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COMCO21: Irrelevant robot social signals

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Abstract

Understanding others 'nonverbal behavior is essential for social interaction, as it allows, among others, for mental states to be inferred. While gaze communication, a well-established nonverbal social behavior, has shown its importance in inferring others' mental states, not much is known about the effects of irrelevant gaze signals on cognitive conflict markers (i.e., gaze signals that are not indicative of correct completion of the task). Moreover, it is unclear how, and if, cognitive-conflict mechanisms communicate with gaze-related attentional mechanisms. Here, we recorded EEG data while participants completed a color-based object categorization task with a robot on a screen. On each trial, participants observed the robot iCub grasping an object from a table and offering it to them to simulate a handover. Once the robot presented the object forward, they were asked to choose where to place the object according to its color (e.g., a blue bin presented on the right side of the screen). Before participants were allowed to respond, the robot made a head/gaze shift towards one of the sides. The gaze shifts were either congruent or incongruent with the object's color category. Since conflict stems from the activation of two responses or two actions, when only one should be selected, we expected that incongruent head shifts would induce more errors and elicit larger amplitudes in electrophysiological markers of cognitive conflict. Furthermore, we also expected that observing incongruent head shifts would evoke neural oscillations linked to cognitive conflict.

EEG and behavioral measures from 34 participants were included in the final analysis. Response time and error rates were extracted for each participant. Coherence values were calculated for each participant for 8 electrodes pairs following our hypothesis (FCz was separately paired with TP7, P5, P7, PO7, TP8, P8, PO8). Coherence values were submitted to a two-way ANOVA with Congruency (congruent vs incongruent) and hemispheres (right vs left) as within factors. Results only showed a significant interaction effect between the two factors ($F(1,540) = 5.635$, $p = 0.018$) highlighting higher lateralized connectivity pattern for incongruent trials ($M_{incongruent\text{-}left} = 0.076$ vs $M_{incongruent\text{-}right} = 0.043$). Results also showed a negative correlation between response times and coherence values in both hemispheres for three of the 8 electrode pairs (TP7: $r = -0.21$, $p = 0.02$; PO8: $r = -0.23$, $p = 0.01$; P7: $r = -182$, $p = 0.04$).

The experiment results are in line with previous gaze following studies (i.e., slower response times for incongruent trials). We also show higher theta amplitudes overall for incongruent trials compared to congruent trials, which suggest a higher degree of unexpectedness. More importantly, we observed higher coherence values between mid-frontal electrode locations and posterior occipital electrode locations in the theta-frequency band for incongruent vs. congruent cues (see Figure 1), which suggest that theta-band synchronization between the two regions allows for communication between cognitive conflict systems and gaze-related attentional mechanisms. In sum, the influence of irrelevant social signals during goal-oriented tasks can be indexed by behavioral, neural oscillation and brain connectivity patterns.

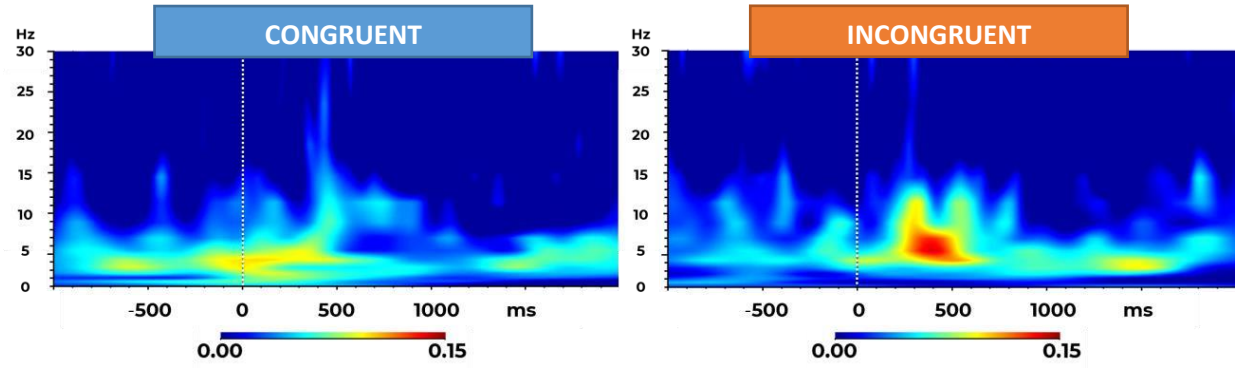

Figure 1. *Time-frequency analysis of EEG data comparing the Congruent vs Incongruent trials. Warmer colors represent higher coherence values among the selected electrodes (i.e. FCz - TP7). The Y axis represents the frequency (measured in Hz). The X axis represents time measured in milliseconds. All results were timelocked to the onset of robot's head signal. Results of the analysis shows a difference in amplitudes in the theta frequency band (3-7Hz) at around 350-400ms.*