

Mindfulness Breaks Through the ‘Involved Participant’ Blind Spot: Evidence from Longitudinal Tracking and fNIRS

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Date: 2024-09-08T00:00:00+00:00

Abstract

This study employed longitudinal tracking and functional near-infrared spectroscopy (fNIRS) to investigate the effects of mindfulness on wisdom performance (wise reasoning and thinking) and its underlying neural mechanisms when individuals confront interpersonal conflicts across different social distances. Results demonstrated differential wisdom performance in individuals facing interpersonal conflicts with varying social distances (pilot study). However, both trait mindfulness (Study 1) and mindfulness intervention (Study 2) positively influenced wisdom performance in interpersonal conflict situations involving close others (compared to strangers), with mindfulness intervention eliminating the performance difference between conflicts involving close others versus strangers. The hemodynamic response in channels associated with the dorsolateral prefrontal cortex (DLPFC) and temporoparietal junction (TPJ) activated by mindfulness constitutes the underlying neural mechanism. In summary, this study provides behavioral and cognitive neuroscience evidence for mindfulness as an approach to overcoming the limitation of personal involvement.

Full Text

Mindfulness for Addressing “Being in the Game”: Evidence from Longitudinal and fNIRS Study

Abstract

This study employed longitudinal tracking and functional near-infrared spectroscopy (fNIRS) to investigate the effects of mindfulness on wisdom performance (wise reasoning and thinking) when individuals face interpersonal conflict situations involving different social distances, as well as the underlying neural mechanisms. The results demonstrated that individuals exhibit differential

wisdom performance when facing interpersonal conflicts with varying social distances (pre-experiment). However, both trait mindfulness (Study 1) and mindfulness interventions (Study 2) positively influenced wisdom performance when individuals faced conflicts involving significant others (compared to strangers). Moreover, mindfulness interventions eliminated the difference in wisdom performance between conflicts involving significant others and strangers. The potential neural mechanism involves increased blood oxygen concentration in channels related to the dorsolateral prefrontal cortex (DLPFC) and temporoparietal junction (TPJ) activated by mindfulness. In summary, this research provides both behavioral and cognitive-neural evidence for mindfulness as a means to resolve “being in the game.”

Keywords: mindfulness, wisdom, social distance, longitudinal, fNIRS

Mindfulness originates from Buddhist meditation and represents a method of regulating body and mind through quiet introspection. Kabat-Zinn (2003) removed its religious elements and, combining it with insight meditation practices, provided an operational definition: paying attention to present-moment awareness purposefully and non-judgmentally. Currently, three main concepts represent mindfulness (Xu, 2024, pp. 16-17): (1) Dispositional mindfulness (trait mindfulness), which views mindfulness as a relatively stable psychological structure similar to personality; (2) State mindfulness, which treats mindfulness as a situational state; and (3) Mindfulness interventions or mindfulness training/meditation, which refer to mindfulness-based practices such as breath awareness, body scans, and mindful walking. Trait-level mindfulness may be an inherent quality measurable with assessment tools, state mindfulness is situational and can be induced through meditation practice, and long-term, systematic mindfulness meditation practice can also enhance trait mindfulness levels.

Scholars have conducted theoretical explorations of the relationship between mindfulness and wisdom (Karunamuni & Weerasekera, 2019), and empirical studies have shown that both trait mindfulness and mindfulness interventions are associated with enhanced wisdom (Sharma, Dewangan, & Kong, 2017; Wang et al., 2022, 2023, 2024). However, no research has yet examined whether mindfulness can eliminate the “self-other” asymmetry in wisdom performance.

Grossmann et al. (2014) proposed Solomon’s Paradox in the psychology of wisdom, suggesting that individuals demonstrate wiser reasoning and provide more sagacious advice when facing interpersonal conflicts involving friends compared to their own conflicts. This aligns with the traditional Chinese wisdom of “the onlooker sees clearly, the player is muddled.” To eliminate the asymmetry in wisdom performance characteristic of “Solomon’s Paradox” or “being in the game,” researchers have directly manipulated individuals to adopt a self-distanced perspective when viewing self-involved conflict events (Grossmann & Kross, 2014), with results demonstrating that self-distancing effectively eliminates the self-other asymmetry in wisdom when facing interpersonal conflicts. Other researchers have verified that pursuing moral motivation can similarly eliminate the self-other difference in wisdom performance (Huynh et al., 2017).

However, existing research has primarily focused on Western participants, who mainly come from Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies. Relative to the global population of over 8 billion people, this represents a small sample, and thus the findings may only be applicable to this WEIRD subset (Henrich, Heine, & Norenzayan, 2010). Based on this, the present study attempts to explore the relationship between mindfulness and wisdom within a Chinese cultural context, building upon existing theories and research to examine whether mindfulness can serve as a means to alleviate wisdom asymmetry—that is, whether mindfulness can resolve “being in the game.”

1.1 Mindfulness and “Being in the Game”: Theoretical and Behavioral Evidence

When studying social distance and wisdom in Chinese culture, the identity of “others” matters significantly. Previous Western-based research has proposed that wisdom reasoning shows asymmetry in self-friend conflict situations (Solomon’s Paradox, Grossmann & Kross, 2014), yet Chinese groups do not exhibit this pattern (Wei & Wang, 2021). This asymmetry only emerges when Chinese participants’ independent self-construal is primed, reflecting differences between individualist and collectivist cultures. Individuals from different cultural backgrounds perceive relational closeness with various others differently. Those from individualist cultures emphasize the distinction between self and others (independent self, Markus & Kitayama, 1991), so Western participants can demonstrate relatively wise reasoning even when facing friends’ conflicts (Grossmann & Kross, 2014). In contrast, those from collectivist cultures emphasize the relationship between self and others, often incorporating significant others into the self-concept (interdependent self, Markus & Kitayama, 1991). Consequently, “players” in the game are not only the self but may also be others with important social relationships (e.g., close friends, partners, relatives), while “onlookers” refer to strangers. Based on these cultural differences in social relationships, we hypothesize that Chinese individuals may demonstrate the wisest reasoning and decision-making when facing conflicts involving stranger others, while showing similarly lower levels of wisdom reasoning and decision-making when dealing with conflicts involving the self or significant others.

The Monitor and Acceptance Theory of mindfulness proposes that mindfulness comprises two core mechanisms: attention monitoring and open acceptance (Lindsay & Creswell, 2017). The former refers to the self-regulation of attention, while the latter involves the ability to regulate psychological distance from the self, which can increase self-distancing tendencies while reducing the negative impact of self-immersion (Sauer & Baer, 2012; Zhang, Fan, & Zhang, 2017). Open acceptance particularly emphasizes de-centering from stimuli (separating the self from experience), enabling individuals to shift to a de-centered perspective when facing conflicts or dilemmas involving significant others or themselves, thereby breaking free from the negative constraints of the immediate situation and interpreting events from a broader, more abstract viewpoint (Chan & Wang,

2019). Therefore, mindfulness may alleviate “being in the game” by fostering an open attitude toward experience, which encourages individuals to consider and accept others’ perspectives and integrate multiple suggestions when making decisions involving two or more parties, ultimately leading to wiser decisions. Mindfulness provides behavioral evidence for alleviating “being in the game” and facilitating wisdom development. First, survey studies have found positive correlations between trait mindfulness and wisdom (Beaumont, 2011; Ringler, 2021; Verhaeghen, 2019; Wang et al., 2022). Second, mindfulness intervention studies have verified that both 4-week and 18-week mindfulness interventions (Al-Refae et al., 2021) can enhance practitioners’ wisdom levels (Sharma et al., 2017; Al-Refae et al., 2021). More importantly, even brief state mindfulness inductions lasting as little as 5 days or 20 minutes can effectively and temporarily enhance individuals’ wise reasoning and thinking, with perspective-taking playing a crucial role (Wang et al., 2023, 2024). This suggests that if individuals possess high trait mindfulness levels or engage in mindfulness practice, they can benefit from wiser reasoning and thinking, and can reconstruct events from a de-centered perspective. Even when facing interpersonal conflicts involving the self or significant others, they can make rational decisions and alleviate asymmetrical wisdom performance.

1.2 Mindfulness and “Being in the Game”: Cognitive Neural Mechanisms

Although researchers have begun to focus on the cultivation and development of wisdom and the relationship between mindfulness and wisdom, few studies have explored the cognitive neural mechanisms of wisdom, and even fewer have directly investigated the neural mechanisms through which mindfulness influences wisdom. Meeks and Jeste (2009) proposed a neurobiological model of wisdom based on its subcomponents (e.g., prosocial attitudes/behaviors, social decision-making/practical life knowledge, emotional balance, reflection/self-understanding, value relativism/tolerance, and effective uncertainty management), suggesting that the prefrontal cortex plays an important role in multiple wisdom subcomponents, particularly in emotion regulation, decision-making, and value relativism. Specifically, the dorsolateral prefrontal cortex is involved in effectively processing and coping with uncertainty, a key aspect of wisdom (Grossmann & Dorfman, 2019), while the medial/ventromedial prefrontal cortex is involved in empathy, moral decision-making, and self-reflection, which also contribute to self-understanding and wisdom development (Ardelt, 2003; Baltes & Staudinger, 1993). Additionally, monoaminergic activity (especially dopamine and serotonin) plays an important role in wisdom, influenced by multiple genetic factors that affect different aspects of wisdom, such as altruistic behavior, social decision-making, emotion regulation, and self-understanding (Meek & Jeste, 2009). An fMRI study measuring participants’ resting-state brain activity combined with wisdom surveys found that when providing advice from a second-person perspective, cognitive humility was associated with low-frequency fluctuation amplitudes in the right rostral anterior cingulate cortex

(ACC) and left dorsomedial prefrontal cortex (PFC) (Hu et al., 2023). Cognitive humility, meta-level flexibility, and perspective-taking are all important components of wisdom (Grossmann et al., 2020). The prefrontal cortex (PFC) is generally associated with higher-level mental activities such as planning and decision-making (van Overwalle, 2009). The right temporoparietal junction (rTPJ) is involved in inferring others' intentions (perspective-taking, Tang et al., 2016; van Overwalle, 2009; Zhang et al., 2017), and perspective-taking is closely related to wisdom (Wang et al., 2023).

Mindfulness and wisdom share overlapping cognitive neural mechanisms. On one hand, mindfulness interventions can regulate serotonin, which acts as an "emotion regulator" (Stoffel et al., 2019), helping individuals experience calm emotions and contributing to overall well-being (Yano et al., 2015). Mindfulness can also enhance cognitive abilities (Xu, 2024, pp. 118-119), helping individuals approach conflict events with a more open and rational attitude for wise decision-making. On the other hand, the cognitive neural mechanisms of mindfulness primarily involve attention control (e.g., ACC, DLPFC), emotion regulation (PFC), and self-awareness (posterior cingulate cortex, PCC) (Tang, Hölzel, & Posner, 2015), with the ACC and PFC potentially serving as neural mechanisms for wise decision-making. Additionally, Hölzel et al. (2011) proposed a mindfulness conceptual model indicating that the temporoparietal junction (TPJ) is associated with enhanced self-regulation resulting from mindfulness, including attention regulation, body awareness, emotion regulation, and changes in self-perspective, with the rTPJ being a key brain region for perspective-taking (Tang et al., 2016; van Overwalle, 2009; Zhang et al., 2017). The S-ART (Self-awareness, self-regulation, and self-transcendence) model describes mindfulness as mental training that increases self-awareness, self-regulation, and self-transcendence (Vago & Silbersweig, 2012). Perspective-taking and self-transcendence are core components of wisdom (Grossmann et al., 2020; Levenson et al., 2005) and effective ways to eliminate wisdom asymmetry.

In summary, mindfulness is not only an effective means for cultivating and developing wisdom but also a solution for eliminating "being in the game." However, previous research has rarely directly examined the effectiveness of mindfulness in alleviating "being in the game" and its underlying cognitive neural mechanisms. Therefore, this article first verifies the traditional Chinese wisdom of "the onlooker sees clearly, the player is muddled" through a pre-experiment. Based on these results, Study 1 employs a three-time-point longitudinal design to explore the causal relationship between trait mindfulness and the wisdom performance associated with "the onlooker sees clearly, the player is muddled." Finally, Study 2 uses functional Near Infrared Spectroscopy (fNIRS) to investigate the cognitive neural mechanisms through which mindfulness interventions alleviate "being in the game," focusing on overlapping brain regions between mindfulness and wisdom (prefrontal cortex, temporoparietal junction) as regions of interest.

2 Pre-Experiment: “Being in the Game”

The pre-experiment manipulated social distance to test the traditional Chinese wisdom of “the onlooker sees clearly, the player is muddled” within a Chinese cultural context. To avoid confounding effects from wisdom measurement methods, wise reasoning and wise thinking were treated as between-subjects variables.

2.1 Participants

We conducted an a priori power analysis for the predicted interaction effect using G*Power, assuming a power of $1-\beta = 80\%$ and $\alpha = 0.05$. Given the study design of 3 (social distance: self, significant other, stranger) \times 2 (measurement: wise thinking, wise reasoning) between-subjects design, the results indicated that at least 244 participants were needed (for Cohen’s $f = 0.20$). Using this as a reference, we recruited 579 participants. Fifty-nine participants voluntarily withdrew from the test due to misunderstanding the construal level measurement items, and 41 participants were excluded because their responses to the “conflict problem” failed to meet quality standards (the question required at least 70 characters based on previous research) and lacked practical significance. The final valid sample consisted of 479 participants (age: 28.21 ± 7.41 , range 16–64 years; 35.70% male; subjective social class: 5.48 ± 1.58 ; 91.00% Han ethnicity; 84.97% with bachelor’s degree). A sensitivity power analysis ($\alpha = 0.05$, two-tailed) indicated that the final sample had 80% power to detect an effect size of Cohen’s $f = 0.14$.

2.2 Procedure

All procedures were conducted online using the Credamo.com platform. First, participants were asked to imagine “themselves, a significant other, or a stranger experiencing two interpersonal conflict events (see Appendix).” Second, participants were required to answer two open-ended questions: (1) “Please describe this conflict event and what you/your friend/the stranger might be thinking and feeling in at least 70 characters”; and (2) “Please describe how you/your friend/the stranger would resolve this conflict in at least 70 characters.” This randomly assigned participants to the self, significant other, or stranger groups. Finally, participants’ wise reasoning or thinking was measured using self-report scales.

2.3 Measures

2.3.1 Wisdom Wise Reasoning was measured using the Situated Wise Reasoning Scale (SWIS) developed by Brienza et al. (2018) to assess situational wise reasoning (e.g., “I/My friend/This stranger would put themselves in the other person’s shoes,” $\alpha = 0.91$). The scale consists of 21 items across five factors: perspective-taking, consideration of change and multiple possibilities, intellectual humility, compromise-seeking, and viewing events from a bystander’s perspective. Each item was rated on a 5-point Likert scale from 1 (completely

disagree) to 5 (completely agree). The total mean score was used as the wise reasoning index, with higher scores indicating higher levels of wise reasoning.

Wise Thinking was measured using the Wise Thinking Scale to assess individuals' thoughts when solving conflict problems (Fu, Wang, & Wei, 2021). The scale comprises 14 items across four factors: multi-sided thinking, insight, benevolence, and uncertainty (e.g., "I/My friend/This stranger would hope to resolve conflicts between all parties as much as possible," $\alpha = 0.76$). Each item was rated on a 6-point Likert scale from 1 (completely disagree) to 6 (completely agree). The total mean score served as the wise thinking index, with higher scores indicating higher levels of wise thinking.

2.3.2 Social Distance Social distance was measured using the Inclusion of Other in Self Scale (IOS), which asks participants to select one of seven pairs of circles with varying degrees of overlap to describe their relationship with the target other (Aron, Aron, & Smollan, 1992). Greater overlap between the circles indicates closer social distance (1 = no overlap, 7 = maximum overlap), with higher scores indicating closer social distance.

2.3.3 Demographic Information Participants completed a demographic survey including age, gender, highest education level, income, and subjective social class (measured by the MacArthur Scale of subjective SES; Adler et al., 2000).

2.4 Results

2.4.1 Manipulation Check for Social Distance Analysis of variance (ANOVA) revealed that, after controlling for all demographic variables, the social distance manipulation had a significant main effect on perceived social distance, $F(2, 468) = 41.24, p < 0.001, \eta^2_p = 0.150$. Specifically, the self group scored significantly higher on the IOS ($M = 4.77, SD = 1.39$) than the stranger group ($M = 3.48, SD = 1.68$), $t(471) = 7.55, p < 0.001, \text{Cohen's } d = 0.90$. The significant other group also scored significantly higher ($M = 4.81, SD = 1.57$) than the stranger group, $t(471) = 8.15, p < 0.001, \text{Cohen's } d = 0.93$. However, there was no significant difference between the self and significant other groups, $t(471) = 0.24, p = 0.810, \text{Cohen's } d = 0.03$.

2.4.2 Wisdom Difference Tests ANOVA indicated that, after controlling for all demographic variables, social distance had a significant main effect on wise reasoning (see Figure 1 [Figure 1: see original paper] left), $F(2, 275) = 4.62, p = .011, \eta^2_p = 0.033$. Specifically, the self group ($M = 3.79, SD = 0.59$) demonstrated significantly lower wise reasoning than the stranger group ($M = 4.07, SD = 0.44$), $t(275) = -3.01, p = 0.002, \text{Cohen's } d = 0.50$, but did not differ significantly from the significant other group ($M = 3.92, SD = 0.60$), $t(275) = 1.43, p = 0.154, \text{Cohen's } d = 0.24$. Additionally, the significant other

group showed marginally lower wise reasoning than the stranger group, $t(275) = -1.74$, $p = 0.083$, Cohen's $d = 0.26$.

Social distance also had a significant main effect on wise thinking (see Figure 1 right), $F(2, 186) = 8.23$, $p < 0.001$, $\eta^2_p = 0.081$. Specifically, the self group ($M = 3.90$, $SD = 0.53$) demonstrated significantly lower wise thinking than the stranger group ($M = 4.21$, $SD = 0.36$), $t(188) = -5.29$, $p < 0.001$, Cohen's $d = 0.94$, but did not differ significantly from the significant other group ($M = 4.05$, $SD = 0.35$), $t(188) = 2.11$, $p = 0.109$, Cohen's $d = 0.37$. The significant other group also showed significantly lower wise thinking than the stranger group, $t(188) = -3.20$, $p = 0.005$, Cohen's $d = 0.57$.

Note: $+p < 0.1$; $p < 0.05$, $p < 0.01$, $p < 0.001$; only significant comparisons are marked in the figure.

2.5 Summary

Figure 1. Effects of social distance on wise reasoning and wise thinking.

Chinese individuals incorporate significant others into the self-concept, as evidenced by no difference in perceived social distance between self and significant others, both of which are significantly closer than strangers. In “the onlooker sees clearly, the player is muddled,” the “player” typically refers to both self and significant others, while the “onlooker” refers to strangers. Thus, wisdom in Chinese culture manifests as an asymmetry between “self/significant other—stranger.”

3 Study 1: Longitudinal Tracking of Mindfulness Alleviating “Being in the Game”

The pre-experiment verified the asymmetry of wisdom in the “self/significant other—stranger” configuration using hypothetical scenarios. Study 1 aimed to use a longitudinal design to test the causal predictive relationship between mindfulness and wisdom, focusing on how mindfulness affects wisdom reasoning and thinking when individuals face interpersonal conflicts with others at different social distances (significant others vs. strangers) in real-life contexts.

3.1 Participants

We conducted an a priori power analysis for the predicted cross-lagged analysis using the powRICLPM package in R (Mulder, 2022), assuming a power of $1-\beta = 80\%$ and $\alpha = 0.05$. Given that the study involved three longitudinal measurements, we set the number of repeated measures to 3, the intraclass correlation coefficient (ICC) to 0.3, and the autoregressive effect to a small-to-medium effect of 0.3 (Cohen, 1988). Based on these parameters, the results indicated that at least 600 participants were needed to detect medium or small autoregressive effects (e.g., $r = 0.30$). Using cluster sampling, we tracked first-year university students from 11 classes at two universities beginning in October 2023. The

three measurement time points were October 2023 (T1, $N = 782$), November 2023 (T2, $N = 792$), and January 2024 (T3, $N = 774$). Ten students who transferred in mid-study were added at T2, and 20 students were lost between T2 and T3, resulting in a longitudinal attrition rate of 2.52%. The final sample included 719 participants who completed all three surveys (mean age: 18.18 ± 0.67 [range 16–21]; 29.70% male; annual income: ¥12,000–24,000 [median]; subjective social class: 4.03 ± 1.20 [range 1–7]; 93.18% Han ethnicity).

3.2 Procedure

Trained graduate students in psychology served as experimenters. Online questionnaires were created on the Credamo platform, with each measurement wave lasting one week. Reminders were sent twice during each wave on day 1, day 3, and day 6 at 10:00 and 18:00, with the survey closing at 20:00 on day 7. First, mindfulness was measured. Second, participants were randomly assigned to either the stranger group ($N = 451$) or the significant other group ($N = 268$) and asked to recall a recent interpersonal conflict event (Grossmann & Kross, 2014): “Please imagine a conflict situation that recently occurred with a stranger/significant other (friend, family member, etc.)” For each conflict event, participants answered a series of questions to ensure effective event reconstruction: (1) When did this conflict occur? (2) What day of the week did it happen? (3) What time of day did it occur? (4) Where were you at the time? (5) Who was involved in the incident? (6) Was the person you had the conflict with the same gender as you? (7) Please describe this conflict event in at least 70 characters. Finally, participants’ wise reasoning and thinking were measured in random order.

3.3 Measures

3.3.1 Mindfulness We administered the Chinese revised version of the Five Facet Mindfulness Questionnaire (FFMQ; Deng et al., 2011), which includes 39 items (e.g., “I am good at describing my emotions with words”) across five factors: observing, describing, acting with awareness, non-judging, and non-reacting. Each item was rated on a 5-point Likert scale from 1 (not at all true) to 5 (completely true). The scale demonstrated good reliability across the three measurements ($\alpha = 0.91, 0.93, 0.95$). The total mean score was used as the trait mindfulness index, with higher scores indicating higher trait mindfulness levels.

3.3.2 Wisdom Wise Reasoning was measured using the same SWIS (Brienza et al., 2018) as in the pre-experiment (e.g., “My friend/This stranger should put themselves in the other person’s shoes”). Reliability coefficients across the three measurements were $\alpha = 0.96, 0.93, \text{ and } 0.97$.

Wise Thinking was measured using the same Wise Thinking Scale (Fu et al., 2021) as in the pre-experiment (e.g., “My friend/This stranger would hope to

resolve conflicts between all parties as much as possible”). Reliability coefficients across the three measurements were $\alpha = 0.95, 0.95,$ and 0.96 .

3.3.3 Social Distance As in the pre-experiment, the IOS scale was used to measure participants’ perceived social distance with significant and stranger others (Aron et al., 1992).

3.3.4 Demographic Information As in the pre-experiment, participants completed a demographic survey including age, gender, income, and subjective social class.

3.4 Data Analysis

First, descriptive statistics and correlation analyses were conducted to examine the means and correlations of variables across the three time points (see Table 1). One-way ANOVA was used to test differences in wisdom performance across social distances (see Table 2).

Second, Longitudinal Multilevel Analysis (LMA) was employed to examine the trajectories of each variable: (1) a simple random intercept model without predictors was established to estimate means, intraclass correlation coefficients (ICC), and within-person and between-person variance; (2) basic trajectories were determined by testing linear and quadratic patterns over time using time and time-squared as predictors (see supplementary materials, Table S1).

Third, multilevel regression models were built to examine the effects of initial mindfulness levels and changes in mindfulness on wisdom (see Table 4).

Finally, Random Intercept Cross-Lagged Panel Models (RI-CLPM; Hamaker et al., 2015) were constructed to explore the predictive relationships between trait mindfulness and wisdom.

3.5 Results

3.5.1 Descriptive Statistics and Correlation Analysis Table 1 presents the means and correlation matrix for mindfulness and wise reasoning/thinking across the three time points. The results showed significant positive correlations among all variables at each time point. The mean values of wise reasoning and thinking showed an increasing trend over time.

Table 1. Means and correlation matrix of variables across three time points.

Note: $p < 0.05$, $p < 0.01$, $p < 0.001$.

3.5.2 Wisdom Difference Tests Table 2 presents the means, standard deviations, and difference tests for wise reasoning and wise thinking across social distances for the total sample and at each time point. The results indicated that, after controlling for all demographic variables and social class, the stranger

group demonstrated significantly higher wise reasoning and wise thinking than the significant other group (except for wise thinking at T3, $p = 0.174$). These results are consistent with the pre-experiment findings, showing that individuals exhibit higher wise reasoning and thinking when facing conflicts involving strangers compared to those involving significant others. Subsequent analyses examined the trajectories of wisdom and influencing factors under different social distance conditions.

Table 2. Difference tests for wise reasoning and wise thinking across social distances.

Note: $p < 0.05$, $p < 0.01$, $p < 0.001$.

3.5.3 Longitudinal Multilevel Analysis The study simultaneously examined between-person and within-person effects of mindfulness on wisdom trajectories.

Wise Reasoning: The initial mindfulness level at T1 was significantly positively correlated with wise reasoning at T1 ($\gamma_{\text{mindfulness_initial}}(B) = 0.71$, $SE = 0.04$, $p < 0.001$), but the interaction with time was not significant ($\gamma_{\text{mindfulness_initial}}(B) * \text{Time} = -0.07$, $SE = 0.06$, $p = 0.262$). Within-person analysis showed that increases in mindfulness level (relative to T1) were significantly positively associated with higher wise reasoning at a given time point ($\gamma_{\text{mindfulness}}(W) = 0.27$, $SE = 0.06$, $p < 0.001$), indicating that when individuals had higher trait mindfulness levels (compared to their initial level), they also exhibited higher wise reasoning. This pattern was consistent across both the significant other and stranger groups (see Table 3, Model 2).

Wise Thinking: The initial mindfulness level at T1 was significantly positively correlated with wise thinking at T1 ($\gamma_{\text{mindfulness_initial}}(B) = 0.82$, $SE = 0.06$, $p < 0.001$), and the interaction with time was marginally significant ($\gamma_{\text{mindfulness_initial}}(B) * \text{Time} = 0.048$, $SE = 0.05$, $p = 0.077$). Simple effects analysis revealed that individuals with high initial trait mindfulness levels showed no change in wise thinking over time (+1 SD: $\gamma_{\text{Time}} = 0.02$, $SE = 0.03$, $p = 0.614$, 95% CI = [-0.044, 0.075]), while those with medium and low trait mindfulness levels showed increases in wise thinking over time (Mean: $\gamma_{\text{Time}} = 0.06$, $SE = 0.02$, $p = 0.005$, 95% CI = [0.018, 0.102]; -1 SD: $\gamma_{\text{Time}} = 0.11$, $SE = 0.03$, $p < 0.001$, 95% CI = [0.046, 0.165]). Within-person analysis showed that increases in mindfulness level (relative to T1) were significantly positively associated with higher wise thinking at a given time point ($\gamma_{\text{mindfulness}}(W) = 0.40$, $SE = 0.07$, $p < 0.001$), indicating that higher mindfulness levels (compared to initial level) were associated with higher wise thinking. This pattern was consistent across both the significant other and stranger groups (see Table 3, Model 2).

Table 3. Model estimates for changes in wisdom with time-invariant and time-varying covariates.

Note: + $p < 0.1$, $p < 0.05$, $p < 0.01$, $p < 0.001$. B = between-person, W = within-person; Model 0 is the unconditional model estimating ICC; Model 1 estimates the basic trajectory of wisdom over time; Model 2 estimates the between-person (time-invariant) and within-person (time-varying) effects of mindfulness on wisdom trajectories.

3.5.4 Random Intercept Cross-Lagged Panel Model Analysis We conducted random intercept cross-lagged panel analysis using the lavaan package in R (version 0.6-17; Rosseel, 2012) to distinguish between-person and within-person effects (Random Intercept Cross-Lagged Panel Model, RI-CLPM; Hamaker et al., 2015).

3.5.4.1 Mindfulness and Wise Reasoning We constructed a random intercept cross-lagged model for mindfulness and wise reasoning across three time points. After sequentially removing non-significant paths, the final cross-lagged model showed good fit indices (see Table 4). The results revealed that the random intercepts for both mindfulness ($\beta = 0.02$, $p = 0.004$) and wise reasoning ($\beta = 0.17$, $p < 0.001$) significantly deviated from zero, indicating significant between-person differences in mindfulness and wise reasoning levels, justifying the random intercept cross-lagged analysis. Furthermore, the covariance between the two random intercepts was significantly positive ($r = 0.04$, $p < 0.001$), suggesting that as individuals' mindfulness levels increased, their wise reasoning levels also increased. As shown in Figure 2 [Figure 2: see original paper], after controlling for all demographic variables and social class, mindfulness predicted wise reasoning (T1-T2: $\beta = 0.48$, $p < 0.001$; T2-T3: $\beta = 0.59$, $p < 0.001$), but wise reasoning did not predict mindfulness. This pattern was particularly evident in the cross-lagged model for mindfulness and wise reasoning in the significant other group (see Figures 3 [Figure 3: see original paper] and 4 [Figure 4: see original paper]).

3.5.4.2 Mindfulness and Wise Thinking The cross-lagged model also showed good fit indices (see Table 4). The random intercept for wise thinking significantly deviated from zero ($\beta = 0.25$, $p < 0.001$), indicating significant between-person differences in mindfulness levels and justifying random intercept cross-lagged analysis. The covariance between the random intercepts for mindfulness and wise thinking was significantly positive ($r = 0.04$, $p < 0.001$), indicating that as mindfulness levels increased, wise thinking levels also increased. As shown in Figure 5 [Figure 5: see original paper], after controlling for all demographic variables and social class, mindfulness predicted wise thinking (T1-T2: $\beta = 0.38$, $p < 0.001$; T2-T3: $\beta = 0.82$, $p < 0.001$), but wise thinking did not predict mindfulness. This was particularly evident in the cross-lagged model for mindfulness and wise thinking in the significant other group (see Figures 6 [Figure 6: see original paper] and 7 [Figure 7: see original paper]).

Table 4. Fit indices for random intercept cross-lagged models of mindfulness and wisdom.

Note: $p < 0.05$, $\mathbf{p} < 0.01$, $p < 0.001$.

Figure 2. Random intercept cross-lagged model for mindfulness and wise reasoning.

Note: $+p < 0.1$, $p < 0.05$, $\mathbf{p} < 0.01$, $p < 0.001$; solid lines represent significant standardized path coefficients, dashed lines represent non-significant standardized path coefficients; blue lines represent positive values, red lines represent negative values. RI = random intercept, W = within-person component, same below.

Figure 3. Random intercept cross-lagged model for mindfulness and wise reasoning in the significant other group.

Figure 4. Random intercept cross-lagged model for mindfulness and wise reasoning in the stranger group.

Figure 5. Random intercept cross-lagged model for mindfulness and wise thinking.

Figure 6. Random intercept cross-lagged model for mindfulness and wise thinking in the significant other group.

Figure 7. Random intercept cross-lagged model for mindfulness and wise thinking in the stranger group.

3.6 Summary

The results of Study 1 indicated that individuals exhibited higher wisdom levels when facing conflicts with strangers (compared to significant others). Cross-lagged analysis further revealed that mindfulness was a stable positive predictor of wise reasoning and thinking, particularly when individuals faced interpersonal conflicts involving significant others. Thus, mindfulness has a long-term predictive relationship with wisdom performance in conflict situations involving significant others, providing causal evidence that mindfulness can alleviate the non-rational decision-making associated with the “player” perspective.

4 Study 2: Behavioral and Cognitive-Neural Mechanisms of Mindfulness Alleviating “Being in the Game”

Study 1 verified from a real-life context perspective that individuals exhibit higher wise reasoning and thinking when facing conflicts involving strangers (relative to significant others), and further demonstrated that mindfulness can predict higher wise reasoning and thinking levels when individuals face conflicts involving significant others. This provides a foundation for examining how mindfulness interventions can alleviate “being in the game.” Accordingly, Study 2 used a mindfulness intervention combined with fNIRS to directly test the effects of mindfulness on wisdom and its effectiveness in alleviating “being in the game.”

4.1 Participants

A total of 126 university students were recruited (age: 19.88 ± 2.44 [range 17–26]; 19.84% male; subjective social class: 4.03 ± 1.20 [range 1–10]; 74.60% with bachelor's degree). All participants were right-handed, had normal or corrected-to-normal vision, normal color vision, and no history of psychiatric or brain disorders. All participants provided written informed consent before the experiment and received compensation upon completion.

4.2 Design and Procedure

The study employed a 2 (experimental manipulation: mindfulness, mind-wandering) \times 2 (social distance: significant other, stranger) \times 2 (wisdom measurement: wise reasoning, wise thinking) mixed design, with wisdom measurement as a within-subjects variable.

Participants were randomly assigned to the mindfulness group ($N = 64$) or the mind-wandering group ($N = 62$). Participants in the significant other group were asked to bring a friend to participate in the experiment, forming 61 friend dyads. Participants in the stranger group were informed that they would complete the experimental task with an anonymous stranger, forming 65 stranger dyads. The experimental procedure consisted of three parts (see Figure 8 [Figure 8: see original paper]): (1) Pre-test: Participants completed pre-tests including demographic information and relevant scales 3 days before coming to the laboratory; (2) fNIRS experiment: Upon arrival, participants sat facing a computer monitor while wearing an fNIRS optode cap. Before the experiment began, participants were informed of the task procedures and rules, and were instructed to remain relaxed and keep their heads as still as possible throughout the experiment. During the formal experiment, participants first rested quietly for 3 minutes, then listened to mindfulness or mind-wandering audio interventions through in-ear noise-canceling headphones (see Appendix for text materials); (3) After the audio intervention and a 30-second rest period, participants completed the conflict imagination task. The experimental task was programmed and presented using E-prime 3.0 on a 17-inch monitor with a spatial resolution of 1920×1080 pixels; (4) Following the fNIRS experiment, the optode cap was removed, and participants completed post-test questionnaires after a brief rest.

Figure 8. Mindfulness intervention fNIRS experimental procedure.

4.3 Measures

4.3.1 State Mindfulness State mindfulness was measured using the Chinese version of the State Mindfulness Scale (SMS; Zhang, Wang, Wang, & Luo, 2023), which includes 21 items ($\alpha = 0.94$) across two factors: mental state mindfulness (15 items, e.g., “I am aware of the different emotions I experience”) and bodily state mindfulness (6 items, e.g., “I notice my body’s movements when I change posture”). Each item was rated on a 5-point Likert scale (1 = completely

disagree, 5 = completely agree). The total mean score was used as the state mindfulness index, with higher scores indicating higher state mindfulness levels.

4.3.2 Wisdom As in the pre-experiment and Study 1, the Situated Wise Reasoning Scale (SWIS; Brienza et al., 2018) and the Wise Thinking Scale (Fu et al., 2021) were administered, with reliability coefficients of $\alpha = 0.95$ and 0.90 , respectively, in this study.

4.3.3 Social Distance As in previous studies, the IOS scale was used to measure perceived social distance (Aron et al., 1992).

4.3.4 Demographic Information As in previous studies, participants completed a demographic survey including age, gender, income, and subjective social class.

4.3.5 fNIRS Data Acquisition We used a LABNIRS functional near-infrared spectroscopy system (LABNIRS/16, Shimadzu Corporation, Kyoto, Japan). The system employs three-wavelength (780 nm, 805 nm, 830 nm) near-infrared semiconductor lasers (safety class 1M under IEC-60825-1 standard). The system can detect relative concentration changes in oxyhemoglobin (Oxy-Hb), deoxyhemoglobin (Deoxy-Hb), and total hemoglobin (Toxy-Hb). This study simultaneously measured relative concentration changes in Oxy-Hb, Deoxy-Hb, and Toxy-Hb in three regions: the prefrontal cortex (channels 1–17), left temporoparietal junction (channels 18–29), and right temporoparietal junction (channels 30–41) (see Figure 9 [Figure 9: see original paper]). Optode placement followed the international 10-20 system, with Nz, Cz, AL, and AR as reference points. In this optode and channel configuration, the distance between light source and detector probes was approximately 3 cm, with a sampling rate of about 47 Hz.

Figure 9. fNIRS optode placement diagram.

4.4 Results

4.4.1 Manipulation Checks Social Distance: One-way ANOVA revealed that, after controlling for all demographic variables, the social distance manipulation had a significant main effect on participants' perceived social distance, $F(1, 119) = 16.63$, $p < 0.001$, $\eta^2_p = 0.14$. Specifically, the significant other group perceived significantly closer social distance than the stranger group ($M_{stranger} = 2.49$, $SD_{stranger} = 1.60$; $M_{significant} = 3.69$, $SD_{significant} = 1.64$).

Mindfulness: A 2 (experimental manipulation: mindfulness group, mind-wandering group) $\times 2$ (measurement: pre-test, post-test) mixed-design ANOVA revealed a significant difference between pre- and post-tests, $F(1, 124) = 13.32$, $p < 0.001$, $\eta^2_p = 0.097$; the main effect of experimental manipulation was not

significant, $F(1, 124) = 0.44$, $p = 0.376$, $^2p = 0.006$. Importantly, the interaction between experimental manipulation and measurement time was significant, $F(1, 124) = 5.14$, $p = 0.025$, $^2p = 0.040$. Simple effects analysis found no significant difference between the mindfulness group ($M = 3.94$, $SD = 0.60$) and mind-wandering group ($M = 3.98$, $SD = 0.59$) at pre-test, $t(124) = 0.39$, $p = 0.694$, Cohen's $d = 0.07$. However, at post-test, the mindfulness group ($M = 4.24$, $SD = 0.42$) scored significantly higher than the mind-wandering group ($M = 4.05$, $SD = 0.56$), $t(124) = 2.16$, $p = 0.033$, Cohen's $d = 0.33$. Additionally, the mindfulness group showed a significant difference between pre- and post-test, $t(124) = 4.22$, $p < 0.001$, Cohen's $d = 0.53$, while the mind-wandering group showed no significant difference, $t(124) = 0.97$, $p = 0.334$, Cohen's $d = 0.12$. These results indicate that the life-course-based mindfulness manipulation was effective (see Figure 10 [Figure 10: see original paper]).

Note: $p < 0.05$, $p < 0.01$, $p < 0.001$; only significant comparisons are marked in the figure.

Figure 10. Manipulation check for state mindfulness.

4.4.2 Wisdom Difference Tests Wise Reasoning: Results are shown in Figure 11 [Figure 11: see original paper]. A 2 (experimental manipulation: mindfulness, mind-wandering) \times 2 (social distance: stranger, significant other) ANOVA revealed that, after controlling for demographic variables, the main effect of experimental manipulation was significant, $F(1, 117) = 10.39$, $p = 0.002$, $^2p = 0.082$. Specifically, the mindfulness intervention group showed higher wise reasoning than the mind-wandering group ($M_{\text{mindfulness}} = 4.66$, $SD_{\text{mindfulness}} = 0.84$; $M_{\text{mind-wandering}} = 4.09$, $SD_{\text{mind-wandering}} = 0.86$). The main effect of social distance was also significant, $F(1, 117) = 10.84$, $p = 0.001$, $^2p = 0.085$, with the stranger group showing higher wise reasoning than the significant other group ($M_{\text{stranger}} = 4.62$, $SD_{\text{stranger}} = 0.80$; $M_{\text{significant}} = 4.12$, $SD_{\text{significant}} = 0.92$). The interaction between experimental manipulation and social distance was not significant, $F(1, 117) = 0.75$, $p = 0.387$, $^2p = 0.006$. However, simple effects analysis indicated that mindfulness intervention reduced the difference in wise reasoning between stranger and significant other groups. Specifically, in the mindfulness group, the difference in wise reasoning between conflicts with strangers ($M = 4.83$, $SD = 0.71$) and significant others ($M = 4.53$, $SD = 0.91$) was not significant, $t(117) = 1.71$, $p = 0.091$, Cohen's $d = 0.43$. In contrast, in the mind-wandering group, wise reasoning for conflicts with strangers ($M = 4.41$, $SD = 0.84$) was significantly higher than for conflicts with significant others ($M = 3.75$, $SD = 0.76$), $t(117) = 2.90$, $p = 0.004$, Cohen's $d = 0.75$.

Wise Thinking: Results are shown in Figure 12 [Figure 12: see original paper]. A 2 (experimental manipulation: mindfulness, mind-wandering) \times 2 (social distance: stranger, friend) between-subjects ANOVA revealed that, after controlling for demographic variables, the main effect of experimental manipulation was significant, $F(1, 117) = 10.30$, $p = 0.002$, $^2p = 0.081$. Specifically, the mindful-

ness intervention group showed higher wise thinking than the mind-wandering group ($M_{\text{mindfulness}} = 4.87$, $SD_{\text{mindfulness}} = 0.71$; $M_{\text{mind-wandering}} = 4.38$, $SD_{\text{mind-wandering}} = 0.95$). The main effect of social distance was also significant, $F(1, 117) = 7.74$, $p = 0.006$, $\eta^2_p = 0.062$, with the stranger group showing higher wise thinking than the significant other group ($M_{\text{stranger}} = 4.83$, $SD_{\text{stranger}} = 0.89$; $M_{\text{significant}} = 4.40$, $SD_{\text{significant}} = 0.80$). The interaction between experimental manipulation and social distance was not significant, $F(1, 117) = 0.98$, $p = 0.325$, $\eta^2_p = 0.008$. Simple effects analysis indicated that mindfulness practice reduced the difference in wise thinking between stranger and friend groups. Specifically, in the mindfulness group, the difference in wise thinking between conflicts with strangers ($M = 5.03$, $SD = 0.78$) and significant others ($M = 4.71$, $SD = 0.59$) was not significant, $t(117) = 1.26$, $p = 0.211$, Cohen's $d = 0.32$. In contrast, in the mind-wandering group, wise thinking for conflicts with strangers ($M = 4.64$, $SD = 0.97$) was significantly higher than for conflicts with significant others ($M = 4.10$, $SD = 0.86$), $t(117) = 2.63$, $p = 0.010$, Cohen's $d = 0.68$.

In summary, mindfulness intervention effectively eliminated the asymmetry in wisdom performance when individuals faced conflicts involving significant others versus strangers.

Note: $**p < 0.01$; only significant comparisons are marked in the figure.

Figure 11. Difference tests for wise reasoning across mindfulness manipulation and social distance.

Note: $*p < 0.05$; only significant comparisons are marked in the figure.

Figure 12. Difference tests for wise thinking across mindfulness manipulation and social distance.

4.5 fNIRS Data Analysis

Four participants were excluded (one due to incomplete data, three due to excessive head movement during the 3-minute resting-state fNIRS data collection), leaving a final sample of 122 participants for fNIRS data analysis.

Data analysis was conducted using the NIRS-KIT toolbox in MATLAB 2013b (Hou et al., 2021). First, raw data collected by the Shimadzu device were imported into NIRS-KIT for format conversion. Second, data preprocessing included: (1) removing signal drift over time using a first-order polynomial fitting algorithm; (2) correcting for head motion using temporal derivative distribution repair (TDDR; Fishburn et al., 2019); (3) applying band-pass filtering using a third-order infinite impulse response (IIR) filter, with cutoff frequencies of 0.01–0.1 Hz to eliminate slow drift, high-frequency noise, and cardiac artifacts based on recent mindfulness fNIRS research (Gao & Zhang, 2023); and (4) removing systematic noise using the method developed by Yamada et al. (2012). Research indicates that HbO concentration changes are the most sensitive indicator of local cerebral blood flow in fNIRS measurements (Hoshi, 2003) and correspond

to BOLD signals measured by fMRI, recommending HbO data as the primary analysis metric (Cui et al., 2011; Strangman et al., 2002). Therefore, this study primarily analyzed HbO concentration changes. Additionally, a 3D digitizer was used to convert the positions of 41 fNIRS channels into MNI coordinates and anatomical locations (see Appendix Table S1).

4.5.1 Channel HbO Concentration Changes

A 2 (group: mindfulness, mind-wandering) \times 2 (experimental condition: rest, manipulation) repeated-measures ANOVA was conducted on HbO concentrations across 41 channels. No significant main effects of group were found across any of the 41 channels (see Appendix Table S3). Significant main effects of experimental condition were found in channels 1, 3, 4, 5, 7, 11, 14, 16, 20, 23, and 34 (channel 5: $p = 0.052$, see Appendix Table S3). Importantly, significant group \times condition interactions were found in channels 15 and 26 (channel 15: $F[1,120] = 4.09$, $p = 0.045$, $\eta^2 = 0.033$; channel 26: $F[1,120] = 4.14$, $p = 0.044$, $\eta^2 p = 0.033$), with marginally significant interactions in channels 4 and 41 (channel 4: $F[1,120] = 2.86$, $p = 0.093$, $\eta^2 p = 0.023$; channel 41: $F[1,120] = 2.83$, $p = 0.095$, $\eta^2 p = 0.033$) (see Figure 13 [Figure 13: see original paper]). Simple effects analysis revealed that, in addition to channels 4, 26, and 41, HbO concentrations in channels 7, 11, 14, 18, 20, and 34 also showed significant increases after mindfulness activation (with channel 34 being marginally significant, $ps = 0.074\text{--}0.089$) (see Table 5 and Table S4). Therefore, mindfulness intervention may have induced greater activation in channels 4, 7, 11, 14, 18, 20, 26, 34, and 41 (see Figure 14 [Figure 14: see original paper]). Channels 4 and 11 correspond to left dorsolateral prefrontal cortex (lDLPFC), channels 7 and 14 to right dorsolateral prefrontal cortex (rDLPFC), channels 18, 20, and 26 to left temporoparietal junction (lTPJ), and channels 34 and 41 to right temporoparietal junction (rTPJ).

The mind-wandering group showed significant HbO concentration changes in channels 7, 11, 14, 15, 16, 20, 25, and 29, with significant decreases in channels 15 and 16 after mind-wandering activation and significant increases in the remaining channels (see Tables S3 and S4). Therefore, mind-wandering intervention may have induced greater activation in channels 7, 11, 14, 20, 25, and 29 (see Figure 14), with channel 7 corresponding to rDLPFC, channel 11 to lDLPFC, channels 20 and 25 to lTPJ, and channel 29 to rTPJ.

Thus, while mind-wandering also activated the dorsolateral prefrontal cortex and temporoparietal junction to some extent, mindfulness induced activation across a larger region of these areas.

Figure 13. Interaction effects between mindfulness/mind-wandering groups and rest/manipulation conditions.

Note: $+p < 0.01$, $p < 0.05$, $\mathbf{p} < \mathbf{0.01}$, $p < 0.001$.

Table 5. Simple effects analysis of group and experimental manipulation for

fNIRS channels.

Note: beta1 = resting state; beta2 = activation state. Bolded indices indicate significant or marginally significant interaction effects. Only marginally significant and significant results are shown; the complete table is available in Appendix Table S4.

Figure 14. Heat map of activation vs. rest contrast in the mindfulness group.

4.5.2 Cognitive-Neural Mechanisms of Mindfulness Alleviating “Being in the Game”

Figure 15 [Figure 15: see original paper]. Heat map of activation vs. rest contrast in the mind-wandering group.

fNIRS data were matched with behavioral data, yielding 119 matched datasets. First, HbO concentration changes induced by mindfulness and mind-wandering interventions were used as independent variables, with wise reasoning/thinking as dependent variables, and gender, age, education level, income, and social class as control variables in regression analyses. The results revealed that HbO concentration changes in channel 18 induced by mindfulness intervention positively predicted wise reasoning ($\beta = 0.28$, $p = 0.002$) and wise thinking ($\beta = 0.30$, $p = 0.001$), particularly for wise reasoning ($\beta = 0.28$, $p = 0.002$) and wise thinking ($\beta = 0.38$, $p = 0.004$) in the significant other group. HbO concentration changes in channel 26 induced by mindfulness intervention positively predicted wise reasoning ($\beta = 0.20$, $p = 0.026$) and marginally significantly predicted wise reasoning in the significant other group ($\beta = 0.20$, $p = 0.093$)¹. Consistent with Study 1, these findings indicate that mindfulness intervention only affects “being in the game.”

¹HbO concentration changes in channel 18 did not predict wise thinking ($\beta = 0.20$, $p = 0.143$) or reasoning ($\beta = 0.13$, $p = 0.365$) in the stranger group; HbO concentration changes in channel 26 did not predict wise thinking ($\beta = 0.07$, $p = 0.447$), nor wise thinking ($\beta = -0.08$, $p = 0.579$) or reasoning ($\beta = 0.16$, $p = 0.273$) in the stranger group.

Second, moderation analysis was conducted with social distance as the independent variable, Δ HbO in channels 18 and 26 as moderators, wise thinking/reasoning as dependent variables, and gender, age, education level, income, and social class as control variables. The results showed no significant interaction between social distance (0 = significant other, 1 = stranger) and Δ HbO in either channel on wise reasoning or wise thinking (wise reasoning: $F[1,110] = 1.95$, $p = 0.166$; wise thinking: $F[1,110] = 0.26$, $p = 0.612$). However, simple effects analysis revealed that higher Δ HbO in channels 18 and 26 (M+SD) reduced the effect of social distance on wisdom to the point of elimination (see Table 6 and Figure 16). Similar results were observed for increased Δ HbO in channels 4, 7, 11, 14, 20, 25, 29, 34, and 41 (see Appendix Tables S5, S6 and Figures S1, S2).

Table 6. Moderating effect of Ch26 Δ HbO on the relationship between social distance and wise reasoning.

Figure 16. Moderating effect of Δ HbO on the relationship between social distance and wise reasoning.

4.6 Summary

Both behavioral and fNIRS studies demonstrated that individuals receiving mindfulness interventions exhibited similar levels of wise reasoning and thinking when facing interpersonal conflicts involving both significant others and strangers, alleviating “being in the game.” The potential cognitive-neural mechanism involves blood oxygen concentration activation in channels related to the dorsolateral prefrontal cortex (DLPFC) and temporoparietal junction (TPJ).

General Discussion

This study verified the traditional Chinese wisdom of “the onlooker sees clearly, the player is muddled,” with the key to being an “onlooker lying in” who the other is.” The results showed that people exhibit the highest levels of wise reasoning and thinking when facing conflicts involving strangers. The study further used longitudinal tracking to verify that mindfulness can robustly and significantly predict wise reasoning and thinking when individuals face conflicts involving significant others. Additionally, the fNIRS study replicated the finding that mindfulness interventions enhance wise reasoning and thinking in conflicts involving significant others, eliminating the performance difference in wise reasoning and thinking between “significant other—stranger” conditions. The potential cognitive-neural mechanism may involve blood oxygen concentration changes in DLPFC and TPJ-related channels.

Mindfulness refers to purposefully and non-judgmentally focusing attention on the present moment (Kabat-Zinn, 2003). It is both a unique psychological state and a psychological trait. The former refers to a state of consciousness induced during mindfulness practice or meditation, aimed at bringing awareness to present experience and connecting with immediate experience through curiosity, openness, and acceptance (Lindsay & Creswell, 2017)—a process of subjectively and temporarily experiencing and gaining insight into the nature of one’s thoughts using a de-centered perspective (Safran & Segal, 1990). The latter refers to attention to and awareness of currently occurring events (Brown & Ryan, 2004). The mechanisms through which mindfulness interventions facilitate wisdom transformation may involve three aspects: First, changes in self-awareness, including recognizing automatic habits and response patterns and enhancing awareness of direct bodily and mental experiences in the present moment; second, changes in self-regulation, including improved emotion regulation, enhanced self-compassion and cognitive flexibility, while reducing rumination and negative emotions and increasing non-attachment and acceptance; and third, enhanced self-transcendence, meaning increasingly stronger de-centering,

greater interdependence between self and others, and higher levels of compassion. Through these three mechanisms, wisdom gradually develops from the awareness, acceptance, and reflection of experience, transcending intellect or knowledge to gain insight into the essence of phenomena (Wang et al., 2023; Verhaeghen, 2019). In summary, when facing conflict or dilemma problems, individuals with trait mindfulness or in a mindful state can de-center from the self, consider problems from a broader perspective, calmly balance multiple interests, and make wiser decisions (Wang et al., 2022)—the core mechanism for alleviating “being in the game.”

More importantly, based on theoretical and empirical foundations of mindfulness interventions for cultivating and developing wisdom, combined with the important characteristic that wisdom originates from life experience, this study developed a “life-course-based” mindfulness intervention and verified its effectiveness. Wisdom stems from life experience, yet not everyone with life experience can live wisely (Weststrate, 2019). The American educator John Dewey believed that we do not learn from experience but from reflecting on experience. Age only brings accumulated life experience, but not all individuals with life experience can live wisely. The key to promoting wisdom lies in being able to approach experience with an open mind and, utilizing internal and external conditions, reflect on and integrate important and meaningful life experiences (Wang et al., 2022). Early research also found that individuals with high wisdom scores almost universally reported personal growth experiences (Ardelt, 2010), providing further evidence for the importance of life experience to wisdom. Accordingly, this study developed a life-course-based mindfulness practice that primarily guides practitioners to non-judgmentally and consciously observe and feel the flow of life. The process includes contemplating the origin of life, recalling past experiences, noticing present-moment thoughts, imagining future life development, and reflecting on approaching the end of life. Throughout the process, practitioners are asked to maintain conscious awareness, observe themselves from a certain distance, but not judge any thoughts as good or bad. The life-course meditation aims to help practitioners connect with the origin of their lives, feel more deeply each stage and subtle change in the growth process, and experience the infinite power of life as a whole. Through acceptance of life and reflection on life-course development, the practice helps practitioners reflect on important life experiences so they can extract crucial life experiences when facing difficult decisions and make wise choices. The results confirmed that this mindfulness approach can effectively facilitate wise reasoning and thinking while eliminating the dilemma of “being in the game.”

To provide stronger evidence, this study used fNIRS cognitive-neural technology to explore the neural mechanisms of the life-course-based mindfulness intervention. The results showed that brief mindfulness intervention effectively activated blood oxygen concentrations in channels covering the dorsolateral prefrontal cortex (DLPFC) and temporoparietal junction (TPJ). Previous research using 20-minute mindfulness and mind-wandering audio interventions found that, compared to the mind-wandering group, the mindfulness group showed significant

activation in right BA9 and BA10 (PFC, frontopolar region), as well as greater activation in left BA10 (frontopolar region) (Gao & Zhang, 2023). Consistent with previous research, mindfulness activated a larger region of attention-related DLPFC channels (Ch 4, 7, 11, 14). Higher HbO concentration changes in these channels were associated with smaller effects of social distance on wise reasoning and thinking, with the effect of social distance disappearing at high levels of blood oxygen concentration change (see Table S4). This suggests that the three channels covering DLPFC may be key neural mechanisms for eliminating “being in the game.” Additionally, mindfulness induced greater activation in TPJ-related channels (Ch 18, 20, 26, 34, 41). Wise individuals may exhibit greater cognitive flexibility and openness to different perspectives, reflected in greater theta wave activity in the brain’s temporoparietal junction (TPJ) (Grennan et al., 2021). In particular, the wisdom component of tolerance for uncertainty and ambiguity is closely related to theta wave activity in the left transverse temporal region ($f^2 = 0.06$, $\beta = 306.73$, $p = 0.006$) (Grennan et al., 2021). Although direct evidence linking rTPJ to wisdom or wisdom-related characteristics is currently lacking, researchers widely recognize rTPJ as the primary neural mechanism for perspective-taking, which is related to inferring others’ intentions (Tang et al., 2016; van Overwalle, 2009; Zhang et al., 2017). Better control of egocentric bias also triggers stronger rTPJ activity (O’Connell et al., 2017). Mindfulness alleviates “being in the game” by enhancing individuals’ de-centered perspective and strengthening bystander introspection ability (Desbordes et al., 2015), thereby enabling individuals to be more empathetic, consider others’ perspectives, and integrate multiple suggestions when making decisions involving two or more parties (Wang et al., 2023). Therefore, this study proposes that both DLPFC and TPJ activation induced by mindfulness intervention are potential brain mechanisms for alleviating “being in the game.”

This study enriches research on wisdom asymmetry and systematically demonstrates the traditional Chinese wisdom of “the onlooker sees clearly, the player is muddled” from an indigenous cultural perspective. It proposes a mindfulness intervention approach to alleviate “being in the game” (the wisdom asymmetry between significant others and strangers) and provides causal evidence and cognitive-neural validation through combined longitudinal tracking and fNIRS studies, yielding valuable and objective results. However, the study has several limitations. First, the sample has limitations. Although the study combined online surveys with offline experiments and used cognitive-neural methods (fNIRS) for validation, aside from the relatively broad demographic information from online sampling, the offline sample consisted primarily of undergraduate students, especially first-year students in the cognitive-neural study. These groups may have limited understanding of wisdom, potentially leading to incomplete wisdom measurement. Therefore, wisdom measurement results may be biased. Future research should recruit more diverse samples, including different regions, age groups, occupations, and even different ethnicities and belief systems, to enhance the ecological validity of the findings. Second, there is measurement unidimensionality. Although the study used multiple methods to

validate result stability, measurements of independent and dependent variables were relatively singular. While the study employed two wisdom measurement methods and verified that measurement type did not affect results, all measures were self-reports. Wisdom is a complex, multidimensional concept that may be susceptible to social desirability and subjectivity due to its positive connotations. Future research should combine qualitative and quantitative approaches, establishing contexts unrelated to the task or difficult for participants to guess the experimental purpose, and ask participants to describe situations and propose solutions in an open-ended manner. Although current research has used hypothetical scenarios combined with self-report scales (Fu et al., 2021), these scenarios are not suitable for diverse populations. If text analysis can be used to mine large samples or big data to establish a context library suitable for different age groups, it could provide richer materials for qualitative wisdom research. Third, the tracking period was relatively short. Although the study used longitudinal design to explore causal relationships, the intervals between the three time points were brief, while wisdom development requires long-term accumulation and reflection on life experience (Wang et al., 2024), which is insufficient to reveal clearer pathways. Future research should conduct longer-term tracking studies to verify result robustness. Fourth, the mindfulness intervention and cognitive-neural study lacked comparison with typical mindfulness awareness conditions. Based on the characteristic that wisdom develops from life experience (Baltes & Staudinger, 2000), this study developed a life-course-based mindfulness intervention but lacked comparison with typical mindfulness interventions such as mindful awareness, mindful breathing, and body scans. Future research should address this limitation by adding comparison groups for mindful awareness or breathing scans to further investigate whether life-course-based mindfulness interventions produce more specific brain activation patterns to enhance wisdom and alleviate “being in the game.” Most importantly, the fNIRS study lacked hyperscanning of interpersonal interaction. Throughout this study, wisdom measurement was primarily based on interpersonal conflict scenarios (e.g., conflicts with friends or strangers). However, due to equipment limitations, no dual-person hyperscanning study was conducted. Future research using fNIRS hyperscanning technology to examine the effects and neural mechanisms when both conflict parties (stranger pairs and friend pairs) jointly bear decision-making outcomes and propose conflict resolution solutions could provide more valuable results for wisdom development.

This study used longitudinal tracking to verify the causal relationship between mindfulness and wisdom, finding that trait mindfulness can significantly predict wise reasoning and thinking when individuals face conflicts involving significant others. Behavioral and cognitive-neural findings consistently demonstrated that mindfulness interventions can alleviate the difference in wisdom performance when individuals face conflicts involving significant others versus strangers—that is, alleviate “being in the game”—with the potential interpersonal neural mechanism being blood oxygen concentration changes in the dorsolateral prefrontal cortex (DLPFC) and temporoparietal junction (TPJ).

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Appendix

Study 1: Basic Trajectories of Variables

Mindfulness: (1) The ICC for mindfulness was 0.302, indicating that 30.20% of the variance in mindfulness was between-person differences; (2) The linear time model for mindfulness was not significant, likelihood ratio (LR) $\chi^2(1) = 0.38$, $p = 0.536$, and the quadratic time model was also not significant, LR $\chi^2(1) = 0.75$, $p = 0.387$. Therefore, trait mindfulness levels did not change over time.

Wise Reasoning: (1) The ICCs for wise reasoning under the two conditions (significant other vs. stranger) were 0.468 and 0.517, respectively, indicating that 46.80% and 51.70% of the variance in wise reasoning were between-person differences; (2) The linear time model for wise reasoning was significant, LR $\chi^2(1) = 10.97$, $p < 0.001$, with the significant other group showing a significant linear time model, LR $\chi^2(1) = 8.43$, $p = 0.004$, and the stranger group showing a marginally significant linear time model, LR $\chi^2(1) = 3.00$, $p = 0.084$; (3) The quadratic time model for wise reasoning was not significant, LR $\chi^2(1) = 0.41$, $p = 0.525$, with neither the significant other group (LR $\chi^2(1) = 1.20$, $p = 0.273$) nor the stranger group (LR $\chi^2(1) = 0.02$, $p = 0.882$) showing significant quadratic effects. Only the linear model was retained in the final model.

Model estimates (Table 3, Wise Reasoning Model 1) showed that participants' initial average wise reasoning level was 3.65, which increased over time ($\beta = 0.04$, $SE = 0.01$, $p < 0.001$). Significant between-person differences existed in initial wise reasoning levels ($F(1, 100) = 0.24$, $SE = 0.03$, $p < 0.001$), with no significant linear change over time and no significant correlation between initial level and linear change over time ($F(1, 100) = 0.07$, $SE = 0.02$, $p = 0.004$). Significant between-person differences existed in initial wise reasoning levels ($F(1, 100) = 0.21$, $SE = 0.04$, $p < 0.001$), with no significant linear change over time and no significant correlation between initial level and linear change over time ($F(1, 100) = 0.03$, $SE = 0.02$, $p = 0.084$). Significant between-person differences existed in initial wise reasoning levels ($F(1, 100) = 0.27$, $SE = 0.03$, $p < 0.001$), with significant linear change over time ($F(1, 100) = 0.04$, $SE = 0.01$, $p < 0.001$). The covariance between initial level and linear change rate was significant ($F(1, 100) = -0.04$, $SE = 0.01$, $p = 0.003$), indicating that participants in the stranger

group who showed high wise reasoning levels at the initial stage (T1) increased more slowly over time.

Wise Thinking: (1) The ICCs for wise thinking under the two conditions (significant other vs. stranger) were 0.468 and 0.517, respectively, indicating that 46.80% and 51.70% of the variance in wise thinking were between-person differences; (2) The linear time model for wise thinking was significant, $LR^2(1) = 12.31$, $p < 0.001$, with the significant other group showing a significant linear time model, $LR^2(1) = 15.23$, $p < 0.001$, and the stranger group showing a non-significant linear time model, $LR^2(1) = 2.06$, $p = 0.152$; (3) The quadratic time model for wise thinking was not significant, $LR^2(1) = 1.47$, $p = 0.226$, with neither the significant other group ($LR^2(1) = 1.60$, $p = 0.207$) nor the stranger group ($LR^2(1) = 0.26$, $p = 0.611$) showing significant quadratic effects. Only the linear model was retained in the final model.

Model estimates (Table S1, Wise Thinking Model 1) showed that participants' initial average wise thinking level was 4.25, which increased over time ($\beta = 0.06$, $SE = 0.02$, $p < 0.001$). Significant between-person differences existed in initial wise thinking levels ($\beta = 0.46$, $SE = 0.04$, $p < 0.001$), with significant linear decrease over time ($\beta = -0.05$, $SE = 0.02$, $p = 0.014$), suggesting potential moderating mechanisms. The correlation between initial wise thinking levels at the initial stage (T1) and the final stage (T2) was 0.11, $SE = 0.03$, $p < 0.001$. Significant between-person differences existed in initial wise thinking levels ($\beta = 0.41$, $SE = 0.07$, $p < 0.001$), with no significant linear change over time and no significant correlation between initial and final wise thinking levels ($\beta = 0.03$, $SE = 0.02$, $p = 0.152$). Significant between-person differences existed in initial wise thinking levels ($\beta = 0.46$, $SE = 0.05$, $p < 0.001$), with significant linear decrease over time ($\beta = -0.05$, $SE = 0.02$, $p = 0.025$). The correlation between initial level and linear change rate was significant ($\beta = 0.06$, $SE = 0.02$, $p = 0.001$), indicating that participants in the stranger group who showed high wise thinking levels at the initial stage (T1) increased more rapidly over time.

Life-Course-Based Mindfulness Practice

Operational Definition: Life-course-based meditation refers to practitioners non-judgmentally and consciously observing and feeling the flow of life. The process includes contemplating the origin of life, recalling past experiences, noticing present-moment thoughts, imagining future life development, and reflecting on approaching the end of life. Throughout the process, practitioners are asked to maintain conscious awareness, observe themselves from a certain distance, but not judge any thoughts as good or bad.

Life-course meditation aims to help practitioners connect with the origin of their lives, feel more deeply each stage and subtle change in the growth process, and experience the infinite power of life as a whole.

[Preparation: Breath and Body Awareness]

Please adjust to a comfortable, safe posture. Maintain this posture, keep your

head naturally upright, relax your shoulders, and keep your back naturally straight. When you feel ready, gently close your eyes and slowly focus your attention on the sensation of breathing. Try to notice the feeling in your abdomen or any other body part where breathing sensations are prominent (3 seconds).

Please maintain conscious awareness for the next period. If your mind wanders, gently bring your attention back to your body (5 seconds).

After spending some time simply being with bodily and breathing sensations, let us enter meditation with a profound question: How have you lived this life?

[Transition: Origin]

You received a very special life through your father and mother. Do you have an image in your mind of this new life entering the world (5 seconds)?

If so, how do you feel about this image (5 seconds)?

Do you have something you would like to say to your newborn self (5 seconds)? What would you like to say? Take your time, you can think slowly (10 seconds).

If you have nothing to say, that's okay too. Just calmly observe this moment of connecting with life's origin (3 seconds), noticing any thoughts and feelings (10 seconds).

[Transition: The Past]

From life's beginning, every minute and second continuously becomes the past. So far, how have you spent these years?

These past experiences may include sadness and joy (3 seconds), regret and determination (3 seconds). Whatever the feelings, they are all acceptable (3 seconds).

Over these years, what events have you been unable to forget (10 seconds)?

What events make you think that if you had acted differently, you could have done better (10 seconds)?

If you cannot recall specific events, that's fine. You can also consciously observe these past experiences and any feelings they bring (5 seconds).

Just feel them calmly (5 seconds). Please take some time to review and reflect (10 seconds).

[Transition: The Present]

If more sadness emerges, that is acceptable; if regret emerges, that is also acceptable.

You can change now. This moment is the best opportunity.

If you find your mind wandering, please bring your awareness back and continue observing (3 seconds).

Time flows constantly. Please slowly move forward to the present (3 seconds).
Not necessarily this exact moment, not necessarily today, not necessarily this
month or year. More importantly, this is a stage you are currently experiencing
(5 seconds).

What does this stage mean to you (5 seconds)?

Please take some time to observe and feel any thoughts and feelings in this
moment (10 seconds).

[Transition: The Future]

Good, please continue maintaining conscious awareness (3 seconds).

Next, please travel through time to meet your future self.

You might see yourself ten years from now (3 seconds).

If you have an image in your mind, what will you look like in ten years (3
seconds)?

Do you have questions for your future self? For example, “Will I still be with
the people I care about in ten years?” “Will I get my ideal job?” Your future
self may give you answers (5 seconds).

You can continue forward to meet yourself twenty years from now, or even in
old age (5 seconds).

Do you still have questions for your future self (5 seconds)?

Or do you just want to quietly observe them without disturbing their life (5
seconds)?

Please take some time to think and imagine. There is no rush (10 seconds).

[Transition: The End of Life]

As time gradually slows and stagnates, you will eventually come to the final
moment of life.

Some say death is the final chapter of the life course, others say it is a node,
with two worlds before and after this node. What do you think death means (3
seconds)?

Looking at yourself before death, do you feel reluctant to part? Reluctant to
leave the people, events, and things in this world (5 seconds)?

Do you feel fear, afraid of facing death (3 seconds)?

Do you have unfulfilled wishes (5 seconds)?

Do you have words for yourself before death (5 seconds)?

Have you made good use of your time in this life (3 seconds)?

If you could do it again, how would you choose?

Please continue observing any feelings and thoughts in this moment (10 seconds).

Then you feel darkness, almost losing consciousness, and suddenly your heart feels completely free, completely clear, so serene.

You feel there is no time, no before or after, you feel you are everywhere and nowhere (5 seconds).

Some people spend their entire lives in the past, others drown their lives in fear. I hope your life is fully lived in your life energy, constantly transforming, constantly evolving, living out your own life.

Now please take some time to experience the present moment and slowly return to now (3 seconds). Please gently and firmly connect with your present self, be completely with your present self (5 seconds).

When you are ready, you can slowly open your eyes and see if you can be completely, right here.

Finally, I wish you to always live in love. Goodbye.

Mind-Wandering Instructions

Hello, now is the time to let your thoughts wander freely.

Before we begin, please adjust to a comfortable, safe posture. Please maintain this posture. Keep your head naturally upright, relax your shoulders, and keep your back naturally straight.

When you are ready, you can close your eyes or keep them open, maintaining your current state.

Please think about anything freely in your mind. You can imagine all kinds of things, letting your thoughts roam freely (30 seconds).

You can immerse yourself in memories, thinking about anything that happened in the past, just thinking freely (3 seconds).

You can also think about what is happening in this moment, but you don't need to deliberately focus your attention on any particular thing (10 seconds).

Of course, your thoughts can also come from the future. Feel free to imagine anything that might happen in the future, letting your consciousness think freely (30 seconds).

Your thoughts don't need to stay focused on one thing. Please think as you wish, without deliberately concentrating on any particular thing (30 seconds).

Please try to stay relaxed. You don't need to deliberately contemplate or focus your mind (30 seconds).

Just let your thoughts move freely, whatever you think about is fine (30 seconds).

Remember, this is your time to let your thoughts fly. Let your consciousness think freely, letting any thoughts enter your mind as they wish (30 seconds).

Please know that you don't need to keep concentrating on one thing. Try to stay relaxed. You can freely think about many different things (30 seconds).

Your thoughts don't need to stay focused on the same thing. Please think as you wish, without deliberately concentrating on any particular thing (30 seconds).

You don't need to keep your attention on one thing for too long. Just think freely (10 seconds).

You can think about as many different things as you want (3 seconds).

Alright, if you closed your eyes, you can slowly open them. That's all for today.

Channel Location Information

Using a 3D digitizer, the positions of 41 fNIRS channels were converted into MNI coordinates and anatomical locations for each channel.

Table S2. fNIRS 41-channel layout with BA regions.

Channel HbO Concentration Changes

A 2 (group: mindfulness, mind-wandering) \times 2 (experimental condition: rest, manipulation) repeated-measures ANOVA was conducted on HbO concentrations across 41 channels. No significant main effects of group were found across any of the 41 channels.

Table S3. ANOVA results for 41 fNIRS channels.

Table S4. Interaction effects between group and experimental manipulation for 41 fNIRS channels.

Cognitive-Neural Mechanisms of Mindfulness Alleviating “Being in the Game”

Table S5. Moderating effect of ΔHbO on the relationship between social distance and wise reasoning.

Table S6. Moderating effect of ΔHbO on the relationship between social distance and wise thinking.

Figure S1. Moderating effect of ΔHbO on the relationship between social distance and wise reasoning.

Figure S2. Moderating effect of ΔHbO on the relationship between social distance and wise thinking.

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv — Machine translation. Verify with original.