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Original Article

Strategic differences in visual scanning between field dependent and field independent individuals on the basis of eye tracking measures

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Abstract

Introduction: According to previous findings, visual scanning approaches may play a main role in cognitive styles, which is also important in learning processes. This study aimed at comparing field dependent (FD) and field independent (FI) groups in their visual scanning indicators during performance on a set of stimuli.

Methods: 68 undergraduate students of Shahid Beheshti University participated in this study through purposive sampling method. Participants were assigned into FD and FI groups through the scores of Group Embedded Figures Test (GEFT). Participants' eye movements, including fixation details, were tracked by a binocular remote eye-tracking system (SMI-RED120Hz) during their performance on the GEFT.

Results: Mixed MANCOVA analyzing was used in this study. Comparing to FD group, FI group fixated their eyes more on the stimuli in shorter time. Revisits were less in FI group and they had longer fixations. Moreover, there were some significant interactive effects among groups and different areas of GEFT.

Conclusions: It seems that FI individuals use some practical strategies in their visual scanning which enables them to succeed in differentiating components of a whole picture. These strategies are related to time management and taking new perspectives from which, they can probe the stimuli in more effective methods.

Declaration of Interest: None

Key words: Cognitive styles, Field dependence/independence (FID), Visual scanning, Eye tracking.

Introduction

The concept of cognitive styles is fundamental in psychological studies prepared for various publications (1). In this field, a number of areas are studied such as individual differences in perception, thinking, learning, problem solving and etc. (2, 3). Field Dependency/Independency (FDI) and Group Embedded Figures Test (GEFT) are actually significant titles in this regard (4). Nowadays, FDI cognitive styles have been used as a predictor of an individual's ability in a different situation, particularly in academic achievement, individual achievements and organizational behaviors (5). Field Independency refers to remarkable ability to analyze a mixed and complex field to distinct recognizable components (6). Cognitively, FI individuals are greatly influenced by impressionable mind (7). FI individuals tend to be less affected by visual information. Therefore, they can perform better in the test (8). Meanwhile, it seems they have no obvious difficulty to extract information from context and adopt an analytic approach (2). Whereas, FD individuals prefers to rely on external pieces of evidence for processing information (3). Also, more dependency on the context and some difficulties in separating of given information from context and exhibit a global or holistic approach have observed between FD individuals (2, 3, 4, 8). Another subtle point, is the cause of these differences in visual scanning between FI and FD individuals (9). Therefore, clarifying whether FI individuals use their strategies purposefully or unconsciously seems to be important (10). Studies have shown that this process is definitely unconscious and it is not related to intelligence coefficient (11).

Eye-Tracking is one of the most useful methods to examine psychological and cognitive features (12). A systematic review results concluded that cognitive style such as FDI was one of the three main factors (demographics, cognitive, and personality) which affects information search behavior as well as the ability to differentiate the shape from context (13). They pointed out that cognitive styles were significantly related to information search behavior and preferences in some of the studies, though there is still some ambiguity regarding what styles have an impact on specific outcomes (14). In short, it has been argued by numerous theoretical and research literatures in the realm of cognitive styles which FI individuals use some visual strategies which enable them to perform successfully in the complex stimuli such as GEFT (15). The aim of this study was to investigate whether FI people differ from FD in way of looking at pictures to detect a simple shape inside a complex background. Based on previous studies, four visual indicators of eyes were assessed in this study: fixation count, revisits, fixation duration, and first fixation duration. According to the investigation of this article's authors there is no publication which uses Eye-tracking method comprehensively with GEFT as stimulus for measuring FDI among Iranian university students. It is worth to note that all aspects of eye movement which is mentioned above were comprehensively measured.

Method

Participants: Eighty students attending Shahid Beheshti University (n_{female}=40, mean age: 22.2±2.67,n_{male}= 40, $mean_{age}$: 23.51±2.4) participated in this study voluntarily. Based on their scores in GEFT, participants were divided into FD and FI groups.

Measures and procedure: A collective version of the Group Embedded Figures Test (GEFT) (3) was used in this study, which had two purposes: 1) Assessing FDI of the initial sample to divide them into FD and FI groups. 2) Investigating eye movements of both groups during their performance on the test. GEFT measures the participants' ability to detect a simple shape hidden within a complex figure. It contains 25 figures. Seven figures are for training purposes and are not counted in the total score. Eighteen figures are presented in two timed sections. The high score is indicative of FI and the low score of FD (16, 17). Cronbach's alpha of its Persian version is 0.78 to 0.82 in some studies on adult populations (18). Classically the test is

performed on the paper so that the simple shape and the complex figure are shown together and the participants should find and highlight the shape within the complex figure. As it mentioned, the aim of this study was to investigate the way the FD and FI people visually scan the picture to find the shape within the complex figure via Eye tracking apparatus, therefore, shapes and figures of the GEFT were transformed by a high-quality camera to digital pictures hence they could be presented in monitor. Each picture contained a simple shape on the left and a complex figure on the right side, both in original size and shape of GEFT. One of the picture's samples was shown on Figure 1.

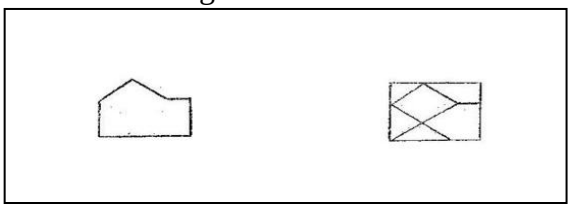


Figure 1: A sample picture of prepared digital GEFT for presenting on the monitor

Participants were asked to look at the pictures and detect the shape within the complex figure using a mouse and click on the Space button to pass to the next picture. Meanwhile, their eye movements were tracked by eye tracking apparatus.

Eye tracking apparatus: an Eye tracking system, SMI-RED-120Hz was used in this study which consists of a 22" monitor for presenting stimuli, a binocular eye tracker device, the iView X™ Software, experiment center software for designing experiments and be gaze software for analyzing data. This system reports the amounts of measurement errors of tracking the eye movements so that trials with high amounts of error can be identified and eliminated from analysis. Participants presented individually at the experimental room of psychology laboratory at Shahid Beheshti University and seated in 60 centimeters distance from the monitor. After giving necessary explanations about the experiment to the participants, a calibration stage was performed followed by a validation trial to measure the tracking errors and then the prepared pictures of GEFT were presented, according to the test instructions (18). Participants were told that they have a total of 10 minutes to complete the two main sections of the test and they should manage this time for 18 pictures. For preventing the interfering effect of the appearance of the cursor on the screen on eye movements, participants had been instructed to not move the Mouse until they have detected the shape and want to show its sides by the mouse. The experimenter was present in the room and registered responses without interfering participants' performances.

Results

At first, the measurement error of the eye tracking apparatus was examined for all 80 initial participants. Analysis revealed that the mean horizontal and vertical errors are 0.67° and 0.82° respectively. Data with errors over 1° in horizontal (2 persons) and/ or vertical (3 persons) direction were excluded increase the accuracy and reliability of the data, that yielded to error amounts equal to 0.55° for the horizontal direction and 0.62° vertical direction for remaining 75 participants. Then the scores on GEFT were examined and participants were divided into FD (35 people with scores below8) and FI (33 people with scores above 10) groups and the remaining (7 persons having scores equal to 8, 9 and 10) were excluded. Table 1 shows the FD and FI groups descriptive data in scores on GEFT and in measurement errors.

Table 1: Descriptive data in GEFT

Group	N	Min.	Max.	Mean	SD	Horizontal error		Vertical error	
						Mean	SD	Mean	SD
FD	35	0.001	7	4.21	2.08	0.52	0.19	0.61	0.23
FI	33	11	18	14.12	1.93	0.58	0.21	0.63	0.23
Total	68	0.00	18	11.17	4.97	0.55	0.2	0.62	0.23

There are two independent variables in this study: 1) group with two levels of FD and FI, and 2) areas of presented pictures with two levels of shape (the simple shape that participants were instructed to detect it within the complex figure) and background (the complex figure). In order to obtain the dependent measures (fixation indicators) according to shape and background, two Areas

of Interest (AOI) were defined. This was performed separately for each picture because of their differences in sizes of shapes and backgrounds, thus the sizes of the defined AOIs are different through the pictures. However, the final analysis was performed on the average of measures obtained from all pictures. Mean and standard deviations of fixation count, revisits, fixation duration and first fixation duration on shapes and backgrounds are presented in Table 2 divided by FD and FI groups.

Table 2: Mean and standard deviations of fixation count, revisits, fixation duration and first fixation duration

Group	AOI	Fixation count		revisits		Fixation duration		First fixation duration	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
FD	Shape	7.85	7.46	5.11	3.4	292.63	101.77	214.03	100.4
	background	19.71	11.19	9.48	4.54	421.44	199.55	199.26	82.36
	Total	13.78	10.76	7.3	3.91	357.03	115	266.64	74.54
FI	Shape	8.06	5.34	4.12	1.86	256.8	93.42	268.41	184.38
	background	36.33	18.22	4.75	1.73	289.02	93.04	368.31	132.5
	Total	22.2	11.18	4.44	1.33	272.91	77.28	318.36	113.22
total	Shape	7.95	6.47	4.63	3.36	275.24	98.74	240.42	148.66
	background	27.77	20.34	7.2	4.2	357.18	169.66	281.3	138.1
	Total	17.86	11.67	5.91	3.27	316.21	106.56	260.86	110.03

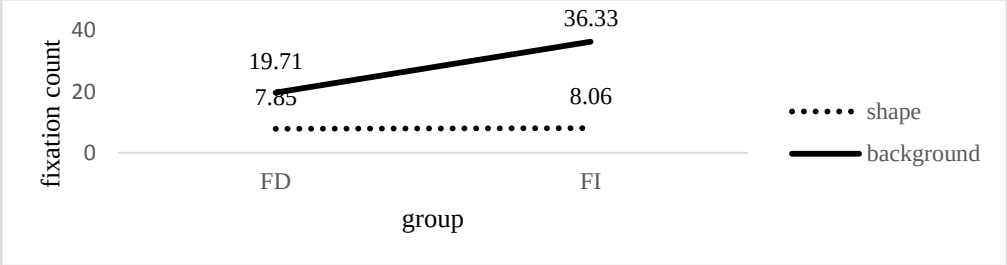
A two (group: FD vs. FI) × two (AOI: shape vs. background) mixed MANOVA was used to analyze data after controlling the assumption of Sphericity of within-subject effect. Results are shown in table 3.

Table 3: MANCOVA test results for comparing two groups

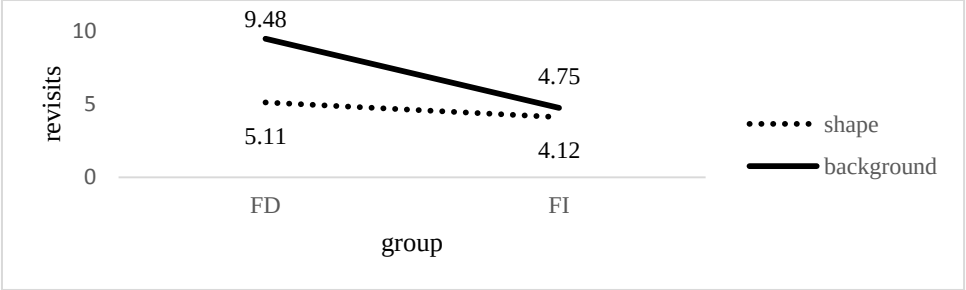
Source		Measure	SS	df	MS	F	Sig.
Between group	Group	Fix. Count	2403	1	2403	10	0.05
		Revisits	278	1	278	15.85	0.01
		Fix. Duration	240372	1	240372	12.38	0.05
		f.f. duration	423971	1	423971	23.35	0.01
	Error	Fix. count	15875	66	240.53		
		Revisits	1156	66	17.53		
		Fix. Duration	1281430	66	19415		
		f.f. duration	1198388	66	18157		
Within group	AOI	Fix. count	13676	1	13676	90.52	0.01
		Revisits	213	1	213	36.71	0.01
		Fix. Duration	220236	1	220236	14.81	0.01
		f.f. duration	61553	1	61553	3.96	0.05
	AOI * group	Fix. count	2288	1	2288	15.14	0.01
		Revisits	118.5	1	118.5	20.42	0.01
		Fix. Duration	79227	1	79227	5.33	0.05
		f.f. duration	111663	1	111663	7.2	0.05
	Error	Fix. count	9971	66	151.08		
		Revisits	383	66	5.8		
		Fix. Duration	981028	66	14864		
		f.f. duration	1024546	66	15523		

According to the results, the main effect of group is significant on all of the dependent measures. That is, FI group have had more fixations on the pictures (22.2) than FD group (13.78) and their fixations have been shorter (272.91 vs. 357.03 ms). Unlike the mean fixation duration, FI group's first fixation has been longer (318.36 ms) than FD group (266.64). About the revisits, FI group have shown less (4.44) revisits than FD group (7.3). Interactive effect of group and AOI is also significant on the dependent measures, means that the effect of group is being moderated by the area of the pictures. As it is illustrated in

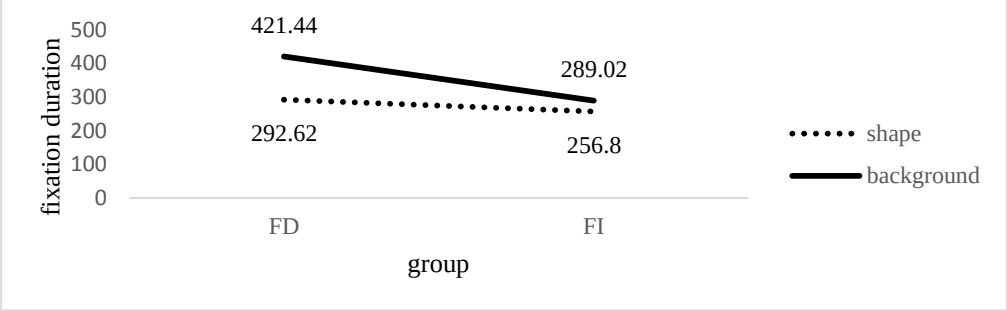
diagram 1, the greater difference in fixation count on the shape and background in FI group than FD group shows that the FI group had their most of fixations on the background rather than the shape.



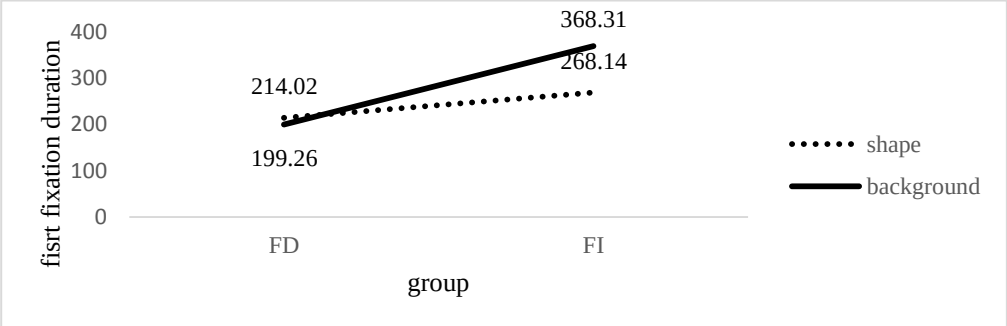
The interactive effect on revisits is contrary; the FI group's revisits are less on both shapes and backgrounds, while the FD group's revisits on the background are more than that on the shape (diagram 2).



About the fixation duration, the interactive effect is in the same way as revisits. That is, fixation duration of FI group on the background is short and close to their fixation duration on shape, while fixation duration of FD group on the background is long and much more than that of on shape (diagram 3).



Finally, FI group's first fixation is longer on the background than on the shape, but FD group's first fixation on the shape and background are almost equal in length (diagram 4).



Discussion

Comparing FD/FI individuals thorough visual scanning was the aim of this study. Therefore, gaze patterns of participants (using an eye tracking system during performance on the GEFT) were examined by the researchers. According to previous studies, FI individuals act better in recognizing images and distinguishing shapes from the background (19). In our study, comparing to the FD group, FI group focused on the background rather than the shape, looked in shape and background in shorter time, revisited less and their first fixation on the shape and background was longer. These differences of visual scanning pattern suggest that FI individuals use some specific strategies which enable them to succeed in the inference of details from complex contexts. For example, more fixations in shorter time make it possible to optimal use of time and dividing picture to its components (20). Therefore, time management by the use of more fixations in shorter time is one of the effective approaches which used by them (21). This finding is consistent with the results of previous researches (22) and is inconsistent with some others (23, 24). It could be concluded that FI individuals paying attention to the next subjects, after getting sufficient information by focusing on the issues. Comparing to the FD individuals less count of revisits among FI group is another novel insight of this finding. Revisit is a fixation that have been registered on the point which have been fixed at least one time previously (25). This shows that FI people use another economic and effective approach which create the opportunity of observing the pictures from different viewpoints by avoiding duplicate fixations (26). It could be resulted, fixating on the points which fixed before is not evaluated informative by FI individuals. In contrast, FD people frequently fixated their eyes on the points that they have already seen. It does not give them any new perspective from which they can examine effectively from pictures. To the authors of this article knowledge no studies have been reported on revisits. But reviewing the literature of problem solving reveals that examining the problems from different and new points of view along with not adhering to a single dimension is related to successful problem solving (14). These findings are in line with students' cognitive style. In this study, FI male students, gain better problems solving and organizing skills, because of looking at the issues from different dimensions and focusing less on the subjects that they had previously focused on. On the other hand, because of lacking of investigation problems from various perspectives, problems solving were unstructured and disorganized in students with context-dependent cognitive style (27). Finally, the results of this study showed that the first fixations of FI group on the shape and background were longer than FD groups. It seems that FI group attempts to obtain as much as information they can acquire in a shorter time. These results are consistent with previous studies (CITE). Therefore, it can be concluded that FI individuals' problem solving is accurate enough. Trying to get the most precise and detailed information, when encountering the problems for the first time, is their dominant trait (28). Compared to FD people, this may lead to a longer time period of the initial looks. No significant correlation was found between understanding issues and problem solving capability in FD people (29, 30). Comprehensive review of the subject at first look and paying sufficient attention to all relevant and irrelevant aspects of the issues are the two main differences between FI and FD individuals in problem solving. Limitations of this study are small sample size, voluntary sampling and restriction of the sampling to the academic society. At the end, eye-tracking and fMRI measures investigated between FDI participants in different populations are suggested by the authors.

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