# ERP Evidence for Understanding Friendly and Hostile Intentions from Dyadic Body Movements

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## Abstract

Previous neuroimaging studies on intention understanding have primarily focused on the brain functional localization of understanding neutral or negative intentions of single individuals, while the dynamic temporal process by which the brain comprehends friendly and hostile intentions expressed through dyadic body movements remains unclear. This study recorded electroencephalographic (EEG) components while 20 healthy participants completed three different intention inference tasks. The three intentions were: 1) friendly intention; 2) hostile intention; 3) neutral non-interactive intention. Behavioral results revealed that response times for understanding hostile intentions were the shortest. Electrophysiological results demonstrated that at the frontal midline N250 (170~270 ms), neutral intentions were more negative than both friendly and hostile intentions, and friendly intentions were also more negative than hostile intentions; at the right hemisphere P300 (270~450 ms), hostile intentions were more positive than both friendly and neutral intentions, and friendly intentions were also more positive than neutral intentions. Source localization analysis of the N250 and P300 for friendly and hostile intentions localized them to the middle frontal gyrus (BA10) and insula (BA45), respectively. The results indicate that the brain categorically comprehends interactive intentions expressed through dyadic body movements across multiple stages, exhibiting earlier understanding of negative hostile intentions and sustained evaluative processing in later stages.

## Full Text

## Preamble

### ERP Evidence for Understanding Friendly and Hostile Intentions Expressed Through Dyadic Body Movements

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**Abstract**

Most neuroimaging studies on intention understanding have focused on localizing brain functions involved in comprehending neutral or negative intentions of single individuals, while the dynamic temporal processes through which the brain understands friendly and hostile intentions expressed via dyadic body movements remain unclear. This study recorded electroencephalographic (EEG) components from 20 healthy participants as they performed three different intention inference tasks: (1) friendly intention, (2) hostile intention, and (3) neutral non-interactive intention.

Behavioral results revealed shortest reaction times for understanding hostile intentions. Electrophysiological results showed that over frontal-midline regions, the N250 (170–270 ms) was significantly more negative for neutral intentions than for both friendly and hostile intentions, and more negative for friendly than for hostile intentions. Over the right hemisphere, the P300 (270–450 ms) was significantly more positive for hostile intentions than for both friendly and neutral intentions, and more positive for friendly than for neutral intentions. Source localization of the N250 and P300 for friendly and hostile intentions identified the middle frontal gyrus (BA10) and insula (BA45), respectively. These results demonstrate that the brain categorizes interactive intentions expressed through dyadic body movements across multiple stages, showing earlier understanding of negative hostile intentions and sustained evaluative processing in later stages.

**Keywords**: Theory of Mind; friendly intention; hostile intention; dyadic interaction; event-related potential

The ability to understand social interactive intentions is a crucial skill for successful interpersonal communication (Cacioppo, Berntson, & Decety, 2010; Wang, Huang, Zhang, Song, & Bai, 2014; Wang, Huang, Zhang, Zhang, & Cacioppo, 2015). This skill becomes particularly important when distinguishing whether others are friends or foes. Numerous empirical studies (Carter & Pelphrey, 2008; Van Wout & Sanfey, 2008; Vrticka, Andersson, & Sander, 2009) have demonstrated that nonverbal behaviors, including facial expressions and body language, provide essential information for attributing interactive intentions to others and help determine whether their behavioral intentions are friendly or hostile. According to philosophy of mind and cognitive pragmatics, interactive (communicative) intention refers to a situation where one individual (A)'s behavioral goal is directed at another person (B) in the present moment and is recognized and received by B (Walter et al., 2004). Dyadic body movements expressing interactive intentions represent not only a common and important social scenario in daily life but also a vital means for individuals to engage in social interaction, mutual learning, and relationship maintenance throughout their lifespan, particularly in early development. Investigating how the brain understands different types of interactive intentions expressed through body movements thus holds significant practical value.

Some scholars (Grafton, 2009; Ortigue, Sinigaglia, Rizzolatti, & Grafton, 2010) have proposed embodied simulation theory, suggesting that when an individual' s past motor experiences align with currently observed actions of others, this facilitates understanding of others' interactive intentions. The more familiar the observed individual is to the observer, the more easily interactive intentions can be understood (Cacioppo, Juan, & Monteleone, 2017). Cognitive neuroimaging research has indicated that the frontoparietal action observation network and the social brain network (including the medial prefrontal cortex [mPFC], temporoparietal junction [TPJ], and posterior superior temporal sulcus) play important roles in understanding interactive intentions expressed through dyadic body movements (Centelles, Assaiante, Nazarian, Anton, & Schmitz, 2011). While most neuroimaging studies (Ortigue et al., 2010; Young & Saxe, 2009) have made progress in examining the neural mechanisms underlying neutral intention understanding, an increasing number of studies have shifted toward investigating action intentions with emotional content.

Over the past five years, the vast majority of neuroimaging studies (Decety & Cacioppo, 2012; Sinke, Sorger, Goebel, & De Gelder, 2010) have focused on revealing the dynamic processing networks for negative (pain or harm) intentions, including brain regions such as the TPJ, dorsolateral mPFC, amygdala, and cingulate cortex that are responsible for action observation, pain processing, theory of mind, and moral judgment. Recent research has also made new progress in investigating the cognitive neural mechanisms of positive intentions. Yoder and Decety (2014) found that in two-person interactive social contexts, compared with harmful actions, mutually assisting actions significantly activated the right dorsolateral PFC and right TPJ—two regions generally considered responsible for self-other evaluation and moral decision-making. Gan, Shi, Liu, and Luo (2018) used transcranial direct current stimulation to confirm the core role of the right TPJ in processing helping intentions. While these neuroimaging studies have been beneficial for revealing the spatial characteristics of how the brain understands different types of interactive intentions, the low temporal resolution of functional magnetic resonance imaging (fMRI) has left the dynamic spatiotemporal processing features of different types of interactive intentions (e.g., friendly vs. hostile) within these neural networks unclear.

Correctly understanding different types of social interactive intentions is an essential skill for individual survival and development. Only by accurately and rapidly comprehending others' interactive intentions can we choose appropriate coping strategies and response patterns, making decisions about whether to cooperate with or confront others (Wang et al., 2014; Wang et al., 2015). Cognitive inference about others' different interactive intentions represents an important component of human social behavior for evaluating whether actions are good or bad, harmful or harmless, friendly or hostile (Blakemore & Decety, 2001; Malle & Holbrook, 2012). Developmental psychology research has found that even 2-year-old infants, and possibly younger, show greater preference for friendly individuals compared with hostile ones (Buon et al., 2014) and can understand whether two people are friends or enemies based on shared or opposing evaluations (Liberman, Kinzler, & Woodward, 2014). To our knowledge, few studies have employed the high temporal resolution of event-related potential (ERP) technology to investigate the neural dynamic processing time course of different types of interactive intentions in social contexts.

Wang et al. (2012) used cartoon comics as experimental materials and found that the N250 component evoked by understanding private intentions was significantly more negative than that for communicative intentions, while communicative intentions evoked a late positive component (LPC) during the 400–600 ms time window that was significantly more positive than private intentions. Based on these findings, they proposed a two-stage processing model in which understanding private intentions (equivalent to biological motion without interaction) precedes understanding communicative (interactive) intentions. Wang, Zheng, Lin, Wu, and Shen (2011) and Wang, Huang, et al. (2012) further found that understanding single-person minds forms the basis for understanding interactive minds, representing different levels of processing within theory of mind, leading to the proposal of a multi-level model of theory of mind. However, these studies did not provide detailed distinctions between different types of interactive (communicative) intentions, leaving the theoretical models in need of further enrichment and support from additional consistent evidence.

Decety and Cacioppo (2012) required participants to watch two brief action scenes with moral implications: intentional harm and unintentional harm. Their results revealed that the right posterior superior temporal sulcus (60 ms), amygdala/temporal pole (122 ms), and ventromedial PFC (182 ms) were sequentially activated when viewing scenes of intentional harm, revealing the rapid information processing spatiotemporal characteristics in the early stages of moral cognition. Proverbio et al. (2011) used high ecological validity picture materials and found that the N2 (160–280 ms) amplitude evoked by cooperative interactive scenes was more negative than that evoked by affective interactive scenes. Wang et al. (2014) and Wang et al. (2015), building on previous research, used ERP technology and higher ecological validity real-person photos as stimuli. They found that in the early stage after stimulus presentation (170–270 ms), the N2 component evoked by friendly intentions was significantly more negative than that for hostile intentions, while in the later stage (270–500 ms), the P3 component evoked by hostile intentions was significantly more positive than that for friendly intentions. Further, during 700–800 ms, they found significant differences in LPC amplitude between interactive intentions (friendly and hostile) and non-interactive intentions. The LPC typically refers to a positive ERP component appearing approximately 300 ms after stimulus presentation and may reflect the brain’ s processing of different hierarchical levels of theory of mind (Wang et al., 2012). Liu, Sabbagh, Gehring, and Wellman (2004) found that in the left prefrontal region, the LPC component for understanding others’ mental states (approximately 800 ms after stimulus presentation) differed significantly from understanding the physical world. Wang, Zheng, Shen, Cui, and Yan (2012) used four-character idioms to examine differences between reading single-person and interactive minds, finding that during 700–800 ms, the LPC in frontal-midline regions was only associated with reading interactive minds.

Although these studies have further enriched research in the social intention domain and directly investigated the spatiotemporal dynamic processing mechanisms of how the brain understands friendly and hostile intentions (for detailed definitions, see Huang, Deng, Ren, Lin, & Wang, 2018), previous research mostly used head-masked or black-and-white photos, leaving room for improvement in ecological validity. Additionally, the neutral non-interactive intention condition in Wang et al. (2014) may have led to two issues: (1) participants could distinguish non-interactive from interactive intentions based simply on physical visual cues (characters standing back-to-back), without involving mental intention processing; and (2) in daily life, two people initially facing each other and then standing back-to-back is easily perceived as a negative social scene (e.g., the two individuals dislike each other or have conflicts). Their behavioral results showing main effects of intention condition on both accuracy and reaction time further suggest significant differences in task difficulty across the three conditions, making it impossible to completely rule out the influence of task difficulty on ERP components. Moreover, Wang et al. (2014) suggested that the early-stage N2 component was only associated with friendly intention understanding, while behavioral results showed significantly longer reaction times for understanding friendly intentions compared to other conditions—findings that do not appear fully mutually supportive. Although they provided appropriate explanations attributing the discrepancy to different psychological processing stages reflected by the two measures, these issues warrant further clarification.

To investigate the dynamic spatiotemporal processing time course of understanding friendly, hostile, and neutral non-interactive intentions, this study recorded EEG changes while participants viewed color photographs of two actors’ body movements expressing three types of intentions and performed intention inference tasks, followed by brain source localization analysis to examine spatial characteristics. Each trial included two photographs: an action preparation photo and an action execution photo. Notably, the neutral non-interactive intention in this study was strictly operationalized following Walter et al. (2004), Wang et al. (2012), and Wang, Huang, et al. (2012), encompassing two individuals’ unrelated private intentions. Based on previous research (Proverbio et al., 2011; Wang et al., 2015; Wang, Huang, et al., 2012; Wang et al., 2014), we hypothesized that in the early processing stage following action execution photo presentation, the N250 component evoked by neutral intentions would be significantly more negative than that for friendly intentions, which in turn would be more negative than that for hostile intentions, showing initial separation among the three intention conditions. In later processing stages, the P300 component evoked when understanding hostile intentions would be significantly more positive than that for friendly and neutral intentions, and the LPC component for both hostile and friendly interactive intentions would be significantly more positive than that for neutral intentions, demonstrating distinct dynamic spatiotemporal characteristics in how the brain understands different types of social interactive intentions.

## Method

### Participants

Twenty university students (10 female, 10 male; age range 19–25 years, mean age 22.5 years) participated in the study. All were right-handed, had normal or corrected-to-normal vision, and no history of psychiatric disorders. Participants provided informed consent prior to the experiment and received monetary compensation afterward.

### Materials

The experimental paradigm followed Wang et al. (2014) and Wang et al. (2015), employing a two-photograph sequence (action preparation and execution photos) to create the impression of motion. Participants were required to understand the relationship between the two photographs and respond as quickly as possible when the second action execution photo was presented (Decety & Cacioppo, 2012; Ortigue et al., 2010). To ensure ecological validity, experimental materials were photographed using a digital camera with actors comprising two male graduate students (both age 27, heights 178 cm and 176 cm) and two female graduate students (both age 24, heights 165 cm and 158 cm). Same-gender actors appeared in each scene, with the left character always serving as the action initiator. Three experimental conditions were created: friendly intention, hostile intention, and neutral non-interactive intention. The friendly condition depicted cooperative scenes (e.g., one person handing a water bottle to another who reaches to accept it; see Figure 1a [Figure 1: see original paper]). The hostile condition depicted conflict scenes (e.g., one person throwing a water bottle at another who raises a hand to block; see Figure 1b). The neutral control condition depicted two individuals engaged in unrelated, independent activities (e.g., one person holding a water bottle to their own mouth while the other looks at their phone; see Figure 1c).

Seventy photo sets were photographed for each condition, with each set comprising two photos, resulting in 140 photos per condition. Since the first action preparation photo was identical across corresponding sets in the three conditions (differing only in the second action execution photo), there were 280 photos total (see Figure 1 for examples). To prevent interference from facial expressions and eye gaze cues, all photos were mosaic-processed in Photoshop. Photo size (4 cm

$\times$ 3 cm), resolution (472 $\times$ 354 pixels), color (full color), brightness, contrast, and saturation were standardized across all stimuli.

Ten university students (equal gender distribution, ages 19–26 years) were randomly selected to rate the photo sets. They judged the activity scenes in each photo set (including both preparation and execution photos) by pressing "J" if they perceived the left character as friendly toward the right character, "K" if they perceived no intention (no interaction), and "L" if they perceived hostility. After each judgment, they rated the difficulty of their decision on a 5-point scale (1 = very easy, 2 = somewhat easy, 3 = neutral, 4 = somewhat difficult, 5 = very difficult). Photos with reaction times exceeding 2000 ms or accuracy below 60% were excluded, leaving 40 qualified photo sets per condition. Ten sets were used for practice, and the remaining 30 sets (15 with male actors, 15 with female actors) served as formal experimental materials. A one-way ANOVA on difficulty ratings revealed no significant difference across conditions, $F(2, 117) = 2.03$, $p = 0.136$, indicating comparable task difficulty.

Another ten university students (equal gender distribution, ages 18–22 years) rated the friendliness or conflict level of each photo set on a 5-point scale (1 = very friendly, 2 = somewhat friendly, 3 = uncertain, 4 = somewhat conflictual, 5 = very conflictual). A one-way ANOVA revealed highly significant differences across conditions, $F(2, 117) = 1111.00$, $p < 0.001$. Post-hoc analyses showed that friendly condition scores ($1.48 \pm 0.24$) were significantly lower than neutral ($3.00 \pm 0.16$) and hostile ($4.21 \pm 0.35$) conditions (both $ps < 0.001$), and neutral scores were significantly lower than hostile scores ($p < 0.001$). These results confirmed good discriminability among the three conditions. None of the participants in these rating sessions took part in the formal experiment.

It should be noted that in daily social interaction, people not only obtain motion intention information by observing others' body language but also frequently combine facial expressions with body language to judge intentions. Many studies (Van Wout & Sanfey, 2008; Carter & Pelphrey, 2008; Vrticka, Andersson, & Sander, 2009; Güroğlu et al., 2008) have found that individuals' facial expressions of different valences influence intention judgments and subsequent decision-making. In this study, mosaic-processing of actors' faces reduced the influence of facial expression and eye gaze cues on body language comprehension, avoiding contamination of results by other factors. Additionally, using color photographs and including female actors improved upon previous studies (Wang, Huang, et al., 2012; Wang et al., 2014) in terms of ecological validity and control of irrelevant variables. Furthermore, all photos were well-matched in physical properties, with characters, objects, and body orientations being nearly identical across conditions, ruling out the possibility that ERP differences were due to variations in physical attributes or task difficulty.

### Experimental Design

A within-subject single-factor three-level (intention level: friendly, hostile, neutral) cognitive experimental design was employed. Behavioral measures included accuracy and reaction time; electrophysiological measures are detailed in section 2.6. The experimental procedure is illustrated in Figure 1 [Figure 1: see original paper].

### Procedure

The trial procedure is shown in Figure 1. In each trial, participants first saw a fixation cross "+" for 500 ms, followed by an action preparation photo for 1000 ms. After a random interval of 400–600 ms, the action execution photo was presented for 1500 ms. Following another random interval of 400–600 ms, the next trial began. The experiment consisted of 270 trials total, with 90 trials per intention condition presented in a pseudo-random order. The experiment was divided into two blocks with a rest period between them. Participants were instructed to understand the relationship between the two photos and respond as quickly and accurately as possible when the action execution photo appeared. Responses were made using the right hand to avoid left-right confusion: press "1" if the left person was friendly to the right person, "2" if the left person had no intention (no interaction), and "3" if the left person was hostile. Responses were required within 1500 ms; responses exceeding this limit were considered non-responses. Response mappings were counterbalanced across participants. Before the formal experiment, participants completed a brief practice session with different materials to familiarize themselves with the procedure.

### EEG Recording

EEG signals were recorded using a NeuroScan system with a 64-channel electrode cap based on the international 10–20 system. All electrodes were referenced to a reference electrode placed on the left mastoid during recording. Offline analysis was performed by re-referencing to the average of bilateral mastoids (subtracting half of the signal recorded from the right mastoid from each channel). Horizontal electrooculogram (HEOG) was recorded from electrodes placed lateral to both eyes, and vertical electrooculogram (VEOG) was recorded from electrodes above and below the left eye. The bandpass filter was set at 0.05–100 Hz with AC sampling at 1000 Hz per channel. Impedance for all electrodes was maintained below 5 kΩ. Offline analysis included ocular artifact correction and automatic rejection of artifacts with amplitudes exceeding ±75 V.

### ERP Data Processing and Statistical Analysis

In this study, only EEG data time-locked to the action execution photo presentation were analyzed and averaged. Based on behavioral responses during photo presentation, EEG data from correct trials were averaged. The analysis epoch was 800 ms following action execution photo presentation, with the 200 ms preceding stimulus onset serving as baseline. This study primarily compared differences in ERP component amplitudes evoked by the three types of action execution photos. Data were entered and analyzed using SPSS 16.0. Based on previous research (Wang, Ling, Yuan, Huang, & Shen, 2010; Wang et al., 2012; Wang et al., 2014) and the present study' s objectives, nine electrode sites were selected for further analysis: F3/FZ/F4, C3/CZ/C4, and P3/PZ/P4. Figure 2 [Figure 2: see original paper] shows the grand-averaged ERP waveforms across the three conditions. Clear N250, P300, and LPC components were evoked under all three conditions (friendly, hostile, neutral). N250 and P300 were measured as peak amplitudes within time windows of 170–270 ms and 270–450 ms, respectively. Additionally, mean LPC amplitudes were measured in 100 ms intervals from 450–750 ms. A three-way repeated-measures ANOVA was conducted on ERP component amplitudes measured at the nine electrode sites, with factors of intention level (friendly, hostile, neutral), electrode laterality (left hemisphere, midline, right hemisphere), and electrode caudality (frontal, central, parietal regions). All main effects and interaction p-values were corrected using the Greenhouse-Geisser method, and post-hoc pairwise comparisons were Bonferroni-corrected. In the formal experiment, each photo set was repeated three times per condition, resulting in 90 trials per condition. After artifact rejection, the average numbers of valid trials for ERP averaging were 70, 71, and 72 for friendly, hostile, and neutral conditions, respectively. The sLORETA software was used for source localization of the N250 and P300 components for friendly and hostile intentions to examine the spatial characteristics of brain activity underlying the understanding of these interactive intentions.

## Results

### Behavioral Results

Mean accuracy rates for the three conditions are shown in Table 1 . A one-way repeated-measures ANOVA revealed no significant difference in accuracy across conditions, $F(2, 38) = 3.40$, $p > 0.05$, indicating comparable task difficulty across the three intention conditions, consistent with the difficulty ratings obtained during material screening.

Mean reaction times for the three conditions are also shown in Table 1. A one-way repeated-measures ANOVA revealed a significant main effect of condition, $F(2, 38) = 42.74$, $p < 0.001$, $MSE = 1741.66$, $p^2 = 0.69$. Post-hoc analyses showed that reaction times for both friendly and neutral conditions were significantly longer than for the hostile condition (both $ps < 0.001$), while the difference between friendly and neutral conditions was not significant, $p > 0.05$.

**Table 1** Accuracy and Reaction Times for the Three Intention Action Classification Tasks (M ± SD)

| Condition | Accuracy (%) | Reaction Time (ms) |
|---|---|---|
| Friendly | $93.22 \pm 3.07$ | $829 \pm 111$ |
| Hostile | $95.19 \pm 1.51$ | $716 \pm 93$ |
| Neutral | $94.71 \pm 3.01$ | $799 \pm 82$ |

### ERP Results

**N250 (170-270 ms)** A three-way repeated-measures ANOVA on N250 peak amplitudes (see Table 2 ) revealed a highly significant main effect of intention level, $F(2, 38) = 15.97$, $p < 0.001$, MSE = 6.59, $p^2 = 0.46$. Post-hoc comparisons showed that the neutral condition amplitude ($-2.72 \pm 0.79$ V) was more negative than both friendly ($-1.69 \pm 0.68$ V) and hostile ($-1.24 \pm 0.82$ V) conditions (both ps $< 0.05$), while the difference between friendly and hostile conditions was not significant, $p > 0.05$ (see left panel of Figure 3a [Figure 3: see original paper]).

The analysis also revealed a significant interaction between intention level and electrode caudality, $F(4, 76) = 4.07$, $p < 0.05$, MSE = 3.16, $p^2 = 0.18$. Simple effects analysis showed significant condition differences across all brain regions (ps $< 0.05$). Further post-hoc analysis revealed that in frontal regions, the neutral condition amplitude was more negative than both friendly and hostile conditions (ps $< 0.05$), and the friendly condition amplitude was also more negative than the hostile condition ($p < 0.05$). In central regions, the neutral condition amplitude was more negative than both friendly ($p < 0.05$) and hostile ($p < 0.001$) conditions, with no significant difference between friendly and hostile conditions ($p > 0.05$). In parietal regions, only the neutral condition amplitude was more negative than the friendly condition ($p < 0.01$), with no other significant differences.

A significant interaction between intention level and electrode laterality was also found, $F(4, 76) = 3.37$, $p < 0.05$, MSE = 0.91, $p^2 = 0.15$. Simple effects analysis revealed significant condition differences across the entire brain (ps $< 0.001$). Post-hoc analysis showed that across all brain regions, the neutral condition amplitude was more negative than both friendly and hostile conditions (ps $<$ 0.05), while friendly and hostile conditions did not differ significantly (ps $>$ 0.05).

Critically, a significant three-way interaction among intention level, electrode caudality, and laterality was observed, $F(8, 152) = 8.61$, $p < 0.001$, MSE = 1.01, $p^2 = 0.31$, indicating that the three intention conditions differed significantly at certain electrode locations. Simple effects analysis revealed significant condition differences at electrodes F3, FZ, F4, C3, CZ, C4, P3, and PZ, but not at P4. Further simple-simple effects analysis showed that in left frontal (F3) and left central (C3) regions, only the neutral condition amplitude was more negative than the hostile condition (ps $< 0.05$), with no other significant differences. At the frontal-midline (FZ), the neutral condition amplitude was more negative than both friendly and hostile conditions ($ps < 0.05$), and the friendly condition amplitude was also more negative than the hostile condition ($p = 0.042$). At F4, CZ, C4, P3, and PZ, the neutral condition amplitude was more negative than both friendly and hostile conditions ($ps < 0.05$), with no significant differences between friendly and hostile conditions ($ps > 0.05$).

In summary, in frontal regions (particularly at FZ), pairwise separation among the three intention conditions was observed: the N250 amplitude for neutral intentions was more negative than for both friendly and hostile intentions, and the N250 amplitude for friendly intentions was significantly more negative than for hostile intentions.

**P300 (270–450 ms)** A three-way repeated-measures ANOVA on P300 peak amplitudes (see Table 2) revealed a highly significant main effect of intention level, $F(2, 38) = 19.85$, $p < 0.001$, $MSE = 27.84$, $p^2 = 0.51$. Post-hoc analysis showed that the hostile condition amplitude (10.73 ± 0.06 V) was more positive than both friendly (8.62 ± 0.74 V) and neutral (7.86 ± 0.77 V) conditions (both $ps < 0.01$), while the difference between friendly and neutral conditions approached marginal significance, $p = 0.069$ (see right panel of Figure 3a).

A significant interaction between intention level and electrode caudality was found, $F(4, 76) = 12.18$, $p < 0.001$, $MSE = 6.51$, $p^2 = 0.39$. Simple effects analysis revealed significant condition differences across all brain regions, $F(2, 38) = 6.90/14.90/27.84$, $ps < 0.01$. Post-hoc analysis showed that in frontal regions, both friendly and hostile condition amplitudes were more positive than the neutral condition ($ps < 0.05$), with no significant difference between friendly and hostile conditions ($p > 0.05$). In central and parietal regions, the hostile condition amplitude was more positive than both friendly and neutral conditions ($ps < 0.01$), with no significant differences between friendly and neutral conditions ($ps > 0.05$).

A significant interaction between intention level and electrode laterality was also observed, $F(4, 76) = 15.23$, $p < 0.001$, $MSE = 2.64$, $p^2 = 0.45$. Simple effects analysis revealed significant condition differences across the entire brain ($ps < 0.01$). Post-hoc analysis showed that in the left hemisphere, only the hostile condition amplitude was more positive than the neutral condition ($p < 0.05$), with no other significant differences. At the midline, the hostile condition amplitude was more positive than both friendly and neutral conditions ($ps < 0.01$), with no significant difference between friendly and neutral conditions ($p = 0.531$). In the right hemisphere, the hostile condition amplitude was more positive than both friendly and neutral conditions ($ps < 0.001$), and the friendly condition amplitude was also more positive than the neutral condition ($p < 0.01$). This pattern indicates a stepwise increase in activation from neutral to friendly to hostile intentions in the right hemisphere.

Critically, a significant three-way interaction among intention level, electrode caudality, and laterality was found, $F(8, 152) = 6.87$, $p < 0.001$, $MSE = 1.26$,

$p^2 = 0.27$. Simple effects analysis revealed significant condition differences at electrodes FZ, F4, CZ, C4, P3, PZ, and P4, but not at F3 and C3. Simple-simple effects analysis showed no significant condition differences at the frontal-midline (FZ), $p > 0.05$. At central-midline (CZ), left parietal (P3), central parietal (PZ), and right parietal (P4) regions, the hostile condition amplitude was more positive than both friendly and neutral conditions ($ps < 0.01$), with no significant differences between friendly and neutral conditions ($ps > 0.05$). At right frontal (F4) and right central (C4) regions, the hostile condition amplitude was more positive than both friendly and neutral conditions ($ps < 0.05$), and the friendly condition amplitude was also more positive than the neutral condition ($ps < 0.05$). This pattern is consistent with the right hemisphere advantage effect mentioned above.

In summary, in the right hemisphere (particularly at F4 and C4), pairwise separation among the three intention conditions was observed: the P300 amplitude for hostile intentions was significantly more positive than for both friendly and neutral intentions, and the P300 amplitude for friendly intentions was significantly more positive than for neutral intentions.

**Table 2** ANOVA Results for N250 and P300 Amplitudes

| Component | F(2, 38) | Condition × Caudality | Condition × Laterality | Condition × Caudality × Laterality |
|---|---|---|---|---|
| N250 (170–270 ms) | 15.97*** | 4.07* | 3.37* | 8.61*** |
| P300 (270–450 ms) | 19.85*** | 12.18*** | 15.23*** | 6.87*** |

Note: Post-hoc comparisons: 1 = friendly, 2 = hostile, 3 = neutral (***$p < 0.001$,*** *$p < 0.01$,* $p < 0.05$)

**LPC (450–750 ms)** A three-way repeated-measures ANOVA was conducted on mean amplitudes in 100 ms intervals from 450–750 ms (see Table 3 ). In the 450–550 ms window, a significant main effect of intention level was found, $F(2, 38) = 12.39$, $p < 0.001$, $MSE = 20.32$, $p^2 = 0.40$. Post-hoc analysis revealed that both friendly (6.14 ± 0.76  V) and hostile (6.94 ± 0.95  V) condition amplitudes were more positive than the neutral condition (4.65 ± 0.78  V, $p < 0.01$), with no significant difference between friendly and hostile conditions ($p > 0.05$).

A significant interaction between intention level and electrode caudality was observed, $F(4, 76) = 14.36$, $p < 0.001$, $MSE = 4.74$, $p^2 = 0.43$. Simple effects analysis revealed significant condition differences across all brain regions (ps

$< 0.001$). Post-hoc analysis showed that in frontal and central regions, both friendly and hostile condition amplitudes were more positive than the neutral condition ($ps < 0.05$), with no significant differences between friendly and hostile conditions ($ps > 0.05$). In parietal regions, the hostile condition amplitude was more positive than both friendly and neutral conditions ($ps < 0.01$), with no significant difference between friendly and neutral conditions ($p > 0.05$).

A significant interaction between intention level and electrode laterality was also found, $F(4, 76) = 6.16$, $p < 0.01$, $MSE = 2.97$, $p^2 = 0.25$. Simple effects analysis revealed significant condition differences at the midline and right hemisphere ($ps < 0.001$). Post-hoc analysis showed that at the midline, only the hostile condition amplitude was more positive than the neutral condition ($p < 0.01$). In the right hemisphere, the hostile condition amplitude was more positive than both friendly and neutral conditions ($ps < 0.05$), and the friendly condition amplitude was also more positive than the neutral condition ($p < 0.001$).

A significant three-way interaction among intention level, electrode caudality, and laterality was observed, $F(8, 152) = 4.27$, $p < 0.01$, $MSE = 1.25$, $p^2 = 0.184$. Simple effects analysis revealed significant condition differences at electrodes F3, FZ, F4, CZ, C4, P3, PZ, and P4, but not at C3. Simple-simple effects analysis showed that in left frontal (F3) and frontal-midline (FZ) regions, only the friendly condition amplitude was more positive than the neutral condition ($ps < 0.01$). At central-midline (CZ), only the hostile condition amplitude was more positive than the neutral condition ($p < 0.01$). At right frontal (F4) and left parietal (P3) regions, both friendly and hostile condition amplitudes were more positive than the neutral condition ($ps < 0.001$), with no significant differences between friendly and hostile conditions ($ps > 0.05$). At right central (C4), both friendly and hostile condition amplitudes were more positive than the neutral condition ($p < 0.01$), and the hostile condition amplitude was also more positive than the friendly condition ($p < 0.01$). At central parietal (PZ) and right parietal (P4) regions, the hostile condition amplitude was more positive than both friendly and neutral conditions ($ps < 0.01$), with no significant differences between friendly and neutral conditions ($ps > 0.05$).

In the 550–650 ms window, a significant main effect of intention level was found, $F(2, 38) = 3.69$, $p < 0.05$, $MSE = 33.57$, $p^2 = 0.16$. Post-hoc analysis revealed that only the friendly condition amplitude ($6.78 \pm 0.75$ V) was more positive than the neutral condition ($5.29 \pm 0.82$ V, $p < 0.05$), with no significant differences between friendly and hostile ($6.54 \pm 0.90$ V) or between hostile and neutral conditions (both $ps > 0.05$).

A significant interaction between intention level and electrode caudality was observed, $F(4, 76) = 9.10$, $p < 0.001$, $MSE = 5.78$, $p^2 = 0.32$. Simple effects analysis revealed significant differences in frontal and central regions ($ps < 0.01$). Post-hoc analysis showed that in frontal regions, only the friendly condition amplitude was more positive than the neutral condition ($p < 0.01$). In central regions, both friendly and hostile condition amplitudes were more positive than the neutral condition ($ps < 0.05$), with no significant difference between friendly and hostile conditions ($p = 1.000$).

A significant interaction between intention level and electrode laterality was also found, $F(4, 76) = 4.34$, $p < 0.01$, MSE = 2.95, $p^2 = 0.19$. Simple effects analysis revealed significant differences only in the right hemisphere ($p < 0.001$). Post-hoc analysis showed that in the right hemisphere, both friendly and hostile condition amplitudes were more positive than the neutral condition ($ps < 0.05$), with no significant difference between friendly and hostile conditions ($p > 0.05$).

A significant three-way interaction among intention level, electrode caudality, and laterality was observed, $F(8, 152) = 2.42$, $p < 0.05$, MSE = 1.41, $p^2 = 0.11$. Simple effects analysis revealed significant condition differences at electrodes F3, FZ, F4, and C4. Simple-simple effects analysis showed that in left frontal (F3) region, only the friendly condition amplitude was more positive than the neutral condition ($p < 0.05$). In right frontal (F4) and right central (C4) regions, both friendly and hostile condition amplitudes were more positive than the neutral condition ($ps < 0.01$), with no significant differences between friendly and hostile conditions ($ps > 0.05$). No significant differences were found at frontal-midline (FZ).

In the 650–750 ms window, no significant main effect of intention level was found (see Table 3), $F(2, 38) = 0.57$, $p > 0.05$, MSE = 31.66, $p^2 = 0.03$. Although significant interactions between intention level and electrode caudality and between intention level and electrode laterality were observed, $F(4, 76) = 6.71/5.66$, $ps < 0.01$, MSE = 5.07/3.30, $p^2 = 0.26/0.23$, no statistically significant differences were found in further analyses.

In summary, during the 450–750 ms time window, the LPC component in the right hemisphere (particularly at C4) showed a developmental pattern: from pairwise differences among the three conditions, to separation between interactive and neutral intentions, to complete disappearance of differences among conditions.

**Table 3** ANOVA Results for LPC Amplitudes (450–750 ms)

| Time Window | F(2, 38) | Condition × Caudality | Condition × Laterality | Condition × Caudality × Laterality |
|---|---|---|---|---|
| 450–550 ms | 12.39*** | 14.36*** | 6.16** | 4.27** |
| 550–650 ms | 3.69* | 9.10*** | 4.34** | 2.42* |
| 650–750 ms | 0.57 | 6.71** | 5.66** | 1.12 |

Note: Post-hoc comparisons: 1 = friendly, 2 = hostile, 3 = neutral (***$p < 0.001$,*** *$p < 0.01$,* $p < 0.05$)

### Topographical Analysis

Notably, the significant differences in N250 amplitudes among the three conditions from 170–270 ms were reflected in the topographical maps, as shown in Figure 3b (left). These maps, based on peak amplitudes within the 270–500 ms time window, displayed patterns consistent with the significant interactions between condition and electrode laterality or caudality found in statistical analyses. Across the whole brain, neutral intentions showed less activation than both friendly and hostile intentions, while friendly and hostile intentions did not differ significantly. The significant differences in P300 amplitudes among the three conditions from 270–450 ms were similarly reflected in the topographical maps, as shown in Figure 3b (right). These maps, based on peak amplitudes within the 270–500 ms time window, revealed that in parietal regions, hostile intentions activated significantly more than friendly and neutral intentions, while friendly and neutral intentions did not differ significantly. In the right hemisphere, a stepwise increase in activation was observed from neutral to friendly to hostile intentions.

**Figure 3** N250 amplitudes (left panel a) and topographical maps (left panel b), and P300 amplitudes (right panel a) and topographical maps (right panel b) for the three conditions

### sLORETA Results

First, sLORETA software was used to perform source localization on the N250 raw waves for neutral versus friendly conditions and neutral versus hostile conditions separately. The maximum suppressed brain regions were found in Brodmann Area 6 (BA6, see Figure 4a [Figure 4: see original paper]) and Brodmann Area 2 (BA2, see Figure 4b), respectively, with no significant differences in activity between conditions. Next, source localization was performed comparing friendly and hostile conditions directly. Activated brain regions for both conditions were primarily located in Brodmann Area 10 (BA10), specifically the middle frontal gyrus (Figure 4c), with no significant differences in activation between conditions. Source localization of the P300 raw waves revealed that for both friendly and hostile conditions, activation was primarily located in BA45, the insula (Figure 4d). Comparisons between conditions revealed significantly stronger negative current differences for hostile versus friendly intentions in 39 voxels located in frontal, sublobar, and limbic lobes (maximum t-value = 0.96, $p < 0.01$). Specifically, 64% of these voxels were in frontal regions (middle frontal gyrus, inferior frontal gyrus, medial frontal gyrus), 18% in sublobar regions (insula), and 18% in anterior cingulate cortex.

**Figure 4** Source localization results showing maximum suppressed brain regions for N250 in neutral vs. friendly (BA6, panel a) and neutral vs. hostile (BA2, panel b) conditions; maximum activated brain regions for N250 and P300 in friendly vs. hostile conditions located in BA10 (panel c) and BA45 (panel d), respectively

## Discussion

### N250 Reflects Initial Categorization of Action Goals' Social Attributes in Interactive Intentions

This study used ERP technology to investigate the dynamic spatiotemporal characteristics of brain activity underlying the understanding of friendly and hostile interactive intentions based on body movements in dyadic contexts. Accuracy analysis showed no significant differences across the three intention conditions, while reaction time analysis revealed that friendly and neutral intentions had significantly longer reaction times than hostile intentions, with no significant difference between friendly and neutral conditions. These results differ partially from Wang et al. (2014), who found that friendly intentions had significantly lower accuracy than non-interactive intentions and significantly longer reaction times than both hostile and non-interactive intentions, with no significant difference between hostile and non-interactive intentions. The discrepancy likely stems from differences in operationalizing the neutral non-interactive intention. The current study strictly followed the operational definitions of Walter et al. (2004), Wang et al. (2012), and Wang, Huang, et al. (2012), constructing neutral non-interactive intentions as two individuals' unrelated private intentions. This approach overcame the limitation in Wang et al. (2014) where participants could understand the neutral condition based solely on physical visual cues (characters standing back-to-back) without engaging mental intention processing. It also eliminated the possibility that ERP components were influenced by task difficulty, as two people standing back-to-back in daily life is easily perceived as a negative social scene (e.g., mutual dislike or conflict).

ERP results showed that the N250 amplitude for friendly intentions over frontal regions was significantly more negative than for hostile intentions, and the N250 amplitude for neutral intentions was significantly more negative than for friendly intentions. In other words, N250 amplitudes showed a progressively more negative trend from hostile to friendly to neutral intentions. Wang, Huang, et al. (2012) found that private (neutral non-interactive) intentions evoked significantly more negative N250 amplitudes than communicative (interactive) intentions. Wang et al. (2014) further distinguished interactive intentions by the social attributes of action goals into friendly and hostile intentions, finding that friendly intentions evoked significantly more negative N2 amplitudes than hostile intentions. Combined with these findings, the current results suggest a stepwise more negative trend from hostile to friendly to neutral intentions, consistent with previous research. Proverbio et al. (2011) found that cooperative interactive actions in high ecological contexts evoked more negative N2 (160–280 ms) amplitudes than affective interactive actions. Decety and Cacioppo (2012) used high-density EEG to show that perception of intentional harm activated ventromedial PFC around 182 ms, reflecting rapid information processing in early moral cognition stages. In the current study, both hostile and friendly intentions evoked frontal N250 components with differential patterns, suggesting that N250 reflects categorical understanding of different social attributes of action goals within interactive intentions. Regarding the discrepancy with Wang et al. (2014), who found that friendly intentions evoked significantly larger N2 amplitudes than hostile intentions (with neutral intentions showing marginal differences), while hostile and neutral intentions did not differ, the current study' s neutral condition construction likely explains the difference. Wang et al.' s neutral condition may have allowed participants to understand intentions based on simple physical visual cues without mental intention processing, and the back-to-back posture may have been perceived as a negative social scene, resulting in similar cognitive-neural resource demands for understanding neutral and hostile intentions. Based on this reasoning, we propose that the N250 component may reflect categorical processing of action goals' different social attributes within interactive intentions, enabling early discrimination among hostile, friendly, and neutral intentions. Reaction time results also showed earliest understanding of hostile intentions, contrary to Wang et al.' s (2014) proposal that N2 was only associated with friendly intention understanding. Additionally, research has shown that body stimuli with more action content evoke larger N170 amplitudes than those with less action content (Borhani, Borgomaneri, Làdavas, & Bertini, 2016). In this study, neutral intentions contained two unrelated body movements with more action content than friendly and hostile intentions, and friendly intentions may have involved greater action content or ambiguity than hostile intentions. Therefore, N250 differences across conditions may also reflect action content complexity or interactive scenario ambiguity. Temporal discrepancies with previous research may be due to differences in experimental materials and tasks.

Cognitive neuroscience research has shown that inferring others' intentions relies on the frontoparietal action observation network and a hypothesized social brain network (Centelles et al., 2011). Most researchers believe these two brain networks play different but complementary roles in action understanding (Isoda, 2016), while others argue they play completely independent roles (Catmur, 2015). The former processes incidental social actions generally, while the latter processes intention understanding resulting from abnormal movement characteristics (Georgescu et al., 2014). The current study found cortical current density differences between friendly and hostile intentions in frontal brain regions. Specifically, significant differences in N250 amplitude and cortical current density between friendly and hostile intentions were found at the frontal-midline (FZ). Source localization of the N250 component for friendly and hostile intentions identified maximum activation in BA10, the middle frontal gyrus, though activation levels did not differ significantly between conditions. Recent neuroimaging studies (Maranesi, Livi, Fogassi, Rizzolatti, & Bonini, 2014; Yoder & Decety, 2014) have found that dorsolateral PFC is significantly activated during early top-down predictive processing when understanding single-person grasping actions or dyadic interactive actions. Amoruso, Finisguerra, and Urgesi (2018) propose that dorsolateral PFC may play a general role in anticipating others' context-based actions. Another fMRI study found that the inferior frontal gyrus was significantly activated when understanding interactive intentions conveyed by hand actions (Möttönen, Farmer, & Watkins, 2016). As a brain region adjacent to dorsolateral mPFC and inferior frontal gyrus, the middle frontal gyrus' s involvement in the current study further demonstrates the important role of prefrontal cortex in understanding friendly and hostile intentions expressed through body movements.

### P300 Reflects Evaluative Processing of Interactive Intentions' Different Socio-Emotional Meanings

During 270–450 ms, ERP results showed that in the right hemisphere, the P300 amplitude for hostile intentions was more positive than for friendly and neutral intentions, and the P300 amplitude for friendly intentions was also more positive than for neutral intentions. These results are consistent with previous research showing that threatening faces or cue words evoke more positive P300/LPC amplitudes (Moser, Huppert, Duval, & Simons, 2008; Weymar, Bradley, Hamm, & Lang, 2013). Hostile intentions in this study contained threatening information and evoked stronger P300 amplitudes. Wang et al. (2014) also found that hostile intentions evoked more positive P3 peaks than friendly and neutral intentions in parietal, midline, and right hemisphere regions. These findings suggest that the P300 component may reflect stronger attentional and evaluative processing of negative information.

However, Wu et al. (2014) found that negative stimuli evoked significantly larger N2 (150–300 ms) amplitudes than neutral stimuli during the late menstrual phase (luteal phase) compared to the early phase (follicular phase) in women. This discrepancy may be due to differences in stimulus materials and experimental tasks. Wieser, McTeague, and Keil (2011) propose that high emotional valence stimuli, such as social threat cues, receive prioritized and sustained processing in the brain. In this study, hostile intentions showed significantly shorter behavioral reaction times and evoked larger P300 amplitudes than friendly intentions, indicating that individuals invested more cognitive-neural resources in understanding hostile intentions with negative socio-emotional meaning, likely involving complex psychological processes including attention, perception, and cognitive evaluation. Maintaining high vigilance and deep processing of threatening information is evolutionarily advantageous for human survival.

Many fMRI studies (Sinke et al., 2010; Decety et al., 2012) have found that participants' frontoparietal action observation networks and brain regions responsible for processing moral violations (TPJ, paracingulate cortex, medial orbitofrontal cortex, amygdala) were significantly activated when viewing threatening movie clips or pictures, with enhanced functional connectivity between these regions and the action observation network. Watanabe et al. (2012) found that anterior cingulate cortex/ventromedial PFC and dorsomedial PFC were strongly activated in healthy participants when making friendly or hostile judgments based on nonverbal cues. The current findings are partially consistent with these results. Many social cognitive neuroscience studies have shown that the P300 component is primarily distributed in parietal regions, whose importance in processing individual actions has been consistently demonstrated. In topographical maps, condition main effects during 270–450 ms showed that hostile intentions activated parietal regions more significantly than friendly and neutral intentions. Source localization of the P300 component for friendly and hostile intentions identified maximum activation in BA45, the insula, with significantly stronger activation for hostile than friendly intentions in frontal (middle frontal gyrus, inferior frontal gyrus, medial frontal gyrus), sublobar (insula), and anterior cingulate regions. Many emotion-related neuroimaging studies (Gilead, Katzir, Eyal, & Liberman, 2016) have shown that the insula plays an important role in processing basic emotional information, including negative emotions such as anger. The insula is a crucial component of the brain network responsible for evaluation and emotional processing, playing a broad role in integrating emotional and cognitive processing (Berntson et al., 2011). The current results suggest that the insula and related regions may be important for evaluating the socio-emotional meanings of friendly and hostile intentions. The topographical differences among intention conditions during 270–450 ms revealed a stepwise activation increase from neutral to friendly to hostile intentions in the right hemisphere, consistent with cognitive psychology perspectives on the right hemisphere' s important role in emotional processing. In this study, hostile intentions as a threatening signal may have inevitably evoked negative emotions (e.g., unpleasantness) in participants. The significant differences in activated brain regions between friendly and hostile intentions may indicate that the brain' s understanding of different interactive intentions begins to show spatial separation around 300 ms, with prioritized evaluative processing for negative hostile intentions. These conclusions supplement the two-stage processing model of intention understanding proposed by previous researchers (Bahnemann, Dziobek, Prehn, Wolf, & Heekeren, 2010) and provide richer neuroelectrophysiological evidence for the Hierarchical & Multi-level Cognitive Framework (HMCF) hypothesis of theory of mind (Wang et al., 2011, 2012). The LPC component showed separation between interactive and neutral intentions during 550–650 ms, suggesting that the late-stage LPC component may be related to more complex social cognitive processing and may reflect subsequent understanding of interactive intentions, consistent with previous LPC findings (700–800 ms) (Wang et al., 2011, 2012; Wang et al., 2014). Temporal discrepancies may be due to differences in experimental materials.

Given that individuals with autism spectrum disorders show impairments in perceiving dyadic body movements in interactive contexts (Kaiser & Pelphrey, 2012), this study provides a valuable paradigm for investigating the mechanisms underlying their social interaction deficits. However, ERP amplitudes in this study may also have been influenced by different kinematic characteristics of actions, which should be better controlled in future research, and interpretations of the current results should be made cautiously. Additionally, some action intention studies (Adenzato et al., 2017; Huang et al., 2018) have found gender differences in intention understanding and new perspectives on how intentions influence movement kinematics (Ansuini, Cavallo, Bertone, & Becchio, 2015), which warrant further investigation.

In summary, this ERP study examined the dynamic spatiotemporal processing of understanding friendly and hostile interactive intentions expressed through dyadic body movements, focusing on the N250 and P300 components (temporal course) and their source localization (spatial perspective). The results indicate: (1) In early brain processing stages, the N250 component shows that around 250 ms, the brain categorizes hostile, friendly, and neutral intentions based on action goals, with pairwise separation among the three conditions. Source localization identified the middle frontal gyrus as the primary generator. Behavioral reaction times revealed earliest understanding of negative hostile intentions. (2) In later brain processing stages, the P300 component shows that around 300 ms, the brain further evaluates the socio-emotional nature of hostile, friendly, and neutral intentions, again showing pairwise separation among conditions. Source localization identified the insula as the primary generator. Right hemisphere processing advantages demonstrate sustained evaluative processing of negative hostile intentions.

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# Brain Spatio-temporal Dynamics of Understanding Kind versus Hostile Intentions Based on Dyadic Body Movements

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## Abstract

Previous social neuroscience studies focused mainly on the neural networks that sustain an understanding of a single individual' s neutral or negative intentions. However, few studies have explored those of different types of social interactive intentions performed by two or a number of individuals and their whole body movements. In addition, the spatio-temporal dynamics of understanding the kind and hostile intentions in the human brain also remain unclear.

In order to address the above issue, the electroencephalograph (EEG) technique was employed to explore the dissociative neural correlates of understanding kind versus hostile intention. Twenty healthy participants were recruited for the experiment. Their behavioral data (accuracy and reaction time) and electrical brain activities were recorded while they were watching colorful photos depicting two actors' actions and performing an intention inference task (IIT). There were three different types of action intentions: kindness, hostility and non-interactiveness (neutrality). The ERP data was analyzed using the Scan and sLoreta software in an off-line way.

The Univariate Analysis of Variance (ANOVA) with repeated measures of mean accuracy showed no significant difference among three conditions, while a main effect of condition existed for reaction time. The reaction times of hostile intention were shorter than those of the kind and neutral intentions, while no significant difference was found between the latter two conditions. The ERP data were analyzed using a three-way repeated measure ANOVA. The ANOVA factors were intention condition (kindness, hostility and neutrality), laterality (left, midline and right areas) and caudality (frontal, central and parietal areas). Electrophysiological results showed, over the frontal area, a significantly more negative amplitude of N250 (170~270 ms) for neutral intention compared to kind and hostile intentions, and the N250 amplitudes for kind intention were also more negative than those for hostile intention, especially on the FZ electrode site. The source localization showed maximum activation in Broadman 10(BA10), in the vicinity of middle frontal gyrus, for N250 for kind and hostile intentions. At the later stage (270~450 ms), the peak amplitudes of the P300 for hostile intention were more positive than those for the kind and neutral intentions, and the P300 amplitudes for kind intention were also more positive than those for neutral intention over the central, parietal areas as well as the right hemisphere. The maximum activation for P300 of kind and hostile intentions was found in BA45, located in the vicinity of insula, and a stronger activity existed for hostile intention compared to kind intention. These findings show that there is a spatio-temporal dynamic dissociation between kind and hostile intentions understanding in the brain. Altogether, the current study provides electrophysiological evidence underlying the kind, hostile interactive intentions and non-interactive (neutral) intention understanding, and suggests a prioritized and sustained processing for hostile interactive intention. The study enriches the contents of the two-stage intention-understanding model and the putative Hierarchical & Multi-level Cognitive Framework (HMCF) in Theory of Mind.

**Key words**: Theory of Mind; kind intention; hostile intention; dyadic interaction; ERP