

ARTICLE

Da Vinci Coding? Using Renaissance Artists' Depictions of the Brain to Engage Student Interest in Neuroanatomy

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This report describes a pair of brief, interactive classroom exercises utilizing Renaissance artists' depictions of the brain to help increase student interest in learning basic neuroanatomy. Undergraduate students provided anonymous quantitative evaluations of both exercises. The feedback data suggest that students found both exercises engaging. The data also suggest that the first exercise increased student interest in learning more about

neuroanatomy in general, while the second provided useful practice in identifying major neuroanatomical structures. Overall, the data suggest that these exercises may be a useful addition to courses that introduce or review neuroanatomical concepts.

Key words: teaching neuroanatomy, history of science, art

Despite its importance in an undergraduate neuroscience education (Wiertelak and Ramirez, 2008) and as part of preparation for medical school (Fitzgerald, 1992), students of varying levels often find neuroanatomy to be a daunting topic (Schon et al., 2002; Estes, 2007; Zinchuk et al., 2010). Educators have described a number of methods to make neuroanatomy more accessible to students, such as employing computer assisted instruction (Gould et al., 2008), combining online and in-class materials (Estes, 2007), and having students construct 3D models of neuroanatomical structures (Estevez et al., 2010). Still, the development of additional techniques to increase student interest in this crucial topic is desirable.

Many educators feel that it is important to integrate other areas of scholarship (e.g., the arts and humanities) into an undergraduate neuroscience education (Wiertelak and Ramirez, 2008), and indeed there is a historically rich relationship between the visual arts and the neurosciences (Geranmayeh and Ashkan, 2008, Lorusso, 2008). As such, exploring this confluence between art and the brain might be useful in helping increase student interest in the topic of neuroanatomy.

The Renaissance was a period of reciprocal advances in the arts and the study of human anatomy (Ginn and Lorusso, 2008). Artists of the time stressed the importance of direct, careful observation of the human form (Paluzzi et al., 2007). This paradigm shift may have been aided by relaxation of religious and/or social strictures against human dissection (Ginn and Lorusso, 2008); though it is perhaps important to note that the moral and legal issues surrounding dissection at this time were complex (Park, 1994). Regardless, artists of the period produced neuroanatomical studies that were both aesthetically and scientifically important (Pevsner, 2002, Ginn and Lorusso, 2008, Lorusso, 2008). It has also been suggested that several Renaissance artists *covertly* incorporated neuroanatomical depictions in their paintings (Meshberger, 1990; Paluzzi et al., 2007; Suk and Tamargo, 2010). It is likely not possible to establish *why* these artists would have 'hidden' neuroanatomical references in their work, though

Paluzzi and colleagues (2007) suggested that it may simply reflect the period's emphasis on scientific discovery.

The current report describes a pair of brief, in-class exercises utilizing well-known Renaissance artists' depictions of the central nervous system. The exercises were designed to "bookend" a course unit that introduced basic neuroanatomical concepts. The first exercise focused on an account of the anatomical studies of Leonardo Da Vinci (Pevsner, 2002), while the second exercise involved reports on possible covert neuroanatomical references in the work of other artists (Meshberger, 1990; Paluzzi et al., 2007; Suk and Tamargo, 2010). For the sake of ease, the first exercise will be referred to as the *Da Vinci* exercise, while the second will be referred to as the *Hidden Images* exercise. The overall goal of both exercises was to increase student interest in the study of neuroanatomy. An additional goal of the *Da Vinci* exercise was to encourage students to consider how and why our knowledge of brain structure and function has evolved over time, while an additional goal of the *Hidden Images* exercise was to give students practice identifying neuroanatomical structures in a unique and engaging setting.

The author presented both exercises to students in a Cognitive Neuroscience course. The course fulfills a graduation requirement for Psychology majors, and as such, attracts students with diverse levels of previous experience with (and interest in) the neurosciences. The students were given the option of completing anonymous, quantitative questionnaires to help the instructor assess the basic efficacy of each exercise.

MATERIALS AND METHODS

See Appendix 1 for an "Instructor's Guide" for these exercises.

Exercise One

The first exercise required approximately 30 minutes and was presented immediately prior to the start of a unit of

three, 90-minute class sessions that reviewed (and for some students introduced) basic neuroanatomy. Prior to the exercise, students were directed to read Pevsner's (2002) discussion of Da Vinci's highly detailed structural neuroanatomical studies, including his work on the cerebral vasculature, visual system, and ventricular system. In this paper, Pevsner (2002) also describes Da Vinci's theories of functional neuroanatomy, which were consistent with those of his contemporaries but are startlingly inaccurate to a modern reader.

The primary goals of this exercise were to increase student interest in the upcoming unit on neuroanatomy and to encourage them to consider the factors that influence progression of our knowledge of brain structure and function. The exercise began with a class discussion of the content of the article, followed by a brief "focused freewriting" session. In focused freewriting, students are asked to write continuously about a particular topic without editing or censoring their work (Hinkle and Hinkle, 1990). Specifically, students were asked to write about why they felt there was a discrepancy between the accuracy (by modern standards) of Da Vinci's understanding of structural versus functional neuroanatomy, and what factors had to change to allow for advances in our understanding of brain function. Students then volunteered to share and discuss their responses for the remainder of the exercise.

Exercise Two

The second exercise required approximately 30 minutes, and was presented as a culmination to the three-class neuroanatomy unit. The exercise was based on articles discussing possible disguised representations of the brain in the paintings of several Renaissance artists. These consist of purported representations of midsagittal views of the brain in Michelangelo's "Creation of Adam" (Meshberger, 1990; Paluzzi et al., 2007; Suk and Tamargo, 2010) and Rafael's "Transfiguration of Christ on Mt. Tabor," a coronal view of the ventricular system and brainstem in Gerard David's "Transfiguration of Christ" (Paluzzi et al., 2007), and a ventral view of several brain structures and the spinal cord in Michelangelo's "Separation of Light From Darkness" (Suk and Tamargo, 2010). The students were naïve to the content of these articles prior to this exercise.

The major goals of the exercise were to further engage students in the study of neuroanatomy and also to afford them practice in identifying brain structures. The instructor began with a reminder of the content of the earlier *Da Vinci* exercise. Next, the instructor explained that several authors have suggested the possibility that other Renaissance artists concealed representations of the brain in some of their most famous works. The instructor then distributed color handouts showing images of 10 paintings. Four of these were the paintings listed above that are purported to have hidden neuroanatomical representations (Meshberger, 1990; Pevsner, 2002; Paluzzi et al., 2007; Suk and Tamargo, 2010). The other six images were controls/foils that consisted of paintings from the same time period that are not purported to 'hide' brain images. The students' task was to work in small groups to try to locate

and identify the hidden brain structures and to prepare to explain/defend their discoveries using appropriate neuroanatomical terminology. After approximately 15 minutes, the class reconvened to discuss the students' findings. Following this, the instructor revealed the "true" hidden images that were described in the published papers.

Student Sample and Feedback Questionnaires

The author presented both exercises as part of standard classroom practices to undergraduate students in a 300-level Cognitive Neuroscience class (enrollment = 27 students, 22 female) at Lewis & Clark College, a selective liberal arts college in Portland, Oregon. Students were primarily of junior and senior standing. Following each exercise, students were informed that they had the option of completing quantitative feedback questionnaires. The purpose of these questionnaires was to allow the instructor to quickly obtain anonymous feedback (e.g., lacking identifying features such as handwriting) for the purposes of assessing and improving his own pedagogy. Each questionnaire consisted of four items (see Table 1) with potential responses scaled from 1 ("Strongly Disagree") to 10 ("Strongly Agree"). The author was interested in the percentage of students who felt the exercises successfully captured their attention and/or achieved certain educational goals (e.g., encouraged students to think about how our knowledge of the brain has evolved). A mean rating ≥ 7 was considered to indicate a positive result. Twenty-three of the enrolled students (85.19%) provided feedback for the *Da Vinci* exercise and 26 (96.30%) provided feedback for the *Hidden Images* exercise.

RESULTS AND DISCUSSION

Table 1 displays the means and standard deviations of student responses to the items in each questionnaire. Student ratings of the "I found this...interesting" items for both the *Da Vinci* ($m = 7.70$) and *Hidden Images* exercises ($m = 8.39$) were favorable. Among respondents, 91.30% rated their interest for the *Da Vinci* exercise ≥ 7 , while 80.77% rated their interest for the *Hidden Images* exercise ≥ 7 (with 57.69% ratings ≥ 9). Students also reported that the *Da Vinci* exercise engaged their "...interest/excitement to learn more about neuroanatomy in general" ($m = 7.57$, 82.61% of ratings ≥ 7), and that the *Hidden Images* exercise should be repeated in future semesters ($m = 8.50$, 80.77% of ratings ≥ 7). Overall, the ratings data suggest that the exercises achieved their primary goal of engaging student interest in a topic that is often looked at with some anxiety.

An additional goal of the *Da Vinci* exercise was to encourage students to consider how and why our understanding of brain structure and function has evolved over time. Student ratings indicated that this goal was accomplished ($m = 8.39$, 100% of ratings ≥ 7). Student ratings also indicated that the *Hidden Images* exercise generally accomplished its secondary goal of affording students "useful practice [in] identifying neuroanatomical structures" ($m = 7.58$, 76.92% of ratings ≥ 7). In summary, these data indicate that both the *Da Vinci* and the *Hidden*

<i>Da Vinci</i> Exercise (N=23)	Mean (SD)
"I found this article interesting"	7.70 (1.36)
"This article made me think about how our knowledge of the brain has changed over the years"	8.39 (1.07)
"This article helped me understand more about the basic organization of the brain (neuroanatomy)"	5.65 (1.47)
"This article made me more interested/excited to learn about neuroanatomy in general"	7.57 (1.38)
<i>Hidden Images</i> Exercise (N=26)	
"I found this exercise interesting"	8.42 (1.75)
"This exercise was useful practice for identifying neuroanatomical structures"	7.58 (2.00)
"This exercise increased my confidence in my ability to identify neuroanatomical structures in general"	6.73 (2.27)
"Dr. Watson should use this exercise in future semesters"	8.5 (2.0)

Table 1. Text of voluntary, anonymous feedback questionnaires with the mean responses for each item. Responses were given on a scale ranging from 1 (Strongly Disagree) to 10 (Strongly Agree). 85.19% of enrolled students provided for the *Da Vinci* exercise and 96.30% provided feedback for the *Hidden Images* exercise.

Images exercises appeared to achieve their secondary, as well as their primary, goals.

It should be noted, however, that these exercises were not universally successful. For example, students reported that the *Da Vinci* exercise was not particularly useful for increasing their understanding of the "...basic organization of the brain". Similarly, while students generally reported that the *Hidden Images* exercise afforded them useful practice in identifying neuroanatomical structures, it was more modestly successful in increasing their confidence in the ability "...to identify neuroanatomical structures in general" ($m = 6.73$; 61.54% of ratings ≥ 7). Still, it could be argued that as the exercise was so brief and required few classroom resources, **any** reported gains in confidence could be beneficial.

From a qualitative perspective, student responses to these exercises were positive. The exercises were also helpful in generating thoughtful classroom conversation. For example, discussions following the 'free writing' session for the *Da Vinci* exercise included such important topics as the relationship between advances in technology and advances in understanding of neurophysiology and the effect of cultural/societal norms on scientific investigation and the interpretation of scientific data.

As a whole, the data indicate these brief classroom exercises utilizing Renaissance artists' depictions of the brain could be a useful addition to the repertoire of educators who teach courses that introduce basic neuroanatomy. Specifically, these exercises may help increase student interest/engagement with the topic material, give students a starting point for considering how our knowledge of functional and structural neuroanatomy evolves over time, and offer students an opportunity to practice neuroanatomical identification in a novel setting. More broadly, these exercises may help reinforce the idea that neuroscience is a truly multidisciplinary field, and that scholarship in the sciences and in the arts and humanities are not mutually exclusive.

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APPENDIX 1**Instructor's Guide for Basic Implementation of the *Da Vinci* and *Hidden Images* Exercises***Da Vinci* Exercise (≈ 30 minutes of class time)

Reference Needed: Pevsner (2002)

- 1) Students read Pevsner's (2002) article prior to class period
 - 2) At the start of the exercise, the instructor asks students to reflect on Da Vinci's structural neuroanatomical studies (e.g., "Look at Figure 1 from the today's reading. What do you notice?"). The instructor then briefly elicits students' opinions of the accuracy of Da Vinci's work (e.g., "Do these images look 'modern'? Could they be useful as figures in a modern textbook?")
 - 3) The instructor then asks students to reflect on Da Vinci's ideas on functional neuroanatomy (e.g., "How did Da Vinci think the brain worked? Would these ideas be useful in a modern textbook?")
 - 4) If necessary, the instructor introduces the concept of a focused freewriting session, and then introduces the writing topic (e.g., "Why was there a disconnect between Da Vinci's knowledge of what the brain looked like and how it worked? What had to change for our knowledge of brain function to evolve?")
 - 5) Students freewrite for approximately 5-10 minutes
 - 6) Instructor guides classroom discussion based on students' responses.
- Examples of possible discussion topics could include:
- "How do societal pressures affect the scientific questions we ask?"
 - "Do societal pressures influence the way we interpret research findings?"
 - "How do changes in technology affect the scientific questions we are able to ask? How do they affect the 'answers' we find?"

Hidden Images Exercise (≈ 30 minutes of class time)

References Needed: Paluzzi et al. (2007); Suk & Tamargo RJ (2010)

Preparation:

- 1) Instructor identifies paintings purported to contain covert neuroanatomical images by referring to the figures from the primary references:
 - Midsagittal view of brain in Rafael's "Transfiguration of Christ" (Paluzzi et al., 2007, Figs 1-2, pg. 541)
 - Coronal view of brain in David's "Transfiguration of Christ" (Paluzzi et al., 2007, Fig 3; pg. 542)
 - Midsagittal view of brain in Michelangelo's "Creation of Adam" (e.g., Paluzzi et al., 2007, Fig 4; pg. 542; Suk and Tamargo, 2010, Figs 1-2, pg. 853-854)

- Ventral views of brain from Michelangelo's "Separation of Light from Darkness" (e.g., Suk and Tamargo, 2010, Fig 1, pg. 853)
- 2) Instructor obtains images of paintings discussed in Paluzzi and colleagues (2007) and Suk and Tamargo (2010) as well as those of "foils" consisting of paintings from the time period that are not purported to contain images.
 - Instructor can search for images of specific paintings using "Google Images" or other search engines. Instructors can get ideas for appropriate "foils" by viewing online/virtual "museums" such as the WebMuseum (<http://www.ibiblio.org/wm/paint/>)
 - 3) Instructor creates a hand out of "hidden image" paintings and foils.

Classroom Exercise:

- 1) Students are instructed to form work-groups with approximately four members
- 2) The instructor briefly reminds the students of the content of the earlier Da Vinci exercise
- 3) Instructor explains that some authors have suggested that famous Renaissance artists "hid" depictions of the brain in their artwork. The instructor then explains that students will attempt to find the "hidden" images (and identify the brain structures they include) that are intermixed with foils
- 4) Students examine the images for approximately 10-15 minutes
- 5) The instructor asks for volunteers to identify "hidden" brain structures. Students must use appropriate neuroanatomical terminology (e.g., dorsal/ventral, coronal, sagittal, etc.) when discussing their "findings"
- 6) At the end of the exercise, the instructor confirms which items the students correctly "identified", and offers students suggestions for further reading

Suggested Reading List for Interested Students

- Ginn SR, Lorusso L (2008) Brain, mind, and body: interactions with art in renaissance Italy. *J Hist Neurosci* 17:295-313.
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