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Research Paper

Effect of Graphic Advance Organizers on Enhancing the Comprehension of German Texts by Adult GFL Learners: An Eye-Tracking Study

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Abstract
Utilizing graphic advance organizers before reading is to construct a mental model of the meaning of the text based on readers' formal prior knowledge of familiar rhetorical schemata, which enhances reading performance. The effectiveness of an animated matrix in improving reading comprehension was investigated in a computer-mediated reading environment. Eye-tracking was employed to examine the reading process of participants performing a German reading task. Two groups of participants (N = 21) were compared in terms of their reading performance quality, the number of main idea units recalled, and the verbatim recall memory. The use of a graphic advance organizer significantly improved reading comprehension quality ($p < .05$). Based on the eye-tracking results, the two groups of participants showed no significant difference, indicating equivalent exposure to the passage. There is evidence that the user-controlled sequential display of elements grants categorical reading of the matrix and provides minimal guidance to deepen the understanding of the passage, as metacognitive skills are not actively used in linking new material read to parts of the organizer.

Keywords: *Advance Organizer; Eye Tracking Graphic; Foreign Language Reading; Matrix*

نقش پیش سازمان دهنده های گرافیکی کمک آموزشی در درک متون آلمانی زبان آموزان ایرانی با استفاده از فناوری ردیابی چشمی
هدف استفاده از الگوی پیش سازمان دهنده قبل از خواندن, ایجاد ساختار ذهنی مطلوب از متن بر پایه دانش پیشین و در نتیجه فهم معنا دار است. پیش سازمان دهنده های گرافیکی با نمایش مفاهیم کلیدی و ارتباط آنها به خصوص به درک همادین متن کمک می کنند. در تحقیق پیش رو اثربخشی یک جدول ماتریس منطبق بر ساختار کلان متن در بهبود درک مطلب در یک محیط مطالعه کامپیوتری بررسی و از ردیابی چشم برای بررسی روند خواندن استفاده شد. دو گروه از ۲۱ زبان آموز ایرانی از نظر کیفیت درک متن، تعداد مفاهیم اصلی یادآوری شده و حافظه لفظی مقایسه شدند. استفاده از پیش سازمان‌دهنده گرافیکی کیفیت درک مطلب را به طور معنی داری بهبود بخشید. مقدار احتمال از احتمال خطای نوع اول کوچکتر بود. بر اساس نتایج ردیابی چشم، آزمون شوندگان در هر دو گروه مواجهه یکسانی با متن داشتند. شواهد نشان داد که در واقع نمایش متوالی عناصر توسط کاربر، به خواندن طبقه ای ماتریس و درک عمیق ترمتن کمک می کند، زیرا آزمون شوندگان از مهارت‌های فراشناختی به طور فعال در پیوند دادن مطالب جدید خوانده‌شده به بخش‌هایی از سازمان‌دهنده استفاده نکردند.
واژگان کلیدی: سازمان دهنده پیشرفته، گرافیک ردیابی چشم، خواندن زبان خارجی، ماتریس

Introduction

Since text-based instructional materials are commonly provided in blocks, it is often challenging for students to make connections between concepts (Kiewra, 2012). The Cognitive Load Theory (Sweller et al., 2011) suggests that the design of instructional materials could cause a cognitive overload, interfere with learning, and result in poor comprehension. In instructional psychology, linguistic, content-related, and formal features of texts are examined to determine how they facilitate or hinder comprehension; accordingly, specific instructional aides are designed to enhance text intelligibility (Christmann & Groeben, 1999). Among the most prominent instructional theories on the reception of linguistic material is Ausubel's (1968) cognitive learning theory. According to this theory, the processing of a text takes place by integrating relevant materials into what the learner already knows and understands. Ausubel maintains that this process, also known as subsumption, can be optimized by providing the learner with an appropriate subsumer, the so-called advance organizer. Using Ausubel's (1968) definition, advance organizers are "appropriately relevant and inclusive introductory materials […] introduced in advance of learning […] and presented at a higher level of abstraction, generality, inclusiveness" (p. 148). In Ausubel's view (1968), the purpose of an advance organizer is "to provide ideational scaffolding for the stable incorporation and retention of the more detailed and differentiated material that follows" (p. 148). Ausubel failed to determine an adequate type and structure of advance organizers as criticized by Weisberg (1970). Therefore, the operationalization of advance organizers became increasingly important. Providing advance organizers according to the global structure of texts is a possibility suggested by Kintsch and van Dijk (1978). According to them, the macrostructure of a text can act as an advance organizer, which satisfies Ausubel's logic requirements. This concept was applied to create graphic organizers that shared similar theoretical origins and purposes (Clark & Bean, 1982). Graphic organizers have been described as visual displays that illustrate the relationships between the main ideas in the text (Hall & Strangman, 2008; Kiewra, 2012; Robinson & Kiewra, 1995; Shaw et al., 2012). Accordingly, graphic organizers differ in the way they are structured and the relationships they represent (Armbruster et al., 1991; Fiorella & Mayer, 2016; Kierwa, 2004; Robinson & Kiewra, 1995; Rovira, 2016). Five rhetorical structures are typically used in expository texts: compare-contrast, problem-solution, cause-effect, sequence, and description (Meyer & Ray, 2011; Raymond, 1993). The main ideas could be organized within a specific organizational structure, by way of example, a matrix for a compare-and-contrast structure, a hierarchy in case of classification, and a flow chart for a cause-and-effect process (Fiorella & Mayer, 2016). The matrix is known as the fundamental form of graphic organizers as it could incorporate the other forms. (Kiewra, 2004). This organizer is used to compare the various features of two or more items by organizing them into columns and rows. (Kiewra, 2004). The definition given by Jairam et al. (2012) denotes the matrix parts and their location well: "A matrix is a two-dimensional, cross-classification table or chart that presents topic names […] along the top row, category names […] down the far left column, and details […] inside matrix cells at the intersection of corresponding topics and categories" (p. 128). It was established early on that the use of a matrix enhanced students' learning of facts and their relationships (Kiewra et al., 1988; Robinson & Kiewra, 1995). This higher performance is justified by the three Matrix functions of signaling, extraction, and location. Access to text information is made easier and more effective by signaling. Extraction implies that the important information within the text is separated from the less important information, while localization refers to how closely related information is displayed. (Kauffman & Kiewra, 2010). This study incorporates a matrix as a specific type of advance organizer including a comparing structure that visualizes the main ideas of text. In contrast with advance organizers and graphic organizers are matrix advance organizers

that depict the comparing structure of text are understudied. The study is based on research on second language acquisition showing graphic organizers aid reading comprehension. (Davoudi & Yousefi, 2016; Heidarifard, 2014; Jiang & Grabe, 2007; Nasir, 2016; Rasouli & Heravi, 2018; Tang, 1992; Torres, 2015; Wu & Alrabah, 2020). However, none of the studies explain how the reading behavior of readers changes when graphic organizational aids are applied. The objective of the current study is to investigate how the use of matrix advance organizers as instructional aids can improve understanding.

Literature Review

Advance Organizers

The research during the 1960s examined whether or not advance organizers facilitated learning from text (see Ausubel, 1978). These studies' findings are not conclusive. In his review, Mayer (1979a) looked at a different question from those raised by similar studies, namely, whether qualitatively different learning outcomes could be obtained. Researchers conducted several studies (e.g., Bromage & Mayer, 1986; Mayer, 1980, 1975a, b) to clarify the idea that the effects of meaningful learning can be evaluated in terms of a range of differently structured outcomes. In conclusion, the results support the idea that advance organizers can encourage readers to focus on key features of passages and the concepts they contain.

Graphic Organizers

Over the period from 1984 to 2020, several studies demonstrated that graphic organizers were beneficial to text comprehension (Armbruster et al., 1991; Bogaerds-Hazenberg et al., 2021; Colliot & Jamet, 2018; Guri-Rozenblit, 1989; Hebert et al., 2016; Kiewra & Robinson, 1995; McCrudden et al., 2009; Moore & Readence, 1984; Robinson et al., 2006; Williams et al., 2009). This benefit differed according to the graphic organizer type and the measure used to assess text comprehension. Graphic advance organizers that depict the structure of the text and comprehension surveys that emphasize the construction of coherent mental models of texts have made a greater impact (Fiorella & Mayer, 2016; Griffin & Tulbert, 1995; Jiang & Grabe, 2007; Meyer & Poon, 2001).

As previously stated, matrix organizers can represent the comparative structure of an expository text. The SOI (select-organize-integrate) information processing model (Mayer, 2010, 2014) supports matrix approaches. This model is based on active processing, which is central to cognitive sciences and builds upon three main cognitive processes involved in meaningful learning: (a) selection of the relevant information in the sensory input, (b) construction of relevant connections based on the underlying structures of the data, and (c) integration of the constructed representation with the existing knowledge structure. It is possible to conclude that a matrix method produces an ordered cognitive structure since the kind of cognitive processes that the learner initiates throughout the learning process strongly correlates with the quality of what is learnt (Mayer, 2009). In order to formulate instructional guidelines, it is important to approach graphic organizers from diverse viewpoints and tie the findings together. Currently, eye movement measurement is considered one of the standard methods for collecting online process data in first-language reading research.

Eye-tracking and using graphic organizers to improve reading comprehension

One can gain valuable insight into how written language is processed by studying eye movement patterns. These examinations are based on the basic information about two types of eye movements: fixations and saccades (Rayner, 1998). When fixation is performed, the eye has micro-movements and appears to be still. Drawing on the “immediacy hypothesis” and the “eye-mind hypothesis”, Just and Carpenter (1980) demonstrated the relationship between fixations and

the underlying cognitive reading processes. Saccadic movements are rapid movements of the eye from A to B. Upon receiving subsequent input, the brain typically saccades (or transitions) to the next or previous portion of the text to review or process it in greater detail (Just & Carpenter, 1980). The E-Z Reader model (Reichle et al., 2006), one of the current explanations for eye movements while reading, contends that lower-level cognitive processes are responsible for controlling eye movements. While such control is in place, it can be overridden by processes at higher processing levels (Rayner et al., 2006).

For almost a decade, researchers have used eye-tracking technologies to investigate the impact of graphic organizers on text comprehension. In the context of this study, several studies (Liu, 2014; Luo et al., 2014; Ponce et al., 2019; Ponce & Mayer, 2014a, b; Salmeron et al., 2009) have looked at the influence of matrix on cognitive reading processing. Both eye movements and text comprehension have been recorded for this purpose. In this respect, focusing on relevant information within the text is viewed as a manifestation of selection. In contrast, saccades are regarded as a sign of organization and integration since they involve creating a coherent structure for incoming information and integrating it with prior knowledge. According to the findings of these investigations, graphic organizational aids activate cognitive mechanisms of selection, organization, as well as integration (Mayer, 2010) and promote an enhanced understanding of the text (Ponce & Mayer, 2014a, b).

Purpose of the Study

In light of the current research literature, the present study aims to examine the impact of graphic advance organizers (matrix) on German-language learners' reading comprehension and eye movement behavior when reading (German) texts with the comparison rhetorical structure. This article attempts both to fill the research gap mentioned and provide empirically sound and realizable findings regarding how to improve text comprehension.

This study is intended to respond to the following primary question: Does the employment of matrix advance organizers affect the performance of foreign language readers? The secondary questions provided below were developed to measure the impact of a matrix advance organizer on reading performance. The first two questions focus on readers' reading comprehension, while the third concerns the mental processes associated with reading:

RQ1. Does the use of advance matrix organizer as an instructional reading aid engender a statistically significant improvement in the reading comprehension performance of GFL learners?

RQ2. Does the memory performance for main ideas between GFL readers who processed text with and without a matrix advance organizer differ significantly?

RQ3. Does the matrix enhance the reading processes of selection and organization, as well as integration?

It is assumed that textual and visual sources would be merged as complimentary sources and integrated with existing knowledge to build a mental representation (Mayer, 1979a; Mayer, 2009), resulting in more frequent and longer eye fixations on main ideas, as well as more organizational and integrative transitions throughout the text.

Method

Design

This study employed a posttest-only experimental control group design, and no measurements were taken before the treatment. The researcher manipulated the independent variable and assessed the effect on the dependent variable. The presumption is that the instructional reading aid will enhance students' reading performance. There were two groups based on a between-subject design: a text-only group, which read a plain text and a matrix advance organizer group,

which obtained the conducted matrix organizer prior to and also along with the text. Participants were randomized to experimental or control groups and tested individually.

Participants

A non-probabilistic sample method, namely a volunteer sampling method, was used to recruit participants, since an appropriate sample frame was not available in the study. Four renowned German institutes in Tehran were contacted. To entice volunteers, researchers placed advertisements aimed at advanced German learners that also included information about the study's subject and technique. A total of 41 responses were obtained. 20 students were not voluntarily participating in the study. The existence of covid-19 limits and health concerns was the primary impediment. 20 Iranian students (10 females and 11 males) participated in this study. They were born into a highly technological world and were high adopters of digital technology (Debb et al., 2020). To measure the participants' general German competency and homogenize them, an online placement test was administered as per the CEFR (Common European Framework of Reference for Languages). According to the results, candidates had acquired advanced language skills equivalent to the fourth (B2) out of six levels. One student in the experimental group was excluded from the data analysis due to the poor quality of data collected from the eye tracker. The groups did not differ significantly regarding placement test scores ($p=.21$) or male-to-female proportion (males=6 and females=4).

Materials

A 235-word expository passage on music and its effect on humans was adapted from Lodewick's (2020) *DSH und Studienvorbereitung* (GFL and Study Preparation), which was shortened and modified to be implemented in a PowerPoint presentation. The readability grade levels of the passage were determined through the application of the Flesch Reading Ease Formula (Flesch, 1948). This passage was rated 42 on Flesch's Reading Ease (Readability) Scale. It was considered difficult by the Flesch Readability Index, meaning that college students could understand it. The passage compared the emotional and physical effects of music on humans across three dimensions (effect type, attributes, and assessment). As such, the organizational structure of this text was compare-contrast (Meyer et al., 1980). Control and experimental groups were shown different versions of the text.

Only the text was displayed on the screen in a text-only version. The text-only design was created as a PowerPoint presentation that contained the content in a format identical to that used for experimental group members. Both groups were instructed to press the space key to read the text. For the experimental group, matrix rows were revealed by self-paced mechanisms before reading the passage, allowing the participants to analyze the matrix horizontally (Jairam et al., 2012; Luo et al., 2017) .Notably, the graphic organizer treatment was created by controlling and sequencing the appearance of rows and columns of the matrix during the presentation. The filled-in graphic organizer was embedded into slide two, displaying the passage on the left side of the screen as well as the matrix on the right. The advantages of expert-constructed organizers lie in the fact that they contain the most crucial concepts in the text, which are commonly reflected in assessment measures and organized logically (Moradi et al., 2020). Eye-tracking data was collected both when participants viewed the matrix before the passage and when they read the passage with the matrix beside it.

Test materials included summary and gap-filling tests (Alderson, 2000). The summary test was used to assess reading comprehension. It consisted of a piece of paper with instructions at the top asking the participant to read the passage and summarize the ideas related to the subsequent topics. After reading the passage, further oral instructions followed, asking the participants to use their native language, Persian, in the summary task.

Procedure

The participants were informed that they were participating in a study investigating eye movement patterns while reading a German text. Participants were informed that their eye movements were being recorded during reading a German text. When participants arrived, they were seated in a quiet room and received an online placement test using a 7-inch tablet computer. The task did not have a time limit and ended once all 25 questions were answered (Mean = 21 minutes). Afterward, each participant was requested to sit in front of a monitor in the eye-tracking lab with the eye-tracking device installed. In this study, the eye tracker utilized was the SMI RED 250, which was mounted on a desktop computer with a 19.5-inch screen. On the computer, the BeGaze 3.7 software was installed and operated at a rate of 250 Hertz.

The aim of the study, the methodology, the operation of the eye tracker, and the calibration of the instrument were all described. A self-paced reading process was adopted, with the restriction that returning to an earlier page was not permitted. By tapping the space bar, participants were led to the following page. Participants were advised that they had a maximum of fifteen minutes to complete the task. They were asked to inform the researcher when they had finished the test. After each participant had completed studying the passage and the recording had ended, they were instructed to write a summary of the text in Persian by answering two questions on the summary sheet. No time limit was imposed on the summary task (Mean = 9 minutes), and it was deemed completed once the summary was submitted. The original passage was not accessible to the participants. Following the summary task, a paper-based gap-filling test worksheet with no time constraint was administered. The study concluded with the participants filling out a paper-based demographics form. The participants were warmly appreciated, and standards for treating human subjects were adhered to. The data was collected on a single visit.

Data Analysis

Each participant was assessed on two measures of summary performance: (a) summary quality and (b) summary quantity. For scoring, the passage was segmented into units of analysis (Alderson, 2000), which were rated based on their significance within the passage's structure into main ideas and details (Riley & Lee, 1996). In terms of quantity, the written summaries were scored according to the number of main ideas that were remembered. One point was assigned to each main idea, and scores could be as high as 16 points. A four-point rubric was developed to assess the quality of the summary protocols written by the participants as per three criteria: (a) summary's structure, (b) attributes of comparison and elements compared in the text, and (c) degree of nonlinearity. Accordingly, the first criterion was assigned 0, 1, or 2 points depending on whether or not the summary reflected the rhetorical compare-contrast structure underlying the text. Two points were maximally assigned for each comparison of the attributes in the summary (effects and measures).

Furthermore, summaries with a nonlinear structure were given one point. The summary test had a maximum score of seven points. A GFL teacher evaluated tests according to the criteria outlined above to determine the reliability of the marking process. The interrater reliability coefficient was above 0.8. On the gap-filling test as a measure of verbatim memory, participants were provided with a piece of paper containing the text, with 23 words struck out and blanks substituted, which the respondents had to fill with answers. There was a single bank of choices for the participants over the passage, comprising the words used in the matrix's cells. Each accurate word was worth one point, for a total score of 23 points. A demographics form was created to collect background information about the participants. Apart from common demographic characteristics such as gender and age, the form enquired about issues such as

online reading habits and self-perception of reading ability, which researchers believe are crucial to describing participants and analyzing their data better in studies on adult reading.

This study sought to use eye movement metrics to assess the impact of a matrix advance organizer on the reading process in a foreign language. Areas of interest (AOIs) were established, which refer to stimulus areas about which the researcher is interested in collecting data for the future analysis of eye movement data (Holmqvist et al., 2011). They usually consist of three to five words or between 5 to 15 characters (Wei & Cook, 2017). AOIs were based on the major concepts in the passage and the same values found in the graphic organizer for the experimental group. Participants in the control group had identical AOIs. The total number of fixations and total fixation time in the AOIs were considered the dependent variables in this study. As defined, total fixation durations refer to all eye fixations made on each region during an online reading task (Holmqvist et al., 2011), regardless of whether they are made on the first reading of the region or subsequent readings of the same region (Wei & Cook, 2017). Throughout the reading of AOIs, the total number of fixations reflects either forward or reverse fixations.

Furthermore, we identified regions in the text and examined the number of transitions (or saccades) between them. The passage was divided into four sections: the first and last paragraphs and two subsections within the second paragraph. This selection was made to compare two attributes (effect characteristics and effect measurements) associated with music. Participants were expected to locate the respective attributes in the first paragraph and in the first section of the second paragraph and to compare them with the corresponding concepts in the last paragraph and the last section of the second paragraph. Two types of transitions were counted: (1) transitions between the first and last paragraphs of the passage and transitions between two sections of the second paragraph (up to down), and (2) transitions between the text and the graphic organizer section (left to right). Transitions between sections were interpreted as an indication that the learner was organizing and integrating specific information from the top and bottom areas of the text to construct a mental compare-contrast structure. Transitions from left to right were considered ways to link the matrix with the passage and establish a compare-contrast structure.

Results

Parametric t-tests were used to test the hypotheses since all variables, except the quality of recall, were normally distributed. Rather than using a parametric equivalent, the Mann-Whitney U test was employed to assess the effects of the graphic organizer structure on recall quality. Since the significance level of the Kolmogorov-Smirnov test for this variable was less than 0.05 (as displayed in Tables 1 & 2), the assumption of normality of the data could not be validated. Besides, the variables did not follow a normal distribution, lending them to analyses using nonparametric tests. The significance level was set to $p < .05$.

Table 1
Test of Normality

	KOLMOGOROV-SMIRNOV		
	Statistic	df	Sig.
PRETEST	.108	20	.200*
GAP-FILLING TEST	.140	20	.200*
QUALITY OF RECALL	.234	20	.005
QUANTITY OF RECALL	.193	20	.050

***. THIS IS A LOWER BOUND OF THE TRUE SIGNIFICANCE.**

Table 2
Test of Normality

	Kolmogorov-Smirnov		
	Statistic	df	Sig.
First Fixation Duration	142	20	.200*
Fixation Count	164	20	167
Fixation Time	125	20	200*

*. This is a lower bound of the true significance.

Considering that eye movement datasets meet the requirements of normality and homogeneity of variance, it was decided to conduct parametric tests to compare the eye behavior of test takers in both conditions. This study utilized the Kolmogorov-Smirnov test for eye-tracking metrics as the significance level was greater than 0.05, and all variables were normally distributed.

Learning outcomes results

RQ1. Does the use of advance matrix organizer as an instructional reading aid engender a statistically significant improvement in the reading comprehension performance of GFL learners?

The primary prediction is that reading the matrix as a spatial arrangement of key concepts within a rhetorical structure that is aligned with the comparative macrostructure of the text will prime the cognitive mechanisms of selecting, organizing, and integrating the material and enhance comprehension on qualitative and quantitative levels (Fiorella & Mayer, 2016). The aim of the summary test was to evaluate passage comprehension. Initially, we investigated the assumption that the matrix advance organizer group would score better on the summary test than the control group in both quantitative and qualitative senses. It was as a result of the matrix advance organizer group's propensity to construct an organized knowledge base through active processing processes, as in the compare-contrast matrix in which two elements (emotional and physical effects of music on people) are analyzed along several dimensions. Tables 3 and 4 detail the results of the Mann-Whitney U test, t-tests, and effect sizes. As predicted, the Mann-Whitney U test demonstrated a significant improvement in learners' qualitative performance in the matrix advance organizer group ($p < .05$). The graphic advance organizer revealed a large effect ($r = 0.53$). In contrast, the difference between the quantitative performance of participants in the matrix advance organizer group and the control group did not prove to be statistically significant ($p > .05$). To see if there was a statistically significant difference between the groups in the placement exam results, a covariance analysis was performed. Matrix advance organizers were significantly associated with recall quality after controlling for placement test scores ($F (1, 18) = 11.767$, $p = .003$).

Table 3
Results of Mann-Whitney U Test of Quality of Recall

		Quality of recall
Graphic AO (N = 10)	Mean	3.9
	Std. deviation	2.28
Text-only (N = 10)	Mean	1.2
	Std. deviation	2.29
Mann-Whitney U		19.5
Z		-2.395
Sig. (1-tailed)		.019
Effect size r		0.53

Table 4

Results of Sample t-tests on Placement, Gap-Filling, and Quantity of Recall Scores

		Pretest	Gap filling Test	Quantity of recall
Graphic AO	Mean	14.90	11.20	5.10
(N = 10)	Std. deviation	3.16	6.77	2.99
Text-Only	Mean	16.5	14.00	4.10
(N = 10)	Std. deviation	3.48	5.79	2.07
MD		-1.65	-2.80	1.00
T		-1.10	-.99	.86
Sig. (2-tailed)		.28	.334	.39
All significant at p < .05.				

RQ2. Does the memory performance for main ideas between GFL readers who processed text with and without a matrix advance organizer differ significantly? We examined the prediction that the matrix group would be superior to the text-only group on the gap-filling test, test of rote memory. In instances where reading the matrix advance organizer initializes the cognitive process of selection, we can conclude that it would manifest as enhanced memory test performance. Contrary to the prediction, the matrix organizer group did not outperform the control group (p >.05) (Table 4).

Eye-tracking results

RQ3. Does the matrix enhance the reading processes of selection, organization, and integration? It was anticipated that participants in the matrix advance organizer group would fixate longer and more frequently on the main ideas (AOIs) compared to participants in the text-only condition, which would demonstrate the activation of the cognitive processes involved in selection. In addition, it was expected that there would be more transitions between the specific areas of a passage, as indicative of the cognitive processes of organization and integration, since the reader tries to make comparisons within the text and compare different areas to one another.

Table 5

Results of Sample t-tests on Total Fixation Count, Total Fixation Time, Number of Transitions, and First Fixation Duration for the Areas of Interest in the Passage

		Total fixation Count	Total fixation time	Transitions in the first & last paragraphs	Transitions in the second paragraph	First fixation duration
Graphic AO	Mean	43.9	25504.52	.70	5.00	226.81
(N = 10)	Std. deviation	28.50	11273.77	1.25	3.39	144.63
Text-Only	Mean	35.5	27805.55	.70	4.50	544.35
(N = 10)	Std. deviation	18.06	9800.96	.94	3.37	424.43
MD		8.4	-2301.03	.00	.50	-317.54
T		.787	-.487	.00	.330	-2.239
Sig. (2-tailed)		.44	.63	1.00	.74	.047
All significant at p < .05.						

A normality test was performed initially to identify which tests would be applied to the data. The results of the normality tests indicated that the respective eye-tracking measures (fixation

time and fixation count) had a normal distribution (as reported in Table 2). Therefore, an independent sample t-test was conducted to investigate the effects of matrix instructional reading aid on the readers' total fixation times and total fixation counts when reading the passage using an eye-tracking device. Table 5 presents the results of the statistical analysis of the research data. As displayed in Table 5, there were no statistically significant differences between the matrix group and the control group with respect to the total fixation time ($p > .05$), the total number of fixations ($p > .05$), and the number of transitions between sections of the passage ($p > .05$). First fixation duration differed significantly for readers who read the graphic advance organizer compared to those who read the text-only version. It was found that readers who received instructional aid spent significantly less time on the AOIs than those who read the text-only version (Table 5).

Discussion

The purpose of this study was to determine the effects of using the matrix advance organizer as an instructional aid on GFL learners' reading performance. In response to the research questions and based on data analysis, this study's results demonstrate that adding an advance matrix to the passage can improve the reader's comprehension quality. Our findings indicate that matrix organizers have benefits for subsumption. Evidence indicates that an animated matrix prompts readers to recall macrostructural information as a schema, which is primed and activated from long-term memory to reorganize and integrate the information mentally. The mean score of prior knowledge of the type of graphic organizers was 2.8 (SD = 0.63) on a scale of 0–3, which indicates very high knowledge. This outcome is in line with previous empirical findings that have found that A graphic organizer aids the creation of coherent cognitive structures. (Armbruster et al., 1991; Colliot & Jamet, 2018; Kiewra & Robinson, 1995; Liu, 2014; McCrudden et al., 2009; Robinson et al., 2006; Ponce & Mayer, 2014a, b; Ponce et al., 2019; Williams et al., 2009) and in particular, with studies of advance organizers that were sensitive to the quality of learning outcomes (Mayer & Bromage 1986; Mayer 1975a, b; Mayer,1980). The matrix advance organizer in this study served as scaffolding to form an initial mental representation of the text and allowed the learner to quickly comprehend the outline of the mental model to be constructed. These findings converge fairly well with those of Eitel, Scheiter, and Schüler (2012) and support the belief that even "a brief initial glance at an instructional diagram could support comprehension and processing of text" (p. 699).

In contrast to our hypothesis, the majority of eye movement measures used in our study of the reader's reading behavior in the matrix organizer condition were not significantly different from those of readers in the read-only condition (as shown in Table 5). These findings contradict those in previous studies (Ponce et al., 2019; Ponce & Mayer, 2014 a, b), which indicated that the graphic organizers serve to prime more transitions and to direct learners' focus on the content of graphic organizers. The instructional aids did not stimulate students to participate in proper cognitive processing while reading the passage could be partly explained by a lack of metacognitive skills, making connections between new material they are reading and parts of the advance organizer. The effectiveness of metacognitive strategies in foreign-language hypertextual reading and the effect of metacognitive direct instructional measures in virtual learning environments have been investigated by Haghani and Sohrabi since 2009. The researchers attribute the problem of the examined GFL learners to the so-called *production deficit* (Sohrabi, 2012, p. 157). This means that the learners do not certainly use the available target-adequate cognitive and metacognitive components appropriately or cannot spontaneously produce and bring about the current usability of strategic behavior (Sohrabi, 2012; Sohrabi & Haghani, 2015).

Based upon the heat map of eye movements in the advance organizer condition (see Appendix), it appears that the participants rarely looked at the graphic advance organizer alongside the document. This finding is consistent with study results from Pellicer-Sánchez et al. (2021), which suggested that L2 learners invested more time reading the text than the graphics when presented with both text and graphics. There may have been a lack of metacognitive sensitivity to the difficulty of the passage as a reason for this. Approximately three-quarters of the respondents (N=15) rated their understanding of the topic as good or very good in response to question 18 on the questionnaire. According to Taki (2016), Iranian readers of English tend to favor bottom-up reading in their L1 and L2. This may be attributed to the absence of global strategies training, including awareness of text structure. If readers were trained on the effective use of graphic organizers for meaningful learning, they would be more likely to utilize them effectively (Merchie et al., 2021; Meyer & Poon, 2001; Meyer & Ray, 2011; Raymond, 1993; Williams et al., 2009).

A statistically significant difference, however, was observed between the matrix advance organizer group and the control group for the first fixation duration (as displayed in Table 5). This is not surprising when we consider that the effect appears in an early measure of processing (first fixation duration) consistent with processes associated with word recognition (Wei & Cook, 2017; Yusri & Soh, 2019). This result might be explained by the fact that the first encounter of the words in the advance matrix organizer condition also affected early processing times on the second encounter.

Conclusion

In terms of theory, there is good reason to assume that the matrix advance organizer can prime formal prior knowledge of readers about familiar rhetorical schemata and integrate them with the incoming text to form a coherent mental model. The eye movement variables examined in this study do not provide a comprehensive account of the qualitative changes in reading performance that result from reading the graphic advance organizer. Notwithstanding that, the study's results indicate that the essential condition is fulfilled, and the matrix is extracted to a large extent. The regulation of the respective strategies must be adequately promoted to enable learners to implement their metacognitive strategic knowledge in strategic actions (Sohrabi & Haghani, 2015). In this regard, the duration of the training programs plays a very decisive role. Short-term interventions have a relatively short-term significant effect (Sohrabi, 2012; Raymond, 1993). They fail to bring about the desired learning effect due to insufficient opportunities for learners to practice and automate the strategies (Sohrabi, 2017) and due to interference processes in which newly learned, requirement-adequate strategies interfere with the suboptimal but still functioning strategies (Sohrabi, 2012; Sohrabi & Haghani, 2015). In addition, the studies by Haghani and Sohrabi (2015) have revealed that relatively short-term intervention measures can only convey simple metacognitive strategies. Complex strategies, which require situation-dependent change and the control of one's learning activities in the sense of executive control, are difficult to change in the short term (Sohrabi, 2012). These findings and their explanation align with theories of metacognition and self-regulated learning. (Bannert & Mengelkamp, 2013). The findings are not, however, generalizable to other text structures, text lengths, graphic formats, or different degrees of coherence between texts and graphics. Further research should examine different rhetorical structures. In order to determine the accuracy of the estimation, we also need to conduct further experiments with a variety of GLF learners with different proficiency levels.

The lack of statistical power to identify small effects is one of the study's limitations. Given the data collection timeframe, which coincided with the implementation of the most restrictive measures to restrict the spread of COVID-19, there were few opportunities to recruit a large number of participants in GFL classes at universities and language schools. The study involved

only 20 participants out of an already modest sample. Larger samples would be beneficial for future research.

The study contributes to the body of research regarding graphic advance organizers as it builds on an animated graphic advance organizer and eye-tracking technology (e.g., Li, Tong, Irby, Lara-Alecio, & Rivera, 2021). It is assumed in advance organizer studies that advance organizers are employed. These findings are particularly relevant because they indicate that the structural aid has been read in advance based on evidence derived from eye-tracking technology. By adding an animated graphic advance organizer illustrating the passage's structure, learners can direct their attention to the items in the matrix as they appear and deepen their understanding of the main ideas contained within it and the relationships among them. Furthermore, this study used a user-controlled sequential display of elements to grant categorical reading of the matrix. Studies (e.g., Jairam et al., 2012) have revealed that categorical reading reduces extraneous cognitive load, which could be caused by chaotic reading. Today, electronic texts or digital texts are utilized to transmit a significant amount of information. As e-texts are presented in the digital reading space, they present an excellent opportunity for the implementation of instructional design that guides active processing, reduces unnecessary cognitive processing, and thus increases text comprehension.

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Appendix

Heat Map of Participants' Eye Movements in the Advance Organizer Conditions