Objective: To use non-invasive MEG brain imaging to determine cortical locations of neural dynamics preceding a brake-like foot response to a visual event during a hands-free cell phone conversation in a validated driving-like simulation.

Method: Twenty-three normal, healthy, control subjects (ages 18-65) all of whom possessed current driver's licenses were monitored by whole head MEG while performing an event detection task in a driving-like scenario. Each subject observed a driving scene displayed on a large screen. The primary task was to depress a foot pedal in response to a small red dot presented to the left of or below the driving scene, at unpredictable intervals. The secondary task was a hands-free cell phone conversation. A button was pressed to answer a ring tone, and questions were covertly answered (e.g., What is your address? What is your birthdate?). For each event, brake reaction time was recorded and a 1 second epoch of MEG data was created. A Partial Least-Squares (PLS) analysis was performed to define an orthogonal MEG data set basis. After mapping each MEG epoch to a set of coordinates in this PLS basis, two linear discriminant functions were created. One discriminant function mapped each MEG epoch to a coordinate that defined differences in MEG data corresponding to brain activity with and without conversation (x axis). The other discriminate function discriminated between conversation states along a coordinate that related differences in MEG data to brake reaction time (y axis).

Result: Preliminary findings show that brain activation affected by cell phone conversation during the brake performance task was observed in superior occipital and parietal cortical neural systems, usually with greater activity on the right side (Fig. 1A). During cell phone conversations, reaction times increase and the amplitudes of the brain responses decrease with greatest alterations detected between 200 and 300 msec, (Fig. 1B). The discriminant analysis of the MEG components revealed reasonable segmentation of the conversation conditions on the basis of the brain data, as seen in Figure 1C.

Conclusions: Visual event detection and response performed as part of simulated driving engages multiple interconnected cortical and sub-cortical neural systems working in dynamic patterns. The spatial and temporal properties of brain mechanisms underlying a driving-like stimulus-response mechanism were identified using MEG. Preliminary data analysis of the initial subjects showed that hands-free cell phone conversations in a laboratory setting tended to diminish the amplitude of a brain response in the parietal association cortex, about 240 msec after light onset, which was predictive of behavioral brake reaction time in these simulated conditions.

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Figure 1 (A) Location of brain regions affected by cell phone conversation task for one subject. (B) Brain activation changes associated with the conversation. Greatest at ~240 msec after the brake stimulus is observed. (C) Discriminant analysis quantifies the MEG signals during conversation related to reaction time. The red dots correspond to MEG data during no conversation; black dots represent MEG data during conversation.
MEG Localization of Cortex Involved in Attentional Processes During a Driving Task

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Objective: To localize the neural dynamics preceding a brake-like foot response to a visual event while watching a driving video and having a conversation, utilizing non-invasive MEG.

Results

Reaction time (RT) was inversely related to the amplitude of brain activity detected by MEG in the right superior parietal lobe (Fig 1A). Increased brain activity (Fig 2A) was seen in the 200 to 300 ms range after the red light came on resulting in short RT, during the primary task alone (no conversation). An inverse relation to RT was also seen in brain activity in the visual cortex in the 85 – 90 ms interval after the red light (Fig 2B). The strengths of these regression relationships were significantly reduced by the addition of the secondary task (Fig 2B). Addition of conversation (secondary task) activated language specific areas, but also dampened brain activity in the right parietal and visual regions while increasing mean RT (primary 926 ms; primary + secondary 993 ms).

Methods

- 148-channel Neuromagnetometer (4-D Neuroimaging Magnes WH2500)
- 19 normal healthy, control subjects [between 18 and 65 years of age]
- All subjects possessed current driver’s licenses

Task: Each subject observed a driving scene displayed on a large screen. The primary task was to depress a foot pedal in response to a small red dot presented to the left of or below the driving scene, at unpredictable intervals. The secondary task was a hands-free phone conversation. A button was pressed to answer a ring tone, and questions were covertly answered (e.g., What is your address? What is your birthdate?). For each event, brake reaction time was recorded.

MEG Data was continuously collected for 20 minutes at 508 Hz with a band pass of 0.1-100 Hz. Pedal and button presses were recorded. Data was forward and backward filtered using a 1-50 Hz bandpass filter; Epochs were created by selecting one second of data after the red light is turned on (Fig 3). Approximately 40 epochs were averaged together. Linear regression analysis was used to identify MEG signals related to RT. A MEG signal subspace was constructed using Partial Least-Squares and linear discriminant analysis of the MEG data. ICA-MR-FOCUSS was used to determine locations of brain activity on an MRI scan that corresponded to RT.

Conclusions

- The spatial and temporal properties of brain mechanisms that modulate reaction times to visual events while watching a driving video were identified using MEG. Data analysis of all subjects showed that conversations in a laboratory setting tended to diminish the amplitude of brain response in the right parietal cortical region (sensory-motor integration), about 240 ms after light onset, which was predictive of a delayed brake reaction time in these simulated conditions. Similar differences were also seen in the visual cortex at 80-110 ms after the red light came on.
- Cortical regions in the right superior parietal lobe of the brain are engaged in cognitive processing when the response time to the red light is short. This area of the brain is responsible for multitasking and being visually aware of one’s surroundings.
- These findings (laboratory setting) suggest that long conversation may affect event detection in two ways: 1. By suppressing the brain activation response in the Visual Cortex 2. By suppressing the brain activation response in the Right Superior Parietal Region -As reaction time increases.
- These laboratory findings should not be interpreted as if real-world conversations are driver distractions, without on-road validation, and comparison to other in-vehicle tasks.

References


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