Stop-Signal Task (SST)

(Logan et al., 1997; Verbruggen et al., 2008; Verbruggen et al., 2019)

Description: The stop-signal paradigm is a useful tool for investigating response inhibition (for a review, see Verbruggen & Logan, 2008). Participants perform a go task (e.g., press left when a left pointing arrow appears/right when a right pointing arrow appears). A stop-signal appears on a minority of trials. This is when a cross replaces the arrow after a variable stop-signal delay (SSD), which signals to the participant not to press left/right (i.e., suppress the go response). STOP-IT is a free program developed by Gordon Logan, Frederick Verbruggen, and Michael Stevens (Verbruggen, Logan, & Stevens, 2008) for running the stop-signal task (SST). Furthermore, the International Society for Research on Impulsivity has found the SST to be superior to other measures of impulsive action, such as Go/No-Go (GNG) and continuous performance testing (CPT), as the SST is the only measure with strong internal, external, and discriminant validity, and reliability (Hamilton et al., 2015). Moreover, it is difficult to determine the effect of experimental manipulation on the GNG (Winstanley, 2011).

NOTE on different versions of the stop-signal task: We have two versions of the task: (1) the new jsPsych version of STOP-IT (All non-Brown/future data at MGH will be with jsPsych) and (2) the original Tscope version of STOP-IT (ALL Brown data with Tscope). Each of these versions is scored differently. For the new jsPsych and original Tscope STOP-IT versions we can use two different versions of ANALYZE-IT, a program provided by the developers of STOP-IT to compute all the variables we need for each participant. For the purposes of simplicity, Hannah Lawrence already scored the original version of the task. Thus, the scoring instructions below are ONLY for scoring the new jsPsych version of STOP-IT.

NOTE on modification to jsPsych version of the task: We made minor adjustments to the jsPsych version of STOP-IT for the studies in our lab. For full changes see "Steps for editing the jsPsych STOP-IT.docx". In the ID we added wave and pre/post. We made pre and post versions of the task where they differ only in the post has 1 practice trial. Refer to document for study specific changes based on number and spacing of waves.

NOTE on combining versions of the stop-signal task: In email communication between Hannah Lawrence and Frederick Verbruggen (developer of STOP-IT), he confirmed that computed DVs **can** be combined across task versions, but raw data **cannot** be combined across task versions. He wrote, "There are some differences in between the Tscope version and the jsPsych version of the stop task (most importantly, auditory vs. visual stop signals), so I suggest you include task version as an additional factor in your analyses if you pool the data (just to make sure that the version does not interact with any variables of interest)."

NOTE on what Hannah Lawrence did to analyze the original Tscope version of task: To analyze original Tscope version of STOP-IT Hannah used corresponding ANALYZE-IT software (https://github.com/fredvbrug/STOP-IT/blob/master/Tscope_version/README-ANALYZE-IT-Tscope.md). There are two versions of the TAILS Tscope version- one with 4 blocks and one with three blocks. In email communication between Hannah Lawrence and Frederick Verbruggen (developer of STOP-IT), he recommended using the four-block version as "our simulations have shown that the estimates will become less reliable [with the three-block

version]. For group-based comparisons, the small difference may not matter much (but it will if you are interested in e.g. individual differences).” Given this information, the four-block version of Tscope should be used as the default. The jsPsych version by default has four blocks.

To process NEW jsPsych STOP-IT data:

A. Process data in ANALYZE-IT

Here are the instructions to process the new, jsPsych STOP-IT version. These instructions come from: https://github.com/fredvbrug/STOP-IT/blob/master/jsPsych_version/README-ANALYZE-IT-JS.md

1. Install R
    a. If PC: https://cran.r-project.org/bin/windows/
    b. If Mac: https://cran.r-project.org/bin/macosx/
2. Install R Studio Desktop on computer (https://www.rstudio.com/products/rstudio/)
3. Open R Studio
4. In the console of R Studio, copy and paste: **install.packages('shiny')**
5. Click Run button (top right on a Mac) or press Ctrl + Enter to run that line of script
    a. A bunch of red text should appear in console as package is downloaded. If this doesn’t happen, it means the package is not installed (make sure you actually ran script and didn’t just press enter).
6. Restart R Studio (close out and open again)
    a. Note: you will only have to do steps 1- 6 once. Once that is taken care of you can always start in step 7.

In the R Studio console, copy and paste: **shiny::runGitHub('STOP-IT', 'fredvbrug', launch.browser = TRUE, subdir = 'jsPsych_version')**

    b. Click Run button (top right on a mac) or press Ctrl + Enter to run that line of script
    c. This will open a local version of the ANALYZE-IT app in the default web browser. You will now be working in that web browser not R Studio.
7. Provide the required input.
    a. Under “Upload the data” browse and select the data files that should be processed. Multiple data files can be selected at once or you can do one at a time. Upload excel or csv files.
    b. Click on the 'process data' button to process the selected data files.
    c. Download table with individual data. This will give you a complete dataset with all possible DVs.

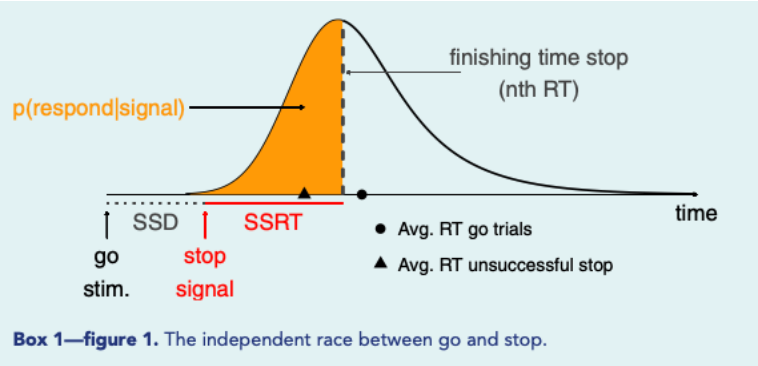
Scoring:

There are 11 possible dependent variables produced by the ANALYZE-IT software:

- presp = p(respond|signal) = probability of responding on a stop trial. P(respond|signal) is also used to determine SSRT.

- ssd = stop-signal delay = the average delay between the presentation of the go stimulus and the stop-signal (in ms)
- ssrt = stop-signal reaction time = how long does it (on average) take to stop a response (in ms)?
- usRT = RT on unsuccessful stop trials (in ms)
- goRT_all = reaction time (RT) on go trials with a response (in ms). This includes choice errors.
- goRT_correct = reaction time (RT) on go trials with a correct response (in ms). Choice errors are excluded.
- goRT_sd = intra-subject variability in response latencies (including all go trials with a response)
- go_omission = proportion of go trials without a response
- go_error = proportion of incorrect responses on go trials with a response (e.g. the go stimulus required a left response but a right response was executed).
- go_premature = proportion of premature responses on go trials (i.e. responses executed before the presentation of the go stimulus)
- Nstop = number of stop trials included in the analyses
- NGo = number of go trials included in the analyses.

B. (If permanently saving) Move ANALYZE-IT data file to Study folder on the server
C. Import ANALYZE-IT data file to SPSS
D. Run SPSS Syntax (SST Syntax.sps)
    a. This will produce all of the variables below as well as test the independent race model and produce a variable that indicates whether it is violated for individual participants



Box 1—figure 1. The independent race between go and stop.

From Verbruggen et al., 2019

Primary DV: SSRT (stop-signal reaction time), a measure of covert latency of response inhibition. Higher SSRT scores reflect greater impulsivity.

SST_SSRT = stop-signal reaction time

Verbruggen et al., 2019 also recommend reporting the following as descriptives:

SST_ go_omission = Probability of go omissions (no response)

SST_ go_error = Probability of choice errors on go trials
SST_ goRT_all = RT on go trials
SST_ goRT_sd = intra-subject variability in response latencies (including all go trials with a response)
SST_ presp = Probability of responding on a stop trial
SST_ ssd = Average stop-signal delay
SST_ usRT = RT of go responses on unsuccessful stop trials

Reliability: NA, see descriptives to report below

Exclusion criteria: If the independent race model is violated, SSRT estimates become unreliable (Band et al., 2003) and should not be interpreted. To check, compare mean RT on unsuccessful stop trials (SST_ usRT) with mean RT on go trials (SST_ goRT_all) for each participant. If SST_ usRT > SST_ goRT_all then SSRT should not be estimated and that case should be excluded.

Time points: Participants complete the SST at three time points (bl, m6, m12). This is under the variable "wave". In studies where participants complete this task twice at baseline, this is labelled in a separate variable "prepost".

Box 3. Check-lists for reporting stop-signal studies

The description of every stop-signal study should include the following information:

- Stimuli and materials
  - Properties of the go stimuli, responses, and their mapping
  - Properties of the stop signal
  - Equipment used for testing
- The procedure
  - The number of blocks (including practice blocks)
  - The number of go and stop trials per block
  - Detailed description of the randomization (e.g. is the order of go and stop trials fully randomized or pseudo-randomized?)
  - Detailed description of the tracking procedure (including start value, step size, minimum and maximum value) or the range and proportion of fixed stop-signal delays.
  - Timing of all events. This can include intertrial intervals, fixation intervals (if applicable), stimulus-presentation times, maximum response latency (and whether a trial is terminated when a response is executed or not), feedback duration (in case immediate feedback is presented), etc.
  - A summary of the instructions given to the participant, and any feedback-related information (full instructions can be reported in Supplementary Materials).
  - Information about training procedures (e.g. in case of animal studies)
- The analyses
  - Which trials were included when analyzing go and stop performance
  - Which SSRT estimation method was used (see Materials and methods), providing additional details on the exact approach (e.g. whether or not go omissions were replaced; how go and stop trials with a choice errors–e.g. left response for right arrows–were handled; how the nth quantile was estimated; etc.)
  - Which statistical tests were used for inferential statistics

Stop-signal studies should also report the following descriptive statistics for each group and condition separately (see Appendix 4 for a description of all labels):

- Probability of go omissions (no response)
- Probability of choice errors on go trials
- RT on go trials (mean or median). We recommend to report intra-subject variability as well (especially for clinical studies).
- Probability of responding on a stop trial (for each SSD when fixed delays are used)
- Average stop-signal delay (when the tracking procedure is used); depending on the set-up, it is advisable to report (and use) the 'real' SSDs (e.g. for visual stimuli, the requested SSD may not always correspond to the real SSD due to screen constraints).
- Stop-signal reaction time
- RT of go responses on unsuccessful stop trials

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From Verbruggen et al., 2019

References:

Verbruggen, F., Aron, A. R., Band, G. P., Beste, C., Bissett, P. G., Brockett, A. T., ... & Boehler, C. N. (2019). A consensus guide to capturing the ability to inhibit actions and impulsive behaviors in the stop-signal task. *elife*, *8*, e46323.

Verbruggen, F., Logan, G. D., & Stevens, M. A. (2008). STOP-IT: Windows executable software for the stop-signal paradigm. Behavior Research Methods, 40(2), 479–483. https://doi.org/10.3758/BRM.40.2.479