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**Estimating Reliability of the Self-Associative Learning Task as a Measure of Self-Prioritization Effect: Re-analyses of a Longitudinal Dataset**

Zheng Liu 1, Yuanrui Zheng2, Jie Sui3\*, Hu Chuan-Peng 1\*

1 School of Psychology, Nanjing Normal University, Nanjing, China

2 School of Education, Kunming City College, Kunming, China

3 School of Psychology, University of Aberdeen, Old Aberdeen, Scotland

\* Corresponding authors: Hu Chuan-Peng ([hu.chuan-peng@nnu.edu.cn](mailto:hu.chuan-peng@nnu.edu.cn))

# **Abstract**

In recent years, the self-associative learning task (SALT) has provided an effective means to study the regulation of self-related information in individual cognitive processing. However, psychometric properties of the self-associative learning paradigm outcomes have been scarcely reported. Also, in tasks simple as SALT, there are multiple ways to quantify the self-prioritisation effect, such as reaction-time based indices and accuracy-based indices. Thus, it remains unknown (1) whether these indices reliably captures the self-prioritisation effect,and if yes, (2) which indices/index is the most reliable one in group-level and individual-level? In order to fill this gap, we plan to re-analyzed a longitudinal dataset collected in 2016, where 34 healthy volunteers were tested in the self-associative learning task in six sessions (separated by one week). We plan to adopt intraclass correlations and multilevel modelling analysis to achieve an in-depth examination of test-retest reliability as well as practice effect in SALT if one exists. The present study will provide valuable information on SALT for further studies, for example, laying the ground for the future uses of SALT in research, clinical usage, and personal performance monitoring.

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# **Introduction**

Self-biases have been shown to be systematic across cognitive domains such as perception, attention, memory, and decision making (Cunningham & Turk, 2017; Desebrock et al., 2018; Sui & Humphreys, 2013). The **self-prioritization effect (SPE)** has long been established as a phenomenon in which people have superior remembrance for information encoded in regard to themselves compared to information encoded in reference to others (Rogers et al., 1977; Symons & Johnson, 1997). People's self-concept is so fundamental that pairing an arbitrary stimulus with it can quickly become salient and influence perception (Humphreys & Sui, 2015; Sui et al., 2015).

Various tests have been administrated to measure the self-prioritization effect, such as the trait-adjectives paradigm (Craik & Tulving, 1975; Rogers et al., 1977), attentional blink paradigm (Shapiro et al., 1997), the ownership task (Cunningham et al., 2008)(see a review on Amodeo et al. (2021)). However, over-learned self-related stimuli, such as the participant's own name or face, are frequently used in research that investigates self-biases in cognition. As a result, it's hard to tell whether such stimuli are processed more quickly because they're associated with the self or because they're more familiar to participants. In recent years, the **self-associative learning task (SALT)** devised by Sui and colleagues has provided an efficient approach to studying the regulation of self-related information in the individual cognitive processing while managed to get around the confound of stimuli familiarity (Sui et al., 2012). The task also rules out the possibility that the SPE is due to a familiarity effect, concreteness, frequency, or length of the words employed. In the task, participants would first learn to associate three geometrical shapes (e.g., triangle, square, and circle) with three different labels (e.g., "You," "friend," and "stranger"). Participants then need to decide whether the following shape-label pairings were appropriately matched or not based on the previously learned relationship in a second stage. Typically, a prominent self-prioritization effect was found with shorter response time, better accuracy and higher sensitivity scores for self-shapes than those of friend and stranger (Schäfer & Frings, 2019; Sel et al., 2019; Sui et al., 2016). The drift-diffusion model was also used to illustrate the perceptual matching task of immediately acquired self-relatedness, with the main effect of self-prioritization being a faster rate of evidence accumulation in the drift-diffusion model – the drift rate, and a bias at the start of the accumulation of information – the starting point (z) (Golubickis et al., 2017; Macrae et al., 2017; Yankouskaya et al., 2020). These effects seem to be robustly replicated in a large number of subsequent studies.

As the SALT is convenient in accessing powerful top-down processing and ability to get around the confound of stimuli familiarity, the use of the associative learning paradigm has grown considerably over the past ten years. For example, because SPE can serve as a trans-diagnostic framework for psychological diseases, clinical and health psychologists have adopted the self-associative learning paradigm to understand atypical self-processing (impaired self-referential cognition) in the clinical population such as autistic population and depressed population (Gillespie‐Smith et al., 2018; Nijhof & Bird, 2019; Sui & Humphreys, 2017). The self-associative learning paradigm is also widely applied in understanding group processes and cross-culture variations (Jiang et al., 2019). It is also modified to be child-friendly to study the automatic self-advantage through child development (Maire et al., 2020).

Surprisingly, although the SALT has been widely applied, there has been microscopic examination and report of the psychometric properties of the self-associative learning paradigm outcomes. To ensure accurate assessment of human perceptual abilities, especially if future study wants to apply the self-associative learning paradigm to clinical settings, such as the diagnosis of depression (Liu et al., 2022), cognitive tests must have high reliability—a high degree of consistency in its measurements (Parsons et al., 2019). Also, in tasks simple as SALT, there are multiple ways to quantify the self-prioritization effect. Thus, it remains unknown (1) whether theses indices reliably capture the self-prioritization effect across times, and if yes, (2) which indices is mostly suitable for repeated measurements?

To fill the current gap, our work seeks to assess the reliability of the self-associative learning task as well as the stability and applicability of the generally used indices of the self-prioritization effect (SPE) in SALT. To this end, we plan to re-analyze a pre-collected dataset in the lab in 2016 where participants were asked to associate three different arbitrary shapes with labels for themselves, a friend, or a stranger across six testing sessions with time intervals for one week. Thus, the current research has three key objectives:

1. Test which index (s) is appropriate and consistent to indicate the group-level self-prioritization effect (SPE) in the SALT;
2. Test which index (s) is consistent to indicate the individual-level self-prioritization effect (SPE) in the SALT;
3. Test whether there is a practice effect across testing sessions.

Our main hypothesis are as follows:

1. (a) Model-based measurements and Reaction time-based measurement are appropriately reliable as group-level SPE indicators in the associative learning task (b) accuracy-based measurement exhibits different degrees of inconsistency from one time point to another.
2. (a) Model-based measurements, which reflect the critical underlying generative process of individuals, are appropriately reliable as individual-level SPE indicators in the associative learning task. (b) RT and accuracy-based measurements exhibits different degrees of inconsistency from one time point to another.
3. (a) There is a practice effect on all indices across testing sessions.

We plan to adopt hierarchical linear mixed model (HLM) and intraclass correlations (ICC) to test these hypotheses (see Analysis Plan for details). The present study will provide valuable information on SALT for further studies, for example, laying the ground for the prospective uses of SALT in research, clinical usage, and personal performance monitoring.

# **Methods**

## **Ethics information**

As the present research aims to perform a secondary analysis, which does not evolve treatment on humans or animals, informed consent and confidentiality are not an issue in this project. The study where pre-collected dataset was obtained is ethically approved by the research committee at Tsinghua University.

## **Secondary Data Description**

To answer our research questions, we plan to use a pre-collected dataset collected by the Hu Chuan-Peng at Tsinghua University in 2016. The purpose of the original study was to compare the SPE between sub-clinical depressed participants and non-depressed participants. However, the original study only collected the health control group due to the difficult to recruit sub-clinical depressed participants (only 6 participants were collected). The dataset provides six waves (separated by 1 week) of long-term data on 34 non-depressed and 6 depressed participants who were recruited from Tsinghua University community. In each wave, participants completed three parts of tasks: experiment A (a modified SALT), experiment B (a modified SALT) and questionnaires. We plan to **use the subset consisting of the neutral condition in SALT B result of the 34[[1]](#footnote-1) participants with relatively low DBI score**.

## **Data Collection Procedures**

In the study, 36 college students from Tsinghua University community participated the experiment and were compensated. All of them are right-handed and have normal or corrected-to-normal vision. Data of one subject was excluded because of providing confusing participant information to experimenter. Data from one male participant of experiment was missing because of an error in the program. The exclusion left 34 valid participants ( = 21.06, =2.52), with 21 females and 13 males.

## **Experimental design**

Experiment B is a 2 (match vs. not-match) ×3 (id: self, friend, stranger) × 4 (emotion: control, neutral, happy, sad) × 6 (sessions: 1-6) experiment. It is originally designed to compare the self-bias under different emotions (happy, sad, neutral, control).

## **Measured Variables**

In each wave, the participants were recorded on their keypress, the reaction time and accuracy in each trial. The questionaries vary across waves and are related to domains as diverse as personal wellbeing, physical and mental health, and psychological distance between self, friend, stranger.

## **Stimuli and materials**

The experiment was finished individually in a dimly lighted room. Stimuli were presented and responses were collected using E-Prime 2.0 on PC. The monitor was at 1024 × 768 resolution with 100 Hz refresh rate.

The experiment had two phases. Following (Sui et al., 2012), the first phase comprised a learning task in which participants were required to associate geometric shapes with labels. The shapes were not presented at this stage. The learning phase lasted for approximately 60 seconds and shape-target associations were counterbalanced across the sample. Next, participants performed a matching task. At the start of each trial, a fixation cross was first displayed in the center of the screen for 500 ms. Then, a shape–label pairing as well as the fixation cross was presented for 100ms, respectively. The next frame showed a blank screen for 1500 ms, or until a response was made. Participants were asked to determine whether the shape was appropriately matched to the label by pressing one of the two response buttons as quickly and precisely as possible within this timeframe.

The participants need to separately learn 4 sets of association between shapes and labels. The associations contain 1 control condition and 3 sets of emotion-based condition. In the control condition, participants learned the association between 3 geometric shapes (circle, horizontal ellipse and vertical ellipse) and three labels (self, friend, stranger). In each of the emotion-based condition, participants would see facial expressions (happy, sad, neutral) appear on the circle, horizontal ellipse and vertical ellipse (see figure 2). In each condition, before beginning the formal experimental trials, participants performed a training session containing 24 practice trials. Following the practice trials, each participant completed 6 blocks of 60 trials in the task. There were six types of shape-label associations: two matches(matched/mismatched) x three shape associations, with 60 trials per association. Participants received a short break (up to 60s) after each block.

Diagram

Description automatically generated

**Figure 2.** Examples of stimuli and time course of the experimental procedure in Experiment B. The labels and feedback appeared in Chinese in the experiment. In the associative learning task, the matched associations of shapes and labels was counterbalanced between participants. Timely feedback was not provided in formal trials.

## **Procedure**

Upon arriving at the laboratory, participants were given written informed consent. After reading and signing the consent, participants finished behavioral experiment A, behavioral experiment B, and questionnaires. The whole experiment was approximately 80 minutes. The participants then completed the same behavioral experiment for five times at the same time in the following five weeks. At each session, participants finished questionnaire: Beck Depression Inventory (BDI)(王振 et al., 2011), Beck Anxiety Inventory (BAI), Positive and Negative Affect Scale (PANAS)(王力 et al., 2007), and state self-esteem scale (Heatherton & Polivy, 1991), as well as psychological distance between self, friend, stranger by visual scale. Also, at the first and last session, participants finish additional questionnaires regarding traits: big-five, Rosenberg Trait self-esteem, IPA (locus of control) (Levenson, 1974; 汪向东 et al., 1999) and belief in free will (Paulhus & Carey, 2010).

## **Pilot data simulated data**

To eliminate possible bias in forming hypothesis, we do not perform any statistical analysis based on the secondary data at stage 1 registration. Instead, we simulated a dataset that has an identical data format as the secondary data. We took an open data of previous research using SALT to examine the self-prioritization effect as the reference to generate the pilot data.

We applied the Bootstrap methods where samples are drawn from the open data of Hu et al. (2020) (accessible at <https://osf.io/mhdsn/>) with replacement (allowing the same sample to appear more than once in the pilot data). Following the format of the secondary data, the pilot data has 6 sessions of 34 participants’ data, where for each participant in each session, there are 24 practice trials and 360 experimental trials (six types of shape-label associations: two matches (matched/mismatched) x three identity associations (self, friend, stranger), with 60 trials per association). Figure 1 shows the first six rows of the pilot data.

Table

Description automatically generated

Figure 1. The first six rows of the pilot data

We ran the pilot data through our proposed statistical analysis to see whether our proposed analysis is appropriate for the secondary data structure (see analysis plan).

## **Analysis Plan**

We will use the Python toolkit HDDM of Bayesian Hierarchical Model (Wiecki et al., 2013) to fit the behavioral data into the drift diffusion model (DDM). All the other analyses will be performed using the statistical software R (R Development Core Team, 2010).

**Data pre-processing**

First, we will pre-process the secondary data using the following criteria (we do not pre-process the secondary data at stage 1 registration):

1. Participant exclusion criteria
2. Participant who has the wrong trial numbers because of procedure errors should be excluded from the analysis.
3. Participants with an overall accuracy < 0.5 should be excluded from the analysis.
4. Participants with any of the conditions with zero accuracy should be excluded from the analysis.
5. Behavioural data exclusion criteria
6. Trials with no response or wrong key press should be excluded from the analysis.
7. Trials with responses less than 200 ms or faster than 1500 ms should be excluded from the analysis.
8. The practice trials will be excluded from the formal analysis.
9. The data under conditions other than the “control condition” will not be used in the current study.

**Calculation of indices & quantifying SPE in the SALT**

Then, we will calculate the indices in the SALT as well as the self-prioritization effect (SPE) revealed by each index at individual-level. We plan to use seven indices which are commonly used in the SALT. In Table 2, we report how the indices is calculated as well as how the self-prioritization effect (SPE) is calculated using these indices.

Table 2. Indices in SALT and corresponding calculation of indices and SPE

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Indices ID** | **Indices Calculation** | **SPE Calculation Based on Indices** | | **Source** |
| Mean Reaction times (RT) |  | Type 1 calculation | Self-match - other-match | Sui et al. (2012) |
| Type 2 calculation | self-all - other-all | Sui et al. (2012) |
| Accuracy (ACC) |  | self-match) - other-match | | Sui et al. (2012) |
| d-prime | z-score (ACC (match) - z-score (1 - ACC (non-match)) | self - other | | Sui et al. (2012) |
| Efficiency |  | self-match - other-match | | Stoeber and Eysenck (2008); Sui and Humphreys (2013) |
| Drift rate (v) | DDM：parameters will be identified through model selection | self-match- other-match | | Golubickis et al. (2017) |
| Starting point (z) | self-match - other-match | | Golubickis et al. (2017) |

*Note.* DDM =drift diffusion model.

We will report means and standard deviations of each index in each session, along with other relevant descriptive statistics.

**Reliability of indices in SALT as individual-level/group-level**

The reliability of indices in SALT will be evaluated using intraclass correlations (ICC). The Intraclass correlation coefficient (ICC) is a commonly used reliability statistic in test-retest, intra-rater, and interrater reliability investigations (Fisher, 1970). Compared with Pearson correlation coefficient, the ICC accounts for both degree of correlation and agreement between multiple measurements, making it a more desirable measure of test-retest reliability (Koo & Li, 2016).

Specifically, we will use two-way single-measurement mixed model with absolute agreement between scores of six session (ICC2k) as the reliability measure of group-level SPE across six sessions. For the calculation of ICC2k estimates and their 95% confidence intervals, the formula is:

*Note.* = mean square for rows; = mean square for error; = mean square for columns; = number of subjects; = number of raters/measurements.

We will use a two-way multiple raters random effect model with absolute agreement between scores of six sessions (ICC2 ) as the reliability measure of individual-level SPE across six sessions. For the calculation of ICC2 estimates and their 95% confidence intervals, the formula is:

*Note.* = mean square for rows; = mean square for error; = mean square for columns; = number of subjects.

For ICC2k and ICC values interpretations, we followed the following recommendations: values less than 0.6 are indicative of poor reliability, values between 0.6 and 0.8 indicate substantial reliability, and values greater than 0.8 indicate excellent reliability (Cicchetti & Sparrow, 1981; Kupper & Hafner, 1989).

**Effect related to practice in SALT**

The potential effect of practice will be explored using hierarchical modelling using restricted maximum likelihood estimates with sessions as fixed effects and a random intercept to account for inter-individual differences in baseline performance. Multilevel modelling allows for the comparison of more than two sessions as well as the inclusion of additional predictors such as the number of previous sessions (Ding & Vancleef, 2022). For example, the disparity between results may be smaller with more practice with the test.

We will construct the hierarchical model for each index. The hierarchical model specification was as follows:

Significance will be calculated using the lmerTest package in R(Kuznetsova et al., 2017), which applies Satterthwaite’s method to estimate degrees of freedom and generate *p*-values for mixed models.

A detailed description of correspondence between each hypothesis, each statistical test and interpretation of results is illustrated in the Design Table.

# **Data availability**

We will adhere to the following open science practices: open materials, open data. We will share the raw data, excluding sensitive participants’ information on acceptance of our Stage 2 manuscript. The simulated data is accessible on the Open Science Framework () and GitHub ().

# **Code availability**

Code used to simulate and analyze the pilot data is made accessible in the same location: Open Science Framework () and GitHub ().

# **Results**

Do **not** include a **Results** section.

# **Discussion**

Do **not** include a **Discussion** section.

# **Acknowledgements**

The present research is support by xxx.

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# **Author contributions**

HCP contributed to the conception and supervision of the study and will provide the methodology expertise. JS contributed to fund raising, HCP contributed to data collection. ZL and ZYR will perform the data pre-processing, analysis and visualize the results. In addition, ZL, JS and HCP will contribute to discussing the results and the drafting of the final manuscript. All authors will critically revise the manuscript.

**Competing interests**

The authors declare no competing interests.

**Figures**

You are encouraged to include Figures in the text or at the end of the protocol. Keep in mind that a total of 8 display elements (i.e., combination of Tables and Figures) is permitted in the final, Stage 2, submission. However, to enable typesetting of papers, we advise making the number of display items commensurate with your overall word length (that is, for a shorter paper the number of display items should be lower, for a longer manuscript a higher number may be allowed). Figures/Tables that are not essential should be included in your Supplementary Information file.

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# **Figure Legends**

**Figure 1. Guidelines for the preparation of figure captions.** Figure captions should be concise. Begin with a brief title and then describe what is presented in the figure and detail all relevant statistical information. If you show pilot data, list the N of each plot and report full statistics. Aim not to exceed 350 words per legend.

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# **Table 1. Design Table**

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Hypothesis (if applicable)** | **Analysis Plan** | **Interpretation given to different outcomes** |
| Which indicator (s) is appropriate and consistent to indicate the group-level self-prioritization effect (SPE) in the SALT? | (a) Model-based measurement (*v, z*) and Reaction time-based measurements (Mean Reaction times) are appropriately reliable as group-level SPE indicators in the associative learning task (b) accuracy-based measurements (accuracy, d-prime, efficiency) exhibits different degrees of inconsistency from one time point to another. | We will use two-way single-measurement mixed model with absolute agreement between scores of six session (ICC2k) as reliability measure of group-level SPE across six sessions. | ICC 2k values less than 0.6 are indicative of poor reliability, values between 0.6 and 0.8 indicate substantial reliability, values greater than 0.8 indicate excellent reliability. |
| Which indicator (s) is appropriate and consistent to indicate the individual-level self-prioritization effect (SPE) in the SALT? | (a) Model-based measurement (*v, z*), which may reflect the critical underlying generative process of individuals, are appropriately reliable as individual-level SPE indicators in the associative learning task. (b) RT and accuracy-based measurements (Mean Reaction times, accuracy, d-prime, efficiency) exhibit different degrees of inconsistency from one time point to another. | We will use a two-way multiple raters random effect model with absolute agreement between scores of six sessions (ICC2) as reliability measure of individual-level SPE across six sessions. | ICC 2 values less than 0.6 are indicative of poor reliability, values between 0.6 and 0.8 indicate substantial reliability, values greater than 0.8 indicate excellent reliability. |
| Is there a practice effect across testing sessions? | There is a practice effect on all indices across testing sessions. | The effect of practice will be explored using hierarchical modelling using restricted maximum likelihood estimates with sessions as fixed effects and a random intercept to account for inter-individual differences in baseline performance. Significance will be calculated using Satterthwaite’s method to estimate degrees of freedom and generate *p-*values for mixed models. | *p*<0.05 as evidence for the presence of a practice effect. |

# **Supplementary information**

Please report pilot data in detail here and include any other material that provides background information.

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1. Based on the average effect size of group-level SPE reported by Sui et al. (2012), G\*Power (f = .40, α = .05, power = 80%) revealed a minimal requirement of 16 participants. Thus, the sample size in the secondary data is sufficient to detect the self-prioritization effect at group-level. [↑](#footnote-ref-1)