

Commentary

The use of an imagery mnemonic to teach the porphyrin biochemical pathway

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Dermatology Online Journal 21 (4): 1

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Abstract

We designed an imagery mnemonic to help medical students and residents learn the porphyrin pathway and associated diseases. Fourth year medical students at the Icahn School of Medicine at Mount Sinai in the spring of 2014 participated. One group (n=11) received the porphyrin pathway in a lecture explaining a mnemonic, whereas a second group (n=11) was simply taught the steps of the pathway. A pre-intervention assessment before the lectures was given to assess baseline differences in knowledge of the porphyrin pathway between the groups. Immediately following the lecture, 1 week after the lecture, and 3 weeks after the lecture, the students were given quizzes to assess their knowledge. Students were aware of the week 1 quiz and were asked not to study for it. The week 3 quiz was a surprise. There were no statistically significant differences in knowledge of the pathway at baseline (p=.45), at the immediate post-intervention (p=.22), or one week post-intervention (p=.40). Three weeks after the lecture, students in the mnemonic group scored 20% higher than controls (p=.02). Students who had learned the mnemonic demonstrated better long-term retention of information than students learning by the control method. This mnemonic minimizes study time while improving long-term retention.

Key Words: Medical Education; Porphyrin Pathway; Mnemonic; Memory; Medical Memorization

Introduction

One of the daunting challenges in medical education is memorizing the basic factual knowledge necessary for higher-order, critical thinking for effective patient care. Retention of so much information can be a source of anxiety for medical students. Many medical education curricula incorporate problem-based, integrative learning over rote memorization to promote retention and critical thinking. Nevertheless, a large body of knowledge still must be memorized to complete medical school and residency successfully. Study techniques such as mnemonics are often used by students to memorize large volumes of knowledge in cell biology, anatomy, microbiology and pharmacology courses for time efficiency.

Mnemonics are a proven device for increasing retention of medical information quickly and accurately. Picmonic[®], an audio visual mnemonic device, was shown to be superior to studying text alone at 1 and 4 weeks [1]. Another randomized clinical trial found that subjects using the 44-55-66PM mnemonic for the Ottawa Ankle and Foot Rules had better long-term knowledge than the control group that was classically taught [2]. The Dean Vaughn Medical Terminology 350 Total Retention System

incorporates a visual image to link the Greek or Latin scientific word root to its meaning. For example, since “gastr-” sounds like “gas trunk,” the learner is taught to create an image of a “gas trunk with a stomach for a tank” to link the Greek word stem with its meaning. High school students using this system had statistically significantly better scores on the posttest than those using rote memorization [3].

In the present study, we explore whether teaching a visual mnemonic strategy to medical students helps in the retention of the names of enzymes in the porphyrin pathway, the order of those enzymes, and the diseases associated with each enzyme deficiency.

Materials & methods

We used the peg-system of mnemonics whereby unique pictures are assigned to the numbers 1 through 8 (Table 1). Each picture has some rational association with the number to facilitate memory by association [4]. One must memorize this list of memory pegs in order to proceed with any mnemonic that relies upon it. For the porphyrin pathway, we identified a unique key syllable from each of the enzymes and the diseases associated with their deficiency (8 enzymes and 8 diseases yielded 16 unique syllables). (We recognize the minor limitation that “syn” appears in both aminolevulinic synthase and uroporphyrinogen synthase.) For each step in the pathway, we created a mnemonic associating three items with imagery: the picture of the number of the step in which the enzyme occurs in the pathway, the unique key syllable of the enzyme name, and the unique key syllable of the associated disease name (Table 2 and Figures 1-8). Specific imagery was selected to create a situation in one’s mind whereby each object is a crisp picture and their interactions evoke emotion (excitement, fear, pain, eroticism, surprise, etc.) utilizing all the senses (sight, touch, sound, smell, and taste, often in that order).

Table 1. Numerical memory pegs using imagery by association.

Number	Image	Reason for Association
1	Tree	trunk looks like the number 1
2	Seesaw	has two seats; goes in two directions (up and down)
3	Stool	has three legs
4	Chair	has four legs
5	Glove	has five fingers
6	Gun	six-barrel gun; six feet under
7	Dice	lucky seven; seven come eleven
8	Skate	rhymes with eight; figure eight in ice skating

Table 2. Porphyrin mnemonic.

Mnemonic	Enzyme	Disease
1. Tree, ALAS, blast	Aminolevulinic synthase (ALAS)	X-linked sidero BLAST ic anemia
2. Seesaw, ALAD, dehydrate	ALA Dehydratase (ALAD)	ALA DEHYDRAT ase deficiency porphyria
3. Stool, Paint Ball Gun, ape	Porphobilinogen (PBG) deaminase	Acute Intermittent Porphyria (AIP)

4. Chair, syn, conjoined/genital	Uroporphyrinogen SYN thase	CONGENITAL Erythropoietic Porphyria
5. Glove, car, tardy	Uroporphyrinogen de CAR boxylase	Porphyria Cutanea TARDA (PCT)
6. Gun, cop, herd	COP roporphyrinogen oxidase	HERED itary Coproporphyria
7. Dice, pro, gate	PRO toporphyrinogen oxidase	Varie GATE porphyria
8. Skate, Pharaoh, PP	FERRO chelata SE	Erythropoietic Protoporphyrin (EPP)

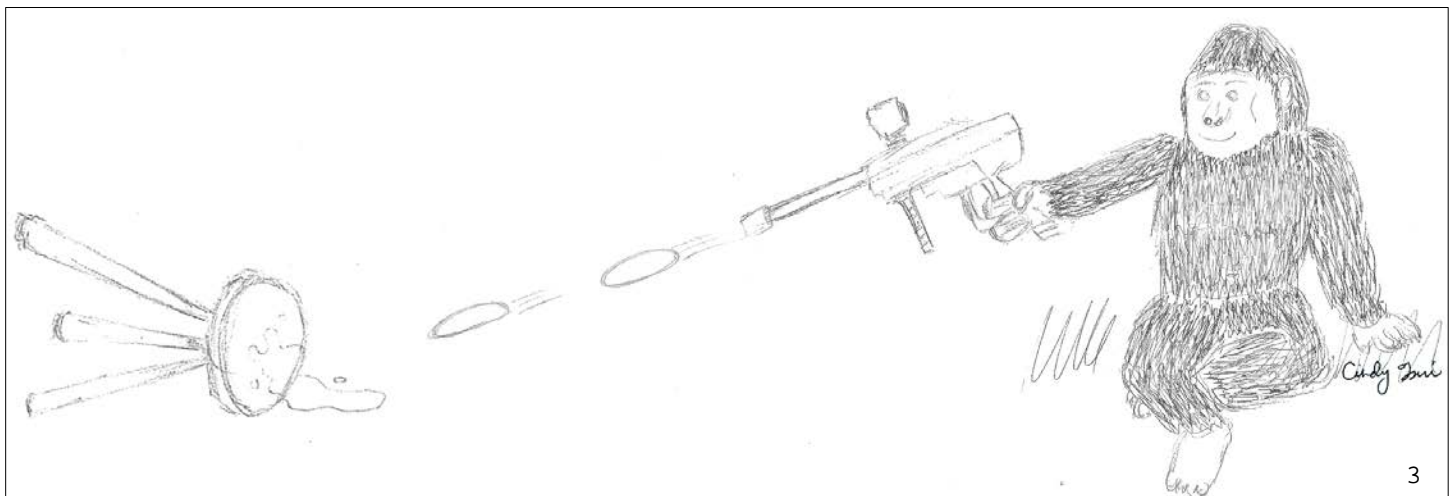
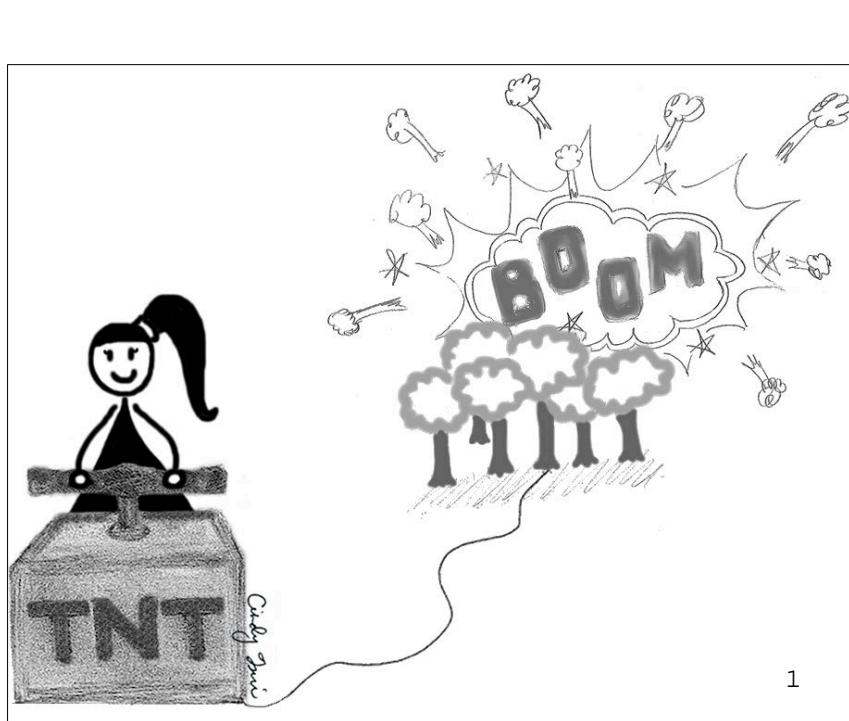


Figure 1. A lass blasts a tree. (ALAS, blast, tree). ALAS = aminolevulinate synthase, blast = x-linked sideroblastic anemia, tree = 1. **Figure 2** A lad dehydrates on a seesaw. (ALAD, dehydrate, seesaw). ALAD = aminolevulinate dehydratase, seesaw = 2. **Figure 3.** An ape shoots a stool with a paintball gun. (paintball gun (PBG), ape (sounds like AIP), stool). PBG = porphobilinogen deaminase, AIP = acute intermittent porphyria, stool = 3.

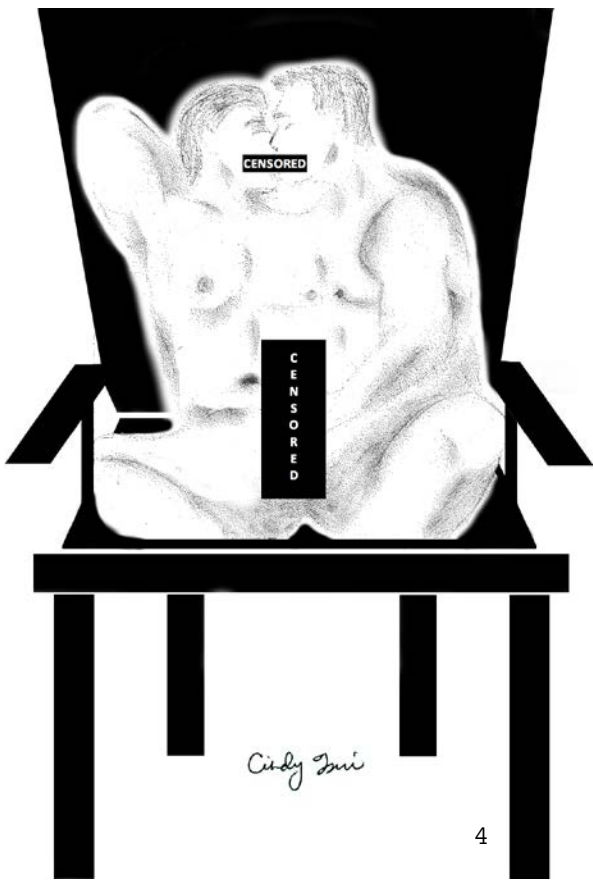


Figure 4. Conjoined twins sinning (with their genitals) on a chair. (*conjoined/genital, syn, chair*). *Conjoined/genital* = congenital erythropoietic porphyria, *syn* = uroporphyrinogen synthase, *chair* = 4. [Alternative: genitals (penis and vagina, without human attachments) sinning (i.e., intercourse) on a chair (must have four legs!)] **Figure 5.** A person's glove gets stuck in the car engine, making the car break down, making the person late/tardy. (*car, tardy, glove*). *Car* = uroporphyrinogen decarboxylase, *tardy* = porphyria cutanea tarda, *glove* = 5. [Alternative: turd instead of tardy → a man cleans a human turd off his car, requiring a glove]

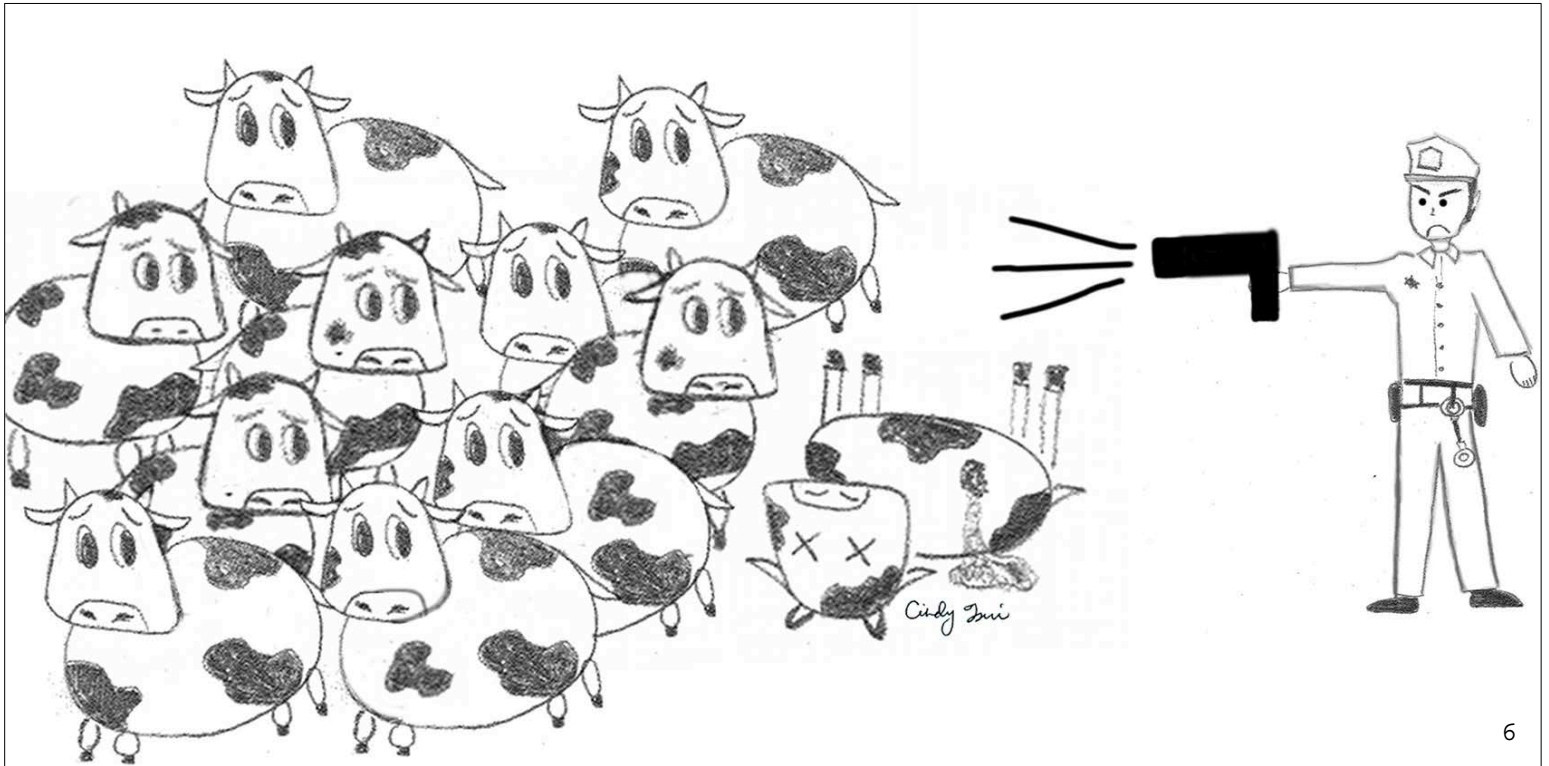


Figure 6. A cop shoots a herd of cows with a gun. (*cop, herd (sounds like herd), gun*). *Cop* = coproporphyrinogen oxidase, *herd* = hereditary coproporphyria, *gun* = 6. [We deliberately avoided ox or oxen as it appears in three of the eight enzymes in the pathway.]

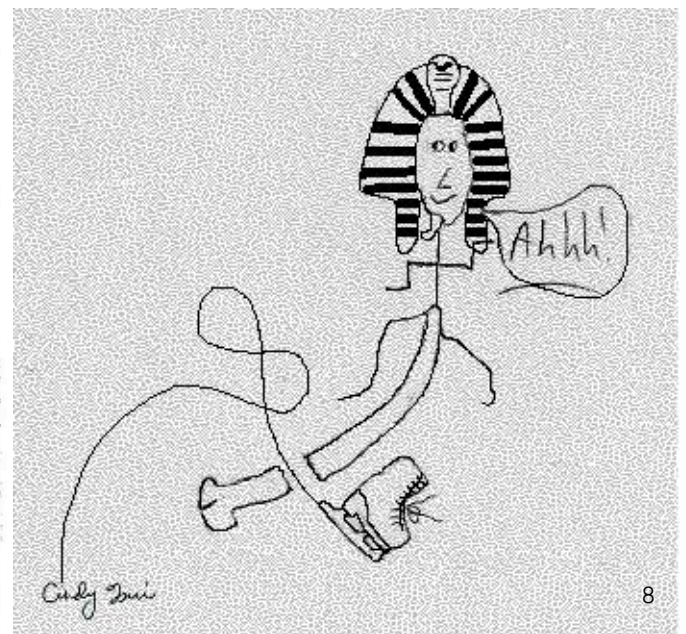


Figure 7. A Vegas dice pro throws dice at a gate (hear the gate rattle). (pro, gate, dice). Pro = protoporphyrin oxidase, gate = variegate porphyria, dice = 7. **Figure 8.** The skate, making a figure 8, cuts off the Pharaoh's long PP. (Pharaoh (sounds like ferro), PP (for penis), skate). Pharaoh = ferrochelataase, PP = erythropoietic protoporphyria, skate = 8. [This mnemonic synergizes with another well-known mnemonic that "There is no PP in EPP," reminding us that no porphyrins will be detected in the urine of an EPP patient. Our mnemonic suggests that the Pharaoh now has "no PP".]

Twenty-two students and research fellows at the Icahn School of Medicine at Mount Sinai volunteered to participate. Eleven subjects were randomized to the control group. Eleven subjects were randomized to the experimental group. On the first day, all students took a 10-question multiple-choice test to assess their baseline knowledge of the porphyrin pathway. Immediately following the quiz, the experimental group received a 20-minute lecture on the porphyrin pathway using the mnemonic while the control group received a similar lecture without use of the mnemonic. Following the lecture, both groups retook the pre-test to assess short-term recall. All subjects were told that there would be an assessment at Day 7 but were asked not to study. On Day 7, the students returned to the classroom, studied either the mnemonic or the control information about the porphyrin pathway for ten minutes, and subsequently took a new 10-question multiple-choice test. On the 22nd day, the students were told to come in to receive vouchers for participating in the study, and they were given an unannounced 20-question multiple-choice test to assess long-term recall. This reduced the possibility of students studying the pathway outside of the allotted study time to prevent confounding variables.

Results

No participants were lost to follow-up. There was no significant difference between the control and experiment groups in the pre-test scores, immediate post-test scores, or Week 1 scores (Figure 9). Scores at Week 3 were significantly different (Mann Whitney test, $p=.018$) (Figures 9 and 10).

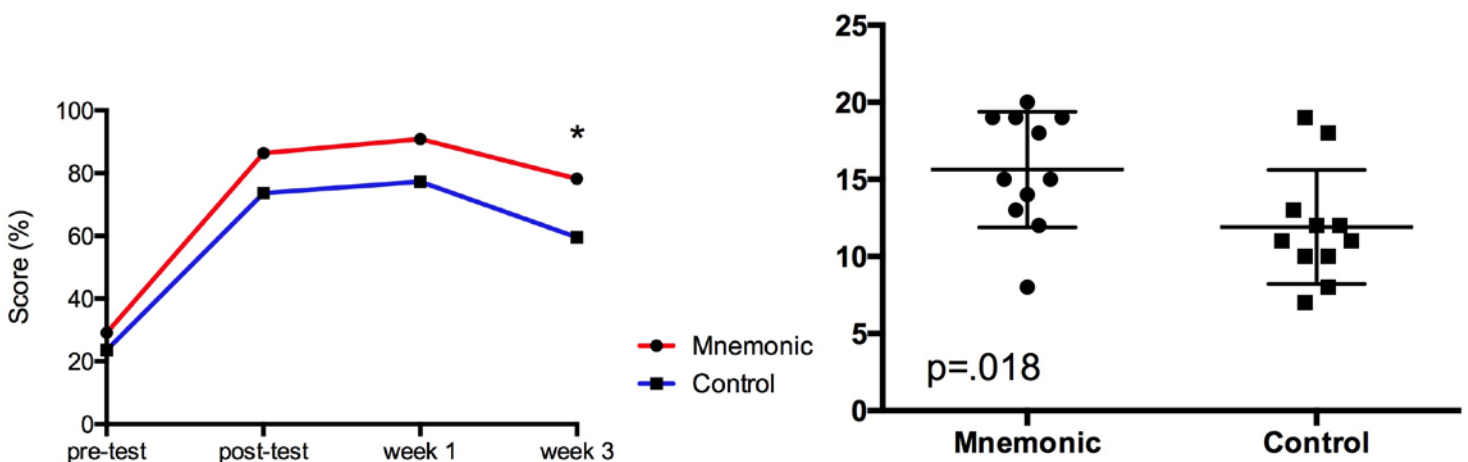


Figure 9. Score trends over time. Statistically significant divergence is seen at Week 3. **Figure 10.** Week 3 test scores for Mnemonic and Control groups (Mann-Whitney test, $p=.018$).

Discussion

Our study demonstrates the effectiveness of imagery mnemonics in learning the porphyrin pathway with long-term retention. Visual mnemonics are currently utilized by medical students in studying for board examinations [1]. We suspect the strategy is broadly applicable to many bodies of medical information that require memorization, including anatomy, biochemistry, and pharmacology. A powerful aspect of the strategy we employed is the intrinsic value of the word being memorized as a trigger for the memory cue. Simpler mnemonics, such as “King Phillip Came Over From Germany Stoned” to remember the taxonomic hierarchy of “Kingdom, Phylum, Class, Order, Family, Genus, Species,” suffer from a lack of any cue other than that the mnemonic and the object to be memorized share a common first letter. The more abstract the name of the object to be memorized becomes, the less helpful such a strategy becomes and the more useful our strategy becomes. Of course, we acknowledge that one must invest more time developing a complex visual mnemonic than a simple acronym.

Memorizing to achieve long-term retention translates to learning, after which the information can be used for higher-order, critical thinking for effective patient care. Despite emphasis on integrative learning, memorization remains a crucial component of medical education, and we have demonstrated that our mnemonic utilizing visual imagery improves retention of this information over the course of 21 days. We offer Figures 1 through 8 as examples of imagery that appeal to the authors. However, any individual learner may have an alternative vision for a given image that rings more true to his or her memory. We believe our system is a valuable tool for learning the heme synthesis pathway and provides the framework to create mnemonics for other difficult-to-memorize topics in medicine.

References

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