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Effects of an Easy Neuroanatomy Book with Schematics on Student Learning

Efectos de un Libro Sencillo de Neuroanatomía con Esquemas Sobre el Aprendizaje de los Estudiantes

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SUMMARY: Numerous students perceive neuroanatomy as a particularly difficult subject due to its overwhelming complexity. Therefore, a neuroanatomy book that concentrates on easy-to-read stories with schematics rather than exhaustive details has been published. This study evaluates the effect of a trial of the new neuroanatomy book on student learning. From the book, a printout on the brainstem and cranial nerve was extracted. Medical students read the printout, and subsequently were examined on their knowledge of and interest in neuroanatomy. Students who read the extract answered examination questions relatively well and were more interested in neuroanatomy. The printout seemed to enhance the knowledge and concentration of the students. After grasping the fundamental information in the book, students are expected to be able to learn advanced concepts comfortably and confidently. In addition, the book with its concise and simple content is suitable not only for short-duration neuroanatomy courses but also for self-learning.

KEY WORDS: Neuroanatomy; Learning; Illustrated books; Examination questions.

INTRODUCTION

As neuroanatomy is the basis of neurology, neurosurgery, neuroimaging, neurophysiology, neuropharmacology, and so forth, neuroanatomy is being learned by numerous students in medical and bioscience fields. Without a grounding in neuroanatomy, one's understanding of neuroscience is built on a weak foundation (Wiertelak & Ramirez, 2008; Hazelton, 2011).

Students usually access neuroanatomy knowledge either via detailed books or Internet sites such as Wikipedia (Encyclopedia). Regretfully, most students perceive neuroanatomy as profoundly difficult because of its overwhelming complexity and extent of material. Consequently, they experience "neurophobia" (Flanagan *et al*., 2007; Lim & Seet 2008; Javaid *et al*., 2018).

To help students overcome "neurophobia" and learn neuroanatomy easily, two Korean anatomists wrote a neuroanatomy book that concentrates on easy-to-read stories rather than exhaustive details. This book primarily addresses the structures that are identifiable in cadaver specimens or stained slices. The extremely simple illustrations explain the course of the sensory and motor nerves, etc. Cartoons and text are included that provide memorization cue, including relating to etymology (Chung *et al*., 2020b).

The purpose of this study was to evaluate the effect of a trial of the neuroanatomy book on student learning. Accordingly, a printout of the brainstem and cranial nerves was extracted from the book. Medical students who read the printout and those who did not were compared. The students were asked to provide their opinions of the printout via multiple-choice questions and free description.

MATERIAL AND METHOD

The authors had prior experience giving whiteboard lectures on all neuroanatomy chapters. For the book, 138

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schematics drawn on the board were digitized on Adobe Illustrator CC (Adobe Systems, Inc., San Jose, CA) (Fig. 1).

The schematics were generated to be simple and consistent. For instance, the cerebrum, thalamus, and brainstem were depicted with three swellings. This represented a new, effective symbolization of the central nervous system. In addition, neurons were drawn in a consistent pattern (Fig. 1).

Some of the book authors' learning comics were chosen to deliver neuroanatomy knowledge in a more relaxed fashion (Fig. 2A) (Kim *et al*., 2017). Accordingly, anatomy comic strips containing helpful mnemonics and relevant jokes were selected or created (Fig. 2C) (Park *et al*., 2011; Shin *et al*., 2013). The various illustrations were explained with simple text (Fig. 2). The text was designed to be logical, successive, and correlated throughout the chapters.

The book was entitled "Visually Memorable Neuroanatomy for Beginners" to emphasize its use of schematics and mnemonics. The book (in paper and electronic versions) was commercially published and distributed (Chung *et al*., 2020b).

To assess the book's learning effects, students in two Korean medical schools (School A and School B) were asked to volunteer after they received an explanation of the research outline. Description of the two medical schools, where the coauthors of this report were affiliated, is summarized in Table 1.

In 2019, the brainstem and cranial nerve were taught by the original lecturers at both medical schools. Multiple-choice-questions were generated and administered by the original lecturers. In 2020, the chapters "brainstem and cranial nerve" from the presented book were printed (Fig. 2) and provided to the students; the book author pre-recorded a lecture video on the basis of the printout. The lecture video was presented to the students on-line in each medical school because the COVID-19 pandemic was ongoing (Table I).

In 2020, fill-in-the-blank questions were generated from the printout (Fig. 3). Then, the questions were randomly divided into 13 questions for School A and 8 questions for School B (Table I).

The multiple-choice questions, which were independent of the printout, were administered in 2019. The same multiple-choice questions as had been administered in the counterpart schools in 2019 were presented in 2020 (Fig. 4, Table I). The questionnaire survey was carried out with the help of volunteer students. In 2020, the students, who were finishing the course, were asked to report for how many hours they had read other neuroanatomy books and for how many hours they had read the printout. The hours spent reading were compared between School A and School B by independent-samples t-test. The Statistical Package for the Social Sciences (SPSS), version 20 (IBM Corp., Armonk, NY) was employed for the statistical analysis.

In 2019, the students were asked "How much did you read another neuroanatomy book?" Responses were selected from four options (very much, much, little, very little). In 2019 and 2020, they were asked to similarly respond to two questions: "How much did you learn about the brainstem and cranial nerve?" and "How much did you become interested in neuroanatomy?"

In 2020, the students were asked to provide their positive and negative remarks on the printout. Only School A students were asked to provide remarks on the one-week neuroanatomy course.

The entire research procedure was approved by the Institutional Review Board (IRB) of Ajou University School of Medicine. The IRB granted an exemption of deliberation (AJIRB-SBR-EXP-15-254).

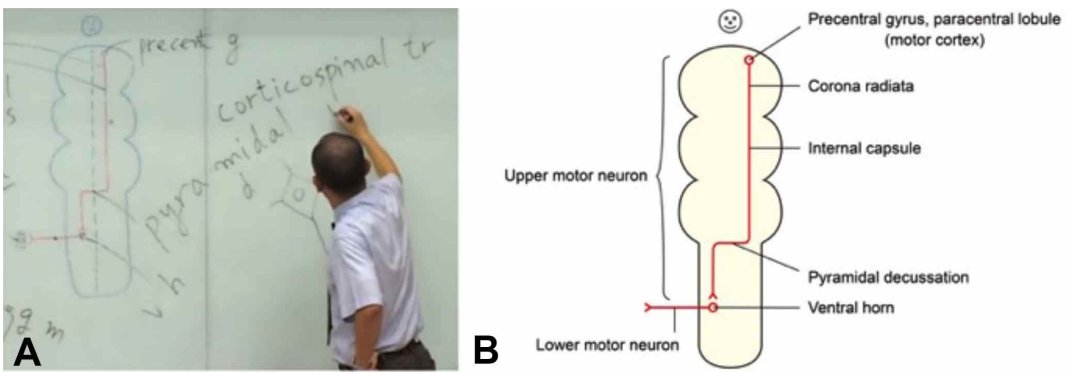


Fig. 1. Simplified neuroanatomy structure. A: Corticospinal tract drawn during the lecture. B: The same figure digitized for the book.

Table I. Situations in two medical schools regarding teaching brainstem and cranial nerve neuroanatomy.

	School A[a]		School B[b]	
Survey year	2019	2020	2019	2020
Number of participating students	40	46	55	46
Sex of participating students	28 males, 12 females	33 males, 10 females (3 unidentified)	32 males, 15 females (8 unidentified)	18 males, 26 females (2 unidentified)
Integrated course	With histology, embryology		With neurophysiology, neuropharmacology	
Weeks of neuroanatomy course[c]	1		4	
Lecture hours of neuroanatomy course[c]	15		25	
Lecture hours	5		2	
Lecturer	Original lecturer	Book author	Original lecturer	Book author
Lecture tools	Slides	Lecture video[d]	Slides	Lecture video[d]
Lab hours	2.5	1	1.5	1.5
Lab tools	Cadaver specimens, plastic models, photos of sections	Cadaver specimens, plastic models, photos of sections	Cadaver specimens, plastic models	Cadaver specimens, plastic models
Textbook	None	Printout	None	Printout
Examination questions	Multiple-choice[g]	Fill-in-the-blank[e], multiple-choice[h]	Multiple-choice[h]	Fill-in-the-blank[f], multiple-choice[g]

School A[a] and School B[b] are Ajou University School of Medicine and Dongguk University School of Medicine, respectively.
[c]These two items are for the neuroanatomy course, while the items below are only for the brainstem and cranial nerve.
[d]Lecture video was generated based on the printout and presented on-line.
Thirteen fill-in-the-blank questionse and eight fill-in-the-blank questionsf were given.
Three multiple-choice questionsg were same between School A and School B, while the other three multiple-choice questionsh were the same.

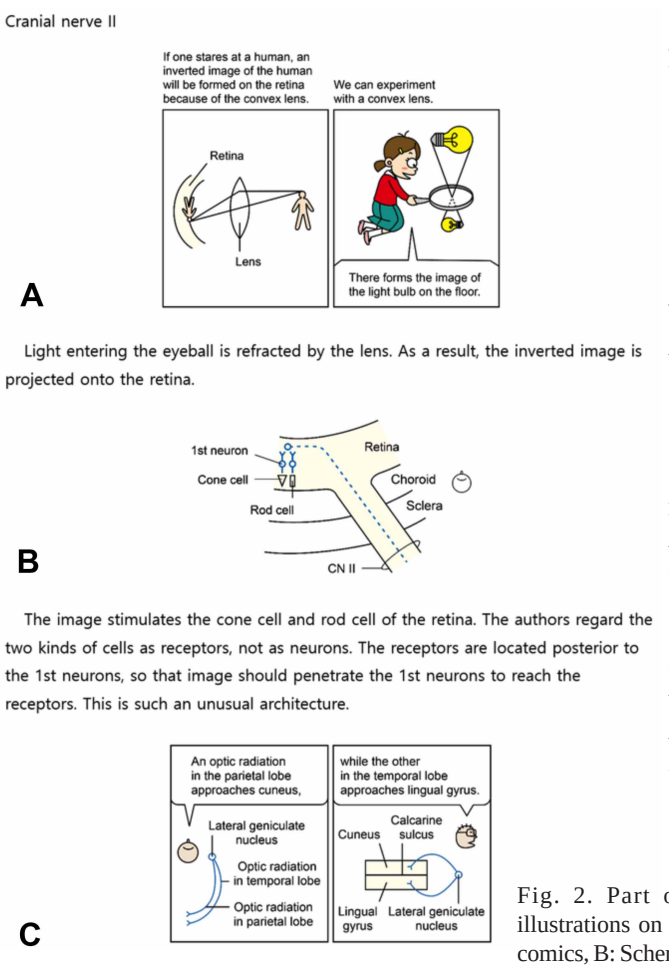


Fig. 2. Part of the printout including illustrations on the optic nerve. A: Learning comics, B: Schematic drawing, C: Comic strip.

RESULTS

There were no remarkable differences according to sex (Table I). Note that some students did not report their sex.

In 2020, the students hardly read other neuroanatomy books (0.8 hours in School A, 1.0 hour in School B). School A students read the printout on the brainstem and cranial nerve (10.2 hours) more than did School B students (4.8 hours; Table II).

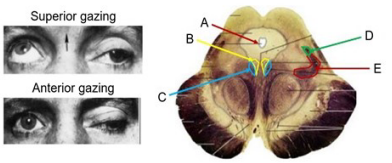
Regarding the fill-in-the-blank questions that were randomly distributed between the two schools (Fig. 3), School A students answered them more correctly (60.3% correct) than did School B students (41.9% correct; Table II).

School B students answered the multiple-choice questions formulated in School A less well (32.6% correct) than did School A students (70.8% correct). However, School A students answered the multiple-choice questions formulated in School B as well (82.9% correct) as did School B students (79.4% correct; Table II).

In the transverse plane, the midbrain is divided into three parts: the [1], the tegmentum, and the tectum (consisting of the [2]).
The [3] mostly sends parasympathetic impulses to the lungs, gastrointestinal tract, and other thoracic and abdominal organs. Therefore, the [3] must be large, to yield the [4] in the floor of fourth ventricle.
(Correct answers are [1] basis pedunculi, [2] superior and inferior colliculi, [3] dorsal nucleus of vagus nerve, [4] vagal trigone.)

Fig. 3. Sample of the fill-in-the-blank questions on the brainstem and cranial nerve that were generated from the printout.

Question 1. The followings are photographs of a patient's eyeball. The left eye did not move when trying to look upward. The left eye went inferolateral side when trying to look forward. This eyeball movement disorder is caused by a lesion in a nucleus. Which lesion in the midbrain would be the case?



Question 2. Which is the wrong description regarding the dorsal side of the brainstem? (Answer: E)
A. Trochlear nerve pair originates from a pair of trochlear nuclei at the level of the inferior colliculus
B. The rhomboid fossa is divided into symmetrical halves by a median sulcus
C. The sulcus limitans is found in the fourth ventricle of the brain
D. Stria medullaris in the floor of the fourth ventricle forms the caudal border of the pons
E. Gracile nucleus is lateral to the cuneate nucleus
(Correct answers to questions 1 and 2 are B and E, respectively.)

Fig. 4. Sample of the multiple-choice questions on the brainstem and cranial nerve, generated independently of the printout.

In 2019, the students hardly read other neuroanatomy books (very much or much: 10.0% in School A, 8.5% in School B), which was the same result as Table II. The students reported good knowledge of the brainstem and cranial nerve in 2020 (very much or much: 90.7% in School A, 90.9% in School B) as compared with in 2019 (very much or much: 77.5% in School A, 83.0% in School B). Both School A and School B students were interested in neuroanatomy more in 2020 (very much or much: 65.1% in School A, 75.0% in School B) than in 2019 (very much or much: 60.0% in School A, 59.6% in School B; Table III).

The students' narrative remarks on the printout were provided in the Korean language and translated into English by the authors. The strengths and weaknesses of the printout were then categorized according to schematics, writing, mnemonics, comics and jokes, difficulty and volume, and summarization. Additionally, the strengths and weaknesses of the short duration neuroanatomy course that was received by School A students were delineated (Table IV).

DISCUSSION

In the present study, a questionnaire survey of medical students was conducted to reveal the effect of a neuroanatomy book on students' learning. The authors selected the brainstem and cranial nerve excerpt, as these are regarded as the core of neuroanatomy.

The students hardly read the neuroanatomy book (excluding the printout) in 2019 (Table III) and 2020 (Table II). This was likely because the course was integrated with other subjects and there was a short duration neuroanatomy course (1-week, 15 lecture hours in School A; 4 weeks, 25 lecture hours in School B; Table I).

However, in 2020, the students read the printout (10.2 hours in School A, 4.8 hours in School B; Table II). A reason for this was the fill-in-the-blank questions, which could be correctly answered only after reading the printout (Fig. 3). Another reason is likely the learning effect of the printout, as emphasized by the students' narrative remarks: "Schematic figures are helpful for understanding complicated neuroanatomical structures. Sentences are short and easy to grasp. Mnemonics are useful to prepare for the examination" (Table IV). The printout promoted students' reading.

Table II. Reading hours and correct responses by students in two medical schools.

	School A		School B	
Survey year	2019	2020	2019	2020
Hours spent reading neuroanatomy book (excluding printout)		0.8 ± 2.3 (43)		1.0 ± 2.3 (44)
Hours spent reading printout		10.2 ± 6.0 (43)**		4.8 ± 3.5 (44)**
Proportion correct of fill-in-the-blank questions		60.3 % (337/559)		41.9% (166/396)
Proportion correct of multiple-choice questions generated in School A	70.8 % (85/120)			32.6 % (43/132)
Proportion correct of multiple-choice questions generated in School B		82.9 % (107/129)	79.4 % (131/165)	

Mean ± Standard deviation (Number of students). **P < 0.005.

Table III. Responses from students in two medical schools.

		School A		School B	
Survey year		2019	2020	2019	2020
How much did you read the neuroanatomy book (excluding printout)?	Very much	0.0 %		2.1 %	
	Much	10.0 %		6.4 %	
	Little	37.5 %		48.9 %	
	Very little	52.5 %		42.6 %	
	Total	100.0 % (40)		100.0 % (47)	
How much did you learn of the brainstem and cranial nerve?	Very much	20.0 %	55.8 %	14.9 %	15.9 %
	Much	57.5 %	34.9 %	68.1 %	75.0 %
	Little	22.5 %	7.0 %	17.0 %	9.1 %
	Very little	0.0 %	2.3 %	0.0 %	0.0 %
	Total	100.0 % (40)	100.0 % (43)	100.0 % (47)	100.0 % (44)
How much did you become interested in neuroanatomy?	Very much	5.0 %	11.6 %	25.6 %	25.0 %
	Much	55.0 %	53.5 %	34.0 %	50.0 %
	Little	37.5 %	32.6 %	34.0 %	20.5 %
	Very little	2.5 %	2.3 %	6.4 %	4.5 %
	Total	100.0 % (40)	100.0 % (43)	100.0 % (47)	100.0 % (44)

(Number of students).

Table IV. Narrative remarks from School A and School B students on the printout in 2020.

	Strengths of the printout	Weaknesses of the printout
Schematics	Schematic figures are helpful for understanding complicated neuroanatomical structures. (56)	Simplified figures cannot show the actual appearance of neuroanatomical structures. (25)
Writing	Sentences are short and easy to grasp. (16) Subchapters are well-organized. (5)	English is more difficult than Korean. (7) Some English expressions are inaccurate. (6)
Mnemonics	Mnemonics are useful to prepare for the examination. (8)	Mnemonics are insufficient, compared to a regional anatomy book. (7)
Comics and jokes	Thanks to the comics and jokes, studying became less boring. (3)	Comics are insufficient, compared to a regional anatomy book. (6)
Difficulty and volume	Only essential contents are included, which is adequate for a short course (4)	Some details are omitted or oversimplified. (5)
Summarization	A figure summarizing the nuclei of cranial nerves was helpful. (3)	There were not enough summary tables and diagrams. (3)
Duration of neuroanatomy course*	Short and intensive course was efficient. (11)	Course duration was too short to cover the vast amount of neuroanatomy. (6)

(Repeated number of remarks among 88 students). *Given only by School A students.

This was the expected result: School A students read the printout (10.2 hours) more than did School B students (4.8 hours; Table II) because School A students had become highly familiar with such a book style during the preceding regional anatomy course (Chung *et al*., 2020a). School A students answered the fill-in-the-blank questions, which were generated from the printout (Fig. 3; 60.3% correct) more correctly than did School B students (41.9% correct). School A students answered the multiple-choice questions, which were formulated in School B independent of the printout, as correctly (82.9% correct) as did School B students (79.4% correct; Table II). The printout might have enabled School A students to adapt to questions unrelated to the printout.

The students understood the brainstem and cranial nerve better in 2020 than they did in 2019. They also became interested in neuroanatomy more in 2020 than in 2019 (Table III). The printout and the lecture based on the printout seemed to enhance knowledge of and interest in neuroanatomy. This might be attributed to the strengths of the printout: understandable schematics, simple text, useful mnemonics, and so forth. Another strength of the printout could be the comics and jokes (Fig. 2; Table IV).

The printout was tailored to the short course and lecture video. In School A, neuroanatomy was taught only for one week (Table I). The students reported strengths and weakness of the course as, “Short and intensive course was efficient. Course duration was too short to cover vast amount of neuroanatomy” (Table IV). The short form anatomy course is a global trend that may be irreversible. (Peterson & Tucker 2005; Chung *et al*., 2020b) In 2020, COVID-19 required

anatomists to perform distance learning via video lectures. (Pacheco *et al*., 2020; Iwanaga *et al*., 2021) The lecture video is closely to self-learning and flipped learning. (Ferrer-Torregrosa *et al*., 2016; Day, 2018) A book that has concise and easy content might be especially suited to supplement short courses and lecture videos. This notion is supported by the students' remarks on the strengths of the printout (Table IV).

The drawings in this printout are extremely simple (Figs. 1 and 2). Such schematics are akin to rough maps for initial visitors to a location. Students may easily redraw the schematics, which is helpful for memorization (Greene, 2018; Reid *et al*., 2019). As anticipated, the students indicated that the schematics represented a strength (Table IV).

Regarding the schematics, the students also noted their primary weakness: "Simplified figures cannot show the actual appearance of neuroanatomical structures" (Table IV). A solution is that teachers could show the schematics together with the actual neuroanatomy during a slide lecture. Another solution for students could be to supplement the schematics with digital learning tools, such as online atlases and videos; such an approach is frequently utilized (Jaffar, 2012; Lewis *et al*., 2014).

That a small amount of neuroanatomy information was presented from the book might be considered a problem. However, the authors believe that after understanding the fundamental information, students can comfortably and confidently study advanced neuroanatomy and subsequent courses (Chung *et al*., 2020a).

Neuroanatomy has close relationship with regional anatomy. The former addresses the central nervous system (brain, spinal cord) and peripheral nervous system (cranial nerve, spinal nerve) together, while the latter concentrates on the peripheral nervous system. The central nervous system cannot be understood without knowing the peripheral nervous system. Therefore, readers of the presented book are encouraged to read the first author's electronic book "Visually Memorable Regional Anatomy," which can be obtained on a website free of charge.

On the basis of the neuroanatomy book, the first author plans to produce an advanced lecture video in English. The complimentary video will be uploaded to YouTube so that it can be watched by anyone. The book and the neuroanatomy lecture video will hopefully produce a synergy effect in students' learning (McNulty *et al*., 2009).

The presented book containing schematics and mnemonics is expected to help students to start learning neuroanatomy with minimal stress.

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RESUMEN: Muchos estudiantes perciben la neuroanatomía como un tema particularmente difícil debido a su abrumadora complejidad. Por lo tanto, se ha publicado un libro de neuroanatomía que se concentra en historias fáciles de leer con esquemas en lugar de detalles exhaustivos. Este estudio evalúa el efecto de una prueba del nuevo libro de neuroanatomía en el aprendizaje de los estudiantes. Del libro, se extrajo una impresión sobre el tronco encefálico y los nervios craneales. Los estudiantes de medicina leyeron la copia impresa y, posteriormente, se les examinó su conocimiento e interés por la neuroanatomía. Los estudiantes que leyeron el extracto respondieron relativamente bien a las preguntas del examen y estaban más interesados en la neuroanatomía. La impresión parecía mejorar el conocimiento y la concentración de los estudiantes. Después de comprender la información fundamental del libro, se espera que los estudiantes puedan aprender conceptos avanzados con comodidad y confianza. Además, el libro con su contenido conciso y simple es adecuado no solo para cursos de neuroanatomía de corta duración, sino también, para el autoaprendizaje.

PALABRAS CLAVE: Neuroanatomía; Aprendizaje; Libros ilustrados; Preguntas de examen.

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