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# A Writing Aid for Synchronous Binary Access Methods (Like Some BCIs)

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*Introduction:* A BCI may produce above-chance performance in the lab, but harnessing it for free spelling is a challenge on quite another level—often practically impossible, unless accuracy is very high. The *Once For Yes* spelling app is designed to narrow this gap. It is optimized for binary access methods in which "yes" and "no" responses are (a) equally difficult or time-consuming for the user to produce, (b) synchronous, and (c) potentially noisy.
*Material, Methods and Results:* A letter- and word-prediction model runs on the user's computer. An interface app runs on a communication partner's mobile device. The two communicate securely via an Internet server. The system is designed to keep a human communication partner in the loop. The partner stays face-to-face with the user, judges when they are ready to be asked a question, reads out the question, cues the user to answer, and can even (optionally, depending on the access method) key in the answer. This approach avoids the Midas-touch and on-off problems, maximizes compatibility, and fosters social contact. Meanwhile, the language model assists the partner by supplying optimal questions, which may offer a candidate set of letters, a final choice of letter, or a word completion—in all cases, aiming to maximize information gain by making "yes" and "no" equiprobable given the preceding text. Optionally, the letter-prediction model can be discarded and a familiar row/column letter-board can be encoded via the same question/answer interface, although this makes information gain very suboptimal and is much less robust to noise in the user's yes/no response, as the simulation results of Fig. 1 show.

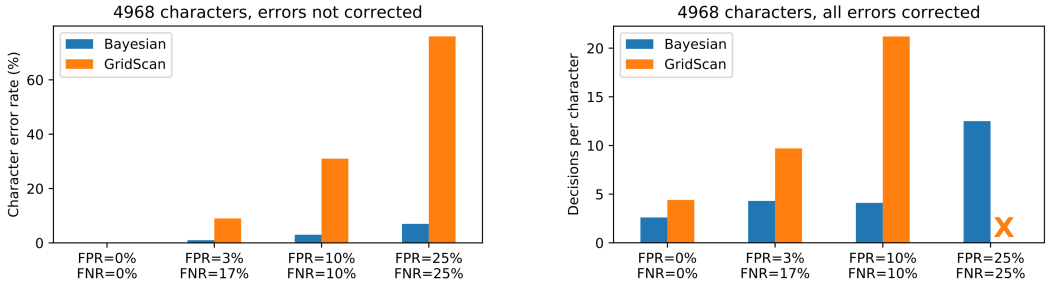


*Figure 1. Simulated copy-spelling of the first 9 paragraphs of "To Kill A Mockingbird" using binary access methods with four different combinations of false positive rate.(FPR) and false negative rate (FNR). The Bayesian variant aims to maximize the information gain at each yes/no decision, whereas the GridScan method encodes the row/column selections of a static letter-board without letter prediction (both variants offer word completions where appropriate). Grid scanning is much more sensitive to noise in the access method, both in terms of character error rate when errors are left uncorrected (left panel) and the average number of decisions necessary per character when errors must be corrected (right panel). When the access method is only 75% accurate, grid-scanning produces errors more frequently than it can correct (marked X).*

*Discussion:* An adaptive information-maximizing binary speller is much more robust, and requires fewer items to be held and manipulated in working memory, than grid scanning. It may however be perceived as more "complicated" simply because its format is unfamiliar. The relative cognitive load of the two modes remains to be quantified. The adaptive approach is likely to be *less* suitable than scanning if the user's "no" signal is merely the absence of a response and their "yes" response can be produced asynchronously with precise timing.
*Significance:* This approach may bring free spelling within reach of BCI users (and other AAC users) whose access methods have hitherto been too noisy.
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