Comprehensive Explanation of the Integration Method for SSRT Estimation

1 Introduction

The integration method is a widely used technique for estimating Stop-Signal Reaction Time (SSRT) in the stop-signal paradigm. This document provides a detailed explanation of the method, its theoretical underpinnings, mathematical formulation, implementation, and interpretation.

2 Theoretical Background

2.1 The Stop-Signal Paradigm

The stop-signal paradigm is an experimental design used to study response inhibition. It consists of two types of trials:

- Go trials: Participants respond to a stimulus as quickly as possible.
- Stop trials: A stop signal appears after the go stimulus, instructing participants to withhold their response.

2.2 The Race Model

The integration method is based on the race model of response inhibition (Logan & Cowan, 1984). This model posits that:

- The go process and stop process are independent.
- These processes race against each other.
- The process that finishes first determines the behavioral outcome.

2.3 Key Concepts

- Go Reaction Time (Go RT): Time taken to respond on go trials.
- Stop-Signal Delay (SSD): Time between the go stimulus and the stop signal.
- SSRT: Time taken to inhibit a response after the stop signal appears.

3 Mathematical Formulation

3.1 Basic Principle

The integration method assumes that the finishing time of the stop process bisects the go RT distribution at a point corresponding to the probability of responding on stop trials.

3.2 Key Equations

$$p(\text{respond}|\text{signal}) = \frac{\text{number of responses on stop trials}}{\text{total number of stop trials}} \tag{1}$$

$$n = \text{round}(N_{\text{go}} \times p(\text{respond}|\text{signal})) \tag{2}$$

$$\text{SSRT} = \text{nth Go RT} - \text{SSD} \tag{3}$$

Where:

- $p(\text{respond}|\text{signal})$ is the probability of responding on stop trials
- N_{go} is the number of go trials
- n is the rank of the RT in the go RT distribution
- nth Go RT is the Go RT at the nth position in the sorted Go RT distribution

4 Implementation

4.1 Algorithm

4.2 Step-by-Step Explanation

1. Separate go trials and stop trials from the dataset.
2. For each unique SSD:
   (a) Calculate $p(\text{respond}|\text{signal})$ for that SSD.
   (b) Determine the nth position in the go RT distribution.
   (c) Find the nth go RT in the sorted go RT distribution.
   (d) Calculate SSRT by subtracting the SSD from the nth go RT.
3. Average the SSRT estimates across all SSDs to get a single SSRT estimate.

Algorithm 1 Integration Method for SSRT Estimation

procedure EstimateSSRT(goRTs, stopTrials)
    ssrts ← []
    for each unique SSD in stopTrials **do**
        $p_{\text{respond}} \leftarrow \text{mean}(\text{stopTrials[SSD].Response} \neq 0)$
        if $0 < p_{\text{respond}} < 1$ **then**
            $n \leftarrow \text{round}(\text{length}(\text{goRTs}) \times p_{\text{respond}})$
            $n \leftarrow \max(0, \min(n, \text{length}(\text{goRTs}) - 1))$
            nthGoRT ← sort(goRTs)[n]
            ssrt ← nthGoRT − SSD
            ssrts.append(ssrt)
        end if
    end for
    return mean(ssrts)
end procedure

5 Considerations and Interpretations

5.1 Advantages

- Accounts for the entire distribution of go RTs, not just the mean.
- Relatively robust to violations of race model assumptions.
- Provides SSRT estimates for each SSD, allowing checks of SSRT independence from SSD.

5.2 Limitations

- Assumes a constant SSRT across trials.
- Can be sensitive to the number of stop trials at each SSD.
- May not perform well if p(respond|signal) is very low or very high.

5.3 Interpretation of Results

- Shorter SSRT indicates more efficient inhibitory control.
- Longer SSRT suggests less efficient inhibitory control.
- SSRT should be interpreted in the context of go RT and p(respond|signal).

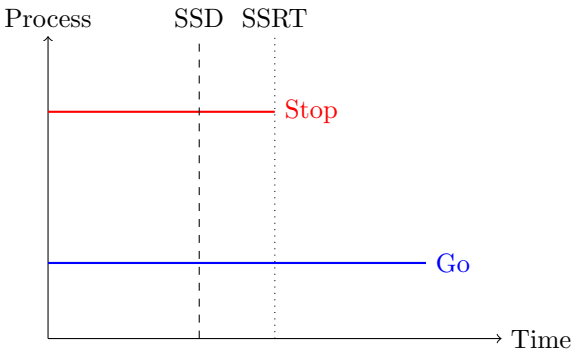

Figure 1: Conceptual diagram of the race model

6 Visualizations

6.1 Conceptual Diagram of the Race Model

6.2 Illustration of Integration Method

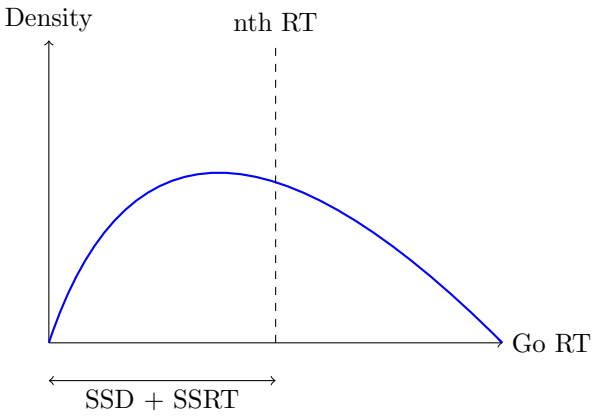

Figure 2: Illustration of the integration method

7 Conclusion

The integration method provides a robust way to estimate SSRT in the stop-signal paradigm. By accounting for the entire distribution of go RTs and the probability of responding on stop trials, it offers a more comprehensive measure of inhibitory control than simpler methods. However, researchers should

be aware of its assumptions and limitations when applying this method and interpreting its results.