



A Study on the Development of the Psychological Assessment a Using Eye-Tracking: Focused on Eye Gaze Processing of Literacy Text

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Abstract. The purpose of this study is to examine the possibility of improving a self-epic diagnosis tool by using a gaze processing method in terms of literacy therapy. In this study, we used an eye-tracker measuring eye-position and eye-movement to read subjects' reactions to the critical region in a context. With this technology, we focused on the fixation and saccade to see what vocabulary subjects focused and how their gaze was shifted. We also explored to find a relationship between their eye-movement and their degree of sympathy by examining their physiological data. This pilot study showed a potential use of a physiological data in the epic of self-test in literacy therapy.

Keywords: Psychological assessment · Gaze · Eye-tracking · Literacy · Psychological diagnosis through processing texts

1 Introduction

This study aims to examine the empathy on literary text through the way of gaze processing, and to explore the possibility of psychological diagnosis using literary text. The possibility that literary text can be utilized as a measure of psychological diagnosis has already been already proposed in the field of “literary therapeutics” and is called the “epic of self-test”. It is based on the premise that literature itself and reaction to literary works are all holistic reflections of human psychology.

The problem with conducting psychological diagnoses using literary text is that it is difficult to ascertain whether the degree of response and empathy toward a text consisting of a long narrative is the result of understanding and response to the entire narrative context, or the result of excessive interpretation or distortion of parts of the narrative. Even if one understands the whole context and shows an empathetic response to the text, how to present and evaluate the level of empathy is difficult. Therefore, this study seeks to find a way to visually measure the human ability to empathize with literary text. For achieving this goal, this study employs the use of eye-tracker devices.

With the recent development of a variety of eye movement control models (Engbert et al. 2002; Engbert et al. 2005; Morrison 1984; O'Regan 1990; Pollatsek et al. 2006; Reichle et al. 1998), research on reading through eye movement tracking is becoming more diverse. In addition to dealing with issues such as perceptual range, saccade-related phenomena, and saccade response times from one fixation, effects of language characteristics on fixation and saccade in real time has also come to be studied.

In accordance with this prior research, this study focuses on the area of interest (AOIs) that contains the core of the text and attempts to understand how much the subject's eyes are fixed and where they move in the key vocabulary and syllables that convey the main theme. This study also aims to discover whether there is a difference in sentences or words between groups with different empathetic abilities. This will help confirm the subject's level of empathy for the core of the literary text. If the subject's eyes deviate from the core, it can be said that the degree of empathy is low, and in the inverse case, that the degree of empathy is high.

Thus, this study attempts to ascertain whether the reading area differs from group to group depending on their empathic abilities (EQ) whether the response to literary text relates to the whole text or to some part of the text, and this correlates with the subject's empathic abilities (EQ).

2 Method

To determine the range of perception, the phenomenon related to saccade, and the time of the saccade response from one fixation based on the level of empathic ability of the viewer, twenty-two college students with literacy skills were recruited. All participants in the experiment have a corrected visual ability of 0.6 or higher and could read the text on the monitor easily. Using the eye-tracker, the subjects' eye movements were recorded as they read 16 narrative stimuli.

After dividing the students into two groups with high EQ scores and low EQ scores, The data was analyzed through fixation, saccade and the heat-map that appeared as they read the text. And factorial extraction and regression analysis of the narrative text survey, which consisted of a five-point Likert scale, was conducted to determine the correlation between 16 narrative texts and EQ scores.

2.1 Hypotheses

The concept of empathy, which is related to sympathy, is important not only in the field of literature, but also in the fields of psychoanalysis and psychological counseling.

Empathy is one feels when one experiences other people's positions or situations and fully understands them, and many studies have shown that people with good sympathy have a better understanding and feeling of narrative texts. However, there are few devices that can scientifically prove where empathy is achieved. In this study, subjects are expected to be easily aware of and empathize with familiar words or sentences.

Therefore, it is predicted that among familiar words or paragraphs, the areas of eye fixation or saccade will appear differently between people with higher and lower degrees of empathy. The following assumptions were derived:

H1: the cognitive process of reading leads eye movement: Focus on frequency of use and prediction (linguistic properties of words).

H2: The comprehension of sentences will vary depending on the level of empathy.

H3: Depending on the level of empathy, the level of interpretation of a particular word or paragraph will vary.

To test the above hypothesis, 16 narrative stimuli and eye-tracker, the epic of self test were used.

2.2 Stimuli

A 2D flat computer display with Full-HD resolution (1920x1090 pixels) was used for which participants would read the text. A single literary text was set up to be displayed on one screen. entirely. After participants finished reading the text on the screen, they proceeded by pressing the ESC button and writing a questionnaire. Psychological tests were read by participants to conduct ‘emotional-response-type epic of self-tests’. The emotional-response-type epic of self-test consists of asking through five Likert scale, ranging from ‘repulsion’ to ‘touching’. In other words, the emotional-response-type

The first question: <The Liver of Son and Stepmother>

(1) A man raised a son with his wife, but when she died, he got a new wife. (2) When the new wife gave birth to a son, she said that she was ill falsely, and she must eat the liver of his ex-wife’s son. (3) To save his new wife, the man ordered a butcher to kill his ex-wife’s son and bring his liver. (4) When the butcher’s wife asked the butcher to catch the dog instead of the child, he let go of the child and brought the dog’s liver. (5) The ex-wife’s son grew up well and became a high official. (6) The ex-wife’s son punished his stepmother, and lived well with his father and the butcher and his wife.

■ Please check your feelings after reading to the above story.

- ① repulsion
- ② uninterested
- ③ nothing special
- ④ interested
- ⑤ touching

■ Please write down the reason why you feel that way.

Fig. 1. An Example of questions: the first question of “The Liver of Son and Stepmother”

epic of self-tests is designed to measure human beings' degree of empathy by measuring the degree of empathy for literary text.

The example is as follows (Fig. 1).

Sixteen questions were created by processing and summarizing the oral folktales from 'The Collection of Korean Oral Literature'.

In folktales, the process from the problem situation to the solution appears compressive (compressed). Thus, the subjects can identify the contents in a short period of time and have an immediate response. The 16 questions were divided into four areas according to the positions of children, the positions of men and women, the positions of husband and wife, and the positions of parents, centering on human relationships as a circular form. These four areas are called the realm of son and daughter, the realm of man and woman, the realm of husband and wife, and the realm of father and mother. They are designed according to the four levels and patterns of human relations. In other words, four levels of stories are arranged in order in each of the four areas. If the subject answers 16 questions, the result will be between 16 and 80 (Table 1).

Table 1. Configuration of clauses and sentences in questions

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Sentence	6	6	6	6	6	6	6	6	8	12	8	15	11	10	13	10
Clause	82	131	121	81	75	114	184	124	186	223	145	245	182	176	207	164

2.3 Tool

In this experiment, the eye tracker device (Gazepoint GP3 eye tracker) was used. The equipment has a collection rate of 60 Hz and a resolution of 0.5 to 1 degree of visual angle accuracy.

2.4 Procedure

The experiment was conducted individually and without distinction between groups. After preparing a consent form for participation in the experiment, the EQ test was conducted for group propensity analysis. To carry out the experiment in earnest, we explained the experiment to the participants, and nine points were presented on the screen in order to calibrate the subjects' eyes.

The 16 story questions in the emotional-response-type epic of self-test are given to participants in 16 projects. After the participant has finished reading the literary text, press the ESC button and select one of the five options in the questionnaire: repulsion, uninterested, nothing special, interested, or touching. Once the selection is complete, check that the line of sight is fixed in the center, and put the text of the second question on the screen so that the subject can re-execute the process that he or she performed in Question 1. This process is to be carried out through Question 16.

Scores that are converted through options selected by the subject will be used to analyze the differences in gaze processing between the group with a high level of empathy and that with a low level of empathy during the analysis phase.

3 Results and Discussion

3.1 Correlation Between Factors Analysis of Literacy Text and Empathic Abilities

Five factors were extracted from the experiment. They are “son and daughter epic”, “father and mother epic”, “man and woman epic”, “husband and wife epic”, and “personal epic”.

The correlation between each factor was not significant and the “son and daughter epic” had a slight effect on the EQ score (Table 2).

Table 2. Correlation between factors analysis of literacy text and empathic abilities

Rotated Component Matrix

	Component						
	1	2	3	4	5	6	7
pa02	.824	.033	.038	-.036	.023	.315	.065
C01	.768	.150	.094	.129	.304	-.125	-.071
C02	.544	-.284	-.473	.025	-.100	-.412	-.154
C03	.373	.790	-.123	.168	-.061	.005	-.132
G02	-.157	.779	.212	.049	-.200	-.157	.035
cu02	-.071	.521	-.277	-.434	.130	.423	.323
pa03	.315	.472	.024	.281	.464	.267	.324
G03	.107	-.034	.906	-.085	.199	-.010	-.140
G01	-.073	.069	.648	.186	-.277	.103	.469
pa01	.278	.184	-.140	.803	-.086	.005	-.006
cu01	-.107	.091	.227	.742	.077	.329	.007
C04	-.221	-.250	-.359	.568	.313	-.092	-.387
pa04	.151	-.104	.227	.043	.867	.149	-.011
G04	.055	-.167	-.274	-.077	.655	-.419	.172
cu04	.128	-.121	.036	.173	-.009	.858	.005
cu03	-.039	-.034	-.019	-.092	.128	-.017	.951

Extraction Method: Principal Component Analysis.
 Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 19 iterations.

Table 3. Correlation between factors analysis of “Son and Daughter epic”

		Correlations					EQscore
		T1	T2	T3	t4	t5	
T1	Pearson Correlation	1	.177	-.081	.101	.260	.306
	Sig. (2-tailed)		.430	.720	.654	.242	.167
	N	22	22	22	22	22	22
T2	Pearson Correlation	.177	1	.004	.050	.000	.009
	Sig. (2-tailed)	.430		.986	.824	1.000	.967
	N	22	22	22	22	22	22
T3	Pearson Correlation	-.081	.004	1	-.069	-.030	.018
	Sig. (2-tailed)	.720	.986		.760	.896	.935
	N	22	22	22	22	22	22
t4	Pearson Correlation	.101	.050	-.069	1	.064	.247
	Sig. (2-tailed)	.654	.824	.760		.777	.267
	N	22	22	22	22	22	22
t5	Pearson Correlation	.260	.000	-.030	.064	1	.089
	Sig. (2-tailed)	.242	1.000	.896	.777		.693
	N	22	22	22	22	22	22
EQscore	Pearson Correlation	.306	.009	.018	.247	.089	1
	Sig. (2-tailed)	.167	.967	.935	.267	.693	
	N	22	22	22	22	22	22

Model summary ^b										
Model	R	R square	Adjusted R square	Std. error of the estimate	Change statistics					
					R square change	F change	df1	df2	Sig. F change	Durbin-Watson
1	.474 ^a	.224	.042	9.29339	.224	1.229	4	17	.335	1.817

a. Predictors: (Constant), pa, G, cu, C

b. Dependent Variable: EQscore

The experiment results above show that the case was insufficient to explain the correlation between the text stimulant and the EQ. However, if sufficient cases are secured through the pilot test, there is a possibility that there will be a link between “son and daughter epic” and the EQ (Table 3).

3.2 Experiment Results of Eye-Tracking

As previously explained, the narrative stimulus that demonstrated a correlation with EQ was the “son and daughter epic” or the story that revolves around the relationship between a parent and child. To test the hypothesis that the level of empathy will change the response and understanding of a text, the upper and lower EQ score groups were established, and the frequency of eye fixation from each group was examined. In order to help visualize this, a heat map was implemented.

Here, the differences between the two groups in relation to the “son and daughter epic” are presented, and the survey contents between the two groups are compared.

In the second “son and daughter epic” question, the groups separated by the EQ score consisted of three participants each, and the frequency of eye fixation was checked (Table 4).

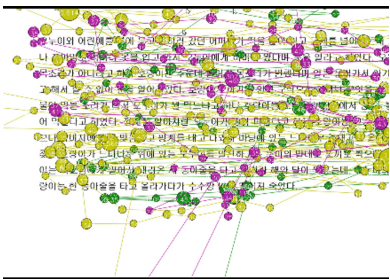
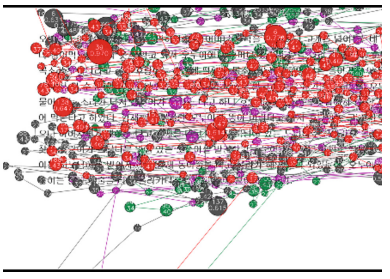
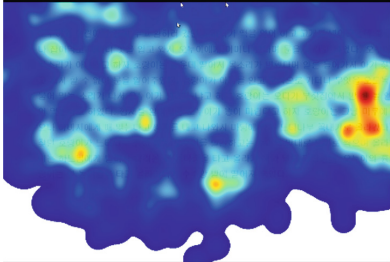
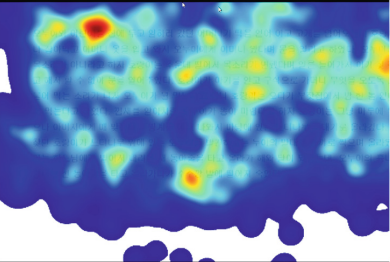
The results show that the upper group was focused on the word “up” from the sentence ‘up to the top of the tree in the yard’, and the lower group was concentrated on the words “child”, and “left children at home” from the sentence ‘mother left little brother and sister and a child at home and went to work’.

The lower group is focused on the first half of the story. The upper group is focused on the second half of the story. Furthermore, the lower group is focused on the characters, while the upper group is focused on the characters’ actions. The point when the brother and sister went up to the sky, a symbol of their independence from their parents’ world, is the sentence that determines the ending of the story.

Therefore, the fact that the upper group was focused on the sentence ‘up to the top of the tree in the yard’ means that the eyes were fixed longer and repeatedly at a story’s point. One of the upper group participants chose ‘interesting’ for this question and responded by saying, “the sheer force of the young children, suspicious that the tiger is different from the mother’s, is funny.” Meanwhile, one of the lower group participants responded, “the content of a tiger eating a baby was horrifying”, and chose ‘repulsion’.

The higher the score on 5-point scale, the more attention is paid to the process of children’s self-reliance and overcoming the conflict with the tiger. On the other hand, the lower the score, the more attention was paid to the element of tiger cruelty.

Table 4. The second question of “Son and Daughter epic”

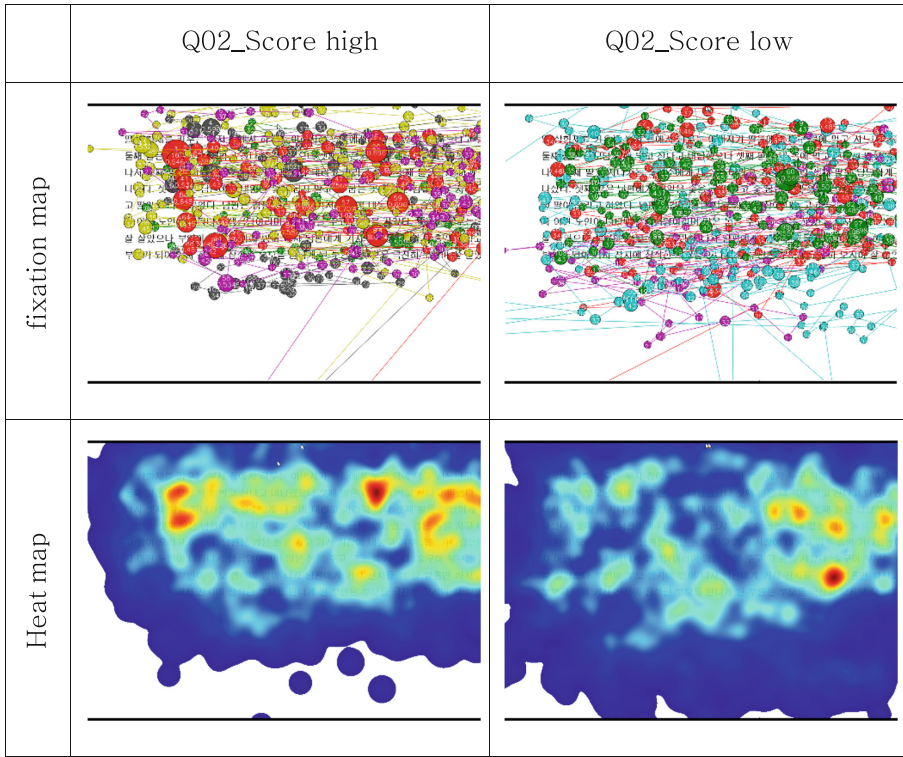
	Q02_Score high	Q02_Score low
fixation map		
Heat map		

This is to be confirmed through the acquisition and analysis of more participants (Table 5).

In the case of the third “son and daughter epic” question, the groups separated by the EQ score consisted of five participants each, and the frequency of eye fixation was checked.

The results show that the upper group was focused on the word “up” from a sentence ‘up to the top of the tree in the yard’, and the lower group is concentrated on the words “child”, and “left children at home” from the sentence ‘mother left little brother and sister and a child at home and went to work’.

As a result, the upper group is focused on the word ‘her good fortune’ from the sentence ‘the third daughter said she lives in her good fortune’, and ‘to a charcoal dealer’ from the sentence ‘father sent the third daughter to a charcoal dealer.’ Alternatively, the lower group was focused on the phrase ‘proper price’ from the sentence ‘she asked him to sell the stones at a proper price’. Here we can see that while the upper group was focused on the conflict between the father and daughter, the lower group was focused on how the daughter became rich. In other words, the upper group is paying attention to problem situations triggered by relationships, while the lower group

Table 5. The third question of “Son and Daughter epic”

is paying attention to wealth. This means that the upper group is focusing on context, while the lower group is focusing on motif.

One of the upper group participants chose ‘touching’ for this question and responded by saying, “I’m impressed by the part where the third daughter serves her parents who drove her away hard and became beggars.” One of the lower group participants responded, “I wonder why the smart daughter lives with people who don’t even have a parent’s qualifications”, and chose ‘repulsion’.

The higher the score on the 5-point scale, the causal context of a rich daughter having a father is understood, and on the other hand, the lower the score, more subjective feelings are projected. This is to be confirmed through the acquisition and analysis of more participants.

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References

- Engbert, R., Longtin, A., Kliegl, R.: A dynamical model of saccade generation in reading based on spatially distributed lexical processing. *Vis. Res.* **42**(5), 621–636 (2002)
- Engbert, R., Nuthmann, A., Richter, E., Kliegl, R.: SWIFT: a dynamical model of saccade generation during reading. *Psychol. Rev.* **112**(4), 777–813 (2005)
- Morrison, R.E.: Manipulation of stimulus onset delay in reading: evidence for parallel programming of saccades. *J. Exp. Psychol. Hum. Percept. Perform.* **10**, 667–682 (1984)
- O'Regan, J.K.: Eye movements and their role in visual and cognitive processes Eye movements and reading. In: Kowler, E. (ed.) pp. 395–453. Elsevier (1990)
- Reichle, E., Pollatsek, A., Fisher, D., Rayner, K.: Toward a model of eye movement control in reading. *Psychol. Rev.* **105**, 125–157 (1998)
- Pollatsek, A., Reichle, E.D., Rayner, K.: Tests of the E-Z reader model: exploring the interface between cognition and eye-movement control. *Psychology* **52**, 1–56 (2006)
- Zhu, Z., Ji, Q.: Eye and gaze tracking for interactive graphic display. *Mach. Vis. Appl.* **15**, 139–148 (2004). <https://doi.org/10.1007/s00138-004-0139-4>
- Laura, A.G., Joachims, T., Gay, G.: Eye-tracking analysis of user behavior in WWW-search. In: Laura A.G. (ed.) Research Gate (2004). <https://doi.org/10.1145/1008992.1009079>
- Salvucci, D.D., Goldberg, J.H.: Identifying fixations and saccades in eye-tracking protocols. In: Proceedings of the 2000 Symposium on Eye Tracking Research & Applications. ACM, pp. 71–78 (2000)