A new quantitative method in analysing the experiments on short term serial memory

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Received January 23, 1998

Abstract A new quantitative method is introduced into the analysis of the experiments on short term serial memory (STSM). In this method, three parameters are defined to quantitatively represent the performance of memory for item and time order information. These parameters are the divergence, the disorder and the similarity. This method is used in analysing the experiments on visuo-spatial STSM. The results show that the parameters may reflect some characteristics of STSM.

Keywords: short term serial memory, item and time order information, method of quantitative analysis.

In cognitive psychological researches on short term serial memory (STSM), memory span, saving score, or recall probability are usually used to evaluate the memory performance. It is known that STSM information consists of two types of information: one is item information, the other is time order information. Although the above-mentioned parameters can be perfectly used to analyse the item memory (memory for item information), they cannot be directly used in analysing the time order memory (memory for time order information). Some available approaches, such as serial position curve and model simulation, are indirect ones. In the present paper, we introduce a new quantitative method into the analysis of STSM experiments. This method contains three parameters that are defined to represent the performance of the item and time order memory, and they are used in analysing the experiments on visuo-spatial STSM.

1 New method of quantitative analysis

In a trial of STSM experiment, a sequence of stimuli (also called the presented list) are orderly presented to the subject at a constant rate. After presented, the list is serially recalled immediately. Under this condition, the subject must remember the item and time order information of the presented list. The subject’s recall list is called the reported list. There may be three types of reported lists:

(i) The reported list is the same as the presented list. For example, the presented list is: 2, 6, 8, 5, 1, 7, 3; the reported list is: 2, 6, 8, 5, 1, 7, 3.

* Project supported by the National Natural Science Foundation of China (Grant No. 39570255) and the National Climbing Project B of China.
(ii) All items in the reported list are the same as those in the presented list, but compared with the presented list, the reported list has some order errors. For example, the presented list is: 6, 4, 9, 2, 5, 7, 1; the reported list is: 4, 6, 9, 5, 2, 7, 1.

(iii) Compared with the presented list, the reported list has some item and order errors. For example, the presented list is: 7, 3, 5, 8, 6, 2, 4; the reported list is: 7, 3, 8, 5, 6, 1, 4.

In order to analyse the item and time order information of the reported list, we established a new quantitative method in analysing STSM experiments.

1.1 The reported list-presented list (RLPL) curve

Some symbols are defined to quantitatively analyse the experimental data. Suppose: the presented list is A: \(a_1, a_2, \ldots, a_n\), the items in A are arranged in the presented order, the number of these items is \(n\), and \(a_i\) is an item in A, \(i = 1, 2, \ldots, n\); the reported list is B: \(b_1, b_2, \ldots, b_n\), the items in B are arranged in the reported order, and \(b_j\) is an item in B, \(j = 1, 2, \ldots, n\). Compare \(a_i\) with \(b_j\):

(i) if \(b_j = a_i\), let \(\theta_i = j\);
(ii) if \(b_j \neq a_i\), \(\theta_i\) is not defined.

The reported list-presented list (RLPL) curve is obtained when \(\theta_i\) is plotted as a function of \(i\).

In the RLPL curve, \(i\) represents the order position of an item in the presented list, and \(\theta_i\) represents the order position of this item in the reported list. So it is possible to compare the item and time order information of the presented list with that of the reported list.

1.2 Parameters

Three parameters are defined to quantitatively analyse the RLPL curve. They are: the divergence (\(D\)), the disorder (\(I\)) and the similarity (\(S\)). The parameters \(D\) and \(I\) describe the difference between the presented list and the reported list. The parameter \(S\) represents the similarity of them.

1.2.1 Divergence (\(D\)).

\[
D_{(n)} = \sqrt{\frac{\sum_{i=1}^{n} (\delta_i - i)^2}{n - 1}}
\]  

(1)

In formula (1), \(\delta_i = \theta_i + \gamma_i\), \(\theta_i\) and \(\gamma_i\) are calculated as follows:

Suppose \(i = 1, 2, \ldots, n\), \(j = 1, 2, \ldots, n\); compare \(a_i\) with \(b_j\):

(i) if \(b_j = a_i\), let \(\theta_i = j\), \(\gamma_i = 0\);
(ii) if \(b_j \neq a_i\), let \(\theta_i = 0\), \(\gamma_i\) is calculated according to the following conditions:

i) if \(i = n\), let \(\gamma_i = (n - 1)^2 + i\);
ii) if \(a_i + 1 \neq b_i + 1\), let \(\gamma_i = (n - 1)^2 + i\);
iii) if \(a_i + 1 = b_i + 1\), let \(\gamma_i = n - 1 + i\).

Suppose the number of trials with the same list length is \(m\). Then the mean \(D_{(n)}\) is

\[
D_{(n)\text{mean}} = (D_{(n)1} + D_{(n)2} + \ldots + D_{(n)m})/m
\]

(2)

In formula (1), \(\delta_i - i\) represents the deviation of an item in the reported list from the presented order, and therefore the divergence reflects the deviation of the reported list from the presented list. This deviation is related to the time order memory. Because \(\delta_i\) of the erroneous item is bigger than that of the correct one, the divergence also represents the performance of item