# Teaching Neuroscience in the Art Museum

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*Neuroscience is an interdisciplinary field that investigates chemical and cellular foundations for perception, emotion, and memory. At Kenyon College, these concepts are reinforced through class sessions at The Gund, Kenyon's teaching art museum, in both lower- and upper-level courses within the Department of Neuroscience. Students explore the neurological basis of visual processing through analysis of abstract works in The Gund's permanent collection. Using guided inquiry, students explore color's nonobjective properties, the variability of these properties based on context (color consilience), how color and color combinations imply or express textures and surfaces, and why color is often used as a metaphor for emotion. Our class sessions, refined over several semesters, reinforce principles discussed in didactic neuroscience lectures and elicit productive intersections between art and science. By upholding the rigors of scientific inquiry within the gallery, we have centered the art museum as a place for interdisciplinary study.*

Visual perception is the process by which the surrounding environment is interpreted via sensation of light. In humans and other animals, visual processing begins with light focused on photoreceptive cells in the retina of the eyes. This signal is transduced to specific brain regions for processing and perception to build our visual sense of the world. Mechanisms driving visual perception are typically taught in neuroscience and psychology courses; however, these principles are also important for understanding how our brains organize the visual elements of a work of art. Both visual processing and visual analysis of art can be reduced to foundational concepts of line, color, and form (ARNHEIM 1997; KANDEL 2016).

Research has shown that the art museum can serve as an informal sector for scientific education, complementing traditional classroom and laboratory settings (STOCKLMAYER 2010). Educational approaches to teaching STEM with and through art can involve displaying specific concepts in an artistic way to communicate more effectively to a lay or secondary school audience. Collegiate educators have also assigned students the task of drawing as a means to visualize challenging biological and neuroscience concepts through illustration (EZIN et al. 2020; GOODSELL 2021). However, we believe the art museum can also be a venue for experimentation through guided observation of, and discussion on, works of art—carefully planned and moderated by the collaborating neuroscience professor and museum educator. In this way, neuroscience students can interrogate core principles through analysis of art that in itself does not intentionally represent or teach a neuroscience concept but can offer compelling and challenging ways of engaging with course content.

Student-centered guided activities in the art museum provide an opportunity for active learning, which has distinct advantages over the traditional classroom-based lecture (FREEMAN et al. 2010). Active learning methods create opportunities for collective exploration and discussion, questioning of knowledge, and critical application of learned concepts. Importantly, active learning pedagogies disproportionately improve outcomes for minoritized students as well as first-year students (FREEMAN et al. 2010; STYERS et al. 2018). Furthermore, active learning via art analysis in the museum has been shown to improve engagement and critical thinking with biology students (MILKOVA et al. 2013).

We therefore decided to bring students in neuroscience courses to The Gund, the teaching museum of Kenyon College, a small liberal arts college in rural Gambier, Ohio. To explore and reinforce principles of visual perception, we designed two activities tailored to different neuroscience courses at Kenyon. Activity 1 links across different sensory systems for the introductory neuroscience course (200-level), whereas Activity 2 explores principles of retinal wiring in the upper-level neurobiology course (300-level). We have run each activity in at least two semesters with different populations of students. Below, we present the learning goals for each activity, including the core concepts for students, followed by the mechanics of the activity including guided prompts. Finally, we describe the students' responses, which demonstrate the effectiveness of the activity.

## Activity 1: Connecting Neuroscience Concepts in the Museum

*Learning goals and core concepts:* At Kenyon, the neuroscience course is offered at the 200-level as the 'on-ramp' to the major, typically following 100-level biology and chemistry courses. This course combines survey of subfields with foundational principles, such as structure-function relationships. Students learn neuroanatomy and major regions of the brain early in the course with a cursory function assigned; for instance, the occipital lobe at the back of the human brain processes visual information, while the hippocampus nearer the front is largely responsible for memory. Throughout the semester, students recall these structures in more thorough discussion of different sensory systems, behavior, emotion, learning, and memory in both healthy and dysfunctional states (e.g. neurological disorders, mental illness, etc.). Ultimately, the course material emphasizes how human perception is influenced by multiple sensations, memory, and emotion.

However, while this discrete topical approach to neuroscience works well for organizing course material, it can lead to compartmentalization. Students sometimes fail to understand or appreciate how these systems connect into complete brain function; for instance, how visual cues can prompt nonvisual responses or suggest information that is not supplied but rather 'filled in' through experience. Given the emphasis on neuroanatomy and structure-function, students might then suppose that different regions or physical connections in the brain (structures) are important for these emergent experiences (function).

Therefore, we created an activity in the museum with the goal that students would integrate their understanding of sensory systems, emotion, and memory in response to visual art. Students would be tasked with applying their knowledge of sensation at the level of receptors, circuits, and perception, which tend to be less variable between individuals, with the modulatory mechanisms that drive memory and emotion, which are likely to be more subjective. Because this is quite broad for introductory students, we invited the students to focus primarily on color, which is a relatively simple way to illustrate how context influences perception.

Activity structure: As noted above, this activity asked students to integrate their understanding of multiple sensory and behavioral systems; as such, we carried out this activity relatively late in the semester, typically in the eleventh or twelfth week of instruction (out of fourteen). Students visited the museum as a group during the class time. Prior to class, students were assigned a review article on color consilience by neuroscientist and visual artist Bevil Conway (2012). This article integrates core neuroscience topics discussed in our class, such as wiring of the visual system and color perception, with applications to art in color and form.

When viewing pieces, students were encouraged to focus on color and other visual cues, such as arrangement of elements, negative space, and visible texture. We worked with four to six artworks for classes of eighteen to twenty-four students, which allowed students to interact closely with the art. We chose abstract pieces to help the students concentrate on formal elements (color, line, shape, space, pattern) rather than subject matter. With an abstract painting, students cannot interpret the artwork iconographically or symbolically; freed of this 'distraction,' they can direct their attention to how our perceptual faculties process color, and how the painting, as an organized set of visual stimuli, triggers sensory systems.

Fig. 1: Pia Fries, *Caluori*, 2001. Oil on board. Collection of The Gund at Kenyon College, Gift of David Horvitz '74 and Francie Bishop Good, 2019.3.2. © 2024 Artists Rights Society (ARS), New York / VG Bild-Kunst, Bonn

*Caluori* (fig. 1), an abstract oil painting by contemporary artist Pia Fries, is a particularly strong example of the work that we have used for this activity. Color is the primary structuring agent in *Caluori*; variations in hue, value, and saturation create the perception of depth on the flat surface. Juxtapositions of colors generate what we see as movement in the form of turbulence, sweeping arcs, swirls, and broad, still passages of modulated whites. Moreover, the exuberant colors in *Caluori* seem to ooze and protrude in viscous swaths and mounds of paint over foamy washes. We can leverage the artist's vigorous application of paint to help draw out associations in our perceptual processing of color and texture, which makes the colors themselves seem almost palpable, conjuring visceral and haptic responses.

Class sessions were led by the museum educator in the art museum, who moderated the discussions with the neuroscience professor. Following a brief introduction to the artwork and the activity, students paired off to view and discuss a single piece of artwork in their small groups. Students were guided in independent discussion by addressing the prompts provided by the instructors (table 1). These prompts required students to reflect on the pre-class reading and their own experience in the museum.

| PROMPT | GOAL |
|---|---|
| 1. Stand closely to the piece; choose a color and describe its tone and hue. Focus on one section of the composition, then find the same color in a different section, where it is surrounded by different colors, and analyze it again. How does that relate to the ideas in the assigned Conway paper? | Recall the pre-class reading; identify contextual influence of color perception |
| 2. Look at a few different color combinations. What are the temperatures of these colors? How do you think they taste? Can you imagine their smells? | Articulate how visual information can connect to other sensory systems |
| 3. Describe any emotional experiences you have while viewing this artwork. Does it evoke a constant state of feeling? Do different emotional moments arise as you visually process the colors? Could different sections of the piece elicit different feelings? Why? | Apply visual information to other major brain systems; identify and appreciate subjectivity in perception |

Table 1: In-class prompts and associated pedagogical goals for connecting concepts across neuroscience systems

Following the museum class session, students used their in-class notes and discussion to craft short essays of two to three paragraphs (table 2). These essay responses were part of regular engagement on our learning-management system (Moodle). Unlike the in-class materials that narrowly focused on the present assignment, these prompts asked students to synthesize their ideas from the museum with previous class materials. Students could draw on their knowledge of basic neural function and neuroanatomy and/or applied understanding of sensory, behavior, and memory systems to address the prompts, depending upon their reported experiences in the museum. Students were given narrative feedback from the instructor on their ideas and how they connected their experiences to other parts of the course. Because the prompts encouraged speculation, students were assessed on their creative application of didactic lecture material to the subjective experiences in the museum, rather than on obtaining a 'right' answer. Most students fully met or exceeded the instructor's expectations for engagement and application.

| PROMPT | GOAL |
|---|---|
| 1. What visual aspects seemed linked to other sensations or emotions? Were these connections universal, or subjective depending upon the individual? | Recall and describe the in-class activity, with emphasis on question 3 (Table 1) |
| 2. Make a few predictions about how these co-incident sensations and emotions could be due to functional connectivity in the brain. Be sure to speak to particular brain regions, circuits, and/or neurotransmitters, etc. that could be responsible for evoking sensations and emotions from a visual experience. | Apply prior knowledge of neuroscience systems to their particular experience in the art museum |

Table 2: Short essay prompts and associated pedagogical goals for connecting concepts across neuroscience systems

*Student outcomes:* During the class activity, students typically focused on color, contrast, and form in the pieces to discuss visual observations as well as connections to other senses. As expected, many students drew from their knowledge of the lecture materials on vision, emotion, and memory in the initial discussion, reinforcing concepts from earlier in the semester. However, several students also recalled their experience and training in other disciplines, including art history, anthropology, and psychology, to frame their observations and provide reasoning for their conclusions. Because every partner pair was called upon to report their observations by going around the room, students had the opportunity to hear and report similar and differing perspectives, so the discussion was not limited nor biased to a few students' experiences. This strategy is aligned with best practices in the STEM classroom, in which carefully structured discussions are critical to promote equity among students of different backgrounds (EDDY et al. 2017)

Importantly, the instructor noted a difference in engagement for some students; many of those students who had previously been 'quieter' in the regular classroom spoke at length during this museum activity and took on a leadership role in conversations with other students. This was noted for students who were, or soon would be, majors in the Neuroscience Department, as well as those in other majors in and out of the natural sciences; therefore, this heightened engagement was from students across disciplines. Volk and Milkova describe this shift in classroom dynamics as one facet of the "productive disruption" that occurs during the curricular museum visit. They point out that because museums are settings in which behavior is influenced by contextual factors, the social dimensions of the class visit should also be considered, along with cognitive assessments, in evaluating the learning benefits. The reorganization of social conduct in the classroom occurs, in part, by defamiliarizing the setting, or the 'crossing' from classroom to museum gallery, which conditions the students for learning in new or different ways. Nevertheless, the cognitive gains of such reorganized social dynamics can only be achieved through a well-planned visit, which is structured to focus students' attention on the intersection between course content and the artwork (VOLK & MILKOVA 2012).

Because this activity asks students to start with a comparison of common vs. different experiences, the post-activity essays often had a different starting point as well. For instance, students reported both positive and negative associations with the same red abstract form (e.g. fragrant flowers vs. bloody river), and accordingly linked these to either pleasant or somber emotions. Students were able to explain how associations were likely based on memory, emotional state, or both, and were able to discuss brain areas (e.g. hippocampus, amygdala, ventral tegmental area) and neurotransmitter systems (e.g. serotonin, dopamine) that would likely be associated with these perceptions. Therefore, students could apply this interrogation of their experiences to core concepts of the course. This cycle of observation, application, and prediction is the foundation of experimental science. Even though students did not actually test their predictions, they nonetheless applied laboratory skills in the art museum.

**Activity 2: Connecting Neurobiology Concepts in the Museum**

*Learning goals and core concepts:* The visual system in humans is complex, yet relatively well-defined at the cellular and anatomical levels. From decades of experiments in animal retinas, scientists can predict how different visual stimuli activate certain cells within the retina and how these cues are relayed to the cortex (information-processing part) of the brain. The details of how this circuitry drives perception is taught in Kenyon's 300-level neurobiology course; a simplified version of this system is shown in fig. 2. We teach these concepts for two reasons. First, this system is fundamental for understanding visual processing specifically and topics in perception, such as receptive fields, more generally. Second, the architecture of the retina can serve as a more general framework for approaching key topics in neuroscience, such as how neurons receive sensory input, how they send signals in response, and how this impacts the animal's experience.

These complex and detailed concepts are challenging to grasp in a traditional class format, even with student-led discussion and practice; therefore, students can particularly benefit from experiential learning in this concept area to reinforce these ideas. However, scientific experiments and demonstrations for these concepts are technically challenging for students and are beyond typical institutional resources, including our own. Therefore, we designed a session in the art museum that allowed students to interrogate how spatial visual cues are mapped onto the retina and drive perception. Ultimately, the goal of the exercise was to reinforce knowledge of visual system wiring to discuss "why they see what they see." We chose to work with a series of abstract prints that are nearly identical in the application and arrangement of formal elements, and therefore require close, focused observation to discern how the unique color palette of each print causes us to perceive differences in composition from one to the next.

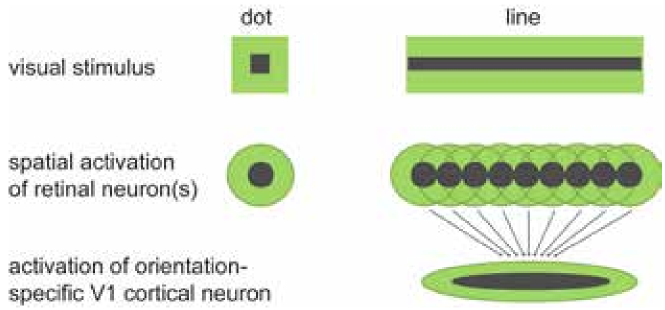


Fig. 2: Simplified framework for information flow during visual processing. Spatial elements in a field of vision (e.g. a dot or a line) activate signaling in specific retinal ganglion cells, which is transduced to the visual cortex to initiate perception. This example specifically illustrates receptive fields of off-center, on-surround retinal ganglion cells receiving input from rod photoreceptors.

*Activity structure:* Students enrolled in this course had already taken the foundational neuroscience course described above, and often they had some upper-level biology and chemistry training as well. At the point in the course in which we conducted the activity, students had already learned physical and chemical properties of the neural membrane and nerve conduction as well as synaptic transmission. Students could then apply these principles to systems and networks, starting with sensory systems. This activity was immediately preceded by two to three days of traditional class instructions (lecture and discussion) to experience and reinforce concepts of visual system wiring. Readings were primarily from the course textbook (NICHOLLS et al. 2012) and focused on seminal works describing retina structure and function (KUFFLER 1953; DOWLING & BOYCOTT 1966). Students also read or reviewed the same Conway review article (2012) from Activity 1 (as not all students had read it in the neuroscience course) to review color vision and begin to apply these principles to visual analysis of artwork.

Each time we have conducted the activity, we have used four prints by contemporary artist Amy Ellingson from her 2018 series titled *Identical/Variation* (figs. 3–6). In creating these prints, Ellingson took inspiration from the layered visual structures of computer-generated imagery. She then combined digital and traditional printmaking methods in a process that involved making an etching in black ink, printed from a plate created on a flatbed printer, of the circuitous linear pattern of one of her paintings, using it as the organizing structure for each print. After this, Ellingson manipulated each print with the addition of acrylic color and, lastly, a layer of laser-etched relief woodcut, printed in a series of four different colors—red, green, black, and blue, as the title of each print denotes. She shifted, slightly, the orientation and color of subsequent layers from one print to the next to reveal variations in the patterns, thereby expressing "originality within repetition." This "originality within repetition," or the ostensible compositional variations from print to print that Ellingson achieved through multiple printmaking processes, subtle shifts in the orientation of the underlying linear pattern, and changes in color, make the prints particularly ideal for this exercise: with focus, students can appreciate the repeating elements; however, this repetition is not apparent at first, which is largely due to differences in orientation and color/contrast. Therefore, students can interrogate these differences by first calling an individual element into their attention and either comparing it to another piece or literally shifting their own perspective.

Figs. 3–6: Amy Ellingson, *Identical/Variation*, 2018. Etching, UV acrylic, and woodblock relief. Collection of The Gund at Kenyon College, purchased with funds provided by Mr. and Mrs. Graham Gund '63. Courtesy Amy Ellingson and Eli Ridgway Gallery

As in Activity 1, students visited the museum during regular class time for the activity, which was led by the curator of academic programs. Following the introduction, students were placed in groups of two to three students and guided in discussion with prompts provided by the instructors (table 3).

*Student outcomes:* Working in pairs, students identified and discussed individual attributes that they could explore simply by moving around the gallery space. As an example, some students noted the arrangement of lines within a piece and recalled how visualization of lines of different orientation depended upon spatial activation of retinal neurons and subsequent activation of particular V1 cortical neurons table 1, question 1). They could then make predictions about how to change stimulation of V1 neurons and experiment with viewing angle and distance (table 2, question 2). We found that the placement and

| PROMPT | GOAL |
|---|---|
| 1. Study one of the Ellingson prints and recall the differences in receptive fields for neurons in the visual system. What features evoke responses in which cells? Consider contrast, lines, orientation, etc. | Recall the pre-class readings and course content to describe principles of visual receptive fields |
| 2. Move around one print and note how your perception of the composition changes. How does the viewing distance or angle influence the features you identified in question 1? Similarly, how does the contrast, orientation, etc. of features result in differences in your perception? | Compare and contrast visual stimuli (before/after movement) as they project differently onto the retina and are therefore perceived differently |
| 3. Now, examine other prints in the collection, and identify how a feature is repeated across at least two compositions (e.g. etching, woodcut print, etc.). How has Ellingson changed (or not changed) the feature across prints, and how does that influence your perception? In other words, how might "originality within repetition" arise based on visual connectivity? | Compare and contrast visual stimuli (different paintings) as they project differently onto the retina and are therefore perceived differently |
| 4. Consider the role of color in your perception of these prints. Again, move around the prints and note how your perception of color changes from different viewpoints. How is color "wired up" in the brain, and how does that influence your perception across prints? | Compare and apply principles of color perception to those of contrast (e.g. dots, lines) to predict differences in perceptions |

Table 3: In-class prompts and associated pedagogical goals for applying concepts in visual system wiring

orientation of the artwork impacted the students' 'experiments': in one semester, the artwork was hung on the wall, and students frequently chose to investigate distance; in another semester, the artwork was displayed flat on tables, and the students walked around the artwork to examine from multiple angles. For both types of 'experiment,' students explained why these perceptual changes were driven by the different projections onto the retina by considering the circuitry of the visual system. For instance, students could focus on horizontal lines at a typical angle or distance. However, when they viewed the piece at a steep angle or long distance, fewer retinal neurons could be activated by these lines; as a result, lines with lower contrast appeared to blur together into a single, relatively uniform shape. These findings are represented in simplified form in fig. 7A.

The "originality within repetition" of the Ellingson prints allowed students to interrogate differences in contrast and color. Because some elements are repeated across prints, students could identify 'control' vs. 'experimental' attributes; for instance, a pattern that was identical across prints but in a different color. Students found that color and contrast were sufficient to substantially change their perception of otherwise identical elements when testing viewing angle and distance (table 3, questions 3–4). Again considering only horizontal lines, students noted that light vs. dark contrast or color opponency affected their ability to interpret the elements at a steep angle or distance (fig. 7B). Students again were able to explain how these changes depended upon the initial activation of retinal neurons and the differential activation of V1 cortical neurons to ultimately alter their perception. Finally, by bringing groups together in discussion at the end of the class session, students were able to identify that different elements within the pieces were subject to changes in perception, while others were relatively stable.

Activity 2 largely demonstrated the commonality of experiences between students, in contrast to Activity 1, in which students identified subjective aspects of their experiences driven by memory and emotion. Because Activity 2 reinforced understanding of relatively stereotyped visual circuits, students rarely differed in their perception, though one exception was a student with self-reported red-green color blindness. However, altering the modality and location of learning about visual circuitry can promote both comprehension and retention of the material for students with different backgrounds. Additionally, students can quite literally see how the visual

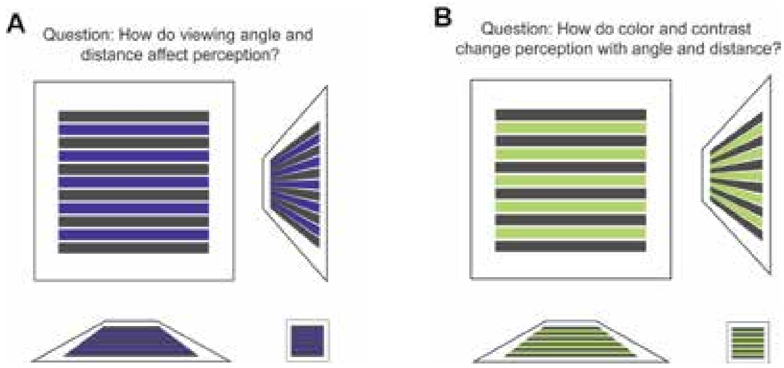


Fig. 7: Sample 'experiments' in visual perception. (A) Students focused on horizontal line elements in the artwork and observed how perception of lines persisted or disappeared based on viewing angle and distance. (B) Horizontal line elements in artwork with higher contrast color persisted even with different angles and distance, which students attributed to differential activation of retinal ganglion cells.

system can respond to relatively straightforward inputs, using stereotyped circuits, in complex and nuanced ways. Finally, while this activity is less open-ended than Activity 1, it nonetheless serves as an opportunity for experiential learning and application of concepts, similar to a laboratory exercise.

**Discussion: The Academic Art Museum as Laboratory**

Through testing and implementing the course activities explained here, we have observed that the art museum essentially becomes a kind of laboratory of inquiry-driven learning, exploration, and experimentation. In other words, by 'asking' students to produce information in response to the artwork, rather than imparting information through 'telling,' we created opportunities for collective exploration and discussion, questioning of knowledge, and critical application of learned concepts. The far-reaching learning benefits that the pedagogical model of active learning holds for STEM students was affirmed in a 2014 article published in the *Proceedings of the National Academy of Sciences* on active learning (FREEMAN et al. 2014). The primary objective of this study was to determine if active learning boosts examination scores and lowers failure rates. Data on instructor-written course exams and other assessments showed that students performed better overall, but there was more significant improvement, on average, in performance on assessments of students' conceptual understanding of a given subject. This could suggest that active learning stimulates cognitive processes that cultivate deeper, more nuanced understanding of course topics, which we observed in the activities described above.

A study by Milkova et al. assessing the outcomes of skill-development exercises for undergraduate biology students at Oberlin College (2014) supports our observations. The article gives insight into how and why implementation of artwork analysis yields higher learning outcomes and retention rates by drawing connections between gains in students' analytic abilities and data on whether or not students found the activities intellectually engaging, meaningful, and thought-provoking. Qualitative data showed that generally, the activity piqued students' curiosity and inspired collaborative work and critical thinking, indicating that teaching biology concepts through art can broaden and deepen students' ways of understanding and engaging with course material.

Students who most often fall behind in class appear to benefit most from active learning methods, which could suggest a means for achieving greater equity in STEM classes (FREEMAN et al. 2014). The results revealed that active learning improves undergraduate education and retention in STEM fields for all students, but especially for students from disadvantaged backgrounds and female students in male-dominated fields. Although the pedagogical methods in the Freeman study took just 10–15% of class time, the fact that they were an integral part of the class structure (rather than taking place outside of class) suggests that something about the classroom dynamics shifted as a result of active learning, to create the conditions for greater success among all students, especially among underrepresented groups.

Teaching with art, like most active learning methods, seems most effective in fostering an open, inclusive learning environment when communication among all students and instructors is possible. We have observed in the class sessions that we conduct in the gallery that engagement with the artwork creates the freedom to ponder, question, express uncertainty, and solve problems creatively and collaboratively, generating a shared communicative space. The nature of this learning moment is the topic of a recent essay on language learning in the art museum, in which the authors argue that engaging with the work of art stimulates radical forms of 'looking' that can ultimately lead students and instructors to think beyond hierarchical and institutionalized ways of acting and interacting in the classroom (KOVACH & RIEGERT, 2023). Based on course engagements with contemporary artwork that they had designed and tested for German literature students, the authors proposed that the aesthetic practice of foreign language and cultural learning, enunciated through engagement with artwork in the museum, creates an inclusive, open, and evolving learning environment that impels learners to interpret the art and course content from unlikely perspectives and through the eyes of others (RANCIÈRE 1991).

Active learning through engagement with art also changes the role of the museum in society from an institution that reinforces hierarchies of higher education to a public space for exploration, as Emily Pringle, Head of Research at Tate, has theorized in her book, *Rethinking Research in the Art Museum* (2020). Our work speaks to Pringle's call for exploring how the art museum can "engender an environment that fosters creative and critical enquiry and the formulation of new knowledge by the many 'experts' that come into contact with the institution, rather than a select few." This expanded notion of research can guide experimental pedagogical approaches in the museum that seek to reorder the dynamics of exchange and generation of ideas among students and instructors and to invite critical engagement with art from a diverse range of disciplinary perspectives.

**Conclusion**

The course activities described here offer two examples of how teaching neuroscience through art for college undergraduates can procure different ways of engaging with and understanding course content, inspiring rigorous application, complex synthesis, and critical questioning of important concepts. Our pedagogical approaches align with active learning methods and, as we have observed, have yielded the many benefits of teaching models based on 'asking' as opposed to 'telling'—not only strengthening students' mastery of key concepts but also cultivating a more sophisticated grasp of the intersection of concepts learned throughout the course. Teaching neuroscience through art transforms the art museum into a dynamic learning laboratory in which students can explore new ideas, take intellectual risks, and produce knowledge that can spark ongoing research.

STEM curricula at colleges and universities, like museum collections, vary among institutions; therefore every approach to teaching neuroscience with art will have an original character. Identifying provocative connections between works of art and scientific concepts invites the curiosity and creativity of instructors and museum educators in developing challenging and meaningful learning activities. Here, we have offered insight into how we have leveraged the unique formal qualities of specific artworks in the collection of The Gund to help ignite students' ability to bridge productive connections between art engagement and scientific thought. There is no formula for choosing the right work of art for a course activity; instead, the process involves a mode of creative, collaborative inquiry, a difficult exercising of our knowledge, departing from certain conventions of our different academic specializations, and the same intellectual risk-taking that we ask of the students. Our work together continues to fuel our curiosity and drive to understand how students learn and how to enable them to think beyond the knowledge we can share with them.

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