Effects of Verbal Tasks on Driving Simulator Performance

Jonathan Rann and Dr. Amit Almor (University of South Carolina)
jrann@email.sc.edu

While it is often argued that both language production and comprehension require cognitive and working memory resources, production is likely more resource demanding due to requiring the simultaneous planning, monitoring and articulating of a single correct utterance, whereas comprehension can involve activating multiple interpretations, and, if errors occur, the system can easily recover (albeit with a measurable short delay). Recently, interest has focused on capturing the dynamic shifting of resource demands during production and comprehension, as well as transitions from one to the other, over the course of conversation (e.g., Boiteau, et al., 2014). The resource allocation of comprehension and production is important theoretically but is especially relevant to many real world scenarios in which language is used in the context of other tasks, such as driving and talking. In turn, these situations are important not only because they have real life implications but also because they can provide critical tests for processing theories in more natural contexts. Here we report two experiments asking whether the postulated resource demands of production and comprehension affect driving performance in ways that are consistent with theories of production and comprehension.

Both experiments used the OpenDS Driving Simulator (Math, Mahr, Moniri, & Müller, 2012) and Continuous Tracking and Reaction task (Mahr, Feld, Moniri, & Math, 2012) in which overall distance from a target on a driving-based tracking task is the dependent measure, and is continuously measured. E1 tested performance under conditions involving either (a) no verbal input or output (absent), (b) passive listening to spoken prompts via headphones (listen), or (c) responding to spoken prompts (respond). E2 tested performance under conditions involving either (a) no verbal input or output (absent), (b) passive reading of written prompts that were overlain on the driving simulator screen (read), or (c) responding to read prompts (respond). Both experiments also tested the effect of the driving task difficulty by manipulating target moving speed (slow vs fast). Overall mean deviance from target during different blocks was analyzed using ANOVAs (Figures 1a & 2a). Then, driving performance was aligned with conversational segments (subject speaking or memorizing vs. subject listening or reading) and Growth Curve Analyses were used to track continuous performance during first 2500 milliseconds of conversation segments (Figures 1b & 2b). We hypothesized that: 1) verbal tasks would tap into the cognitive resources used by driving; 2) production would require more resources than comprehension; 3) because driving and reading both involve the visual modality, performance in E2 would show stronger effects of the verbal task; 4) these requirements would vary dynamically during different conversational segments; and 5) the relative resource allocation between the verbal and driving task can change as a result of the relative difficulty.

Results from E1 analysis (Figure 1a) showed no significant differences in performance among verbal task conditions during slow target speeds. During fast speeds, performance steadily decreased as verbal task difficulty increased, with worse performance during respond conditions. For E2, results (Figure 2a) showed significantly worse performance in verbal conditions compared to absent during slow speeds. Performance during fast speeds decreased in similar fashion as E1, but was more pronounced. Time-course analysis of performance during the first 2500 ms in conversation segments (Figure 1b) revealed worse performance during talking compared to listening segments in most conditions. Fast-Respond conditions showed clear decreasing performance as participants prepared to speak, and increasing performance as they talked. This pattern was more pronounced in the fast conditions, and was observed (and even more pronounced) in all conditions of E2 (Figure 2b). Overall, data from both experiments supported our hypotheses, revealing dynamic performance changes in line with current theories of language production and comprehension, placing the requirements of both in the domain of general theories of resource allocation (i.e., Lavie, et al., 2004; Wickens, 2002).

FIGURES

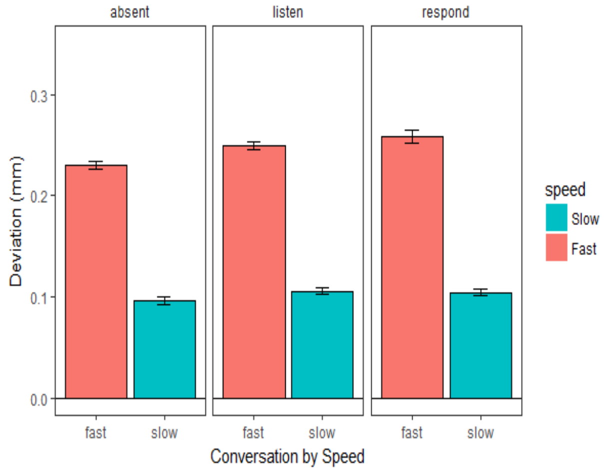

Figure 1a : E1 - Overall deviation during different conditions (*Error bars* show standard error of mean). ANOVAs revealed main effects of Speed, $F(1, 29) = 917.56$, $p < .001$, and Conversation, $F(2, 58) = 12.96$, $p < .001$, and interaction between Speed and Conversation, $F(2, 58) = 3.87$, $p < .05$.

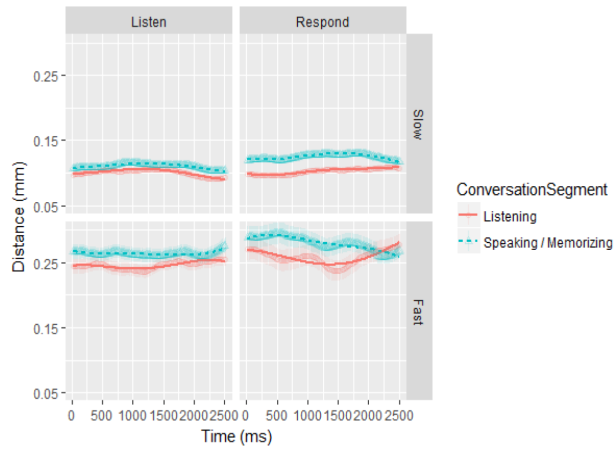

Figure 1b: E1 - Deviation during first 2500 milliseconds of task onset for slow and fast conditions conversation segments. Cubic time model was found to best fit the data, $\chi2(7) = 12.812$, $p = .07$.

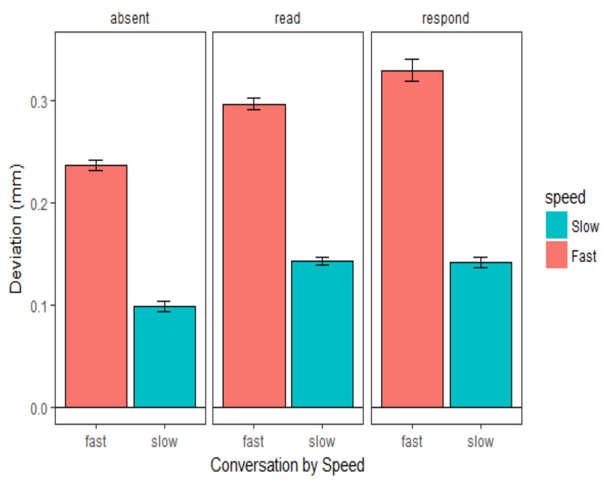

Figure 2a: Overall deviation during different conditions. (*Error bars* show the standard error of the mean). ANOVAs revealed significant main effects of Speed, $F(1, 29) = 603.43$, $p < .001$, and Conversation, $F(2, 58) = 72.75$, $p < .001$, and interaction between Speed and Conversation, $F(2, 58) = 11.38$, $p < .001$.

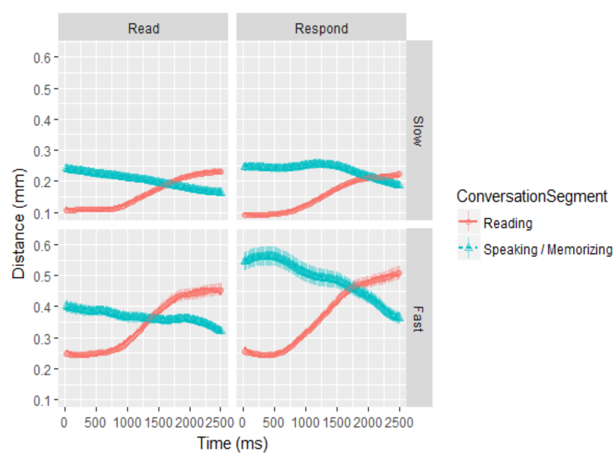

Figure 2b: Target deviation during first 2500 milliseconds of task onset for slow and fast conditions during Read-Only and Read-and-Respond conversation segments. Cubic time model was found to best fit the data, $\chi2(7) = 225.73$, $p < .001$.

REFERENCES

Boiteau, T. W., Malone, P. S., Peters, S. A., & Almor, A. (2014). Interference between conversation and a concurrent visuomotor task. Journal of experimental psychology: General, 143(1), 295.

Lavie, N., Hirst, A., De Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. Journal of Experimental Psychology: General, 133(3), 339.

Mahr, A., Feld, M., Moniri, M. M., & Math, R. (2012). The contre (continuous tracking and reaction) task: A flexible approach for assessing driver cognitive workload with high sensitivity. Automotive user interfaces and interactive vehicular applications, 88-91.

Math, R., Mahr, A., Moniri, M. M., & Müller, C. (2012, October). OpenDS: A new open-source driving simulator for research. In Adjunct Proceedings of the 4th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, NH, USA (pp. 7-8).

Wickens, C. D. (2002). Multiple resources and performance prediction. Theoretical issues in ergonomics science, 3(2), 159-177.