Poster #5109

Contribution of ipsilateral motor areas to response initiation: Test of the hemispheric coactivation hypothesis.

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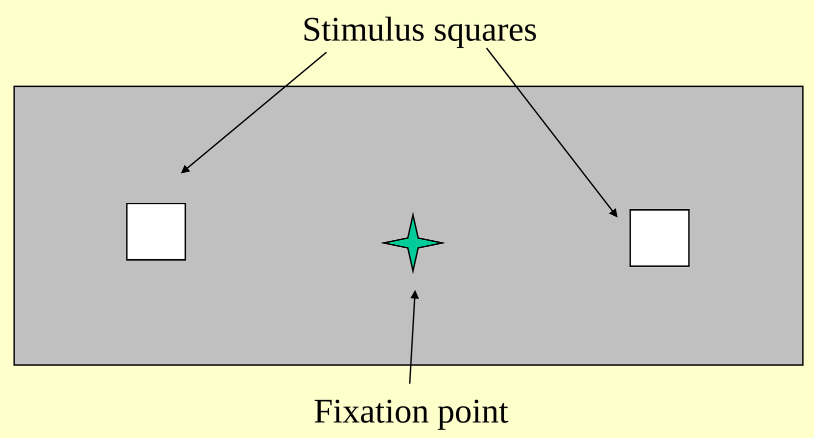
1. Introduction:

The processes underlying visual divided attention have often been studied with a simple reaction time (RT) task like that shown in Figure 1. A standard finding in this task—called *redundancy gain* (RG)—is that responses are faster when both visual stimuli are presented than when just one is presented. Often, tests of RT distributions (Miller, 1982) support coactivation models in which the two stimuli jointly activate the response.

Figure 1: Stimulus display for a simple RT task. In each trial, either the left square, the right square, both squares, or neither square was presented. Observers had to press a single response key as quickly as possible if either or both stimulus squares appeared.



Studies using this task with split-brain individuals indicate that these people produce increased RG relative to normals (e.g., Reuter-Lorenz, Nozawa, Gazzaniga, & Hughes, 1995). This is surprising: If the two visual stimuli project to disconnected hemispheres, it is difficult to see how these stimuli could activate brain processes that would work together in activating the response.

To explain the increased RG in split-brain individuals, Miller (2004) proposed the *hemispheric coactivation model*. According to this model, *both* hemispheres of the brain are involved in the activation of a unimanual motor response, contrary to the standard idea that each hand is completely controlled by the motor areas of the contralateral hemisphere (e.g., Poffenberger, 1912).

Purpose of the present study: To test the hemispheric coactivation model, electroencephalographic (EEG) activity of both hemispheres was monitored in normal participants. If this model is correct, the *ipsilateral* hemisphere should be active during response initiation, in addition to the contralateral hemisphere.

2. Experiment 1: Simple RT and Count Tasks

Table 1: Correct Response for Each Experimental Condition

Task (Blocked)	*Stimulus Square(s)* None	Left	Right	Both
Respond to any square with left hand	*Do nothing*	*Respond with left hand*		
Respond to any square with right hand	*Do nothing*	*Respond with right hand*		
Count squares	*Do nothing*	*Add 1 or 2 to the total N of squares*		

Method:

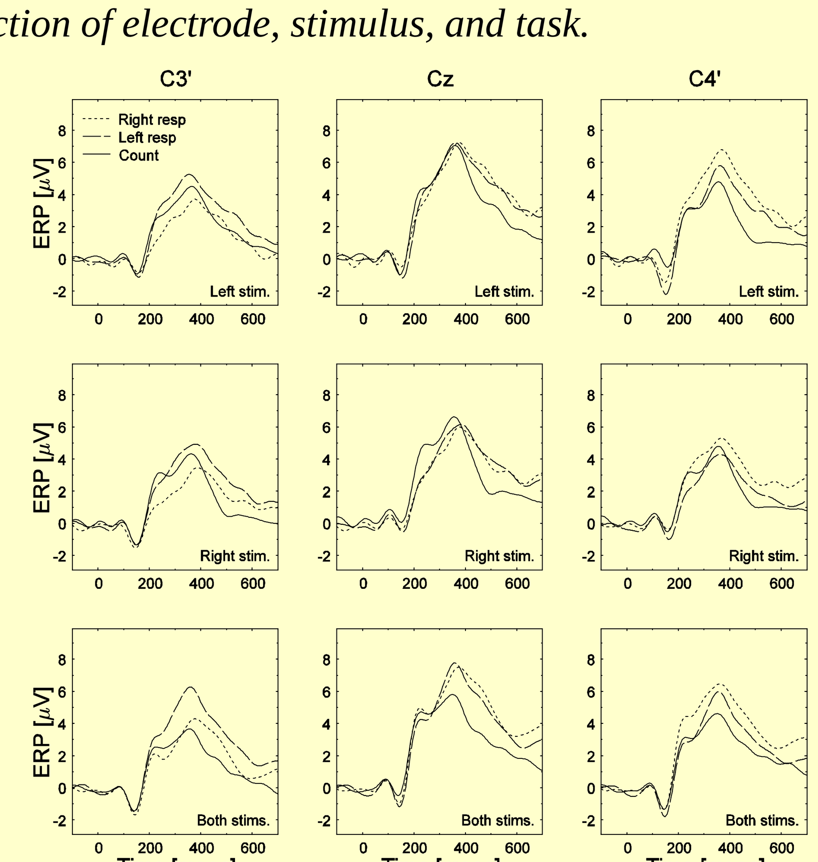
As shown in Table 1, participants were required in different blocks of trials to either (a) respond to any stimulus with the left hand, (b) respond to any stimulus with the right hand, or (c) count the total number of squares presented, reporting the total at the end of the block. EEG was recorded over the left and right sensorimotor cortices (C3' and C4', respectively), as well as at the midline (Cz).

Behavioral Results:

Redundancy gain was replicated, with responses to both squares 28 ms faster than responses to single squares. Participants reported the correct count (±1) in 89% of the count blocks.

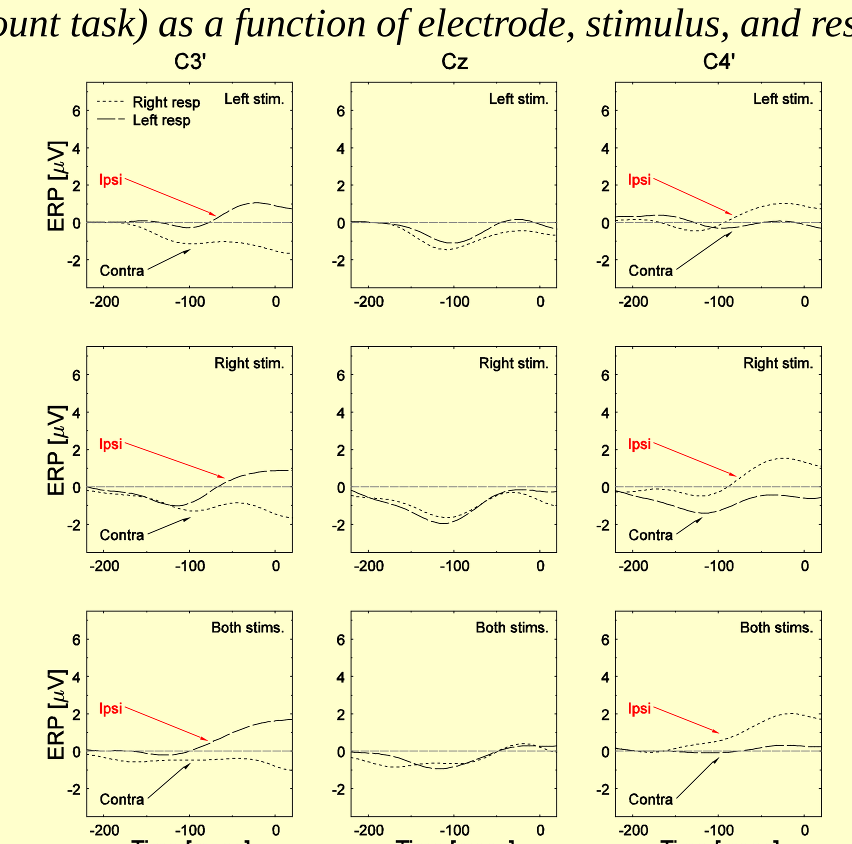
Psychophysiological Results:

Figure 2: Stimulus-locked event-related potentials (ERPs) as a function of electrode, stimulus, and task.



Note that the ERPs in Figure 2 are rather independent of task for at least 200 ms after stimulus onset, suggesting that the stimulus-related effects depend little on the task. It therefore seems appropriate to use difference waves (response task minus count task) as possible measures of motor processes. Figure 3 shows these difference waves, time-locked to the key press response in order to emphasize the contributions of motor potentials.

Figure 3: Response-locked difference ERPs (left or right response task minus count task) as a function of electrode, stimulus, and response.



In the last 100 ms preceding the key press at time 0, difference waves became slightly negative ($p<.10$) at the hemisphere contralateral to the responding hand, consistent with the standard view that the contralateral motor areas activate the response. In the same time range, the ipsilateral difference waves became quite positive ($p<.025$). **Conclusion:** *The ipsilateral motor areas also contribute to response initiation*. The positivity of ipsilateral areas (as opposed to the negativity of contralateral ones) might mean that the ipsilateral contribution is to suppress the unused response hand.

3. Experiment 2: Choice RT and Count Tasks

Experimental Question: To what extent, if any, will the results of Experiment 1's simple RT task generalize to a choice RT task with responses made by the left and right hands? For the choice RT task, participants responded to any visual stimulus with one hand, exactly as in Experiment 1, but responded to a tone with the opposite hand.

Table 2: Correct Response for Each Experimental Condition

Task (Blocked)	*Stimulus Square(s)* Tone	Left	Right	Both
Respond to any square with left hand	*Respond with right hand*	*Respond with left hand*		
Respond to any square with right hand	*Respond with left hand*	*Respond with right hand*		
Count squares	*Do nothing*	*Add 1 or 2 to the total N of squares*		

Method:

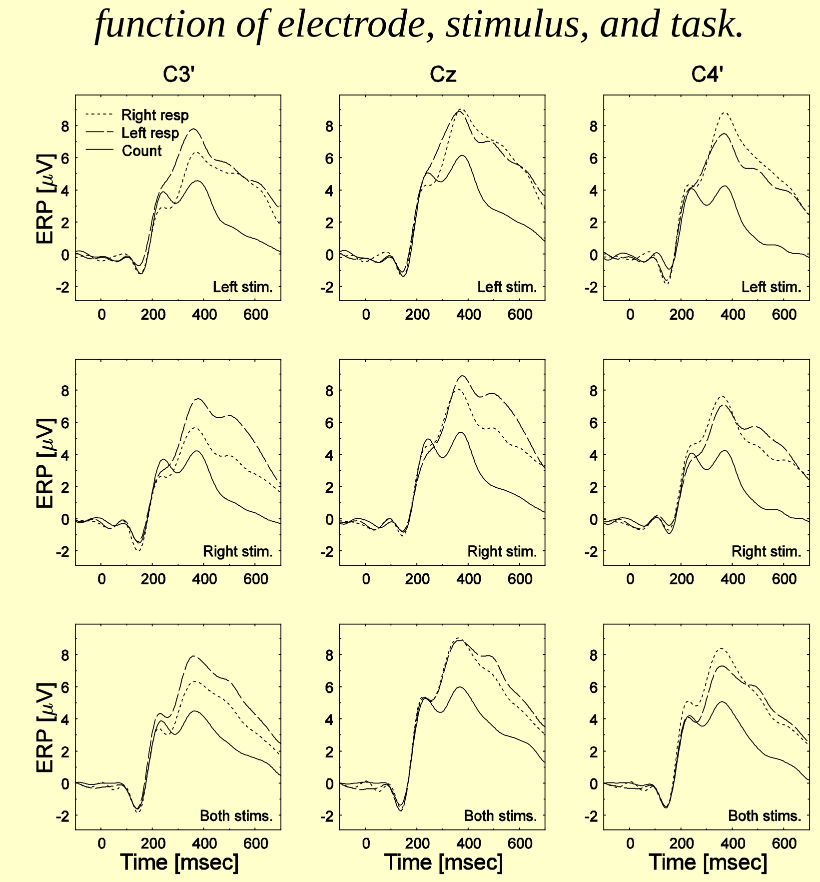
As shown in Table 2, the differences from Experiment 1 were that (a) tones were presented in trials with no visual stimulus, and (b) in the RT task blocks participants had to respond to the tone with the opposite hand from that used in responding to squares.

Behavioral Results:

Redundancy gain was replicated, with responses to both squares 35 ms faster than responses to single squares. Participants reported the correct count (±1) in 86% of the count blocks.

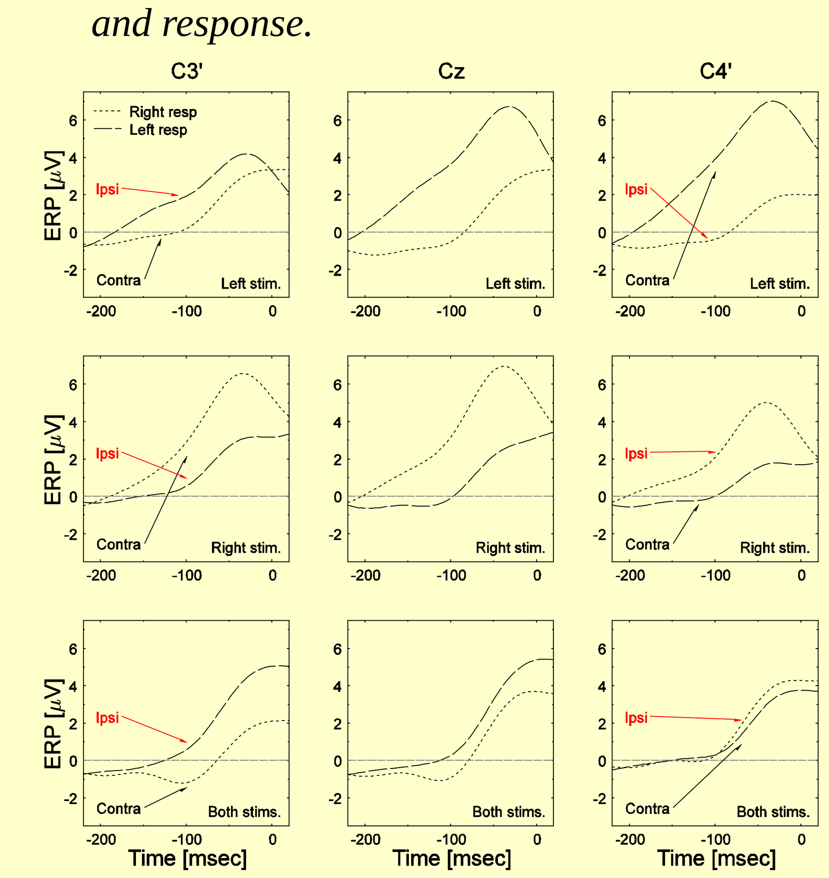
Psychophysiological Results:

Figure 4: Stimulus-locked ERPs as a function of electrode, stimulus, and task.



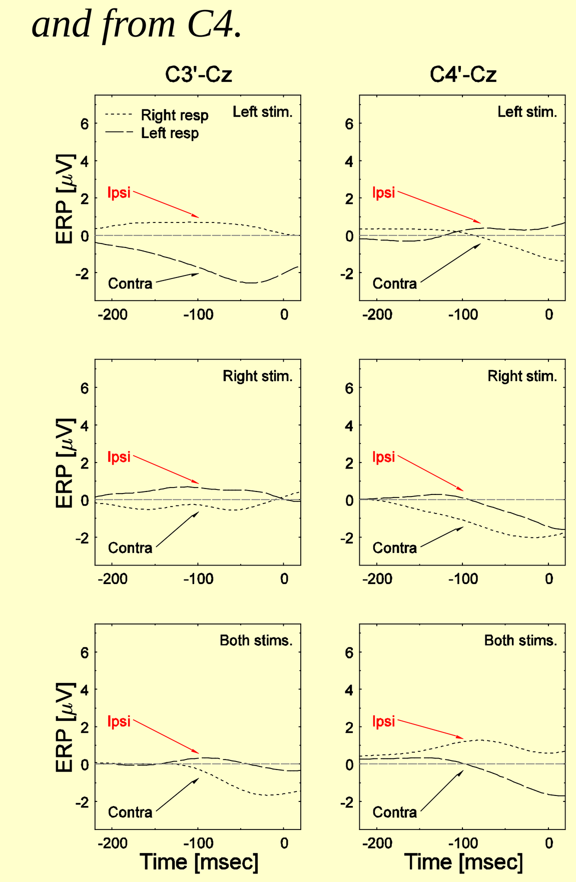
As in Figure 2, the ERPs are rather independent of task, suggesting that difference waves can again be used as measures of motor processes. These difference waves are shown in Figure 5.

Figure 5: Response-locked difference ERPs (left or right response task minus count task) as a function of electrode, stimulus, and response.



Activity over both contralateral and ipsilateral motor areas is superimposed on a strong positivity that is also present centrally (i.e., at Cz). Interestingly, this positivity is greatly enhanced when the side of a single stimulus matches the side of the response. This central positivity must be subtracted out to obtain estimates of hemisphere-specific activity (see Figure 6).

Figure 6: Response-locked difference ERPs as a function of electrode difference (C3-Cz or C4-Cz), stimulus, and response. Waveforms were formed from Figure 5 by subtracting Cz from C3 and from C4.



After correcting for the positivity that also affects Cz, there is negativity at contralateral electrodes but no positivity at ipsilateral ones. **Conclusion:** *Ipsilateral positivity is limited to simple RT tasks.*

4. Overall Conclusions

The ipsilateral hemisphere contributes to response initiation in the simple RT task, as predicted by the hemispheric coactivation model's account of increased redundancy gain for split-brain individuals. The ipsilateral hemisphere does not contribute in an analogous choice RT task, suggesting that such individuals may show normal redundancy gain in that task.

5. References

Miller, J. O. (1982). Divided attention: Evidence for coactivation with redundant signals. *Cognitive Psychology, 14*, 247-279.

Miller, J. O. (2004). Exaggerated redundancy gain in the split brain: A hemispheric coactivation account. *Cognitive Psychology, 49*, 118-154.

Poffenberger, A. T. (1912). Reaction time to retinal stimulation with special reference to the time lost in conduction through nerve centers. *Archives of Psychology, 23*, 1-73.

Reuter-Lorenz, P. A., Nozawa, G., Gazzaniga, M. S., & Hughes, H. C. (1995). Fate of neglected targets: A chronometric analysis of redundant target effects in the bisected brain. *Journal of Experimental Psychology: Human Perception and Performance, 21*, 211-230.

6. Acknowledgements

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