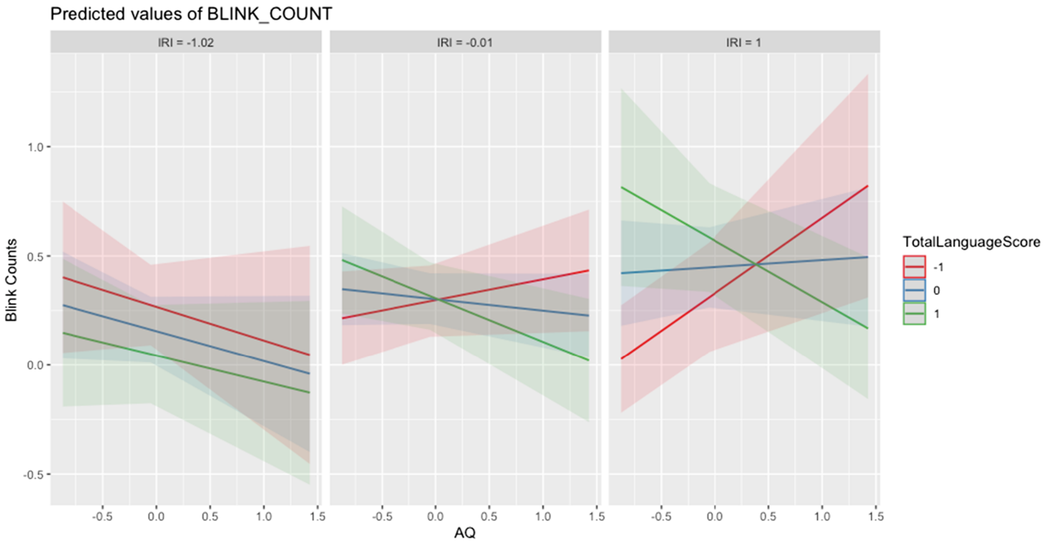
The purpose of this study was to examine how individual differences in empathy and social cognition interact with second language experience to impact executive control to social and nonsocial information in nonautistic adults[1] without a history of language, cognitive, hearing, or vision impairments. To this end, participants completed a social and nonsocial version of the Flanker task and well-established surveys that quantified social cognition, empathy, and second language experience. We first explored how second language experience relates to empathy and social cognition, before exploring their interactions using behavioral and eye-tracking measures.

We initially hypothesized that second language proficiency would predict empathy and social cognition; however, it did not. Though this finding was unexpected, it does align with literature suggesting that individual variation in second language experience alone may not be sufficient to explain differences in participants' cognitive or social performance and that various dimensions of an individual's enculturation and/or acculturation must be measured and integrated to more fully account for individual differences. Second language experience has historically been conflated with cultural experience; however, reviews of evidence indicate that second language experience is not a proxy for culture and that the two should be assessed separately (Xie et al., 2022). To this end, collecting multiple continuous indicators of an individual's culture (e.g., individualism vs. collectivism), which will necessarily vary within cultures (Smith & Bond, 2019), is likely to be much more sensitive to differences than grouping or ascribing culture based on categorical data (e.g., nationality). On the experimental task, one main effect, and three interactions were significant across all three dependent variables (see Table S5 in the online supplemental materials for a summary).

[1] While the term "neurotypical" is often used to describe control participants without any neurodevelopmental diagnoses, it is more accurate and aligned with preferences of the adult autistic community to refer to control participants by relevant exclusion criteria, rather than implicit assumptions that the control group is "typical."

Figure 5

Participants Scaled and Centered AQ Performance Is Displayed Along the x*-Axis by Terciles (Left to Right) of Lowest to Highest Empathy (IRI)*

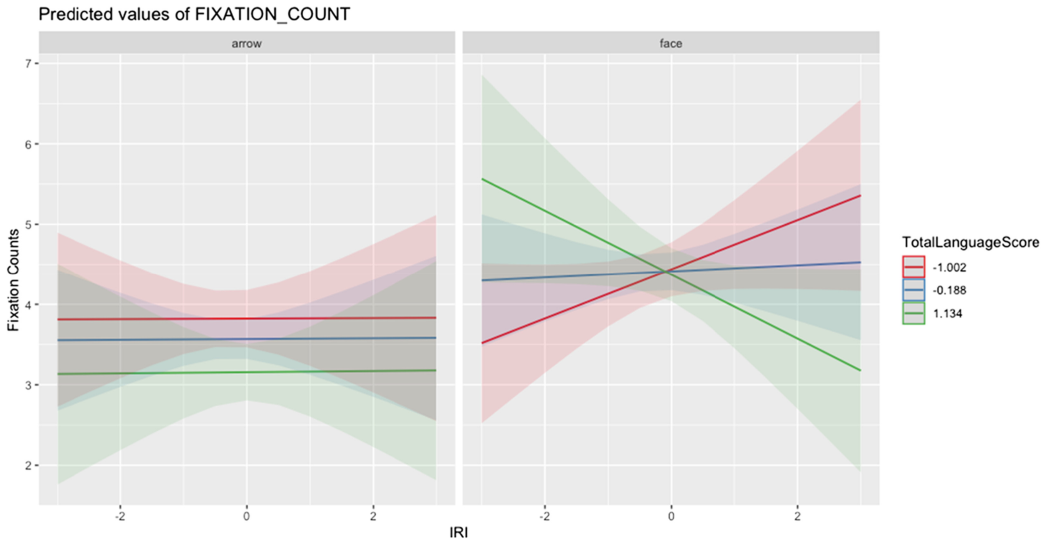


Note. Recall that higher AQ scores reflect worse social cognition, whereas lower scores reflect better social cognition. Participants scaled and centered Total Language Scores (from the LEAP-Q) reflect terciles of second language proficiency, with the green line representing the highest second language proficiency and the red line signaling the lowest second language proficiency. See the online article for the color version of this figure.

The main effect of social task significantly predicted slower reaction times, more blinks, and more fixations than the nonsocial task for all participants. While we predicted slower reaction times and higher fixation counts evidencing greater inhibitory costs of the social, versus nonsocial task, blinking increased instead of decreasing, which was unexpected. This finding is not necessarily inconsistent with our hypothesis but rather suggests that changes in blinking patterns may reflect different underlying constructs based on features of the experimental task. For example, blinking is inhibited (lower) for salient stimuli when kept static for a period (e.g., when reading; Ratiu et al., 2022) or when changes in stimuli are fluid (e.g., watching movies; Shultz et al., 2011). That blinking increased on the social task instead of decreased likely reflects the trial-to-trial nature of our experimental task in which task goals remained the same, but stimuli changed iteratively following a keypress that advanced to the next trial. On a trial-to-trial basis, more spontaneous eye blinks on incongruent versus congruent trials have been found to reflect greater recruitment of executive control resources to resolve the conflict of incongruent stimuli (van Bochove et al., 2013). Therefore, the higher-blinking rates found on incongruent social (vs. nonsocial) trials in this experiment do not reflect lower demand, but rather signal greater executive control resources needed to resolve the conflict caused by the more salient (and therefore more distracting) social Flankers; an interpretation that aligns with the significantly slower reaction times and higher fixation counts found on the social (vs. nonsocial) task. The task-by-time interaction that resulted in increasing blink counts, faster reaction times, and decreasing fixation counts suggests that while incongruent social trials produced greater conflict, greater conflict increased executive control, improving their ability to resolve conflicting social information over time on the social task. This finding aligns with an adaptation-by-binding account of executive control (Verguts & Notebaert, 2009) by which executive (cognitive) control is activated by conflict which increases associations between the target (center stimulus), incongruent stimuli (social Flankers) and behavioral response (keypress), thus “binding” these events together and improving performance on future trials (van Bochove et al., 2013).

Figure 6

Participants Scaled and Centered IRI Performance Is Displayed Along the x*-Axis for the Nonsocial (Arrow) and Social (Face) Tasks*



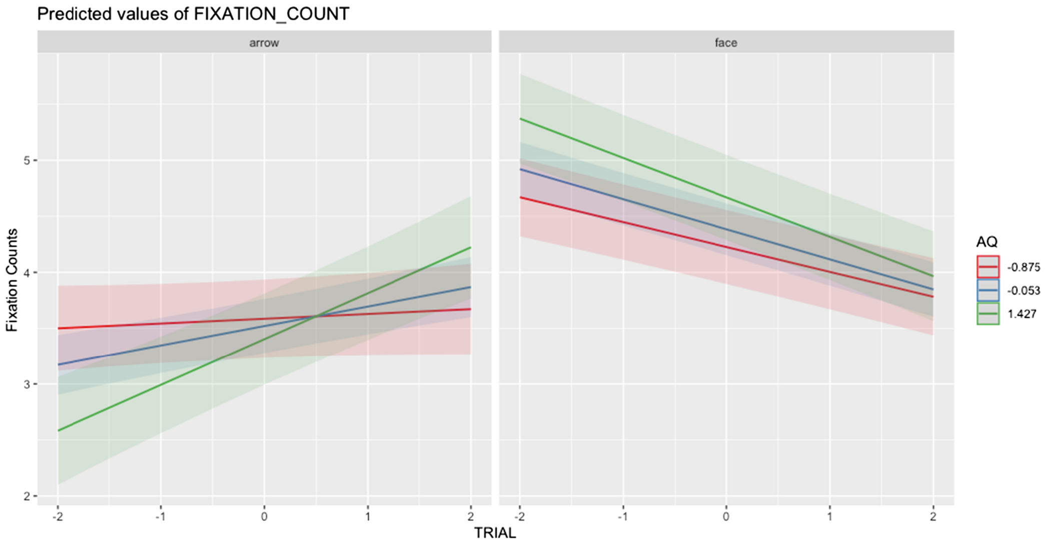
Note. Participants scaled and centered Total Language Scores (from the LEAP-Q) reflect terciles of second language proficiency, with the green line representing the highest second language proficiency and the red line signaling the lowest second language proficiency. See the online article for the color version of this figure.

The social task interacted with second language proficiency and empathy to significantly predict faster reaction times and fewer fixations, but lower blink counts. As our results suggest that higher overall blink counts reflect greater executive control on a by-trial basis, lower overall blink counts on incongruent social trials suggest that more empathetic bilingual participants incurred greater inhibitory costs of social distractors while still performing better on the task. Empathetic bilinguals may show a greater capacity to inhibit irrelevant external information but may additionally need to inhibit irrelevant *internal* information primed by social stimuli (e.g., the desire to understand and comprehend the feelings of others). Previous literature indicates that bilinguals demonstrate greater executive control abilities than monolinguals (Bialystok, 2017), and empathetic adults have shown greater attention to social features (e.g., eyes) compared to less empathetic individuals (Cowan et al., 2014). Bilinguals' better executive control abilities may interact with the tendency of more empathetic individuals to attend to social information (including social distractors) to improve task performance, even with greater inhibitory costs. While not initially hypothesized, the interactions of empathy and bilingualism with time contextualize this finding.

Empathy interacted with time to improve performance on later compared to earlier trials. More empathetic adults were faster and showed fewer fixations on later trials, compared to earlier trials, suggesting that empathy improved performance across all (social and nonsocial) incongruent trials. It may be that highly empathetic participants initially broaden attention by visually exploring target and flanking stimuli (fewer blinks, more fixations) before engaging executive control (more blinks) to narrow attention (fewer fixations) and improve behavioral performance in later trials. Empathetic and bilingual processing cohered, as more empathetic bilinguals showed a similar, but more dramatic temporal signature when processing incongruencies: Bilinguals with greater empathy incurred greater initial conflict on incongruent trials, which then more dramatically recruited executive control (higher blink counts), narrowed attention (fewer fixations), and improved performance (faster responses) over time. The adaptation-by-binding account of executive (cognitive) control informs this finding by suggesting *how* executive control of attention may emerge

Figure 7

Participants Scaled and Centered Trial Information (Time) Is Displayed Along the x*-Axis for the Nonsocial (Arrow) and Social (Face) Tasks*



Note. Participants scaled and centered AQ performance is displayed in the legend for nonsocial (arrow) and social (face) tasks. Recall that higher AQ scores reflect worse social cognition, whereas lower scores reflect better social cognition. The green line reflects higher AQ scores—worse social cognition. The red line represents lower AQ scores—better social cognition. See the online article for the color version of this figure.

from empathetic bilinguals' unique processing of conflicting stimuli: They assume greater costs of broadening attention to incongruent stimuli early on, but subsequently benefit from the enhanced cognitive-behavioral control that emerges from conflict over time.

While none of our participants were autistic, our results also provide some insight into how greater empathy may confer different effects of executive control in clinical populations, specifically in adults with worse social cognition (i.e., higher scores on the AQ signaling higher levels of autistic traits). For example, participants with the lowest social cognition who were also the least empathetic were fastest on social incongruent trials; a finding that aligns with previous work showing lower inhibitory costs of social distractors in autistic adults (Remington et al., 2012). Interestingly, participants with the highest levels of autistic traits and the greatest empathy or the highest second language proficiency, respectively, were slowest on incongruent social trials, suggesting that empathy and second language proficiency may increase attention to (and therefore inhibitory costs of) social information in those with worse social cognition; a finding that might be further tested via online and offline measures.

Conclusions

Our results suggest a unique interactive benefit of empathy and second language proficiency on executive control of attention. Empathy and bilingualism appear to broaden attention to social stimuli, including targets and Flankers on incongruent trials. Across incongruent trials, bilinguals appear to benefit from greater empathy, showing enhanced executive control engaged by greater initial conflict. Empathetic bilinguals showed a unique temporal signature of conflict processing over time that was characterized by early broadened attention to conflicting stimuli, followed by enhanced executive control and behavioral performance. While increased empathy benefited bilinguals, it impaired task performance in those with worse social cognition. In conclusion, greater empathy may interact with second language experience differently than with social cognition to influence executive control and task performance; a finding that warrants further investigation.

References

Adesope, O. O., Lavin, T., Thompson, T., & Ungerleider, C. (2010). A systematic review and meta-analysis of the cognitive correlates of bilingualism. *Review of Educational Research*, *80*(2), 207–245. https://doi.org/10.3102/0034654310368803

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

Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: An investigation of adults with asperger syndrome or high functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders*, *34*(2), 163–175. https://doi.org/10.1023/B:JADD.0000022607.19833.00

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "reading the mind in the eyes" test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry*, *42*(2), 241–251. https://doi.org/10.1111/1469-7610.00715

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): Evidence from asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders*, *31*(1), 5–17. https://doi.org/10.1023/A:1005653411471

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, *68*(3), 255–278. https://doi.org/10.1016/j.jml.2012.11.001

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1–48. https://doi.org/10.18637/jss.v067.i01

Beatty-Martínez, A. L., Navarro-Torres, C. A., Dussias, P. E., Bajo, M. T., Guzzardo Tamargo, R. E., & Kroll, J. F. (2020). Interactional context mediates the consequences of bilingualism for language and cognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *46*(6), 1022–1047. https://doi.org/10.1037/xlm0000770

Bialystok, E. (2007). Cognitive effects of bilingualism: How linguistic experience leads to cognitive change. *International Journal of Bilingual Education and Bilingualism*, *10*(3), 210–223. https://doi.org/10.2167/beb441.0

Bialystok, E. (2017). The bilingual adaptation: How minds accommodate experience. *Psychological Bulletin*, *143*(3), 233–262. https://doi.org/10.1037/bul0000099

Byers-Heinlein, K., Chen, K. H., & Xu, F. (2014). Surmounting the tower of babel: Monolingual and bilingual 2-year-olds' understanding of the nature of foreign language words. *Journal of Experimental Child Psychology*, *119*, 87–100. https://doi.org/10.1016/j.jecp.2013.09.011

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

Cowan, D. G., Vanman, E. J., & Nielsen, M. (2014). Motivated empathy: The mechanics of the empathic gaze. *Cognition and Emotion*, *28*(8), 1522–1530. https://doi.org/10.1080/02699931.2014.890563

Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology*, *44*(1), 113–126. https://doi.org/10.1037/0022-3514.44.1.113

Decety, J. (2010). The neurodevelopment of empathy in humans. *Developmental Neuroscience*, *32*(4), 257–267. https://doi.org/10.1159/000317771

Decety, J., & Lamm, C. (2006). Human empathy through the lens of social neuroscience. *The Scientific World Journal*, *6*, Article 280363, 1146–1163. https://doi.org/10.1100/tsw.2006.221

DeLuca, V., Rothman, J., Bialystok, E., & Pliatsikas, C. (2019). Redefining bilingualism as a spectrum of experiences that differentially affects brain structure and function. *Proceedings of the National Academy of Sciences*, *116*(15), 7565–7574. https://doi.org/10.1073/pnas.1811513116

Dewaele, J. M., & Wei, L. (2012). Multilingualism, empathy and multicompetence. *International Journal of Multilingualism*, *9*(4), 352–366. https://doi.org/10.1080/14790718.2012.714380

Dick, A. S., Garcia, N. L., Pruden, S. M., Thompson, W. K., Hawes, S. W., Sutherland, M. T., Riedel, M. C., Laird, A. R., & Gonzalez, R. (2019). No evidence for a bilingual executive function advantage in the nationally representative ABCD study. *Nature Human Behaviour*, *3*(7), 692–701. https://doi.org/10.1038/s41562-019-0609-3

D'Souza, A. A., Moradzadeh, L., & Wiseheart, M. (2018). Musical training, bilingualism, and executive function: Working memory and inhibitory control. *Cognitive Research: Principles and Implications*, *3*(1), 1–18. https://doi.org/10.1186/s41235-018-0095-6

Erb, C. D., Smith, K. A., & Moher, J. (2021). Tracking continuities in the flanker task: From continuous flow to movement trajectories. *Attention, Perception, and Psychophysics*, *83*, 731–747. https://doi.org/10.3758/s13414-020-02154-4

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception and Psychophysics*, *16*(1), 143–149. https://doi.org/10.3758/BF03203267

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

Kobayashi, C., Glover, G. H., & Temple, E. (2006). Cultural and linguistic influence on neural bases of 'theory of mind': An fMRI study with Japanese bilinguals. *Brain and Language*, *98*(2), 210–220. https://doi.org/10.1016/j.bandl.2006.04.013

Marian, V., Blumenfeld, H. K., & Kaushanskaya, M. (2007). Bilinguals and multilinguals. *Hearing Research*, *50*(4), 940–967. https://doi.org/10.1044/1092-4388(2007/067)

Melchers, M., Montag, C., Markett, S., & Reuter, M. (2015). Assessment of empathy via self-report and behavioural paradigms: Data on convergent and discriminant validity. *Cognitive Neuropsychiatry*, *20*(2), 157–171. https://doi.org/10.1080/13546805.2014.991781

Naeem, K., Filippi, R., Periche-Tomas, E., Papageorgiou, A., & Bright, P. (2018). The importance of socioeconomic status as a modulator of the bilingual advantage in cognitive ability. *Frontiers in Psychology*, *9*, Article 1818. https://doi.org/10.3389/fpsyg.2018.01818

Paap, K. R., Johnson, H. A., & Sawi, O. (2014). Are bilingual advantages dependent upon specific tasks or specific bilingual experiences? *Journal of Cognitive Psychology*, *26*(6), 615–639. https://doi.org/10.1080/20445911.2014.944914

Paap, K. R., Mason, L., Zimiga, B., Ayala-Silva, Y., & Frost, M. (2020). The alchemy of confirmation bias transmutes expectations into bilingual advantages: A tale of two new meta-analyses. *Quarterly Journal of Experimental Psychology*, *73*(8), 1290–1299. https://doi.org/10.1177/1747021819900098

Palermo, R., & Rhodes, G. (2007). Are you always on my mind? A review of how face perception and attention interact. *Neuropsychologia*, *45*(1), 75–92. https://doi.org/10.1016/j.neuropsychologia.2006.04.025

Perani, D., & Abutalebi, J. (2015). Bilingualism, dementia, cognitive and neural reserve. *Current Opinion in Neurology*, *28*(6), 618–625. https://doi.org/10.1097/WCO.0000000000000267

Pons, F., Bosch, L., & Lewkowicz, D. J. (2015). Bilingualism modulates infants' selective attention to the mouth of a talking face. *Psychological Science*, *26*(4), 490–498. https://doi.org/10.1177/0956797614568320

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, *13*(1), 25–42. https://doi.org/10.1146/annurev.ne.13.030190.000325

Psychology Software Tools. (2016). *E-Prime 3.0*. https://support.pstnet.com/

Ratiu, I., Fissel-Brannick, S., Whiting, M., Murnion, L., & Azuma, T. (2022). The impact of mild traumatic brain injury on reading comprehension and eye movements: Preliminary results. *Journal of Communication Disorders*, *96*, Article 106197. https://doi.org/10.1016/j.jcomdis.2022.106197

R Core Team. (2021). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing.

Remington, A., Campbell, R., & Swettenham, J. (2012). Attentional status of faces for people with autism spectrum disorder. *Autism*, *16*(1), 59–73. https://doi.org/10.1177/1362361311409257

Shultz, S., Klin, A., & Jones, W. (2011). Inhibition of eye blinking reveals subjective perceptions of stimulus salience. *Proceedings of the National Academy of Sciences*, *108*(52), 21270–21275. https://doi.org/10.1073/pnas.1109304108

Singh, L., Quinn, P. C., Xiao, N. G., & Lee, K. (2019). Monolingual but not bilingual infants demonstrate racial bias in social cue use. *Developmental Science*, *22*(6), Article e12809. https://doi.org/10.1111/desc.12809

Singh, L., Tan, A. R. Y., Lee, K., & Quinn, P. C. (2020). Sensitivity to race in language comprehension in monolingual and bilingual infants. *Journal of Experimental Child Psychology*, *199*, Article 104933. https://doi.org/10.1016/j.jecp.2020.104933

Smith, P. B., & Bond, M. H. (2019). Cultures and persons: Characterizing national and other types of cultural difference can also aid our understanding and prediction of individual variability. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.02689

Titone, D., & Tiv, M. (2023). Rethinking multilingual experience through a systems framework of bilingualism. *Bilingualism: Language and Cognition*, *26*(1), 1–16. https://doi.org/10.1017/S1366728921001127

van Bochove, M. E., Van der Haegen, L., Notebaert, W., & Verguts, T. (2013). Blinking predicts enhanced cognitive control. *Cognitive, Affective, and Behavioral Neuroscience*, *13*(2), 346–354. https://doi.org/10.3758/s13415-012-0138-2

Verguts, T., & Notebaert, W. (2009). Adaptation by binding: A learning account of cognitive control. *Trends in Cognitive Sciences*, *13*(6), 252–257. https://doi.org/10.1016/j.tics.2009.02.007

Villard, S. (2021). Attention. In M. L. Kimbarow (Ed.), *Cognitive communication disorders* (3rd ed., pp. 1–39). Plural Publishing.

Vogeley, K., & Roepstorff, A. (2009). Contextualising culture and social cognition. *Trends in Cognitive Sciences*, *13*(12), 511–516. https://doi.org/10.1016/j.tics.2009.09.006

Westergaard, M. (2021). Microvariation in multilingual situations: The importance of property-by-property acquisition. *Second Language Research*, *37*(3), 379–407. https://doi.org/10.1177/0267658319884116

Wickham, H. (2016). *Ggplot2: Elegant graphics for data analysis*. Springer-Verlag. https://ggplot2.tidyverse.org

Xie, W., Altarriba, J., & Ng, B. C. (2022). Bilingualism, culture, and executive functions: Is there a relationship?*Languages*, *7*(4), 247–270. https://doi.org/10.3390/languages7040247

Received October 3, 2022
Revision received July 27, 2023
Accepted July 30, 2023 ■