
Cranial Nerve Clock

Part I. A Declarative Memory Paradigm¹

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Rationale and Objectives. The authors performed this study to compare a declarative memory paradigm developed to help teach medical students about the cranial nerves with a traditional text-based approach.

Materials and Methods. The authors designed a clock-based paradigm to help medical students learn about the cranial nerves. To enhance memorization and related brain activation, the paradigm uses visual, spatial, and word associations in the context of an analog clock face. Twenty-one undergraduate students were randomly divided into two groups. Group T viewed traditional text slides, and group C viewed text slides followed by the corresponding cranial clock slides. Subjects were tested before and after these sessions.

Results. Group C performed significantly better than group T in learning the names of the cranial nerves and their correct order ($P < .011$). Recall of name, number, and function was better for 11 of 12 cranial nerves, with statistical significance reached for nerves III ($P = .005$), V ($P = .04$), and X ($P = .03$).

Conclusion. Alternative teaching strategies may help improve declarative memory.

Key Words. Education; memory; nerves, cranial.

Alternative strategies for facilitating declarative memory have been successfully used for thousands of years, with much recently written in the popular press. According to legend, Simonides of Ceos, the Greek poet and orator, championed the use of visual imagery loci as a mnemonic tool in 477 BC. Fortuitously escaping the collapse of a banquet hall ceiling, Simonides was able to recall the position of his audience, now mangled beyond recognition, thereby leading to their correct identification. Although Simonides did not actually use a mnemonic strategy to

learn the guests' places (1), this experience was said to have triggered his invention of the loci mnemonic (2). Centuries later, Roman orators routinely used this device, which led to the expression "in the first place . . . , in the second place," and so on.

Other mnemonic strategies, including multimodal associations (links) (1,3), letter-cueing, and visual imagery, have been associated with successful encoding and subsequent retrieval (4). Most scientific investigations of mnemonic strategy have used experimentally contrived learning tasks. Using such a contrived paired-associate memory task, Staub and Granaas (5) demonstrated the efficacy of a variety of memory strategies, including nonimaginal, separate image, and interactive image techniques. There is, however, a paucity of scientific investigation regarding the systematic application of mnemonic techniques to a fundamental learning task with behavioral and functional neuroimaging correlation.

Memory may be subcategorized into implicit (non-declarative) and explicit (declarative) components. Declarative memory refers to knowledge to which we have con-

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scious access. Such memory may be semantic, which involves the acquisition and use of one's general knowledge of the world, or episodic, which involves conscious access to the personally experienced past (6). Learning the cranial nerves is a prototypic declarative memory task. Each year tens of thousands of health science students studying medicine, dentistry, or nursing are faced with the daunting task of memorizing the number, names (Latin or Greek), and function of the 12 cranial nerves. Students are expected to recall this information at subsequent examinations and to apply this explicit knowledge to patient care during the course of their careers.

Traditionally, the cranial nerves are taught didactically and memorized with a brute force approach. Students often later rely on a first-letter acrostic (staid or risqué) to help recall the name and order of the cranial nerves. The classic acrostic to cue the 12 cranial nerves is "On Old Olympia's Towering Top A Finn And German Vault And Hop," which corresponds to the olfactory, optic, oculomotor, trochlear, trigeminal, abducens, facial, acoustic (vestibulocochlear), glossopharyngeal, vagus, accessory, and hypoglossal nerves. Although popular, such acrostics have limited usefulness. The information being cued must already be well learned for the mnemonic phrase to be an effective cue. The mnemonic does not provide random access to the individual cranial nerves and, given the three O's, two T's, and three A's, lacks specificity (7).

The effectiveness of different mnemonic strategies depends in part on the user and/or audience and setting. Developmentally, young children are primed to assimilate language readily (8,9). As such, rhymes, jingles, and songs may work particularly well in this population. Many of us still recall the number of days in each month by chanting the well-learned verse starting "30 days hath September, April, June, and November." Older children and adults more readily deploy mnemonic strategies and possess a greater fund of knowledge to create associations (links) than younger children (10,11). In adults, the ability to visually image words has been demonstrated to affect the ability to remember them; words that are difficult to picture are harder to remember in recall tasks (12,13). Noise may have a negative effect on memory recall and alter the mnemonic strategies of subjects. In a noisy environment, individuals with an external locus of control shift toward the use of lower-level perpetual (rhyme) strategy from higher-level semantic strategy (content categories) (14).

We performed this study to determine whether direct incorporation of verbal and visual spatial mnemonics into



a.

1. Olfactory nerve

- Sensory
- Smell

b.

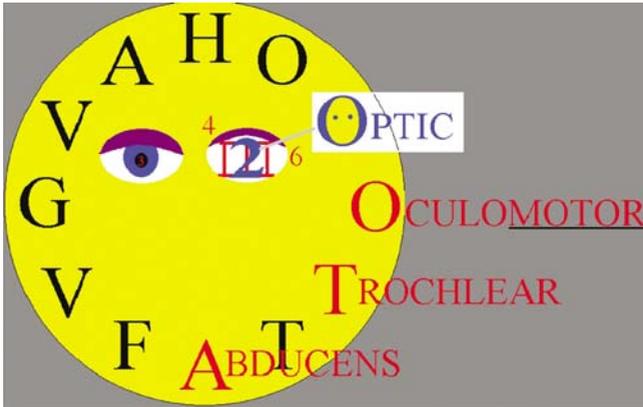
Figure 1. (a) Cranial nerve clock diagram and (b) text related to cranial nerve I.

a cranial nerve presentation would improve student recall of this material. In addition to improving recall of cranial nerves, we believe that students would learn valuable declarative memory strategies. Behavioral analyses of individual nerve recall performance could lead to improvement in subsequent paradigm iterations. Moreover, related paradigms might be used in functional neurologic imaging experiments to explore the structural-functional underpinnings of successful declarative memory (15).

As concluded by Bellezza (1), "The study of mnemonic devices can make important contributions to the study of human memory.... Teachers must learn to activate appropriate information in the memories of their students by using specifically designed materials to initiate the development of useful knowledge structures. Current research provides reason to be optimistic."

MATERIALS AND METHODS

We designed a clock-based paradigm to help health science students learn about the cranial nerves. To enhance memorization and related brain activation, the paradigm uses novel visual, spatial, and word associations in the context of an analog clock face (Figs 1a, 2a, 3a, 4a, 5a, 6a, 7a, 8a, 9a, 10a, 11a, 12a). To test its efficacy, 21 undergraduate students were randomly divided into two



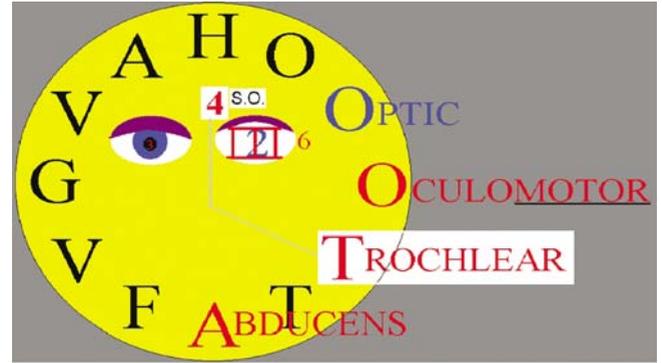
a.

2. Optic nerve

- Sensory
- Vision

b.

Figure 2. (a) Cranial nerve clock diagram and (b) text related to cranial nerve II.



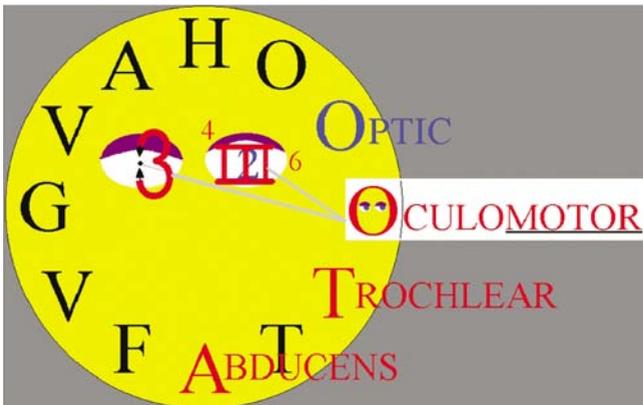
a.

4. Trochlear nerve

- Motor
- Eye movement
- Superior oblique (S.O.) muscle

b.

Figure 4. (a) Cranial nerve clock diagram and (b) text related to cranial nerve IV.



a.

3. Oculomotor nerve

- Motor
- Eye movement
- Constricts pupils
- Opens eye

b.

Figure 3. (a) Cranial nerve clock diagram and (b) text related to cranial nerve III.

groups. Informed consent was obtained. All students were right-handed, spoke English as their primary language, and were ostensibly naive to the cranial nerves. Students

were asked to fill out a free-recall questionnaire to test their knowledge of the cranial nerves. Specifically, they were asked to fill out a chart with rows numbered 1–14 and columns labeled cranial nerve name, motor function, and sensory function. Fourteen rather than 12 rows were chosen so as not to cue the students to the actual number of cranial nerves. The subjects subsequently viewed a slide show and were instructed to memorize the name, number, and function of the cranial nerves. One group (group T) viewed traditional text slides every 18 seconds (Figs 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b, 10b, 11b, 12b). The other group (group C) was presented with text slides every 9 seconds followed by corresponding cranial clock slides every 9 seconds (Figs 1–12).

Both the text and clock slides were similarly color coded so that blue corresponded to sensory function and red to motor function. This color coding mimics that used by Netter (16). In addition, we, like Netter, presented cranial nerve VI before cranial nerve V so that the cranial nerves associated with vision (2–4,6) would be viewed consecutively. Otherwise, the cranial nerves were presented in numeric order.

Each group viewed their respective slide series three times. The free-recall cranial nerve test was repeated 10 minutes later. Subsequently, we administered a cued-recall test, with the first letter and appropriate blank spaces provided for each cranial nerve. Tests were scored



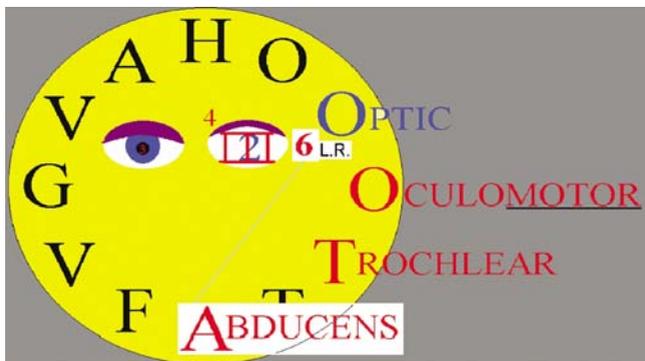
a.

5. Trigeminal nerve

- Sensory
 - Face 3 divisions
- Motor
 - Chewing

b.

Figure 5. (a) Cranial nerve clock diagram and (b) text related to cranial nerve V.



a.

6. Abducens nerve

- Motor
 - Eye movement
 - Lateral rectus (L.R.) muscle

b.

Figure 6. (a) Cranial nerve clock diagram and (b) text related to cranial nerve VI.

blinded to subject group. Knowledge of each cranial nerve with both free-recall and cued-recall tests was scored on a scale of 0 to 25. The number of correct cra-



a.

7. Facial nerve

- Motor
 - Facial expression
 - Cry, spit
 - Close eye
- Sensory
 - Taste anterior 2/3 of tongue

b.

Figure 7. (a) Cranial nerve clock diagram and (b) text related to cranial nerve VII.

nial nerve names written by each subject was tabulated from 0 to 12. To be scored correct, more than one-half of the letters had to be accurate and correspond to the respective cranial nerve number. Additionally, a composite score of 0–25 was generated to measure the subject’s knowledge of a cranial nerve’s name, number, and functions. In this composite score, 10 points were awarded for the correct name and five points were awarded for the correct function category or categories (ie, sensory and/or motor). We gave the remaining 10 points, or a fraction thereof, for correctly naming the specific function(s), with the 10 points subdivided in the case of multifunction cranial nerves.

RESULTS

There was no significant difference in the pretest performance between group C and group T, with both



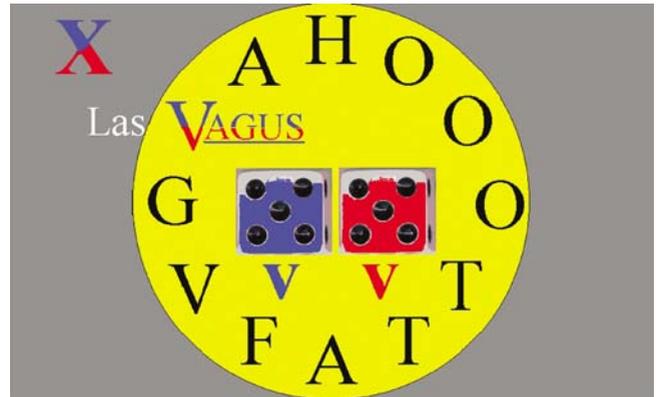
a.

8. Vestibulocochlear nerve

- Sensory
 - Hearing
 - Balance

b.

Figure 8. (a) Cranial nerve clock diagram and (b) text related to cranial nerve VIII.



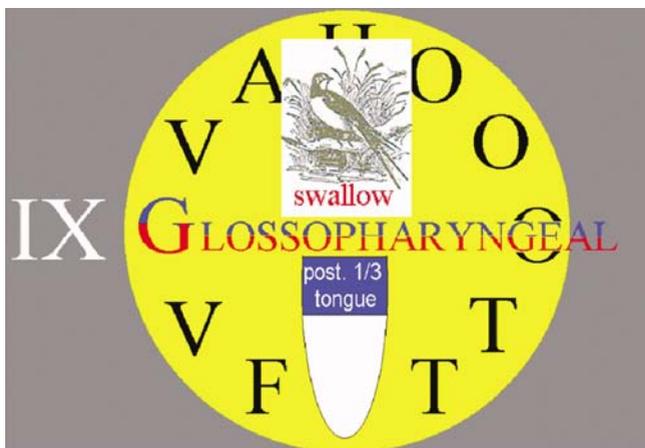
a.

10. Vagus nerve

- Sensory
 - Diverse
- Motor
 - Diverse

b.

Figure 10. (a) Cranial nerve clock diagram and (b) text related to cranial nerve X.



a.

9. Glossopharyngeal nerve

- Sensory
 - Posterior 1/3 of tongue
- Motor
 - Swallow

b.

Figure 9. (a) Cranial nerve clock diagram and (b) text related to cranial nerve IX.



a.

11. Accessory nerve

- Motor
 - Shoulder movement
 - * Trapezius muscle
 - * Sternoleidomastoid muscle

b.

Figure 11. (a) Cranial nerve clock diagram and (b) text related to cranial nerve XI.

groups revealing only minimal knowledge of the cranial nerves. The mean number of correct cranial nerve names and number at the pretest was 0.50 ± 1.08 (from a possible 12) for group C and 0.55 ± 1.04 for group T ($P = .470$).

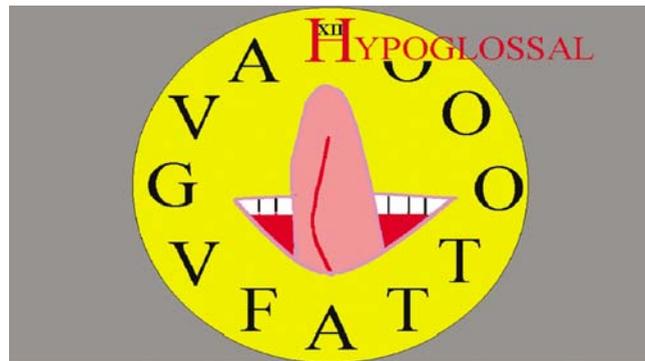
Group C performed significantly better than group T on the free-recall postparadigm test in learning the names of the 12 cranial nerves (mean score, 7.70 ± 3.27 [from a possible 12] vs 4.09 ± 3.40 ; $P < .012$). Group C also scored better than group T in recalling the name, number, and function of 11 of the 12 individual nerves. Statistical significance was reached for cranial nerve III (mean score, 19.0 ± 2.94 [from a possible 25] vs 9.73 ± 9.75 ; $P < .005$), cranial nerve V (mean score, 7.60 ± 7.00 vs 2.77 ± 5.18 ; $P < .042$), and cranial nerve X (mean score, 14.0 ± 12.43 vs 4.55 ± 8.20 ; $P < .026$). Both groups performed better with the first three cranial nerves than with the remaining nine. Group C had a mean score of 19.33 ± 5.74 (from a possible 25) for the first three nerves and 9.70 ± 5.20 for the remaining nine ($P < .053$). Group T had a mean score of 12.64 ± 8.41 for the first three nerves and 5.37 ± 6.30 for the last nine ($P < .025$) (Fig 13).

Results of subsequent cued-recall tests demonstrated more comparable scores for both groups relative to those scores at free-recall tests. Specifically, the mean number of correct cranial nerve names was 10.10 ± 2.08 (from a possible 12) for group C and 9.27 ± 3.55 for group T ($P < .27$).

DISCUSSION

As hypothesized, incorporation of alternative learning strategies led to improved declarative memorization performance at least during the short interval tested. Results reached statistical significance despite a relatively small study population. The use of larger populations and longer postparadigm testing intervals may be warranted. Parenthetically, the results of behavioral analysis at a subsequent related functional magnetic resonance (MR) imaging experiment suggest good retention of cranial nerve knowledge at 1 week, as well (15).

Students in both groups received their best scores with the first three cranial nerves, which likely, in part, reflects the well-established primacy effect. The primacy effect is thought to represent transfer from short- to long-term memory through rehearsal. The primacy effect may be confounded and perhaps artifactually accentuated by the relative simplicity of the first two cranial nerves, which



a.

12. Hypoglossal nerve

- Motor
- Tongue movement
- * Tongue muscles

b.

Figure 12. (a) Cranial nerve clock diagram and (b) text related to cranial nerve XII.

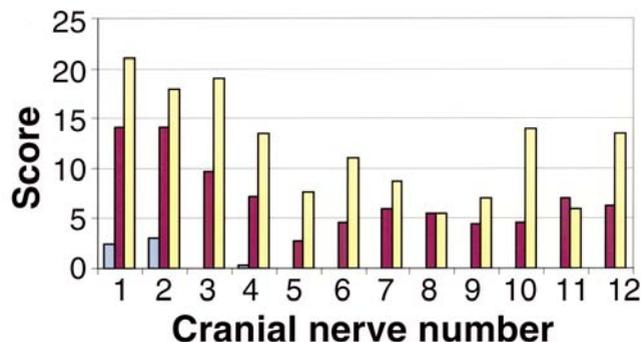


Figure 13. Bar graph depicts the mean student scores (from a possible 25) for each cranial nerve. Blue bars represent the preparadigm performance of all students ($n = 21$), red bars represent the postparadigm performance of group T ($n = 11$), and yellow bars represent the postparadigm performance of group C ($n = 10$).

each have only one function. In addition, the first three cranial nerves all start with the letter O. Further evaluation of primacy effects might be subsequently studied by randomizing the order of cranial nerve presentation. A recency effect, which reflects retention in short-term memory, is less evident and may be a function of the time to postparadigm testing. Furthermore, both primacy and recency effects may have been attenuated by the serial repetitions of the 12 cranial nerves (17).

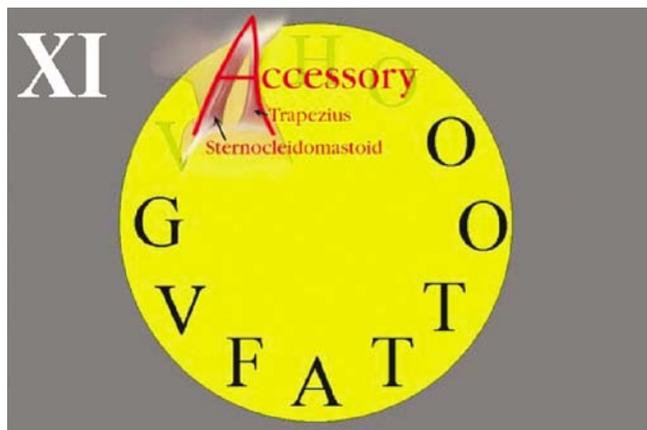


Figure 14. Modified version of cranial nerve XI clock.

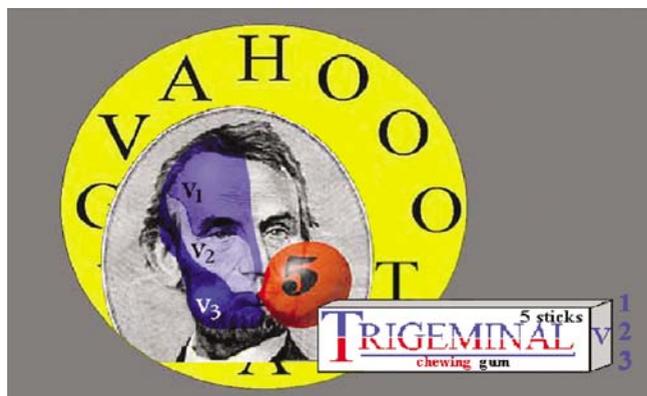


Figure 15. Modified version of cranial nerve V clock.

The performance related to the cranial nerve clock was not uniform for all cranial nerves, and paradigm modifications may be considered to improve results by using cranial nerves III, V, and X as exemplars. To improve the cranial nerve XI clock, a graphic mnemonic with the letter “A” superimposed on a sketch of the sternocleidomastoid and trapezius muscles might be repositioned to the 11-o’clock position to strengthen the visuospatial association (Fig 14 vs Fig 11b). As another example, the clock for cranial nerve V might be made more effective if Abraham Lincoln’s face, taken from a \$5 bill and shown blowing a bubble marked “5,” were substituted for the unfamiliar cartoon face depicted in Figure 5b (Fig 15). This should uniquely strengthen the number “5” association and provide further differentiation from the cartoon face in Figure 7b, potentially improving scores for both cranial nerves V and VII.

Teaching the cranial nerves in two segments (cranial nerves I–VI and VII–XII) might facilitate declarative memory. This “chunking” technique might help better

address the limits of working memory, typically seven units of information with a range of five to nine (7). Teaching the nerves in two sessions may activate an episodic memory component and provide additional primacy effects starting with cranial nerve VII.

To avoid an additional confounding variable, a cranial nerve acrostic was not included in this study. We, however, typically employ a modified version of an often-used, sexually provocative acrostic, keeping the first seven words the same. Our version is “Oh, Oh, Oh, To Touch And Feel Veins, Gooey Veins, Ah, Heaven!” Although lacking the rhyme of the classic acrostic, the context may be more relevant and thereby more memorable to students in the health profession embarking on cadaver dissection. Moreover, in keeping with the cranial nerve clock, the mnemonic uses the letter V for vestibulocochlear rather than A for acoustic.

To simplify analysis and replication of the paradigm within a noisy functional MR imaging environment, we relied solely on visual presentation in the current experiment. An auditory component to the paradigm, might, however, be expected to further enhance encoding and recall. Anecdotally, the recent addition of concurrent music snippets (eg, *Smiling Faces Sometimes* by The Undisputed Truth for cranial nerve VII, *Dizzy* by Tommy Roe for cranial nerve VIII, and *The Wanderer* by Dion for cranial nerve X) to related medical student lectures and scientific exhibition has been well received and may be worthy of empiric testing. Moreover, the mnemonic associations established with the cranial clock may be expanded to synergistically link related topics such as cranial nerve anatomy, neurologic imaging, and pathology (18).

The knowledge base, particularly in the sciences, continues to expand at an exponential rate. As a result, students are required to learn and retain increasingly vast quantities of information. Educators, health professionals, and the general public might consider alternative learning strategies as exemplified by the cranial nerve clock mnemonic. As population demographics shift to older ages, such mnemonic strategies may become more important (19). New paradigms that exploit our increasing understanding of the mind and memory processing can be developed, continually refined, and rigorously tested.

In conclusion, the clock paradigm, in which visual, spatial, and word associations were used in the context of an analog clock face, enhanced recall of the 12 cranial nerves (ie, their name, number, and function). Countless

health science students undertake this declarative memory task each year.

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