Showercap Mindmap: a spatial activity for learning physiology terminology and location

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Vanags T, Budimlic M, Herbert E, Montgomery MM, Vickers T. Showercap Mindmap: a spatial activity for learning physiology terminology and location. Adv Physiol Educ 36: 125–130, 2012; doi:10.1152/advan.00095.2011.—Students struggle with the volume and complexity of physiology terminology. We compared first-year undergraduate psychology students’ learning of physiological terms using two teaching methods: one verbal (control group; n = 16) and one spatial and multisensory (experimental group; n = 19). The experimental group used clear plastic shower caps to mark brain regions and affix labels to another participant’s head. The control group learned the material verbally through a game. When tested verbally, both the control and experimental groups recalled more of the 10 terms immediately after the activity (+106% and +83%, respectively) and 2 wk later (+53% and +31%, respectively) than at the pretest (P < 0.0005). When participants’ knowledge was tested spatially (labeling a brain diagram), the experimental group recalled more terms at the posttest (+76%) and followup (+73%) than at the pretest (P < 0.0005), but the control group who showed no improvement at either time point (+12% and +14%, respectively). These findings support the notion that spatial and multisensory learning produces improved spatial recall over time while also supporting the notion of transfer-appropriate processing.

anatomic terms; kinesthetic learning; spatial learning

MANY STUDENTS find it difficult to learn the large number of terms relating to structures of the nervous system, the brain, and the body (2). One way of assisting students with this material is through active learning tasks. Educators have been adopting active learning and teaching methods for several years now because it leads to significant improvements in the retention and application of knowledge, particularly compared with passive learning (6). There is ample evidence to show that active learning benefits students by promoting student engagement, collaborative learning, cooperative learning, and problem-based learning (11).

Learning the physiology of the body involves other challenges. One of these is integrating the information (14); this can be achieved with kinesthetic and three-dimensional learning (3). Representing information in more than one way, for example, visually as well as verbally, creates stronger associations in long-term memory; multiple mental representations produce multiple associations and more paths for retrieving that information (5, 9). Kinesthetic and three-dimensional learning have been achieved through the use of plastic/clay models and manikins (3, 13). However, with some cheap plastic shower caps, students may find life-sized brain models in their peers.

Clear shower caps placed on another participant’s head create a blank canvas for an external representation of the brain. Although participants could be left to label this brain without specific guidance, an effective learning activity involves information being presented in a structured way to promote deeper learning and better long-term retention (1). Structuring information allows participants to relate and integrate similar brain functions thereby constructing knowledge and building on that knowledge as the task unfolds (constructivism) (1).

Another important consideration for learning and memory is the type of processing involved in the learning phase (encoding) and the test phase (recall). Recall is improved if the mental processes involved at test are the same as those engaged during learning. This is known as transfer-appropriate processing (5, 8). Learning material verbally produces better verbal recall than recall using another modality (e.g., spatial). Similarly, optimal test performance is achieved on a spatial task if the material is learned using spatial processing. A kinesthetic, three-dimensional form of learning involves such spatial processing as well as the verbal learning involved with the physiology terminology. For this reason, spatial learning should be evaluated with both verbal and spatial testing tasks. Finally, testing that occurs immediately after a learning activity reflects some knowledge that will be forgotten over time but remains in short-term memory for the duration of the test due to the recency effect (5). Hence, a robust evaluation of a teaching method should include immediate recall as well as recall after a substantial time delay.

In the present study, we examined the effectiveness of a teaching method involving a three-dimensional, kinesthetic task using a life-sized model of the brain. This teaching method was compared against the verbal learning that occurs during a game known to be effective for learning physiological terms (15). In line with our previous findings (15), we hypothesized that both teaching methods would produce improved performance on a verbal recall test both immediately after the exercise and at a 2-wk followup. In accordance with transfer-appropriate processing, we further hypothesized that those involved in the three-dimensional, kinesthetic activity would perform better on a spatial recall task than those learning the material in a verbal manner only.

METHODS

Participants

Participants were 73 undergraduate students enrolled in a first-year introductory psychology unit at an Australian university. Although sex and age were not collected for this experiment, the demographics of the psychology unit were as follows: 66% female students and 34% male students with ages ranging from 18 to 64 yr (mean: 22.48 yr, SD: 6.81 yr). Participants received 1 h’s research participation credit
toward their course for doing this study. We ran four sessions of the experiment, and participants were in the experimental group (n = 36) or control group (n = 37) depending on which time slot they chose. Of the original 73 participants, 35 participants completed the followup test 2 wk later (19 students in the experimental group and 16 students in the control group). The study was approved by the Human Ethics Committee of the University of Canberra.

Materials

Key terms, the brain diagram sheet, and cheat sheets. The 15 key physiological terms used in this experiment came from chapter 3 of the textbook, Psychology and Life (4). They included terms such as Broca’s area, the parietal lobe, the corpus callosum, and the occipital lobe. The brain diagram sheet (used for the pretest, posttest, and followup) was a lateral view diagram of the brain (10) with 10 empty boxes for labeling (see Fig. 1). The cheat sheets were color photocopies of pages 69 and 76–80 of Psychology and Life (4) and contained all the information participants needed for the experimental activities.

Showercap Mindmap packs. The Showercap Mindmap packs included a clear, unmarked plastic shower cap, a whiteboard marker, and 15 sticky, color-coded labels. Lobe labels were blue (occipital, temporal, parietal, and frontal). Specialist areas were green (the corpus callosum, Broca’s area, and Wernicke’s area). Labels relating to information processing were yellow (hearing; heat; pain and temperature; and interpretation and integration of information). Cortex labels were orange (motor, association, somatosensory, auditory, and visual).

Brain Bingo sheets. There were two bingo sheets adapted from our previous study (15), which consisted of a 3 × 3 grid of 9 of the 15 key terms (see Fig. 2).

Experimental Design

The experiment was a two (control/Brain Bingo group and experimental/Showercap Mindmap group) by three (pretest, posttest, and followup) mixed factorial design with one between-subjects factor (teaching method) and one within-subjects factor (time of recall).

Procedures

At the start, the experimenter read aloud 10 free recall questions based on the definitions of the key terms (pretest). Participants had 15 s to record an answer to each question. Examples of questions included “In which lobe is the somatosensory cortex located?” (answer: the parietal lobe) and “Which lobe contains the visual cortex?” (answer: the occipital lobe). Students wrote their answers on a sheet of paper and handed it in. The experimenter then gave participants the brain diagram to label and collected these after 5 min.

Experimental (Showercap Mindmap) group. Participants formed teams of three or four students/team. The experimenter gave each team a Showercap Mindmap pack, and teams nominated a shower cap wearer from their group. The experimenter then gave each group a set of the cheat sheets. The group had 5 min to draw the four lobes on the shower cap using the whiteboard marker and to stick the lobe labels in the appropriate sections of the shower cap. Then they had 5 min per set of labels to place the color-coded labels on the shower cap. The
order of activities was specialist area labels, information processing labels, and then cortex labels. Participants were encouraged to use the cheat sheets if they did not know where the labels belonged. The experimenter gave no assistance.

**Control (Brain Bingo) group.** Participants formed teams of three or four students/team, and the experimenter gave all participants two different Brain Bingo sheets. Teams selected a sheet for the first round with the understanding that all members of a team used the same sheet for the same round. The experimenter had a set of cards with all key terms and their definitions on them and began the round by reading a definition aloud. The experimenter told participants that on hearing a definition they should cross off the corresponding key term (if it was present) on their bingo sheet. Team members were free, and encouraged, to confer. Once a team had crossed out three key terms in a single row, column, or diagonal, they called out “Bingo!” and the round finished. Teams then played a second round with the other bingo sheet. The Brain Bingo activity did not involve feedback (cf. control group, experiment 2) (15).

Both the Showercap Mindmap and Brain Bingo activities lasted 30 min.

**Posttest.** The experimenter read the 10 free recall questions used at the pretest aloud, and participants recorded their answers and handed in their sheets. The experimenter gave participants another copy of the brain diagram to label and collected these after 5 min.

**Followup.** In a tutorial 2 wk after the experiment, all participants had the opportunity to participate in a surprise test. The tutor read the same 10 free recall questions used for the pre- and posttests, and participants recorded their answers on sheets and handed them in. The tutors gave students another copy of the brain diagram and 5 min in which to label it. Tutors collected the sheets.

**RESULTS**

**Pretest Knowledge**

To ensure that the knowledge of the Showercap Mindmap and Brain Bingo groups was comparable before participating in the study, an independent *t*-test analysis was done on the pretest scores. There was no difference between the two groups on the verbal learning task [free recall questions, *t*(33) = 0.442, *P* = 0.661] or the spatial learning task [brain diagram labeling, *t*(33) = 0.517, *P* = 0.609].

**Verbal Learning**

Both Showercap Mindmap and Brain Bingo participants showed verbal learning as a result of the Showercap Mindmap and Brain Bingo tasks with a significant amount of that learning retained for a further 2 wk. Two (Showercap Mindmap and Brain Bingo) by three (pretest, posttest, and followup) split plot ANOVA showed a strong effect for time [Wilks’ Λ = 0.233, *F*(2,32) = 52.688, *P* < 0.0005, multivariate partial η² = 0.767] but no effect of teaching method (*P* = 0.064) and no time by teaching method interaction (*P* = 0.101).

**Effect of the teaching method.** Although the main effect for teaching method approached significance (*P* = 0.064), the only difference between the Brain Bingo and Showercap Mindmap scores was immediately after the activity (posttest), when the Brain Bingo group recalled more terms than the Showercap Mindmap group *t*(2,32) = 2.214, *P* = 0.034 (equal variances not assumed). The difference at followup only approached significance (*P* = 0.085) (equal variances not assumed).

**Effect of time (within subjects).** Both groups showed increased knowledge after doing the activities [*F*(1,33) = 102.395, *P* < 0.0005, partial η² = 0.756 (posttest)] and 2 wk later [*F*(1,33) = 23.984, *P* < 0.0005, partial η² = 0.421] than before the activities. However, participants did forget some of these terms. After 2 wk, Brain Bingo participants recalled 1.7 fewer terms than they did immediately after the activity [*t*(15) = 2.966, *P* = 0.010], and Showercap Mindmap participants recalled 1.5 fewer terms [*t*(18) = 3.581, *P* = 0.002; see Table 1 and Fig. 3].

**Spatial Learning**

To determine how well participants could label the brain diagram after the activities, we conducted two (Showercap Mindmap and Brain Bingo) by three (pretest, posttest, and followup) split plot ANOVA. This again showed a very large effect for time (*P* < 0.0005) and no effect for teaching method (*P* = 0.332). However, in contrast to the verbal learning test, the spatial learning test produced a large time by teaching method interaction [Wilks’ Λ = 0.853, *F*(2,32) = 5.256, *P* = 0.011, multivariate partial η² = 0.247].

**Interaction of teaching method and time.** The Showercap Mindmap participants’ ability to label the brain diagram improved with the learning activity, and this improvement was retained for the next 2 wk. In contrast, Brain Bingo participants showed no improvement on this task either immediately after their activity or after the 2-wk delay (*P* = 0.286 and *P* = 0.182, respectively). Those in the Showercap Mindmap group correctly labeled an additional 2.8 areas straight after the activity (*t*(18) = 4.766, *P* < 0.0005, Cohen’s *d* = 1.098) and an additional 2.4 areas 2 wk later (*t*(18) = 5.247, *P* < 0.0005, Cohen’s *d* = 1.251) compared with pretest. Importantly, they did not forget any material in this 2-wk period (*t*(18) = 0.307, *P* = 0.762; see Fig. 4).

**Effect of the teaching method.** Again, despite one group (this time the Showercap Mindmap group) having higher scores than the other (the Brain Bingo group), there was no significant difference between these scores at posttest or followup (*P* = 0.755 and *P* = 0.109, respectively). This is somewhat surprising but consistent with the lack of main effect for teaching method from the split plot ANOVA (*P* = 0.332). We suggest that the small sample sizes and the size of the SE may have been contributing factors.

**Effect of wearing the showercap.** As four participants in the Showercap Mindmap groups wore the shower cap and could be considered less engaged with the spatial learning activity, we analyzed the shower cap wearers’ performance against the performance of other group members. Due to the small sample size (*n* = 4) and some violations of normality, Mann-Whitney *U*-tests were used. On the verbal test, the team member wearing the shower cap performed on par with the other team members.

| Table 1. Numbers of correct responses for each teaching method and type of question for the pretest, posttest, and followup |
|---------|----------------|----------------|----------------|
|         | Pretest         | Posttest       | Followup       |
|         | Mean  | SD   | Mean  | SD   | Mean  | SD   |
| Verbal learning (questions) |       |      |       |      |       |      |
| Control group | 3.2   | 1.39 | 6.6   | 1.72 | 4.9   | 2.15 |
| Experimental group | 2.9   | 1.70 | 5.3   | 1.75 | 3.8   | 1.53 |
| Spatial learning (diagram labeling) |       |      |       |      |       |      |
| Control group | 4.3   | 3.13 | 4.8   | 3.15 | 4.9   | 3.22 |
| Experimental group | 3.7   | 2.75 | 6.5   | 3.01 | 6.4   | 2.52 |

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How We Teach

SHOWERCAP MINDMAP

Fig. 3. Mean scores for the Showercap Mindmap and Brain Bingo groups in response to 10 free recall questions. Participant numbers were 19 students in the Showercap Mindmap group and 16 students in the Brain Bingo group. Errors bars = 95% confidence intervals. Split plot ANOVA comparing participant knowledge at the pretest, posttest, and followup both within subject and between subject (across groups) showed significant improvement in performance between the pretest and posttest and between the pretest and followup but no differences across the two groups at the pretest and followup. There was a significant difference between the groups at posttest (immediately after the activity), with the Brain Bingo (control) group outperforming the Showercap Mindmap (experimental) group on this verbal task.

DISCUSSION

This study sought to evaluate a learning activity for brain anatomy terminology and the physical location of that anatomy. The activity integrated active learning with a deeper level of understanding by encouraging the use of structured spatial and multisensory learning. When tested for verbal learning (free recall questions), both Showercap Mindmap and Brain Bingo groups recalled more terminology immediately after the activities and at a 2-wk followup than at the pretest, and the Brain Bingo group outperformed the Showercap Mindmap group immediately after the activity. However, when the testing involved spatial learning (labeling a diagram), there was an interaction between time and teaching method. Participants in the Showercap Mindmap group 1) performed better at both time points than they did at the pretest and 2) retained that learning over the 2-wk period. This was not true for the Brain Bingo group.

These results suggest several things. First, the Showercap Mindmap activity leads to participants not only learning the physiological terminology but also integrating that information with the physical location of brain components. Spatial learning improved recall when “reconstructing” the brain (at least in a diagram). Many studies have shown that the recall of information is improved when the processing style at encoding (learning) matches the processing style at retrieval (testing) (5). For the diagram labeling task better suited to spatial learning, the time by teaching method interaction showed the Showercap Mindmap group improved their knowledge of the material and retained that knowledge over time. The Brain Bingo group, whose learning style was verbal, showed no improvement on the diagram labeling task. In contrast, for the verbal test, the Brain Bingo group outperformed the Showercap Mindmap group at the posttest and almost outperformed them at the followup (P = 0.085). These results are consistent with transfer-appropriate processing and the expectation of improved recall when the mode of processing at test is similar to the mode of processing during learning. This suggests that the role of transfer-appropriate processing in the retention of learned teaching materials over time is worthy of further investigation.

The retention of knowledge by the Showercap Mindmap group over a 2-wk delay without dropoff may be attributable to members both immediately after the Showercap Mindmap activity [U = 26.0, z = −0.220 (mean rank = 9.6, n = 14 team members; mean rank = 9.0, n = 4 shower cap wearers)] and 2 wk later [U = 26.0, z = −0.215 (mean rank = 9.4, n = 14; mean rank = 10.0, n = 4 show cap wearers)]. Similarly for the diagram labeling task, there were no differences in the performance of the team members and the person wearing the shower cap at posttest [U = 22.0, z = −0.654 (mean rank = 9.1, n = 14 team members; mean rank = 10.0, n = 4 shower cap wearers)] or 2 wk later [U = 25.5, z = −0.270 (mean rank = 9.7, n = 14 team members; mean rank = 8.90, n = 4 shower cap wearers)]. Hence, wearing the shower cap did not prejudice a team member’s learning.

Fig. 4. Mean scores for the Showercap Mindmap and Brain Bingo groups in labeling a brain diagram with 10 key terms. Participant numbers were 19 students in the Showercap Mindmap group and 16 students in the Brain Bingo group. Errors bars = 95% confidence intervals. Split plot ANOVA comparing participant scores at the pretest, posttest, and followup both within subject and between subject showed significant improvement in performance between the pretest and posttest and between the pretest and followup for the Showercap Mindmap group only. There were no differences between the Showercap Mindmap and Brain Bingo group scores on the pretest, posttest, or followup.
this activity engaging more senses during learning than the Brain Bingo task which involved only vision and audition. Not only, did the Showercap Mindmap group have verbal and auditory cues, they may also have recalled the act of picking up labels and placing them on different parts of the shower cap. This would have produced integrative learning as they discussed the terms and where to place the labels. In contrast, team discussions in the Brain Bingo group activity were focused on identifying the correct answer from a list of terms. In addition, the time pressure of Brain Bingo (wanting to be the first group to call out “Bingo!”) focused participants on selecting the most accurate or “best guess” response before the experimenter moved on to the next definition. The Showercap Mindmap group discussions focused on using sources of information (cheat sheets) to correctly place labels. There was no concept of winning. The outcome they sought was their own complete shower cap representation of the brain. Furthermore, although limited to 5 min/category, unlike the Brain Bingo group, we saw no Showercap Mindmap participants showing signs of time pressure during this activity.

An unexpected finding from this study was that shower cap wearers performed as well at test as those sticking the labels onto the shower cap. This was true both immediately after the activity and 2 wk later. We expected to find that those wearing the shower cap did not perform as well because they were less involved in the task. On reflection, we suggest three factors that might account for the learning by the shower caps wearers. First, during the activity teams worked cohesively to determine where each label went and to create lines for the lobes. It was not uncommon to see the shower cap wearer holding the cheat sheets and being involved in these discussions. Second, sticking the labels onto the shower cap required pressure, which would have been felt by the shower cap wearer. It is highly likely that having three people talk about Broca’s area, discuss where to place the label, and then feeling the sensation of a Broca’s area label being pressed onto your scalp is likely to produce learning. Indeed, memory for information is better when we can relate the information to ourselves; this is known as the self-reference effect (12). For shower cap wearers, the self-reference effect would have been highly activated. Finally, in all cases when the activity was complete, the shower cap wearers took off the shower cap and the group admired their handiwork. We observed team members pointing and having discussions in this phase. Furthermore, we did not rush teams to put the shower caps away before the posttest phase of the experiment. For groups who finished the last labeling task quickly, they may have had 5 min for this reflection. We suggest that these factors could account for the fact that shower cap wearers learned as much as the rest of the team.

One drawback to this activity is the time required to prepare the materials. While clear plastic shower caps are cheaply available through the internet (we paid A$8 for 100 caps), it takes time to prepare the colored labels. There is also time involved in categorizing the terminology into meaningful groups, but we contend that many teachers are already doing this preparation. As teachers are frequently time poor, it is possible that the preparation of color-coded labels could create another learning activity for students; students would benefit from categorizing related terminology and then transferring that knowledge to a spatial learning activity. However, as with all learning activities, there is a trade off between students spending too much time preparing for the activity and actually learning from doing the activity. Future studies might investigate whether categorizing and making the labels leads to better learning outcomes than the current activity. Whichever is the case, one important aspect of this activity is the structuring of information to assist learning.

The long-term retention of information by the Showercap Mindmap groups relates to the notion of constructivism. We color coded the adhesive labels specifically to encourage concurrent learning of related terms. In a pilot of the Showercap Mindmap activity labels were color coded so that correct placement resulted in all labels of one color being colocated on the left hemisphere and all those of another color on the right hemisphere. However, we observed that students did not approach the task in a systematic manner, and, surprisingly, they did not identify the color-hemisphere correlation. In the pilot, different team members picked up labels at random and placed them according to their own knowledge or according to the cheat sheets they were holding. In fact, students would swap a label for one that did relate to the reference material they had, rather than research the term itself. By grouping the terms in a functional manner and structuring smaller tasks of related material, we observed teams working cohesively and solving the problem as a unit. We suggest that by constructing their understanding together while working cooperatively on a kinesthetic, three-dimensional task, Showercap Mindmap participants experience good learning outcomes that last over time (1, 7). This study demonstrates that multisensory learning incorporating cooperativity, constructivism, and self-reference aligns with the tenets of active learning and provides further evidence of the benefits of active learning.

DISCLOSURES
No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

REFERENCES


