Experimental manipulations of production effort: Methodological challenges in studying communicative efficiency

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Language has been argued to be *efficient* across many domains (e.g. Zipf, 1949; Gibson et al., 2019; Kemp et al., 2018; Hawkins, 2004; Meylan & Griffiths, 2024; Piantadosi et al., 2011; Xu et al., 2020; Zaslavsky et al., 2018; Mollica et al., 2021): languages are characterised by properties that strike an optimal balance between competing pressures. Among these are two pressures at work during real-time communication: minimising production effort, and maximising recoverability of the intended message in comprehension.

One common approach to studying the trade-off between these pressures is the use of experimental communication games (Müller & Raviv, 2025). Typically, two variables are manipulated in these tasks: the effort required to produce different linguistic signals, and the amount of ambiguity associated with those signals. The idea is to uncover the conditions under which participants develop efficient communication systems — using a less effortful option whenever they can, and a more effortful option only when they really need to (e.g. when the low-effort option would be ambiguous and likely lead to failed communication).

But how — in a relatively short, artificial, and highly idealised experimental setting — can researchers most effectively simulate the articulatory and cognitive effort involved in real language production? Here, we point out that this seems not to be easy: a review of methodologies suggests that the effects of effort manipulations may be somewhat unstable, with not all effort manipulations producing the intended outcome of penalising high-effort options.

While effort in natural spoken, signed or written language involves more physical movement (e.g. of the motor articulators in speech) and/or cognitive processing (e.g. lexical retrieval), in the experiments we are aware of, the operationalisation of "effort" generally comes down to the amount of time it takes to produce a signal. For example, Kanwal et al. (2017a, 2017b) had participants choose between a 3-letter and a 7-letter word, and then click-and-hold for 1200ms per letter to send their chosen word to a partner. Similarly, Tal et al. (2023) required multiple clicks to send longer signals (one click per character), but there was *also* an

enforced 3000ms pause between each click. Both of these methods were effective in incentivising participants (adults in the former, children aged 4–9 in the latter) to avoid expending extra effort when it was not required: participants tended to develop efficient communication systems, whereby they reserved more "effortful" (i.e. slower to send) signals for contexts where a less effortful option would be too ambiguous.

However, the efficacy of these paradigms might depend more on the *waiting* time than on the total time to transmit a message. Simply ramping up the number of clicks required to send certain signals intuitively feels functionally equivalent — and indeed, closer to the instantiation of effort in natural communication — but the only (unpublished) studies we are aware of using this method find no or limited evidence for effort avoidance (Tong, 2022; Clarke, 2023). It is also not clear that the click-and-hold method works consistently: Koshevoy et al. (2024) found that participants were equally likely to use long or short words, even when the waiting time to produce a long word was four times longer than for a short word (although this may have been because participants were insensitive to a different aspect of the experimental manipulation). Other, more indirect methods of making certain signals slower to produce — such as making their component parts harder to find or more error prone — seem to prompt some effort minimisation, but as long as the extra time is still spent doing *something* (e.g. hunting for the correct button in an array), this tendency appears too weak to reliably give rise to efficient communication systems (Keogh et al., 2026).

These inconsistent effects might suggest that effort manipulations are not particularly robust or reliable, or they may reflect a tendency for participants in explicitly communicative tasks to place more weight on accuracy than on minimising effort expenditure. Consistent with this, in non-communicative tasks, it seems that even very subtle manipulations (e.g. one additional button to click, or one additional syllable to pronounce in oral production) might be sufficient to prompt efficient production strategies (Fedzechkina et al., 2012, 2017; Fedzechkina & Jaeger, 2020; Kurumada & Grimm, 2019). It is also possible that more naturalistic tasks like oral production — or free-typing (Smith & Culbertson, 2025) — are simply more effective than forced choice or button-clicking tasks in this domain.

Overall, it seems that experimental manipulations of production effort are rather tricky to calibrate, and may be somewhat context-dependent. Therefore, to provide future researchers with a more thorough picture of what works and under what circumstances, there is a pressing need to systematically test the space of possible design choices e.g. number of clicks vs. enforced waiting, communicative interaction vs. non-communicative recall, forced choice vs. free production. Given the ubiquity of communication games as models of language evolution, improving methodology in this area is critical for theory building; poorly calibrated effort manipulations risk biasing conclusions about how and why languages come to be so efficient.

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