The Hyperscanning fMRI Platform with Reliable Synchronization Timing Revealed Brain Activities and Correlations between Subjects during Competitive or Collaborative Social Interactions

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Abstract:

Most social neuroscience studies mainly focus on how the brain activity of one single subject influenced by social situations. On the other hand, how two brains interact with each other during social interactions can be investigated using hyperscanning techniques by simultaneous recording of brain activations from two subjects during online social tasks. It has been suggested that hyperscanning fMRI could be used to determine which brain regions constitute the inter-brain neural network during social interactions. However, this kind of inter-subject correlation analysis relies on the synchronization timing accuracy between MRI scanners located at different institutes. But the timing properties of scanners from various vendors are different. After receiving start signal, there is a preparation time before actual start of the first fMRI image. The problem is that preparation times of scanners are quite different, and may fluctuate even for the same scanner. In the present study, we established a hyperscanning fMRI platform to allow multiple scanners acquiring brain activities as well as subjects' behavioral responses with reliable timing accuracy. Using appropriate internet communication, we coordinated multiple scanner consoles and related computers to run fMRI experiments across institutes. The timing accuracy is ensured by standard network timing protocol that provides precise timestamp for each synchronization event. Instead of direct connections between each computer, we adopted a client-server framework to simplify message communication, avoid possible conflicts during internet trafficking, and reduce possible network security issues. The server arranges the engagement of scanners, and announces the starting time of the experiment. Each scanner console read this information behind a secured firewall. Then a customized program for each console calculates its own estimated preparation time to initiate the scan process in advance, so that all scanners can start imaging precisely at the announced time. After careful calibration, differences of start time among scanners can be very small, far less than the temporal resolution of fMRI. This hyperscanning fMRI platform is flexible and

expandable, which allows the possibility to explore the neural mechanism of social interaction among multiple persons. We demonstrated a hyperscanning fMRI experiment to investigate brain activities during competition and collaboration task using two scanners located at National Taiwan University and National Cheng Kung University. Subjects were asked to press different buttons according to specific visual stimuli. Under different conditions, they were required to compete or collaborate with each other, or just do the task alone. The server synchronized the MRI scanning and stimulus presentation between two sites. Subjects' responses were also communicated via the server, and reaction times were recorded using local computer to achieve millisecond precision. The results showed that temporal-parietal junction and other regions were activated, and their brain activity time courses were significantly correlated. Furthermore, we also incorporate a third scanner at National Chengchi University to investigate neural synchronization across multiple subjects during collaborative and competition tasks. Our results indicated that neural synchronization only occurred between subjects interacting with each other, but not with a separate person running the task at the same time. In summary, this hyperscanning fMRI platform is accurate and reliable to measure brain activities during online social interaction, and can be a powerful tool to study social cognitive neuroscience.

Keywords: hyperscanning fMRI, social interaction, synchronization timing accuracy, competition, collaboration