Zanjan University of Medical Sciences

Comparison of Effectiveness of Presenting Images in Visual Education of Students on Brain Function

Neda javadi[1*] iD, Mahdieh Rahmanian[2], Ahmad Alipour[3]

[1]candidate of Psychology in Azad University of Tehran markaz Branch, Tehran, Iran.

[2]Psychology Department, Payame Noor University, Tehran, Iran.

[3]Psychology Department, Payame Noor University, Tehran, Iran.

Article Info

Abstract

Background & Aim: Instead of being based on reality, theoretical approaches related to the occurrence of learning are more based on the observations by researchers. One of the approaches is the study of the effect of changes in virtual education based on the physiological approach. This study aimed to compare the effectiveness of presentation of images in visual education on the brain function of students.

Materials and Methods: This study had a 2x2x2 factorial experiment design to compare the effects of three independent variables of spatial intelligence (low and high), depth (2D and 3D), and motion (statistic, dynamic) on two dependent variables of alpha power and recall. Statistical population included all students of Baqiyatallah University of Medical Sciences, Tehran, Iran, who were selected by purposive sampling and were randomly divided into two test groups. The mental rotation test by Vandenberg and Kuse was applied to classify the two groups into high and low spatial intelligence groups while a research-made test and an electroencephalogram were exploited to measure recall and record brain waves, respectively.

Results: According to the results of the analysis of variance, no significant difference was observed among visual educational styles in terms of the range of alpha. However, the interaction effects of spatial intelligence and motion on the power of alpha waves were significant.

Conclusion: According to the results of the study, the mean scores of the alpha wave was lower in the group of high spatial intelligence, compared to the other group, during a teaching by static images. Through education with animated images, the alpha waves were higher in the subjects with high spatial intelligence, compared to the other participants. It could be concluded that 2D animated images and 3D animated imaged were more effective for individuals with low and high spatial intelligence, respectively.

***Corresponding author:** Neda javadi, **Email:** ned.javadi.psy@iauctb.ac.ir*

Introduction

Today, distance learning or virtual education, mobile learning, animations, educational simulators, and educational films have opened their way to the field of education that is known as e-learning (1). The revolution in information technology has created new challenges in the area of education (2). Therefore, one of the most important features of the present age is the increasing acceleration of scientific and technological developments. On the other hand, in almost all societies, recreating the culture and transferring the valuable methods of the predecessors to the future generation and being the origin of changes and social innovations are expected from the education unit. This means that the education system must be able to, in addition to coordinating with the developments of today's society, anticipate changes and transformations in the future and direct the changes toward creating a favorable condition in the future. These changes occur when learning is established among society members (2).

One of the factors contributing to changing students' learning experiences in classrooms is the use of multimedia training, especially educational animations (3). Students prefer animations to other images, such as static photos (4). Recent advances in the field of neurology research and the increasing use of educational animations in the classroom have created remarkable conditions to advance our understanding of how to use 3D animations in education in a way that it could affect the brain and the learning process. The study of learning and its affecting factors in the field of virtual educations can be considered as one of the basic needs and fundamental studies in the field of education. Virtual education has provided the ability to create multimedia educational content. Today, we can easily create various 2D and 3D images and animations. The effects of these facilities on learning can be assessed by different approaches. In this regard, one of the approaches to studying the effects of developments in virtual education is a study based on a physiological approach.

Numerous studies have compared learning through animations (animated pictures) and static images. Nevertheless, their results are not clear. Some believe that static images are often more effective in learning, compared to animations (5). On the other hand, others believe that animations have an advantage over static images (6, 7). Some results suggest that static images are suitable for study, whereas animation is appropriate for learning

a process. In addition, some other researchers argue that the use of 3D animations is effective in learning process knowledge (8) and helps in long-term preserving of information (9). In some of the existing studies, spatial intelligence has been evaluated as a component of intelligence in learning. The results of such studies suggest that students with low spatial intelligence learn more through animations (10, 11). Meanwhile, some other studies propose that individuals with higher spatial intelligence are more likely to benefit from animations (Mayer & Sims), in particular, the 3D animations (2, 12).

Therefore, the present study evaluated the effects of 2D and 3D animations on learning, aiming at presenting a more accurate vision of learning of human beings in the education process, which could add to the literature of psychology and educational technology. This study will take a step toward providing evidence on explaining the learning process. Furthermore, review of the literature revealed the lack of presence of a study that has evaluated the combination of brain activity, spatial intelligence, and learning outcomes related to image presentation styles (2D, 3D, static, and dynamic). With this background in mind, this study aimed to determine the impact of different image presentation methods in visual educations on the brain function of students.

Materials and Methods

This research had a 2x2x2 factorial experiment design to compare the effects of three independent variables, each with two levels of spatial intelligence (low and high), depth (2D and 3D) and motion (static and dynamic) on two dependent variables of Alpha brain waves and recall. The statistical population consisted of all students of Tehran University of Medical Sciences, Tehran, Iran in the academic year of 2015-2016. In order to implement the research, it was necessary to first identify individuals with high and low spatial intelligence. To this end, volunteers took the mental rotation test by Vandenberg and Kuse (1978). Finally, 60 students with high spatial intelligence and 60 students with low intelligence were selected using purposive sampling. The score range of 12-24 was recognized as high spatial intelligence, whereas the score range of 0-10 was low spatial intelligence. All trial sessions were held individually, and subjects of each group of high and low spatial intelligence were randomly divided into four groups (2D with static images, dynamic 2D, 3D with static

images, and dynamic 3D). In the next step, each student's brain activity was recorded by EEG during the training. After training, a 10-item multiple-choice test was performed to assess the remembering of each student. Each subject was scored within the range of 0-10 based on their responses.

The research tools were the mental rotation test by Vandenberg and Kuse (1978), Electroencephalogram and recall test. In order to identify individuals with high and low spatial intelligence, the mental rotation test by Vandenberg and Kuse, (which is consistent with the objectives of the present study,) was applied. In this regard, the subjects answered the questions of the test (N=24), where each question encompasses a criterion or target form. The questions included 3D images presented in a 2D form and on paper. The participants were asked to perform the assignment of rotating and manipulating an object or image and recognize how it is placed in the 3D space. The questions encompassed discovering the similarities and differences between the objects.

It is noteworthy that the test has no cultural dependency and its internal consistency (Kuder Richardson formula 20 [KR-20]) and retest reliability were 0.88 and 0.83, respectively (13, 14). Brain wave recording was carried out during the receiving of visual education by the subjects in the trial groups. Virtual education is a refractive surgical technique for correction of blurry vision. For this tutorial in 3D animation mode, a 3D animation (length=one minute and 11 seconds) was created by the Amra company, which presents each stage of the LASIK process in 3D. For static 3D training, a 3D page, consisting of seven photos of each stage of the LASIK process, was created in 3D animation form.

For training in an animated 2D mode, an animated one-minute flash was created, which showed each stage of the LASIK method in 2D mode. For 2D training, a one-minute page was created, consisting of seven photographs that showed each stage of the LASIK method in 2D animation mode. Mindset electroencephalographic system was used to record brain waves of the subjects according to different visual presentation methods. This system has a sensory arm located on the forehead of the subject, containing an EEG electrode, and the minimum and maximum detectable frequencies are 3 Hz and 1000 Hz, respectively.

Recall test: After providing training to different groups, a 10-item test designed to measure students' ability to recall was

performed. In this multiple-choice test, there is one correct answer for each item. The training provided was in the field of medicine and LASIK surgery, and the test questions designed by the researcher were in the field of educational materials presented. Data analysis was performed in SPSS version 19 using two-way analysis of variance, as well as descriptive and inferential statistics.

Results

In this study, we used a two-way analysis of variance to compare the effectiveness of static and dynamic 2D and 3D visual presentation styles on the power of EEG Alpha waves. In Table 1, the mean and standard deviation of the recall scores in the interaction among spatial intelligence, altitude, and motion are presented.

Table 1: Average Scores Reminders by Spatial Intelligence, Elevation and Movement

Mean Std.Deviation			high	Spatial intelligence
8.82±1.61		Constant		
7.76±1.77	3d			
7.11±1.64	2d	Dynamic		
8.69±1.77	3d			
7.49±1.76	2d		low	
9.08±0.98	3d	Constant		
8.4±1.35	2d	Dynamic		
7.60±2.22	3d			

We also applied the three-way analysis of variance to evaluate the main effects of spatial intelligence and visual presentation styles and their interactive effect on alpha waves of the subjects. The assumptions for analysis of variance were evaluated before presenting the

results. Moreover, Kolmogorov-Smirnov and Shapiro- Wilk test were applied to assess the normal distribution of the variables of the research, the results of which are presented below:

Table 2: A Review of the Normal Distribution of Variables

Kolmogorow-smirnov			Shapiro-wilk			
statistic	df	sig	statistic	df	sig	
.129	19	.200*	.966	19	.696	Recalling
.194	19	.057	.932	19	.185	Spatial intelligence
.102	19	.200*	.964	19	.658	Presentation Style

As it is shown in Table 2, all research scales had a normal distribution. Levene's test was used to evaluate the equality of variances.

Table 3: Levene`s Test of Equality of Error Variances

sig	Df2	Df1	F
.642	118	2	.686

Table 3 shows the results of the Levene's test for measuring the equality of error variances of recall score between various groups of high and low spatial intelligence and different visual presentation styles. Given the fact that the significance level of the F statistic was above 0.05, it could be expressed that the error variance of the two groups was equal, and no difference was observed in this regard. In the table below, the summary of a three-way analysis of variance in the Alpha variable is reported. According to the results, at a 95% confidence level, the only significant difference was observed in the interactive effect of spatial intelligence and motion on the power of the Alpha waves (F $(1,112)=3.9$ and P=0.05).

Therefore, it seems that the motion-based visual educational methods (animation and static) have different effects on Alpha waves in the two groups of spatial intelligence. In this regard, no significant difference was observed regarding other interactions.

According to the results, during the presenting of static images, the mean scores of the Alpha wave of the high intelligence group was lower, compared to the other group (3.01 vs. 4.5). On the other hand, the Alpha waves of the high spatial intelligence group were higher than the other group when the images were presented in the form of animations (4.72 vs. 3.2).

The results presented in Table 5 showed that the mean of recall scores in the three-way interactions of independent variables at the 95% confidence level was significant (F $(1,112)=33.8$, df=0.001). Therefore, there was a significant interaction between spatial intelligence, altitude and motion on recall scores. In other words, motion and altitude had different effects on recall in two levels of spatial intelligence. The interactive diagram is illustrated below.

Table 4: F Table of Main Effects and Interactions

Partial Eta Squared	Sig	F	Mean Square	Df	Sum of Squares	Source
.002	0.9	0	0.008	1	0.009	Spatial intelligence
0.12	0.14	2.2	42.23	1	42.23	depth
.004	0.72	0.12	2.41	1	2.41	motion
.09	0.16	1.96	37.1	1	37.5	*Spatial intelligence depth
.21	*0.05	3.9	75.01	1	75.01	
.07	0.1	1.7	33.8	1	33.8	depth*motion
.006	0.7	0.15	3.05	1	3.05	* Spatial intelligence depth *motion
				112	2202.75	Error

Figure 1: Comparison of Alpha Power Mean in Motion Styles

Table 5: Main Effects and Interaction Effects

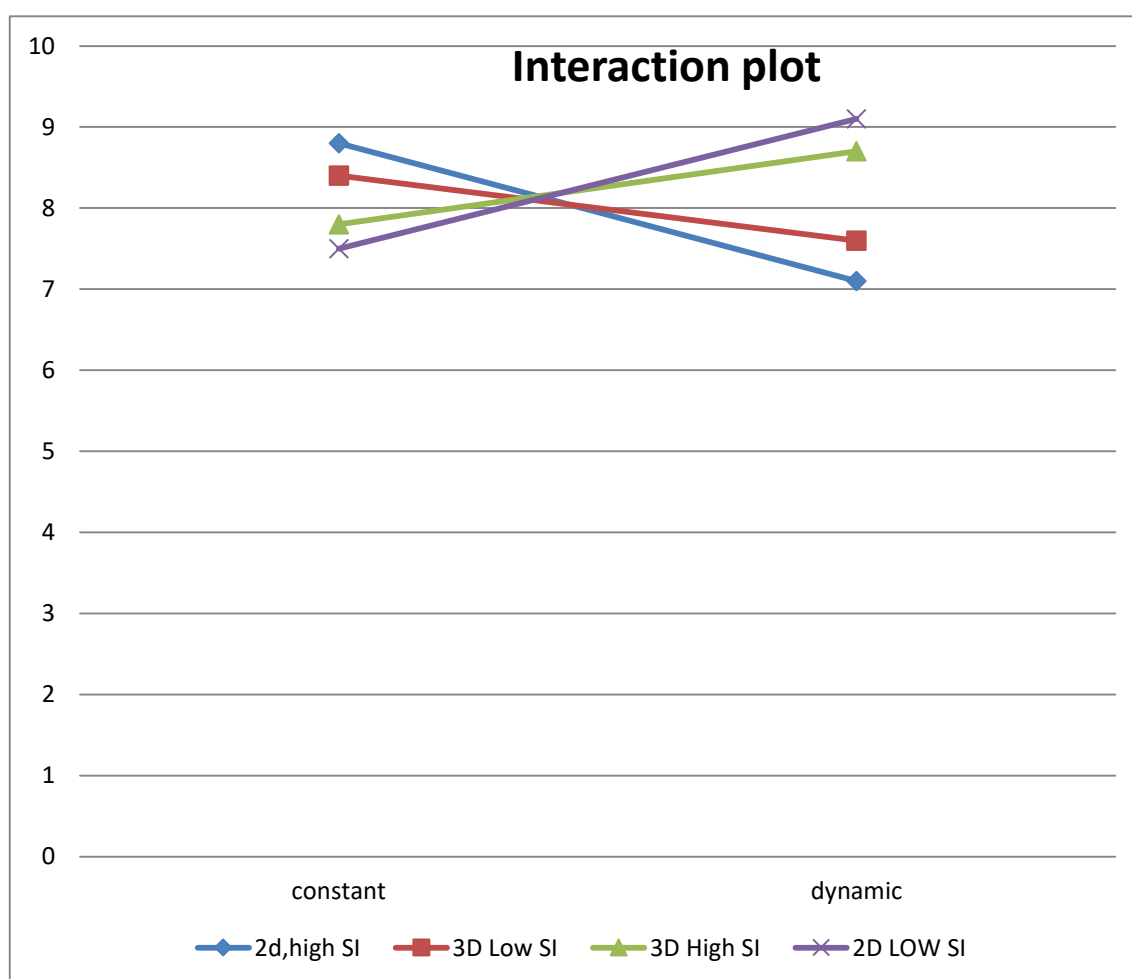| Partial Eta	P value	F	Mean square	df	Sum of squares	Source
.012	0.7	0.14	0.39	1	0.39	Spatial Intelligence
.13	0.08	3.04	8.4	1	8.4	Depth
.16	0.053	3.8	10.54	1	10.54	Motion
.031	0.5	0.35	0.9	1	0.9	*Spatial intelligence Depth
.029	0.54	0.3	0.99	1	0.99	*Spatial intelligence Motion
.011	0.7	0.1	0.29	1	0.29	Depth*Motion
0.42	0.001*	12.5	33.8	1	33.8	* Spatial intelligence Depth *Motion
			2.7	112	312.79	Error

Figure 2: Comparison of Reminder Meanings Based on Imagery Styles and Spatial Intelligence

Discussion

The present study aimed to compare the effectiveness of the presentation of images in visual education on students' brain function. The results demonstrated that change in the visual and motion levels had no significant impact on Alpha wave power. Previous research suggests an inverse relationship between the power of Alpha waves and cognitive load (15-18). It means that the decrease of cognitive load is associated with an increased range of Alpha waves and vice versa. In the current research, it was assumed that presenting high-level images and close to reality (3D and animation) contributes to cognitive load, thereby causing the reading of a high level of alpha waves power. Nevertheless, this hypothesis was not supported by statistical data.

Despite the fact that the statistical data were

not significant, both motion and images close to reality (in terms of altitude) can help to reduce cognitive load. With regard to the impact of motion on recall, our findings are in line with the visions suggesting that animated images may be more effective than constant images when learning process knowledge. A possible explanation for higher benefit from animated educational materials in the process knowledge could be the reliance on performance in most relevant assignments of the method.

These performance-dependent assignments often involve multiple stages of continuous movements, rather than discrete ones. The educational materials that include this motion are closer to reality and thus facilitate the recall. In a study, Lu et al. (19) marked the considerable role of visual-spatial abilities in medicine and engineering. This result can demonstrate the distinction between spatial actions and language-dependent actions, generating the assumption that mental rotation and dependent spatial skills are independent verbal abilities. In addition, the results obtained by Johnson et al. (20) indicated that changes depending on spatial actions, and the use of computers that is combined with the experiences of everyday life, have provided the possibility of more spatial changes for

medical students, thereby guaranteeing their excellence in this ability.

In addition, considering the effect of motion on recall, the results showed that with a 95% confidence interval, animated images were more effective than static images. In this section, our findings are in congruence with the results of some of the previous studies, which demonstrated the effective impact of education through animated images (21). Moreover, the effects of educational animated images are higher on learning method knowledge (8, 22, 23). A possible explanation of the educational effect of the animation is that the mental visualization process of learners is associated with scaffolding that receives help from a prepared-created model. Therefore, it helps the learning of method knowledge (11, 24). However, some previous studies do not support the effect of teaching by animated pictures. Chan Lee (25) marked that animated and static images had similar impacts on method knowledge. Meyer et al. (26) demonstrated that while animated and static images had more effects, compared to text alone, there was no difference between the effectiveness of animated and static images. In a study, Hinojosa (27) declared that the use of mental imagination and position allocation method during 10 weeks

significantly improved the memory and recall function in terms of faces and names of people.

With regard to the effect of motion on recall, our findings are in accordance with the visions that propose that animated images might be more effective than static images during the learning of method knowledge. A possible explanation for the greater benefit of using animated educational materials for learning method knowledge is that this type of knowledge often includes performance-dependent assignments. These performance-dependent assignments often involve multiple stages of continuous movements, rather than discrete ones. The educational materials that include this motion are closer to reality and can facilitate the recall.

In addition, the results indicated that with regard to the effect of realism on recall at a 93% confidence interval, 2D images were more effective, compared to 3D images. There are studies that support the effect of the 3D presentation teaching style (28). Some researchers assume that the use of altitude signs created on 3D images will help learners better understand the visualization processes (13, 28).

Furthermore, results were indicative of no significant impact of difference at the spatial

intelligence levels on the Alpha domain. The power level of alpha waves may not be an accurate indicator of the level of intelligence. As discussed earlier, a research demonstrated the presence of an inverse correlation between the power of alpha waves and intelligence in certain visual assignments (29). Our findings also showed that the difference in spatial intelligence level had no significant effect on the recall. This could be justified by the fact that space intelligence level varies even among people with similar levels of general intelligence. While measuring spatial intelligence by mental rotation test by Vandenberg and Kuse is used to assess spatial intelligence, the level of cognitive ability might not be accurately evaluated, as occurred in the present study. This is mainly due to the fact that the visual education of the current study had more emphasis on altitude and motion, rather than rotation.

While our findings are not consistent with the results of previous studies on the relationship between spatial intelligence and learning, there is no area for future studies in order to determine whether it is possible to design spatial intelligence tests that can measure a specific spatial ability or not (such as paper folding). In the present study, brain activity based on brain waves was obtained using an

electron-encephalogram device. Given the time and financial constraints, the research was performed in a multiple-purpose center without the possibility of removing additional sounds, which might have distracted the subjects, and possibly, affected the accuracy of measuring the cognitive load level during the test.

It is hoped that the subject covered in this research be turned into future discussions, where it could contribute to understanding the mechanism of various visual styles and how to increase our comprehension of learning through brain response test and learning results. With the increased use of visual materials in the classroom and the technological advances in brain-computer interface technology, it is time to determine the effects of educational materials on understanding and preserving information, short and long-term learning and how learning could be improved.

Conclusion

Our findings showed a significant interaction between spatial intelligence and motion on the power of alpha waves. In terms of the high spatial intelligence group, animated images had more impact on the power of Alpha waves, compared to static images. Regarding the low spatial intelligence group, static images had a higher effect on the power of Alpha waves, compared to animated images. The results obtained from the research indicated that Alpha waves had a greater range in people with high spatial intelligence when learning with animated images. According to the results of the present study, there was a significant interaction between spatial intelligence, altitude, and motion on recall scores. For the group with low spatial intelligence, 2D animated images caused significantly more recall, compared to static 2D images and 3D animated images. For the high spatial intelligence group, 3D animations caused greater and more significant learning, compared to 3D static images. It seems that 2D animated images and 3D animated imaged had more effect on individuals with low and high spatial intelligence, respectively. This could be explained by the structure effect of animation, helping the mental visualization process using pre-designed models (13, 31), and decreased the cognitive load of 2D images (12, 15, 32). Therefore, the neurosciences have the potential to help researchers to understand the genetic context that manifests itself in the brain of each individual, as well as the natural context that

affects the development of individuals through education and training (33).

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