

Using Alternative Names and Pictures to Facilitate Learning Afferent and Efferent Nervous System Connections

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Abstract

Background: According to most students, neuroanatomy is difficult to learn. Although different approaches have been suggested for learning neuroanatomical correlations, it seems that none have been effective in aiding learning of afferent and efferent connections. The aim of this study was to develop an innovative method that will facilitate learning of afferent and efferent nervous system connections.

Methods: A total of 140 medical students at the Mazandaran University of Medical Sciences participated in the current study, of which 69 subjects were trained using traditional methods (control group). An innovative method was employed for the remaining 71 subjects (intervention group). In the intervention group, a name and figure were first allocated to each of the nervous system structures in a way that would remind students of the origin of the structure. The students created 3-part names for the allocated structures that were, if possible, humorous. The first part was the alternative name for the structure, and the second and third parts were the alternative names for afferent and efferent structures. The students learned the afferent and efferent connections through the phrases. Each group passed a 12-item pretest and posttest. Results of the tests were analyzed with SPSS using the paired t-test; $P \leq 0.05$ was considered to be significant.

Results: There was no significant difference in the pretest scores between the study groups (control: 1.64 ± 0.86 ; intervention: 1.60 ± 0.89 ; $P = 0.40$). The posttest score of the intervention group (8.15 ± 1.16) was significantly higher than that of the control (3.75 ± 0.077 ; $P < 0.001$).

Conclusions: An innovative method can facilitate student learning of afferent and efferent nervous system connections.

Keywords: Learning, Afferent, Efferent, Neuroanatomy

1. Background

The fundamental importance of anatomy in the curriculum of medical students is well-known. The anatomy of the neurological system (neuroanatomy) is one of the main categories of anatomy and is one of the most challenging to learn (1). Different approaches were developed to overcome difficult barriers to learning neuroanatomy. One method for learning neuroanatomy that was considered by the researchers was drawing different structures of neural systems, since this was the basis for compiling a book on neuroanatomy (2). Further, due to the volatile contents of neuroanatomy, reviewing the lessons after a period of time was suggested as an approach to remind students of previously learned content (3). Another proven method for educating students on the important relationships between brain structures and their functions (4) was to divide the students into small groups and educate them as a team, which requires more interaction between the teacher and students (5). A group of researchers aimed to improve 3-dimensional (3-D) comprehension among stu-

dents to facilitate learning. It has been shown that even the use of clay models can facilitate learning of body structures by improving 3-D understanding (6). In another study, students made 3-D models of ventricular structures out of malleable, colored paste under the supervision of a professor. Results of the current study indicated that students in the intervention group were better able to answer questions that required a good 3-D understanding of the organs than were students in the control group (7). Newly introduced technologies, especially computers, have been shown to facilitate learning and may make neuroanatomy more attractive. Some of the studies conducted in this regard developed different computer-based learning methods, including designing 3-D models of brain ventricles based on magnetic resonance imaging (MRI) and computed tomography (CT) scans (8), mapping a stereoscopic 3-D image to provide real images (9), using educational multimedia to learn neuroanatomy (10), online presentations (11), and teaching neuroanatomy via image files (12). Despite all of these suggested learning methods,

students still face various complications in learning neural system relationships. One of the reasons for this difficulty is the complicated and interwoven nature of the central nervous system (CNS); teachers should inevitably mention some other structures that are in efferent and afferent correlations with the nervous system structure that is presented. Remembering the efferent and afferent correlations is difficult for students because of the different and difficult names of the structures.

Although several different methods have been developed to facilitate learning neuroanatomy, there is no easy and applicable method to learn neuroanatomic correlations. The current study aimed to meet such a need and suggests an innovative method to facilitate learning the afferent and efferent connections of the nervous system.

2. Methods

A total of 140 medical students from Mazandaran University of Medical Sciences (Sari, Iran) who passed the neuroanatomy course for the first time were enrolled in the study. First, students were divided into 2 groups: control (A) and intervention (B). In the control group, the teacher presented the correlation between efferent and afferent neurons using lectures and a slideshow. At the end of the session, students were given a table containing efferent and afferent connections of the nervous system structure derived from the Clinical Neuroanatomy handbook (13) and the Textbook of Human Neuroanatomy (Table 1).

The innovative learning method was applied to the intervention group. First, each structure was given a name and figure in such a way to remind the student of the origin of the structure. For example, a picture of a pigeon was allocated to the thalamus, as it is similar in shape and size to a pigeon's egg; the hypothalamus was imaged as a pigeon's nest as it is located beneath the thalamus. For the spinal cord, the first and last 2 letters were selected, and it was called "Spaniard" and associated with a picture of the famous Spaniard Gerard Pique. Since the cortex is grey, it was shown with an elephant picture. Considering the role of the reticular formation in the level of consciousness, a picture of a sleepy man was used to refer to this structure. The red nucleus was shown with a picture of a strawberry because of its red color; the olive nucleus was associated with a picture of an olive. The cerebellum, which means small brain in Persian, was shown with a picture of baby. The vestibulocochlear nucleus, due to its role in controlling balance, was shown with a picture of a funambulist, and a picture of a rope was used for the vestibulocochlear nerve. Since the caudate nucleus and putamen functionally work as a unique set the so-called striatum or

Table 1. Nervous System Afferent and Efferent Connections^a

Structure	Afferent	Efferent
Spinal cord	Cortex, red nucleus, reticular formation, vestibulocochlear nucleus	Thalamus, reticular formation, cerebellum, olive nucleus
Olive nucleus	Spinal cord, cortex	Cerebellum
Vestibulocochlear nucleus	Cerebellum, vestibulocochlear nerve	Cerebellum, spinal cord, thalamus
Substantia nigra	Caudate nucleus and putamen	Caudate nucleus and putamen, cortex
Red nucleus	Cortex, cerebellum, globus pallidus, substantia nigra, spinal cord	Spinal cord, reticular formation, thalamus
Cerebellum	Spinal cord, cortex (via pontine nuclei), vestibulocochlear nucleus	Red nucleus, thalamus, reticular formation, vestibulocochlear nucleus
Thalamus	Spinal cord, cerebellum, caudate nucleus and putamen, globus pallidus, nucleus amygdalæ, reticular formation	Cortex, reticular formation
Hypothalamus	Cortex, thalamus, cerebellum, nucleus amygdalæ	Thalamus, cerebellum
Reticular formation	From almost all structures	To almost all structures
Nucleus amygdalæ	Cortex, thalamus, reticular formation	Reticular formation, hypothalamus
Caudate nucleus and putamen	Cortex, thalamus, reticular formation, nucleus amygdalæ	Globus pallidus, substantia nigra
Globus pallidus	Caudate nucleus and putamen	Substantia nigra, thalamus
Cortex	Thalamus, reticular formation	Spinal cord, reticular formation, caudate nucleus and putamen, cerebellum (via pontine nuclei)
Pontine nuclei	Cortex	Cerebellum

^aData extracted from Clinical Neuroanatomy by Snell and the Textbook of Human Neuroanatomy by Singh (14).

corpus striatum a picture of zebra was used. Globus pallidus means faded sphere; therefore, it was shown with the picture of a ball. The amygdalæ was shown with a picture of an almond, based on its Latin name. Substantia nigra means a black mass, so a picture of charcoal was used for it. A picture of millet was used for the pontine nuclei, as it is a multitude and spread structure.

Next, all alternative names and the reasons for their selections were explained to the students. Their visual memory was involved to help them better remember the infor-

mation through the use of big colored pictures of all alternative symbols. A4-sized sheets were made for each structure, and another A4 sheet of paper included about 10 pictures of alternative symbols. The original names of the structures were also printed in large fonts. The big pictures were stuck on birthday hats, and small pictures remained at the disposal of the person who wore the related hat. The students were divided into 14 groups (according to the number of structures). A representative from each group was assigned to wear the hat. For example, a hat with a picture of a pigeon indicated that the person represented the thalamus; however, the name of thalamus was also printed above the pigeon picture in a large font. The students also had some small pictures of a pigeon, which would be stuck on the hats of those who were in efferent connections with thalamus. Hats, pictures, and tables including efferents and afferents of the nervous system were distributed among the students. The representative of each group took the name and picture of the structure and stuck it on his/her hat and also stuck the small pictures on the hats of participants who were in efferent connections with the student's structure. Finally, students took the pictures of all hats, and then groups were given 1 day to make 3-part and if possible humorous phrases for each structure and to use the alternative name of the structure stuck on representative's hat. Second, the alternative names for the afferents and efferents shown in the small pictures were stuck on each representative's hat. The groups had no limitations on helping each other create phrases, and the teacher also helped by providing some examples. For instance, the following phrase was developed by the teacher to introduce the nucleus amygdalæ and its connections:

“Daddy's almond seed”; “If the elephant is as sleepy as the pigeon”; “It fell asleep in the pigeon nest”

According to the abovementioned phrases, the connections of nucleus amygdalæ (almond) are as follows:

Afferents: cortex (elephant), thalamus (pigeon), and reticular formation (asleep)

Efferents: hypothalamus (pigeon nest) and reticular formation (asleep)

Finally, the students made up 14 phrases with which they could better learn their efferent and afferent connections.

To evaluate the level of students' knowledge regarding efferent and afferent connections, a 12-item quiz (each item was worth 1 point) was distributed as the pretest and posttest among the participants in both groups. All respondents completed the forms within the same suitable amount of time. Quiz papers were scored by 2 other teachers to prevent personal bias. Data were analyzed with SPSS version 23 software using the paired t-test; $P \leq 0.05$ was set as the level of significance.

3. Results

Mean and standard deviation (SD) of the control and intervention groups in the pretest were 1.60 ± 0.89 and 1.64 ± 0.86 , respectively. The minimum and maximum pretest scores in both groups were 0 and 3, respectively. The mean \pm SD of the control and intervention groups in the posttest were 3.75 ± 0.77 and 8.15 ± 1.16 , respectively. The minimum and maximum posttest scores, respectively, were 2 and 5 in the control and 4 and 9 in the intervention groups (Table 2).

There was no significant difference between the mean score of the pretests between the intervention and control groups. The difference between pretest and posttest mean scores in the intervention group was significantly higher than that of the control group (Table 3).

4. Discussion

According to the study by Deal, assigning students to small groups improved their level of knowledge in the neurosciences (5). In addition, results of the current study were consistent with those of Kooloos, who applied an innovative learning method and improved the 3-D understanding of students, resulting in a significant increase in the mean posttest score (6). Estevez compared traditional teaching methods with an innovative method using physical models to increase the 3-D comprehension of students; he showed that the innovative method increased the 3-D understanding of his students in such a way that students in the intervention group were better able to answer questions that required good 3-D understanding of neuroanatomic structures (7). In a study by Kockro, the traditional teaching method was compared with a novel method in which educational software was used to increase 3-D understanding. The software showed 3-D images from inside the third ventricle. What was noteworthy about his study was that, although there was no significant difference between the mean scores of the students in the two groups, the students confessed that the software was better than the traditional teaching method in 4 aspects: spatial understanding, applicability in future anatomic courses, higher efficiency, and attraction (9). In a study by Gould, application of learning software improved learning by the students and was a good instrument for reinforcing neuroanatomic basics (10). All studies shared a similar objective in that researchers attempted to make learning easier, more effective, and attractive using novel educational methods. The results showed that they were somehow successful. Results of the current study were in line with those of the studies cited.

Table 2. Mean \pm Standard Deviation of Pretest and Posttest Scores in the Study Groups^a

Group	Students, N	Minimum Score	Maximum Score	Mean \pm SD
Control, pretest	69	0	3	0.89 \pm 1.60
Control, posttest	69	2	5	0.77 \pm 3.75
Intervention, pretest	71	0	3	0.86 \pm 1.64
Intervention, posttest	71	4	9	1.16 \pm 8.15

^aMaximum score is 12.

Table 3. Comparison of the Mean Pretest and Posttest Scores between the Applied Learning Methods Used in the Study Groups

Evaluation	Group		P Value
	Lecturing (traditional) method, Mean \pm SD	Suggested (innovative) method, Mean \pm SD	
Pretest	0.89 \pm 1.60	0.87 \pm 1.65	0.40
Posttest	0.77 \pm 3.75	1.17 \pm 8.14	< 0.001

Abbreviation: SD, Standard Deviation.

Neuroanatomy is one of the most difficult lessons for medical students. The introduction of a reputable textbook in anatomy starts with the phrase, "Anatomy is the nightmare of many medical students" (2). Lower mean score of the control group in the posttest is likely due to the difficulty of the contents.

According to the conditions of the control group, participants could receive the highest possible score only if they could remember Table 1 completely, which is impossible for most medical students. Results of the current study indicated that the mean score on the posttest was significantly higher than that on the pretest in the intervention group. In addition, the difference between pretest and posttest mean scores was significantly higher in the intervention group, compared with the scores of the control group. There was no significant difference in the mean scores of the pretest between the groups. Hence, it can be concluded that, based on the results of the pretest, the level of knowledge in both groups was similar before any intervention. In other words, the suggested method significantly improved students' learning of efferent and afferent connections. Undoubtedly, one of the main reasons for the success of the innovative method was the use of simple and tangible phrases instead of scientific names. However, for the sake of better analysis, all components involved should be evaluated.

Teamwork, which is the main factor for the innovative method, increases the interaction between students and teacher. According to studies by Arya et al. (15), Vasan et al.

(16), and Rehman et al., students showed better results in teamwork learning, and the output of such methods was also higher (17). Kamei et al. (18) evaluated the effectiveness of teamwork and reported that students achieved higher scores when they received educational contents before a class and they only spent time on proper understanding of lessons and problem solving by teamwork under the supervision of the teacher. Results of a 20-year meta-analysis by Springer et al. (19) on learning through small groups in different scientific disciplines showed that this method of learning can result in achieving greater academic goals, better learning situations, and increased ability to remember.

On the other hand, Schuh et al. (20) showed that informal methods of teaching, such as playing games and humorous learning atmospheres, are more effective. In addition, Guatier et al. indicated that the motivation of students in optional studying increases when it is associated with playing a game (21).

It should be considered that researchers believe that about 75% of learning is through the sense of sight. Sticking pictures on birthday hat, in addition to providing a sense of play and amusement, facilitated learning via the sense of sight. Hence, the suggested learning method presented in this study had the advantage of teaching by more than 1 model. A study by Lujan et al. (22) found that most students preferred learning through different models.

4.1. Conclusion

Many attempts have been made to facilitate learning the anatomy of the CNS. In most methods, the main emphasis was to increase 3-D understanding of the nervous system. Although these methods are very valuable, they do not provide much help in learning the efferent and afferent connections of the nervous system. The current study showed that using names and pictures, and creating humorous phrases with the names, can facilitate learning efferent and afferent connections. It appears that students' tendency toward amusement and humor is a permanently available, cheap, and vital resource that can be used to assist and guide them to achieve educational goals.

Supplementary Material

Supplementary material(s) is available [here](#).

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