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Review Article

The Use of Magazine Spreads as a Tool in Neuroscience Pedagogy

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Abstract

Innovative pedagogical strategies that integrate both the social and natural sciences within undergraduate psychology curricula are much needed. Our study used magazine formats to facilitate a more creative method of delivering of integrative-based neuroscience content (which is representative of the aforementioned concern). Short- and long-term memory tests and an attitudinal survey on pedagogical engagement were conducted after materials were delivered. Results showed that more relevant magazine content yielded greater retention of content, which suggest the magazine spreads may be effective to disseminate neuroscience content in undergraduates.

Keywords: magazine; neuroscience; metaphors; pedagogy; memory

Introduction

For almost ten years, neuroscience has become a common part of psychology curricula within colleges and universities (Stoloff et al., 2010). Psychology is a discipline that has been historically considered a social science, but the field has become more interdisciplinary, as it continues to integrate the social sciences with natural sciences like biology, chemistry, and physics (Crisp & Muir, 2012). While neuroscience is an example of Science, Technology, Engineering, and Mathematics (STEM) learning, a priority across the American educational system (Barnard-Brak, Stevens, & Ritter, 2017; Rampey, Dion, & Donahue, 2009), students with little background in the natural sciences may struggle with understanding the complexities of this discipline. For instance, neuroscience requires students to familiarize themselves with jargon that is common from both social and natural sciences (Nikitina, 2002), and vocabulary that is unfamiliar for students without a solid natural science background may lead to difficulties in finding meaning with unfamiliar vocabulary (Chundler & Konrady, 2006; Varma, McCandliss, & Schwartz, 2008). Furthermore, such content which extends beyond just knowing unfamiliar vocabulary (i.e., having to use the vocabulary to understand mechanisms within neuroscience) has been shown to create anxiety in students with weaker scientific backgrounds (Birkett & Shelton, 2011). The popularity of neuroscience continues to rise both in education and research within psychology, so the field seems to have concerns to alleviate some of these problems for students who struggle with concepts beyond the social aspects of psychology.

In order to address such problems, there has been considerable research exploring the use of non-traditional methods in an attempt to create visual metaphors for abstract and complex scientific content (e.g., Carney & Levin, 2002; Carter & Pitcher, 2010; Chundler & Konrady, 2006; Niebert, Marche, & Treagust, 2012; Sabeti, 2012). The use of standard illustrations in vehicles like neuroscience textbooks have been questioned in terms of their relative effectiveness to comprehend integrative content (Fernandez-Duque, Evans, Christian, & Hodges, 2015), while the creation of ancillary materials that link more engaging illustrations to scientific content have been shown to be an effective strategy for non-science majors to understand principles of the natural world (e.g., Aleixo & Sumner, 2017; Hosler & Boomer, 2011; Naylor, 2013; Ültay, 2015). The use of science-derived comic illustrations has been effective for science- and non-science-oriented students in areas like biology, chemistry, and physics (see Naylor, 2013; Ültay, 2015). Furthermore, the use of story-based media like comics and graphic novels have also been effective in better retention of concepts seen in neuroscience at both short- and long-term intervals (e.g., Aleixo & Sumner, 2017; Hosler & Boomer, 2011; Smith, et al., 2019). Such ancillary materials seem to create a more engaging yet appropriate way to build visual metaphors for content that requires one to personify abstract principles by linking them in a more palatable manner (see Jee & Anggoro, 2012).

One reason why visual metaphors are being explored as educational tools may pertain to how well visual aids go beyond reading standard texts. Numerous studies have characterized a picture superiority effect, a phenomenon that demonstrates pictures and images are more likely to be remembered than words (Paivio, 1971; Paivio, Rogers, & Smythe, 1968). The effect is presumably due to the notion that pictures draw upon image and verbal codes, while words only draw upon verbal codes (Paivio, 1971, 1986). This results in a redundant encoding, which is more likely to persist in memory. An alternative theory is that pictures are more memorable because they provide a more distinct visual representations in comparison to words (Nelson, 1979) and can be categorized more quickly than words (Potter & Faulconer, 1975). Regardless of the underlying mechanism, all of these theories share the common theme that pictures produce a more elaborate code than words alone, which is why pictures are better remembered and persist longer in memory. This means that for pedagogical purposes, the use of pictures outweighs the use of words when trying to get the information to persist in memory for some time.

In addition to graphic novelization (in which illustrated narratives are linked to scientific content), other strategies may also utilize visual imagery towards a better retention of material. It has been suggested that visual advertisements (as seen in magazines) can effectively and creatively grab one's attention and aid in a link between symbolic imagery and a desired product or brand (e.g., Baack, Wilson, & Till, 2008; Mohanty & Ratneshwar, 2015; Phillips & McQuarrie, 2004). Advertisements serve a distinct purpose to engage a potential consumer with visualizations that link the effectiveness of the product with verbal prompts within the picture (Babin & Burns, 1997; Phillips, 2000; Phillips & McQuarrie, 2004). Furthermore, it has been demonstrated that original advertisements can promote effective memory recall of a product, as long as such advertising can create a universally relevant message rather than appeal to specific target samples of people (Pieters, Warlop, & Wedel, 2002; Proctor, Proctor, & Papasolomou, 2005; Smith, MacKenzie, Yang, Bucholz, & Darley, 2007). Mohanty and Ratneshwar (2015) suggested a mechanism behind such a premise, in that visual metaphors (e.g., petals of a white lily intended to symbolize the softness of a brand of napkin) promote a "need for cognition," making a person more receptive in comprehending an advertisement that represents the intended product. These studies collectively stress that salient, visual metaphors exist in advertisements, and they often are successful in grabbing the attention of the viewer while delivering a clear message as to why the metaphor is a reflection of a product. If this premise is correct, then the use of similar techniques could be a valuable strategy in engaging viewers towards educational concepts to which visual metaphors may represent.

The notion of using visual advertisements as a way to signal viewers into cued concepts has not been well studied, but some attempts have been made to use such a strategy for pedagogical purposes. For instance, Anderson (1990) has shown that symbolism within environmental art can be a powerful way to convey symbolic methods about society and history in students within the discipline of art education. Furthermore, he suggests that the effectiveness of an advertisement in terms of education parallels marketing strategies by grasping the attention of the viewer and conveying a clear message (Anderson, 1990, Phillips & McQuarrie, 2004). Similarly, the ability to grab a students' attention in photographs and create a symbolic reaction about social industrialism (known as the Burtynsky effect) was also shown (Smith, Goodmon, & Hester, 2018). In this study, college undergraduates rated landscape photographs that projected industrialism (and permanent pollution in the environment) more negatively than both completely natural and humanmade landscapes. This would suggest that the Burtynsky photographs created a clear message to the viewer about permanently destroying the natural landscape despite the promotion of urbanization. This use of advertisements in education has also been seen in much younger children, in which characters from popular culture were used in advertisements to attract the interest of preschool children, in which messages were conveyed in order to motivate cognitive development in education curriculum (Buckingham, & Scanlon, 2001). These studies collectively suggest that there is potential for creating advertisements that promote thinking among an organized educational curriculum, but there has been no attempt to use such an attention-grabbing strategy in the sciences for the sake of comprehending neuroscience content. With a strong urgency for students with weaker science backgrounds to develop better understanding of novel vocabulary and usage of such vocabulary in a field like neuroscience (e.g., Chundler & Konrady, 2006; Varma, McCandliss, & Schwartz, 2008) newly creative methods must be developed. The present study attempts to see whether science-based advertisements can be used to create more visually relevant principles of neuroscience in both a short- and long-term retention of what is conveyed.

Purposes of the Current Study and Hypotheses

The purpose of the current study was to see how cued advertisements may be effective in symbolizing neuroscience content in terms of cued priming (in both text-based presentations and illustrations in a magazine style format). Similar to what has been seen in graphic novelization studies (e.g., Aleixo & Sumner, 2017; Hosler & Boomer, 2011; Smith et al., 2019), the notion that visual metaphors may effectively engage students to attend and grasp complex information from the imagery provided in other non-traditional materials was assessed. The present study attempted to see how well an initial exposure to a magazine spread (i.e., text-based material with "advertised" imagery that symbolize content) served as a method of disseminating neuroscience content. We hypothesized that the implementation of relevant information in magazine advertisements, regardless of text or pictures, may be helpful as a tool to grasp a better understanding of how hormones function in the nervous system. Moreover, we also hypothesized that relevant information from a magazine that was pictorial-based would lead to better memory retention than text-based materials, supporting classic literature that visual metaphors are more important than narrative information (Paivio, 1971; 1986; Paivio, Rogers, & Smythe, 1968). Finally, we hypothesized that magazine spreads would be rated more engaging if the format was relevant to the testing, especially with image-based content (Sabeti, 2012). The current study attempts to demonstrate how magazine-based illustrations can be used to grasp attention in a topic that can utilize visual imagery towards complex integration of social and natural sciences.

Method

Participants

A total of 100 undergraduates from a small, liberal arts college in the southeastern United States were sampled from the psychology research participation pool. The sample ages ranged from 18 to 22 years (M = 19.46, SD = 1.78).

Materials

***Text Materials**:* Text and image materials were defined as either being relevant (i.e., pertaining to what was tested) or irrelevant (i.e., not pertaining to what was tested). Participants were randomly assigned to one of four conditions that varied based on text- and image-relevance: appropriate content about eight different hormones (e.g., angiotensin and its role in water retention), or eight control readings that did not pertain to the study (e.g., content about being prepared for tornadoes). Participants in all conditions received readings and images that were approximately one page long for each hormone or corresponding control content. Participants received both their text- and image-based advertisements in the form of a magazine spread (i.e., both the text and image could be seen at the same time with left and right panels).

***Short/Long-Term Test**:* A multiple-choice test was used to measure participants' short- and long-term retention of the content. The test was composed of sixteen items; each question had four possible answer choices, but only one correct answer. Half of the questions assessed content based on the eight hormones that were addressed in the materials, while the other half assessed knowledge of eight different hormones that were not covered in the materials.

Scores ranged from 0 – 8 for each subscale with higher scores reflecting a higher recognition of the content (in either the short- or the long-term).

***Attitudinal Survey**:* An attitudinal survey was used to measure participants' attitudes towards the ancillary materials. This item contained five questions (e.g., "*I consider this ancillary material to be engaging for my understanding of hormones*") rated on a five-point Likert-scale, where 1 is "*Strongly Disagree*" and 5 is "*Strongly Agree.*" Scores on this survey ranged from 5 to 25, with higher scores reflecting higher positive attitudes towards the materials.

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Design and Procedures

The current study employed a 2 x 2 x 2 mixed-subjects factorial design with relevance of text (relevant, irrelevant) and relevance of images (relevant, irrelevant) as the between-subjects factors and testing interval (short- and long-term) as the within-subjects factor. Recognition scores on the short- and long-term tests served as the dependent measures. A separate 2 x 2 between-subjects factorial design was also employed with relevance of text (relevant, irrelevant) and relevance of images (relevant, irrelevant) as the between-subjects factor and engagement scores as the dependent measure.

Participants were randomly assigned to a relevance condition for both the text- and image-based content. Thus, the four different conditions were as follows: 1. relevant text, relevant image, 2. relevant text, irrelevant image, 3. irrelevant text, relevant image, and 4. irrelevant text, irrelevant image. A representative sample of the relevant text, relevant image and irrelevant text, irrelevant image magazine spreads can be seen in Figure 1. Once assigned to a condition, participants received their materials in the form of an eight-panel magazine spread. They were given a total of ten minutes to read through all eight spreads, after which they immediately completed the short-term test of content. This was followed by the attitudinal survey and a demographics questionnaire. Participants were then dismissed for their participation for the first half of the experiment. One week later, the researchers distributed the long-term memory test to all participants, concluding the experiment.

Results

Recognition percentages for multiple choice scores were calculated by dividing the number of correctly answered multiple choice test questions by the total number of possible correct responses. All descriptive statistics are reported as percent numerical values (range = 0.00% to 100%).

A 2 x 2 x 2 mixed-subjects factorial ANOVA was conducted with relevance of text (relevant, irrelevant) and relevance of images (relevant, irrelevant) as the between-subjects factors and testing interval (short- and long-term) as the within-subjects factor. Scores on the short- and long-term tests for the eight hormones that were not covered in the ancillary materials served as the dependent measures. There was not a significant main effect of text relevance, $F(1,96) = 1.07$, $p = .31$, nor a significant main effect of image relevance, $F < 1$. Thus, we excluded these eight questions from the remainder of data analysis and just performed subsequent tests on the items that assessed the eight hormones that were covered in the magazine spreads.

A 2 x 2 x 2 mixed-subjects factorial ANOVA was conducted with relevance of text (relevant, irrelevant) and relevance of images (relevant, irrelevant) as the between-subjects factors and testing interval (short- and long-term) as the within-subjects factor. Recognition scores on the short- and long-term tests served as the dependent measures.

There was a main effect of text relevance on recognition scores, $F(1,96) = 18.62$, $p < .001$, Cohen's $d = .70$. Overall, scores for those who received relevant text ($M = 72.25$, $SD = 16.66$, $SE = 2.36$) were significantly higher than scores for those who received irrelevant text ($M = 59.00$, $SD = 20.87$, $SE = 2.95$). Furthermore, there was a significant interaction between testing interval and text relevance, $F(1,96) = 14.86$, $p < .001$. Subsequent independent samples t-tests revealed that collapsed across image relevance, at the short testing interval, there was a significant difference in recognition scores between those who

Angiotensin is a peptide hormone that causes vasoconstriction and a subsequent increase in blood pressure. It is part of the renin-angiotensin system, which is a major target for drugs that lower blood pressure. Angiotensin also stimulates the release of aldosterone, another hormone, from the adrenal cortex. Aldosterone promotes sodium retention in the distal nephron, in the kidney, which also drives blood pressure up. The liver creates and releases a protein called angiotensinogen. This is then broken up by renin, an enzyme produced in the kidney, to form angiotensin I. This form of the hormone is not known to have any particular biological function in itself but, is an important precursor for angiotensin II. As it passes in the bloodstream through the lungs and kidneys, it is further metabolised to produce angiotensin II by the action of angiotensin-converting enzyme. Following binding to its receptor, found in most tissues of the body, Angiotensin II has effects on blood vessels (vascular) to cause constriction (narrowing) of the blood vessels and hence to increase blood pressure. It also influences nerves function, which cause the sensation of thirst, desire for salt and stimulation of the release of anti-diuretic hormone from the pituitary gland and noradrenaline from sympathetic nerves. Angiotensin also affects adrenal glands to stimulate aldosterone production, resulting in the body retaining sodium and losing potassium from the kidneys. Finally, it directly impacts the kidneys to increase sodium retention and to alter the way the kidney filters blood. This increases water reabsorption in the kidney to increase blood volume and blood pressure. The overall effect of angiotensin II is to increase blood pressure, body water and sodium content.

Figure 1. A Representative Sample of a Relevant Text, Relevant Image (*Top Panel*) Spread and an Irrelevant Text, Irrelevant Image (*Bottom Panel*) Spread

received relevant text ($M = 79.50$, $SD = 15.72$, $SE = 2.22$) and those who received irrelevant text ($M = 59.25$, $SD = 23.11$, $SE = 3.27$), $t(98) = 5.12$, $p < .001$, $d = 1.02$. However, at the long testing interval, there was no difference in recognition scores between those who received relevant text ($M = 65.00$, $SD = 22.59$, $SE = 3.19$) and those who received irrelevant text ($M = 58.75$, $SD = 21.76$, $SE = 3.08$), $t(98) = 1.41$, $p = .16$, $d = .28$.

There was a main effect of image relevance on recognition scores, $F(1,96) = 49.01$, $p < .001$, $d = 1.28$. Overall, scores for those who received relevant images ($M = 76.38$, $SD = 11.93$, $SE = 1.69$) were significantly higher than scores for those who received irrelevant images ($M = 54.88$, $SD = 20.61$, $SE = 2.91$). The interaction between testing interval and image relevance was approaching significance, $F(1,96) = 3.20$, $p = .08$. Subsequent independent samples t-tests revealed that collapsed across text relevance, at the short testing interval, there was a significant difference in recognition scores between those who received relevant images ($M = 81.75$, $SD = 13.88$, $SE = 1.96$) and those who received irrelevant images ($M = 57.00$, $SD = 22.04$, $SE = 3.12$), $t(98) = 6.72$, $p < .001$, $d = 1.34$. Similarly, at the long testing interval, there was also a difference in recognition scores between those who received relevant images ($M = 71.00$, $SD = 17.02$, $SE = 2.41$) and those who received irrelevant images ($M = 52.75$, $SD = 23.32$, $SE = 3.30$), $t(98) = 4.47$, $p < .001$, $d = .89$.

The interaction between text relevance and image relevance was not significant, $F(1,96) = 3.21$, $p = .076$. Subsequent independent samples t-tests revealed that for both text relevance conditions, those who received relevant images recognized significantly more information than those who received irrelevant images. Specifically, for those who received relevant text, there was a significant recognition benefit for those who received relevant images ($M = 80.25$, $SD = 9.83$, $SE = 1.97$) over those who received irrelevant images ($M = 64.25$, $SD = 18.36$, $SE = 3.67$), $t(48) = 3.84$, $p < .001$, $d = 1.09$. Similarly, for those who received irrelevant text, there was a significant recognition benefit for those who received relevant images ($M = 72.50$, $SD = 12.76$, $SE = 2.55$) over those who received irrelevant images ($M = 45.50$, $SD = 18.62$, $SE = 3.72$), $t(48) = 5.98$, $p < .001$, $d = 1.69$. Subsequent independent samples t-tests also revealed that for both image relevance conditions, those who received relevant text recognized significantly more information than those who received irrelevant text. Specifically, for those who received relevant images, there was a significant recognition benefit for those who received relevant text over those who received irrelevant text, $t(48) = 2.41$, $p = .02$, $d = .68$. Similarly, for those who received irrelevant images, there was a significant recognition benefit for those who received relevant text over those who received irrelevant text, $t(48) = 3.59$, $p = .001$, $d = 1.01$. Furthermore, there was a significant memory benefit for those who received both relevant forms of materials over those who received both forms of irrelevant materials, $t(48) = 8.25$, $p < .001$, $d = 2.33$. Finally, there was a marginally significant memory benefit for those who received the irrelevant text relevant image spread over those who received the relevant text irrelevant image spread, $t(48) = 1.84$, $p = .07$, $d = -.52$.

There was a significant main effect of testing interval on recognition scores, $F(1,96) = 17.06$, $p < .001$, $d = .35$. Overall, scores after the short-term testing interval ($M = 69.38$, $SD = 22.15$, $SE = 2.21$) were significantly higher than scores after the long-term testing interval ($M = 61.88$, $SD = 22.29$, $SE = 2.23$). Finally, the three-way interaction between testing interval, text relevance, and image relevance was not significant, $F(1,96) = 1.54$, $p = .22$. As shown in Table 1, follow-up independent samples t-tests revealed that for those who received relevant text, there was a recognition benefit of exposure to relevant images over irrelevant images at both the short testing interval, $t(48) = 4.52$, $p < .001$, and long-term testing interval, $t(48) = 2.47$, $p = .02$. Furthermore, for those who received irrelevant text, there was also a recognition benefit of exposure to relevant images over irrelevant images at both the short testing interval, $t(48) = 6.99$, $p < .001$, and long-term testing interval, $t(48) = 3.99$, $p < .001$.

There was not a significant main effect of text relevance on engagement scores, $F(1,96) = .22$, $p = .64$, $d = -.09$. Those who received relevant text ($M = 15.80$, $SD = 3.76$, $SE = .53$) did not give significantly different engagement scores than those who received irrelevant text ($M = 16.18$, $SD = 4.38$, $SE = .62$). The main effect of image relevance on engagement scores was approaching significance, $F(1,96) = 3.82$, $p = .054$, $d = -.09$. Those who received relevant images ($M = 16.78$, $SD = 4.26$, $SE = .60$) gave marginally significantly higher engagement scores than those who received irrelevant images ($M = 15.20$, $SD = 3.74$, $SE = .53$). The two-way interaction between text and image relevance on engagement scores was not significant, $F < 1$. Subsequent independent samples t-tests also revealed that for both text relevance conditions, there was not a difference in total engagement scores between those who received relevant images and those who received irrelevant images. Specifically, for those who received relevant text, there were no differences in engagement scores between those who received relevant images ($M = 16.52$, $SD = 3.73$, $SE = .75$) and those who received irrelevant images ($M = 15.08$, $SD = 3.71$, $SE = .74$), $t(48) = 1.37$, $p = .18$, $d = .39$. Similarly, for those who received irrelevant text, there were no differences in engagement scores between those who received relevant images ($M = 17.04$, $SD = 4.78$, $SE = .96$) and those who received irrelevant images ($M = 15.32$, $SD = 3.84$, $SE = .77$), $t(48) = 1.40$, $p = .17$, $d = .40$. Furthermore, there was not a significant difference in engagement scores between those who received both relevant texts and ads and those who received irrelevant texts and ads, $t(48) = 1.12$, $p = .27$, $d = .32$. Finally, no significant differences were found between those who received relevant texts irrelevant images and those who received irrelevant texts and relevant images, $t(48) = -1.62$, $p = .11$, $d = -.45$.

Discussion

Finding effective teaching strategies that enhance student learning in the classroom is a challenging process, especially in fields that are as interdisciplinary as neuroscience. It is well documented that learning styles vary across students, and teaching methods between instructors

Table 1. Sample Sizes, Means, Standard Deviations, and Standard Error for the Three-Way Interaction Between Testing Interval, Text Relevance, and Image Relevance

			n	Mean	SD	SE
Short-Term Testing Interval	Relevant Text	Relevant Image	25	88.00	11.68	2.34
		Irrelevant Image	25	71.00	14.75	2.95
	Irrelevant Text	Relevant Image	25	75.50	13.25	2.65
		Irrelevant Image	25	43.00	19.12	3.82
Long-Term Testing Interval	Relevant Text	Relevant Image	25	72.50	17.31	3.46
		Irrelevant Image	25	57.50	25.00	5.00
	Irrelevant Text	Relevant Image	25	69.50	16.96	3.39
		Irrelevant Image	25	48.00	20.94	4.19

may benefit some students over others, especially within the sciences (Leonard, 2000; Vaughn, & Baker, 2001). When a teaching method does not align with the learning preferences of the student, a disconnect can be problematic, especially in disciplines that integrate the social and natural sciences (Crisp, & Muir, 2012; Nikitina, 2002). Thus, more interactive and engaging pedagogical strategies can bridge the gap in such disconnects, and they can contribute to the overall enrichment of the learning environment, which has been heavily emphasized in the STEM learning fields (Bobek & Tversky, 2016; Chi, 2009; Freeman, et al., 2014). It has been shown that students with weaker backgrounds in educational topics benefit from visualizations of complex materials (Bobek & Tversky, 2016). If this is the case, then students who are in neuroscience classes can certainly benefit from such techniques, as much of the vocabulary in the field may seem foreign to students without strong backgrounds in the natural sciences (Chunder, & Konrady, 2006; Nikitina, 2002; Varma, et al., 2008). The current study further explored how cued visual aids (as seen in magazine spreads) can enhance engagement and understanding of neuroscience principles. While the use of magazine advertisements have been shown to promote attention, enhance memory, and promote cognitive functioning to better comprehend intended targets (Baack, Wilson, & Till, 2008; Smith, et al., 2007; Mohanty & Ratneshwar, 2015), there has been little work to see if such a technique can be used in a classroom setting (Anderson, 1990; Buckinham & Scanlon, 2001). Thus, the purpose of the present study was to investigate how cued advertisements can be effective in teaching neuroscience content.

We found support for our first hypothesis in that delivering relevant information via magazine advertisements (both in text- and picture-based formats) help students better grasp the functional aspects of hormonal function within the nervous system, which is consistent with other works that utilize metaphors in conveying scientific principles (e.g., Aleixo & Sumner, 2017; Hosler & Boomer, 2011; Smith et al., 2019). More specifically, those presented with relevant text performed better during the short-term testing compared to those presented with irrelevant text, while the relevant-relevant condition produced the best recognition scores across all testing intervals. Interestingly, we did not find any statistically significant differences between other conditions (when looking at just text relevance) at the long-term testing interval. However, there was a main effect of image relevance on recognition scores at both the short- and long-term testing intervals. This finding is consistent with previous research that suggests both words and images are effective learning tools, and the supplemental use of appropriate imagery further enhances learning (Dewan, 2015; Pressley, Johnson, Symons, McGoldrick, & Kurita, 1989; Schuler, Pazzaglia, & Scheiter, 2019). In addition, there was not a significant interaction between text relevance and recognition scores, but this was to be expected, as we saw the same effect across conditions, regardless of the text relevance (those who received relevant images performed significantly better than those who received irrelevant images).

We did not find support for our second hypothesis in that relevant information from a magazine that was pictorial-based would lead to better memory retention than text-based materials (Paivio, 1986; Paivio, & Ernest, 1971; Paivio, Rogers, & Smythe, 1968). Specifically, there were no significant differences in recognition scores between those presented with relevant images with irrelevant text compared to those presented with irrelevant images with relevant text. This finding suggests that as long as one of the formats was relevant, memory formation was aided, demonstrating that even though the participants may have been exposed to irrelevant material, it did not take away from the gains they achieved from the utilization of the relevant material.

Finally, we did not find support for our final hypothesis in that the magazine spreads would be rated more engaging if the format was relevant to the testing, especially with image-based content. No significant differences were found in engagement scores between conditions (for either text- or image-based materials). Although this finding contradicts previous research (e.g., Baack, Wilson, & Till, 2008; Mohanty & Ratneshwar, 2015), we attribute our findings to some study-design related pitfalls. It is important to note that we did not gather an in-depth academic background information on the participants (i.e. differentiate majors and assess prior knowledge of neuroscience material). Thus, we were not able to ascertain whether previous experience or understanding of hormones influenced how engaging a magazine format may actually be. Future investigations could implement a prescreening questionnaire to assess prior knowledge of the content and then use either a standard cut off method for participants or a matched design to spread the levels across conditions. Also, the materials throughout the study were used as stand-alone content rather than as a supplement to standard methods of content delivery. Furthermore, even though the participants were asked to rate the magazines compared to background materials commonly used in science (i.e., basic textbook reading), there was no actual format to make a clear comparison. Our study intended to explore the pedagogical benefits as a stand-alone medium, but in hindsight, future studies will need to make a direct comparison between the magazine spreads and standard educational methods.

It is worth mentioning that the parameters of the testing intervals may also warrant further consideration. Throughout our study, memory performance on the short-term test was significantly higher than that of the long-term, suggesting that some degree of memory drop-off or lack of consolidation may have occurred. In the current study, we utilized a long-term test, but the true long-term benefits of such a creative format was not addressed. Previous work has demonstrated that sharp decreases in retention occur between immediate exposure to content and weeks later, but further decreases in memory retention occur from weeks to even years after initial learning (Bahrick, 1984; Bahrick & Hall, 1991; Conway, Cohen, & Stanhope, 1992). Thus, it would be interesting to test the long-term attainment of complex/foreign/novel concepts in STEM students in 6, 12, or even 24 months after first exposure. Advertisements are designed as a tool to stay with the consumer, and it has been shown that imagery in an advertisement that successfully links to a target can remain with the viewer for years (Keller, 1987). An example of this might be how people can easily recall specific details from numerous GEICO advertisements after they have not been used for years. Our results suggest that using advertisements to grab one's attention holds promise as a successful tool for the dissemination of neuroscience content. If the magazine spreads can captivate viewers in terms of creative imagery that link to the text, then it is possible that the format can promote a more enduring memory effect when compared to standard educational materials. The demands for STEM-based learning in education continue to rise (Barnard-Brak, Stevens, & Ritter, 2017; Erdogan, Navruz, Younes, & Capraro, 2016), and new implementations of creative arts are now promoting STEAM-based learning (Boy, 2013; Radziwill, Benton, & Moellers, 2015). If college education continues to go in this direction, then the use of creative pedagogical strategies to promote comprehension of integrative fields like neuroscience should be further developed. Future studies using advertisements for sustained STEAM-based education may be insightful for better learning opportunities within the field.

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