DISCOVERING VISUAL SCANNING PATTERNS IN A COMPUTERIZED CANCELLATION TEST

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ABSTRACT

The purpose of this study was to develop an attention sequential mining mechanism for investigating the sequential patterns of children's visual scanning process in a computerized cancellation test. Participants had to locate and cancel the target amongst other non-targets in a structured form, and a random form with Chinese stimuli. Twenty-three children aged between 10–12 years were recruited and took part in this experiment. Sequential pattern analysis for stimulus cancellation revealed that the structured form has a visual guiding effect producing a maximum of 18-sequence in a horizontal scanning pattern. The sequential pattern of the random form, showed no guiding effect, was vertical and yielded only 2- to 4-sequence patterns. The results demonstrated that the organization of stimulus layouts (i.e., structured or random forms) might have implicit visual guiding effects in visual scanning.

KEYWORDS

Cancellation test, Sequential pattern mining, Visual scanning, Computerized assessment

1. COMPUTERIZED CANCELLATION TESTS

Visuospatial attention is how someone attends to the visual stimuli in a specific space. Cancellation tests have been largely used to evaluate the performance of visuospatial attention in education and medical settings. Individuals are required to cancel the target scattered randomly throughout the structured or random array. A computerized cancellation test system can trace and record the sequence of cancellation mapping onto the test screen. The response path would represent a visual scanning pattern in a series of lines connecting the positions by order of the cancelled stimuli.

Sequential pattern mining is one of data mining technologies concerned with interesting sequential patterns based on time series among a large database (Chand et al, 2012). With huge amounts of data continuously being collected and stored by a computerized cancellation test system, sequential pattern mining can be used to discover the potential interesting sequential patterns of the visual scanning paths. In this study, a K-sequence is an ordered list of items I_i ($i = 1 \sim k$) such that $S = <I_1, I_2, …, I_k>$. Sequence S in a cancellation task that contains k sequences of cancellations (i.e., k successive responses) is called a frequent sequential pattern if it occurs more than the minimum support threshold value.

Previous studies suggested different findings regarding the patterns of visual searching in visuospatial tasks. Abed (1991) explored eye movement among subjects with different cultural backgrounds. The study showed that East Asian subjects used more vertical than horizontal movements comparing with American or Middle Eastern subjects. Woodword (1972) addressed that the distance between the stimuli would influence the scanning pattern and lead the individual to search for the next closest target. A previous study found that a structured form with the Chinese stimulus elicited a more organized visual scanning pattern, but a randomized form did not (Wang et al, 2006). However, the traces of visual scanning in both forms were not quantitative data and thus, cannot be compared statistically to examine the differences between scanning patterns.

Therefore, the purpose of this study was to develop an attention sequential mining mechanism to discover the sequential patterns of children's visual scanning process in order to validate the discrepancies of scanning patterns in different layouts.

2. EXPERIMENT

2.1 Subjects

A total of 23 participants (9 boys, mean age = 11.33 years; 14 girls, mean age = 11.43 years) participated in the experiment. All recruited participants were free of any physical illness, neurological deficits, visual or motor problem, or perceptual disorders. Participants were instructed and allowed to practice until they understood the procedure before starting the test.
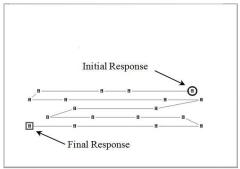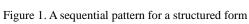
2.2 Materials

Two different stimulus layouts (i.e., structural array and random array) with the Chinese stimulus were used in this experiment. The target on the Chinese test was the radical "日" (meaning "sun"). Other Chinese radical, such as "月" and "目", were used as non-targets in the test. In the structured form, the spacing of any two adjacent stimuli in a row or column was equivalent, but for the random form, the spacing of any two adjacent stimuli varied.

To mine the frequent sequences for visual scanning patterns, a user-specified minimum support was required as the threshold for discovering all sequences having a frequency greater than the minimum threshold. Based on the testing result, a minimum support threshold was set as 0.2 in this study.

3. RESULTS AND DISCUSSIONS

A total of 2650 records of participants' responses were analyzed: 1322 records for the structured form and 1328 records for the random form. The results showed that the structured form has a visual guiding effect, and a maximum of 18-sequence horizontal pattern was found (see Figure 1). Most horizontal patterns were left-right or right-left tracing as an S-shape with top-down order in the structured form. However, the random form showed no guiding effect and only a maximum of 4-sequence vertical pattern was found (see Figure 2). Table 1 shows part of the results of K-sequence in structured and random forms. For the structured form, one maximum 18-sequence was found ($S = <217, 210, 207, 200, 221, 225, 236, 240, 257, 248, 267, 272, 277, 282, 306, 301, 292, 287>$), followed by two 17-sequences, three 16-sequences, and so on. For the random form, only 2-sequence ($S = <64, 65>$) to 4-sequence ($S = <142, 163, 204, 220>$) were found.

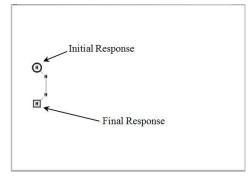Figure 1. A sequential pattern for a structured form

Figure 2. A sequential pattern for a random form

From the sequence length results, we conclude that the stimulus layouts may have implicit visual guiding effects. In the random form, the individual showed very inconsistent scanning patterns from each other, and a change was found in the orientations for cancelling the next target without following any horizontal or vertical direction. Woodword (1972) indicated how the short and vertical scanning pattern was influenced by each individual's searching orientation and majorly by the next possible stimulus one attended around. The sequence results found in this study supports the layout effects for visual scanning.

Table 1. Comparisons of the number of K-sequence on the two stimulus layout

Structured form		Random form	
K-sequence	No. of K-sequence	K-sequence	No. of K-sequence
18	1	-	-
17	2	-	-
16	3	-	-
4	35	4	1
3	46	3	11
2	84	2	75

4. CONCLUSION

In this paper, a visualized sequential pattern mining approach to visuospatial attention has been developed. The results of the preliminary experiment also revealed that the stimulus layout would affect the sequential patterns of visual scanning in attention process, which causes significant discrepancies in sequential patterns between the searching behavior in structured and random arrays. Further issues for the relationship between the patterns of visual scanning and the performance of visuospatial attention will be explored.

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