What did we learn from forty years of research on semantic interference? A Bayesian meta-analysis

A. Bürki, S. Elbuy., S. Madec, & S. Vasishth, University of Potsdam, Germany

Contact: buerki@uni-potsdam.de

When participants in an experiment have to name pictures while ignoring distractor words superimposed on the picture or presented auditorily (i.e., picture-word interference paradigm), they take more time when the word to be named (or target) and distractor words are from the same semantic category (e.g., cat-dog) than when the two words are unrelated (e.g., cat-bed). This experimental effect is known as the semantic interference effect, and is probably one of the most studied in the language production literature. Since Lupker (1979) reported the effect in the first response time experiment about 40 years ago, more than 300 similar experiments have been conducted. Many authors consider that this effect reflects the competitive nature of lexical access (e.g., Roelofs, 2018). Other authors hypothesize that the semantic interference effect occurs much later in the production process, and as a consequence, cannot be used to inform models of lexical access (e.g., Mahon et al., 2007). Many studies have examined the experimental conditions in which the effect arises in order to shed light on its functional origin.

In this study, we present a comprehensive theoretical review of the semantic interference effect and perform a series of Bayesian meta-analyses and meta-regressions of this effect, taking into account the relevant evidence collected to date. The first aim of this contribution is to quantify the size of the semantic interference effect and the uncertainty associated with it. The second aim is to estimate prospective power based on the meta-analysis. The last aim is to review and explore further the conditions in which the semantic interference effect is present.

A Bayesian meta-analysis including the data of 162 studies in which the distractor and picture were presented simultaneously or in close temporal relationship (short stimulus onset asynchronies or SOA) reveals that the effect is of about 21 ms with a 95% credible interval ranging from 18 to 24 ms. This result confirms that overall and taking into account studies with different designs, languages, and materials, distractors of the same semantic category interfere more with the preparation of the response than distractors of a different semantic category.

Prospective power analyses using the variance component estimated from 57 studies for which the raw datasets were available and the outcome of the meta-analysis as an estimate of effect size suggest that the majority of datasets had a power below 80% (see Figure 1).

A series of meta-analyses and meta-regressions, conducted with the R package brms (Bürkner, 2018) reveals that repetition and SOA modulate the semantic interference effect. As the number of repetitions of the target word increases, the semantic interference effect decreases. Moreover, the semantic interference effect is only found when the distractor word and the picture are displayed at the same time or within a short time interval (plus/minus 160 ms). For all the other factors claimed to modulate the semantic interference effect that we considered, namely familiarization with the test material, number of pictures, number of semantic categories, number of repetitions, response times, whether the distractors are part of the response set, distractor frequency, length, and picturability, these analyses do not provide support for (or against) the hypotheses that these factors modulate the semantic interference effect.

Taken together, the qualitative review and the quantitative analyses reveal that after 40 years of research, the empirical evidence regarding the factors that modulate the semantic interference effect is not sufficient to decide whether this effect arises during lexical selection or later. We conclude that the available evidence to date offers little information about the nature of the semantic interference effect and can hardly be used to model the nature of lexical access.

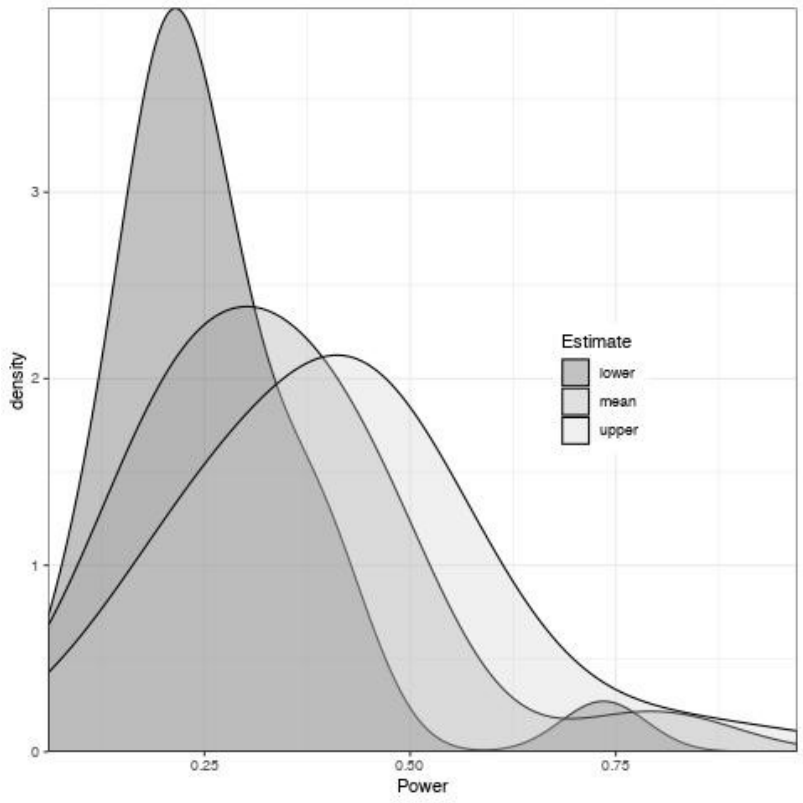

Figure 1*. Distribution of power across the 57 studies with raw datasets, considering an effect size of 21 ms (meta-analytic estimate obtained in Analysis 1) of 18 ms, and 24 ms (lower and upper bounds of the 95% credible interval, respectively).*

References

Bürkner, P. (2018). Advanced bayesian multilevel modeling with the R Package brms. The R Journal, 10(1), 395–411. https://doi.org/10.32614/RJ-2018-017.

Lupker, S. J. (1979). The semantic nature of response competition in the picture-word interference task. Memory & Cognition, 7(6), 485–495. https://doi.org/10.3758/BF03198265

Mahon, B. Z., Costa, A., Peterson, R., Vargas, K. A., & Caramazza, A. (2007). Lexical selection is not by competition: A reinterpretation of semantic interference and facilitation effects in the picture-word interference paradigm. Journal of Experimental Psychology. Learning, Memory, and Cognition, 33(3), 503–535. https://doi.org/10.1037/0278-7393.33.3.503

Roelofs, A. (2018). A unified computational account of cumulative semantic, semantic blocking, and semantic distractor effects in picture naming. Cognition, 172, 59-72. https://doi.org/10.1016/j.cognition.2017.12.007