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Designs for no-control functionality using dynamic stopping algorithms as gatekeepers in P300 BCIs

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Introduction: The ability to communicate only when intended is vital, but brain-computer interface (BCI) no-control performance is understudied. Dynamic stopping methods designed to improve the speed of event-related potential (ERP) BCI designs can also function as gatekeeper algorithms to enable no-control performance [1]. Conceptually, a dynamic stopping algorithm stops presenting stimuli when it finds the available information sufficient for an accurate decision. However, it may still produce an output, even if of questionable accuracy, when the pre-determined maximum sequences of stimuli are complete. Asynchronous BCIs may use separate control-state algorithms to decide if the user is attempting BCI use. Such control-state algorithms act as gatekeepers to determine whether the BCI types. However, there are several designs that enable the dynamic stopping algorithm to also function as a gatekeeper and produce asynchronous BCI function for P300 BCI designs.

Methods and Results: A P300 BCI speller is designed around classifying the brain response to each presented stimulus as indicating a target or non-target. A **sequence** contains one presentation of each stimulus. Stimuli are usually groups of keys (originally rows and columns). In the original design [2], the key at the intersection of the row and column with the highest average classification scores was selected after a fixed number of sequences. We define additional concepts: The **Decision Window** is the group of sequences used to make a selection, which can have a ***fixed*** duration (original P300 BCI) or a ***variable*** duration (dynamic stopping) with minimum and maximum numbers of sequences. If the duration is variable, a **Gatekeeper** algorithm is needed with **Gatekeeper Criteria** that must be met for a selection to be made. The **Decision Type** governs what happens at the end of the decision window. A ***forced*** decision type selects the key with the highest score, regardless of whether it met the gatekeeper criteria. A ***forced-abstention*** decision type produces an ***explicit abstention*** output if no key passes the gatekeeper criteria. After a forced or forced-abstention decision, a new decision window is started. However, a ***sliding*** decision type discards the oldest sequence in the decision window and appends a new sequence without pausing the stimulus presentations (an ***implicit abstention***).

Decision window width, decision type, and gatekeeper criteria affect performance (Fig. 1). Forced decisions produce more errors but are less sensitive to optimal gatekeeper criteria than forced-abstention decisions, which can frustrate users by repeated failures to select a key. Sliding windows can appear to get stuck and make no selections if gatekeeper criteria are too stringent. However, sliding windows can also be both responsive during intended typing and robust during no-control. During intended typing, the decision window restarts after each selection, supporting rapid typing. But once the decision window is filled with no-control sequences, no-control performance is relatively robust.

Conclusion: Dynamic stopping algorithms used as gatekeepers can provide both rapid selections and robust no-control performance. On-line testing will quantify benefits and optimize gatekeeper criteria.

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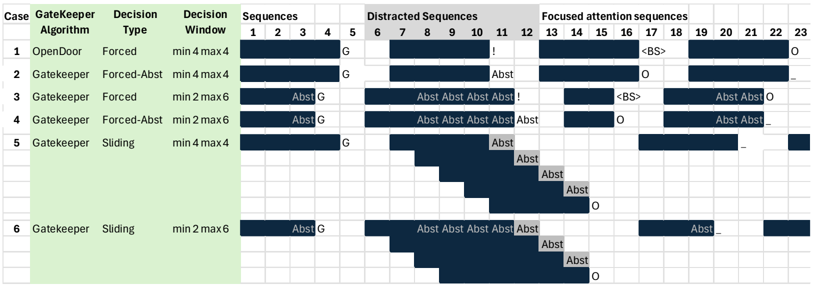

*Figure 1: Six examples of the effects of different combinations **of gatekeeper algorithm, decision type,** and **decision window** duration. Explicit (Abst) and implicit abstentions (Abst or Abst) enable no-control performance instead of errors during distractions (sequences 6-12).*

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