Mouse Tracking to Explore Motor Inhibition Processes in Go/No-Go and Stop Signal Tasks

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OBJECTIVES

Response inhibition relies on reactive and proactive mechanisms that exert a synergic control on actions[1]. In studies on inhibitory control, responses are usually recorded by a key-press method. However, the analysis of discrete variables (present or absent response) could be insufficient to capture dynamic features of response inhibition[2].

In the present study a mouse-tracking procedure was used to continuously register and evaluate the movement profiles related to proactive and reactive inhibition, by comparing the performance in a cued Go/No-Go (GNG) and a Stop Signal Task (SST). The cued GNG mainly involves proactive control whereas the reactive component is mainly engaged in the SST[3].

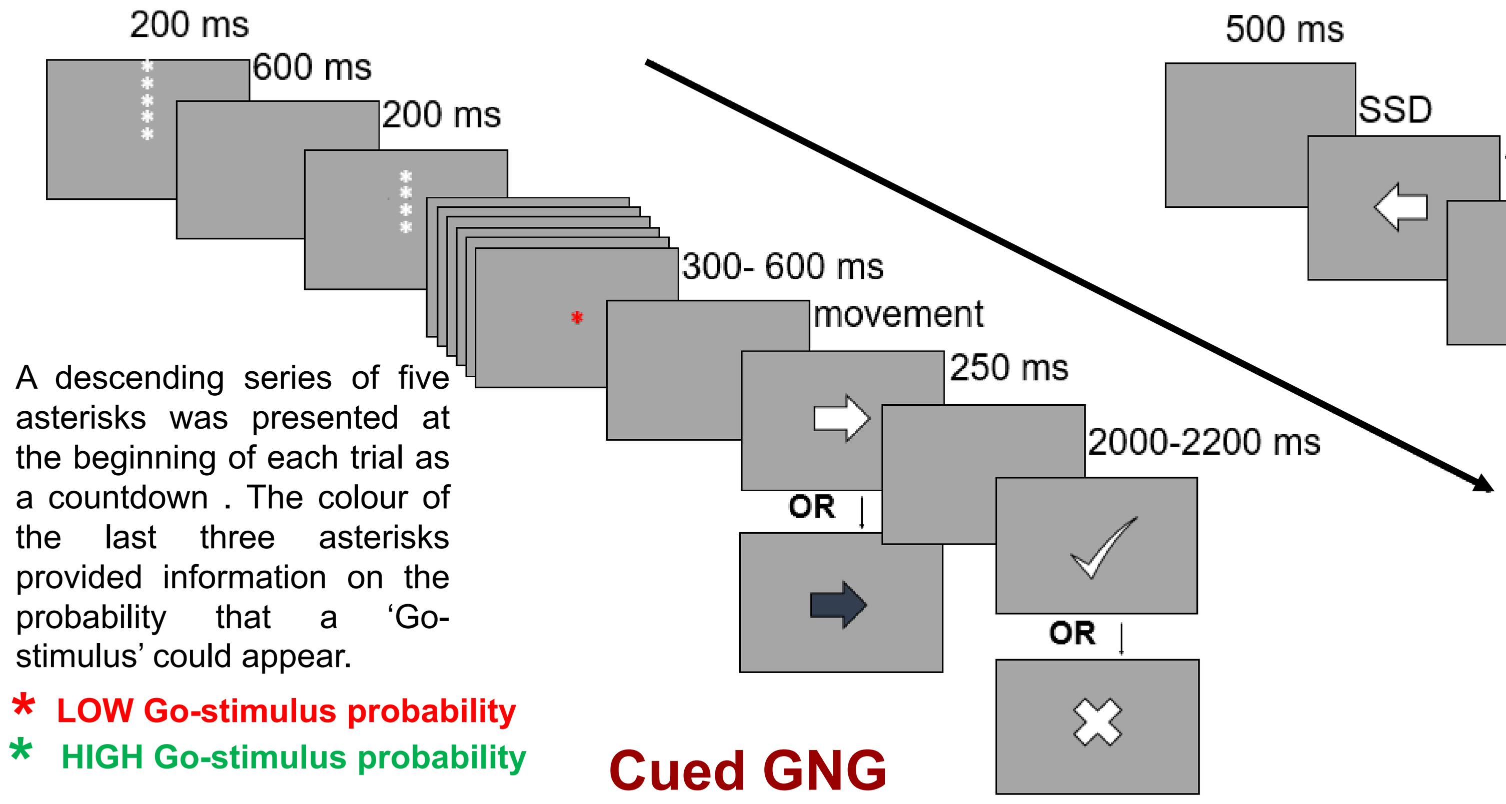
WE HYPOTHESIZE THAT DIFFERENT MOVEMENT PROFILES COULD BE ASSOCIATED WITH INHIBITORY FAILURES IN THESE EXPERIMENTAL PARADIGMS, REFLECTING THE INFLUENCE OF PROACTIVE AND REACTIVE MECHANISMS ON MOTOR PREPARATION AND EXECUTION.

METHODS

- **Subjects:** 53 participants (37 women; mean age 24 years; range 18–40)
- **Procedure:** Participants performed a **Cued GNG** (consisting of two conditions: high vs. low Go-stimulus occurence probability) and a **SST**. Subjects performance was recorded by a **mouse tracking system**. Velocity profiles were extracted from mouse trajectories, classified as one-shot or non one-shot.
- **Mouse tracking set-up**: A mouse device (230 DPI, 500 Hz polling rate, KEY IDEA G10S) positioned in the centre of a rectangular board. In the Go-conditions, subjects were instructed to move the mouse as quickly and accurately as possible in the direction indicated by the Go-stimulus (i.e., white arrow indicating left or right) until they reached a set barrier, bumping against it (sponge material, in yellow). In the No-go/Stop conditions (blue arrow) they were requested to suppress the response.

Stimuli were presented on a monitor positioned in front of participants. The centre of the board was positioned slightly on the right with respect to the monitor centre for a correct position of shoulder joint, arm and hand; in order to allow an equally comfortable mouse movement to both right and left directions.

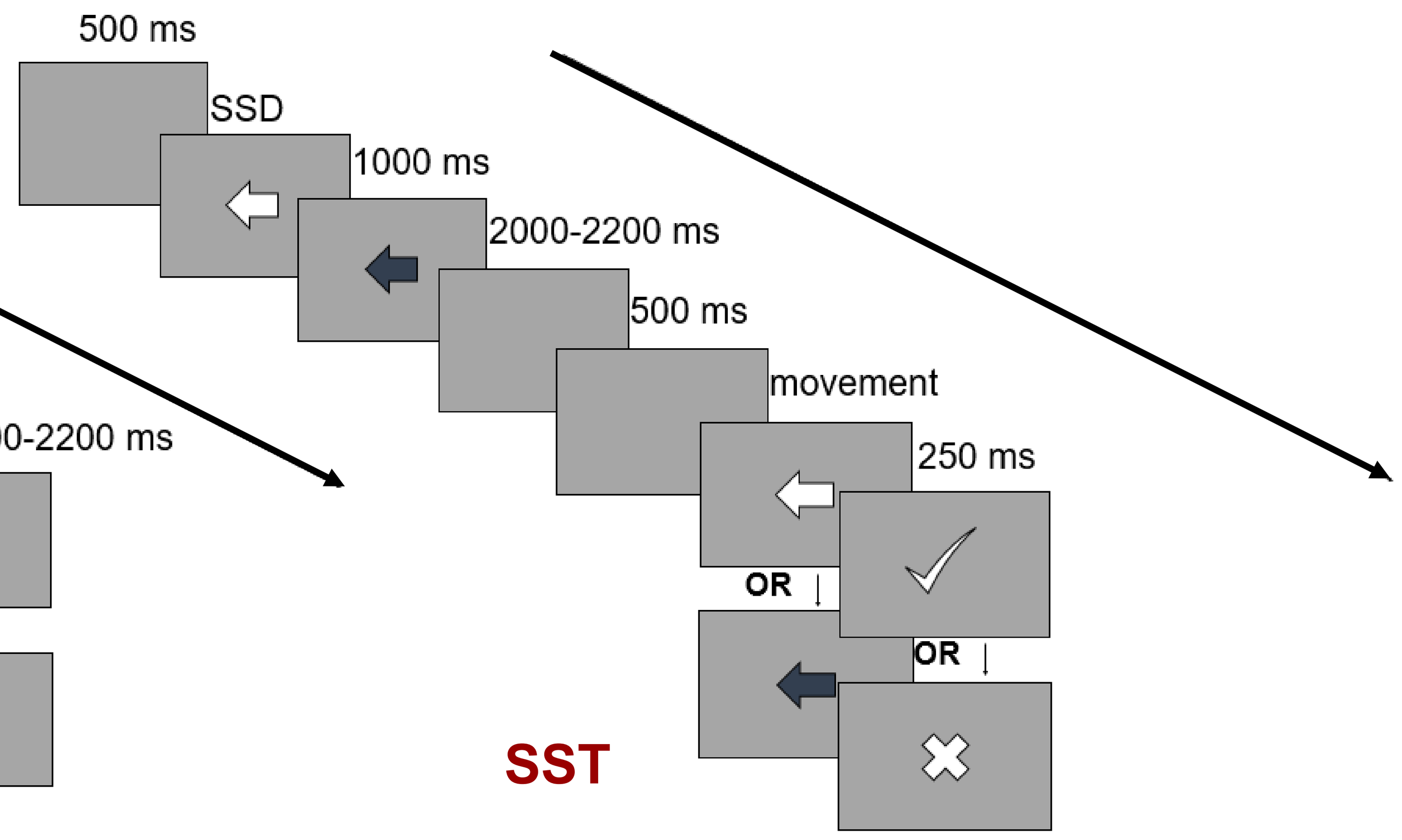
- **Experimental paradigms:**



A descending series of five asterisks was presented at the beginning of each trial as a countdown . The colour of the last three asterisks provided information on the probability that a 'Go-stimulus' could appear.

* LOW Go-stimulus probability
* HIGH Go-stimulus probability

Cued GNG

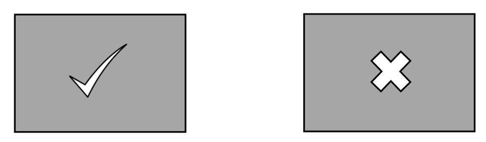


SST

Targets

Go-stimulus | No-go/Stop stimulus

Feedback on response speed



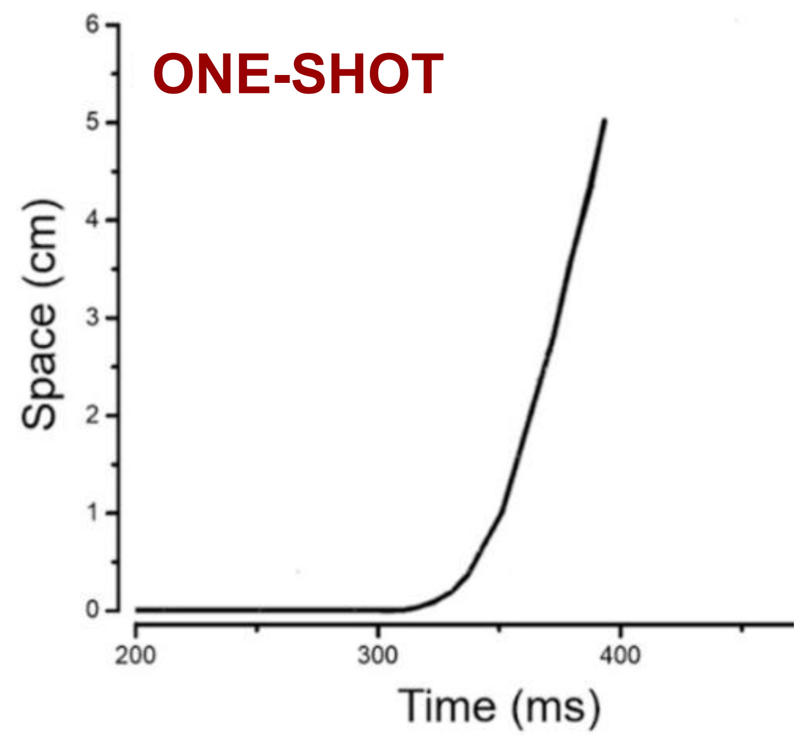
Sufficient speed | Slow, speed up

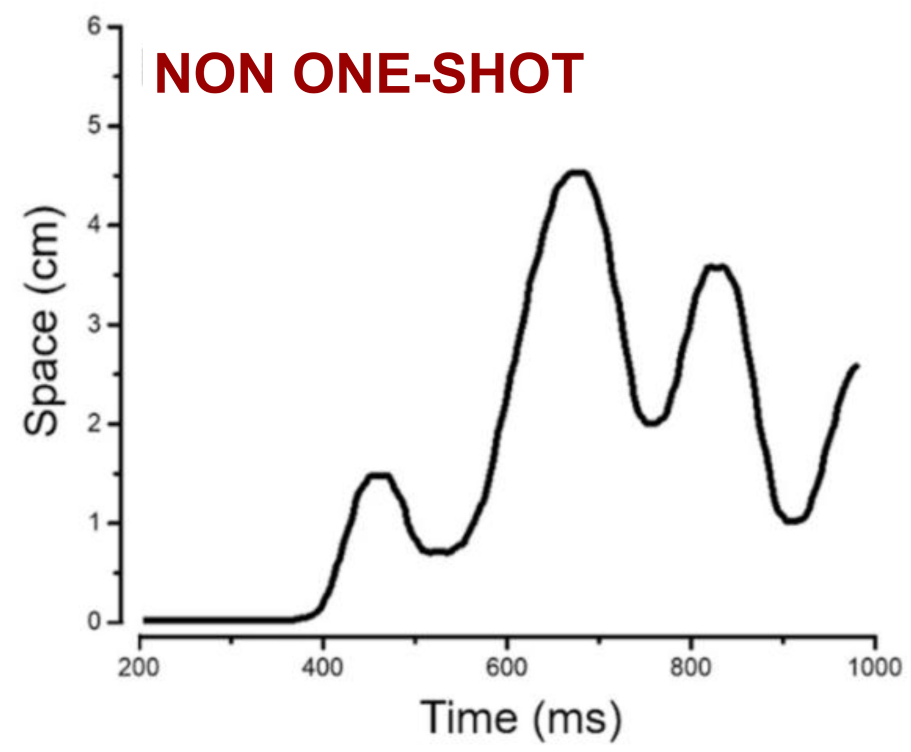
Feedback on response speed was given after a Go trial in order to limit the slowing tendency which can be adopted as a strategy to improve accuracy. The maximum response time after which the negative feedback was provided was the mean response time obtained at a simple CRT (attended before main protocol) minus one standard deviation. This procedure allowed a stringent but realistic time threshold reflecting individual differences in processing and response speed.

- **Movements profile:** Velocity profiles were extrapolated from mouse trajectories both for responses obtained in the **Go-conditions** and **for inhibitory failures**. Movements were classified as **one-shot** or **non-one-shot** on the basis of their velocity profile.

One-shot movement profile consists of a steep slope without any peaks that reflects a smooth movement without motor command alteration[4], as presented on the displacement-time graph on the left.

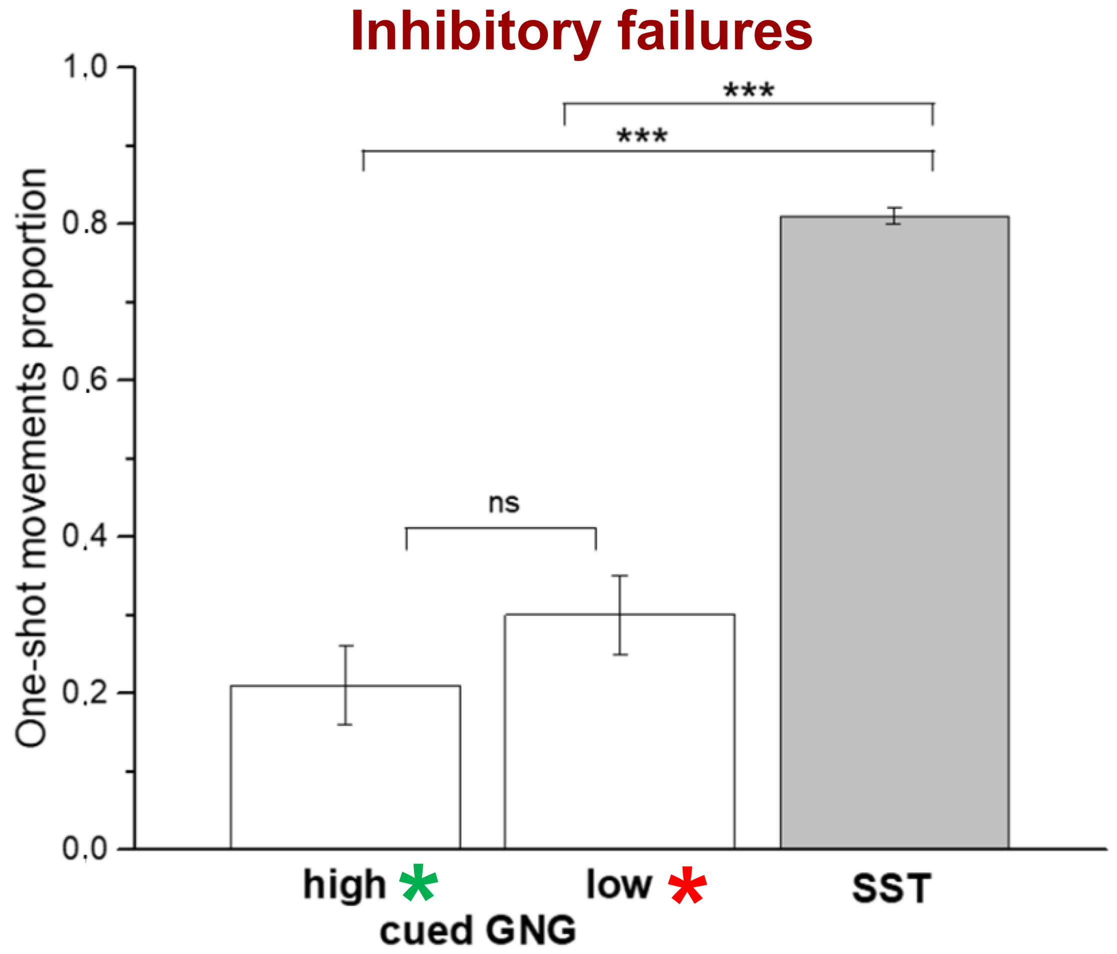
Non one-shot movement profile consists of a multi-peaked velocity profile reflecting motor command alteration[5], as presented on the displacement-time graph on the right.





RESULTS

A significantly higher percentage of one-shot movements was found in the SST (81±9%) compared to both conditions of the GNG (high condition: 21±34%, low condition: 30±33%) when subjects failed to inhibit responses ($p<0.001$), with consequently higher non-one-shot profiles proportion in the GNG. Conversely, no differences in responses profiles emerged between tasks for Go-conditions.



DISCUSSION

When the inhibitory mechanisms engaged were mainly reactive (as in the SST), trajectory corrections to the initial motor plan observed for inhibitory failures were less frequent compared to the cued GNG. In contrast, the opposite trend emerged when the inhibitory demand was mainly proactive (as in the cued GNG).

SMOOTH TRAJECTORIES OBSERVED IN RAPID MOVEMENTS CLASSIFIED AS ONE-SHOT SUGGEST THAT THE INFLUENCE OF INHIBITORY CONTROL PROCESSES ON MOTOR PLAN MAY BE ABSENT OR MARGINAL. WE HYPOTHESIZED THAT PROACTIVE CONTROL MAY BE RESPONSIBLE FOR UNSMOOTH PROFILES IN INHIBITION FAILURES, SUPPORTING A DIFFERENTIATION BETWEEN THESE TASKS.

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