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Art *as* Vision Science

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Abstract

Three levels can characterize interactions between art and the vision sciences. The first level, commentary, is limited but promotes interdisciplinary appreciation. The second level, interchange, uses information from each discipline to theorize and investigate aspects of visual processing. The fractal analysis of Jackson Pollock's work (Taylor, Guzman, Martin, Hall, Micolich, Jonas, & Marlow, in press) combined with Johansson's (1973) work on cycloid and biological motion are used as an illustration of the interchange level. The proposed third level, convergence, is one in which the methodologies of art and vision science would be merged to create a system of exploration that would use image production to investigate avenues for empirical research in human vision.

Art *as* Vision Science

It often strikes me as odd that investigations into visual phenomena continue to maintain two such separate but nearly parallel tracks as art and vision sciences. It seems like a fantastically inefficient way to go about decoding a system as vital and complex as human vision. I should admit from the outset that I am an artist. I have been an artist all my life. It has only been in the past 5 or 6 years that I have been attempting to absorb the theory, methodology, and practice of psychophysical experimentation in a university lab. I am a late convert to the study of human visual perception. What I have noticed most about vision science is not its obvious relevance to image production—that is the reason I returned to school—but how relevant image production could be to vision science if the two tracks were to converge. This paper is an argument not only for the rapprochement of art and vision science but also a proposition for explicit merging; for the creation of a unified field that would demystify superficial differences and employ the strengths of both disciplines.

It is possible for varying degrees of interrelatedness between art and vision science. Here I intend to focus on three specific levels of relationship: the level of commentary; the level of interchange; and the level that I am proposing, the level of convergence.

The Commentary Level

Much of the present interface between art and the vision sciences exists at the level of commentary and polite observation. And much of it is speculative. On the art side you might find a visual artist intrigued by some new finding in vision science reported in the science section of the newspaper. In this case, interaction between fields

typically goes no further than the artist speculating that the experimental results might explain some phenomenon he has observed in the course of producing pictorial work.

Art critics occasionally like to dabble in the theories of neuroscience. The often-embarrassing results are illustrated in this quote from Michael Kimmelman's review of the Bonnard Retrospective at the Musée d'Art Moderne in Paris:

> Artists — I would add, good ones anyway — try to generate as many "a-ha" moments as possible, Dr. Ramachandran says, because the wiring of our visual centers to our emotional centers "ensures that the very act of searching for the solution is pleasing." His formulation that art "may be thought of as a form of visual foreplay before the climax" applies especially to Bonnard, whose subjects were themselves teasingly hard to pin down and purposefully incomplete. (p. 2)

And neuroscientists, such as V.S. Ramachandran referenced in the quote above seem keen to use their knowledge of how brains work to explain how art is experienced (1999). Too often, though, the focus is on aesthetics. This seems a bit premature. As Semir Zeki (1999) correctly notes about the analysis of art through the lens of neuroscience, "We are still far from understanding how the brain perceives the entire work, and even further from learning how it attributes an aesthetic quality to it" (p. 131).

In reviewing neuroscientists' commentaries on art, I have yet to read about any of these scientists stepping into the studio to experiment with visual production, to understand first hand what the challenges and limitations of visual communication are. I find this curious but perhaps they would be reticent to make this kind of personal visual experimentation public in any case. Most prominent neuroscientists who write about art do so conscientiously, visiting museums and absorbing art theory from texts before

launching themselves into uncharted waters. But much of their speculation is based on the art of artists who are dead; artists who cannot answer questions about why they chose to represent something in a given way. There are a great number of art practitioners alive today, and most of these are presumably functioning at cognitive levels that would allow them to engage in conversations with neuroscientists trying to understand the art process.

It is not my intent in this paper to disparage the commentary level of relations between the art and vision science communities. After all, commentary is a good first step and it can foster appreciation between disciplines. But I question how productive it is in answering critical questions about how internal images are constructed, and how they can convey meaning. The next level, the interchange level, begins to produce more tangible and useful results.

The Interchange Level

The relationship between vision science and art at the level of interchange is one in which knowledge and insights from each field begin to influence the other, promoting new explorations and generating new theories. Hints about what may be happening at the perceptual level can be gleaned from illusions and anomalies in art. And understanding why certain things happen on the canvas that elude traditional art theory can often be explained satisfactorily by experimental results in vision research. There are a variety of examples of this but recent fractal analysis of Jackson Pollock's paintings (Taylor, Guzman, Martin, Hall, Micolich, Jonas, & Marlow, in press) brings together a number of empirical results in an intriguing and informative way.

The Abstract Expressionist painter Jackson Pollock was famous for using a technique called "action painting" or "gestural abstraction" in which he moved around

the canvas—which was often un-stretched and on the floor—using his whole body to drip paint from his brush to create highly energetic works. About this process, Pollock commented that he felt as if it allowed him to enter into the painting, "On the floor I am more at ease. I feel nearer, more part of the painting, since this way I can walk around it, work from the four sides and literally be in the painting" (in Johnson, 1982, p. 4).

The results of Taylor et al. (in press), combined with results of previous psychophysical studies suggest that Pollock may in fact be in his paintings and in a way that is extractable by the viewer. To understand how this could be it is necessary to go back to the to the psychophysical research of Gunnar Johansson (1973) at the University of Uppsala. Johansson's research focused on how the visual system extracts form from motion. From his mathematical analysis of the perception of cycloid movement, he hypothesized that information about human gait could be extracted using the same "geometric-kinetic" principals. Johansson reasoned that the particles, that is the mathematical points that carry motion, would be found in the joints; that the form of the skeleton would determine the movement pattern; joints would carry the motion; and rigid regular "pendulum-like motions" would be produced from the limbs that were related to those joints (p. 201). Johansson's hypothesis was confirmed by startlingly robust results. Viewers proved to be highly sensitive to what is now termed "biological motion." Using information from only a few markers placed at the joints of the stimulus form, viewers demonstrated the ability to almost effortlessly extract vast amounts of very nuanced information about the activities of the moving "point-light walker." While Johansson conceded that experience probably contributed something to the extreme sensitivity for biological motion, he insisted, and demonstrated empirically, that it was the underlying

mechanics that provided the structure for coherent motion perception, "Mathematically lawful spatio-temporal relations in the proximal stimulus pattern (complex or impoverished) determine the perceptual response" (p. 210).

Are the patterns of Pollock's biological motion encoded in his work, mediated by paint, brush, and canvas? If so, can it be determined that those patterns are mathematically unique to Pollock, to the fixed relative distances between the artist's joints, to the flexibility of his limbs, and any unique predispositions for certain kinds of movement?

Taylor et al., (in press) used fractal analysis on authentic works by Pollock, works of disputed origin, as well as works produced by students using a Pollock paint pouring technique. They found distinct differences in fractal patterns between the authentic Pollocks and the Pollock-like work. Noting that human movements used in the restoration of balance are essentially fractal, the researchers suggested that Pollock might have been exploiting a kind of free-form falling motion when he painted. Interestingly, Taylor (1999) found that a pendulum dripping paint onto a surface could produce fractal patterns if the pendulum's movement was intermittently constrained. This echoes Johansson's characterization of human motion, that movements extending from the joints are essentially "pendulum-like" (p. 201). But what distinguishes Pollock's authentic works is that they exhibit characteristic scales of fractal patterns that are unmatched in the disputed or imitative works (Taylor, et al., in press). This suggests that Pollock's physiometry may have contributed to the uniqueness of the work's fractal signature.

From a vision science perspective, what is impressive is that human observers, at least those familiar with the body of the artist's work, could see the difference between

the authentic and the disputed works. In other words, it seems that at some level Pollock's original biological motion is extractable by the viewer. In this sense, Pollock was successful at putting himself into his paintings. Art theory has long history of understanding that gesture marks can encode motion, that it is possible to extract from those marks the intent of the artist (Gombrich, 2000). More recently, this extracting of motion information residual in the making of a mark has been empirically demonstrated in studies on the legibility of handwriting. Viewers can use the knowledge of the motion used to construct a letter form to decipher ambiguous markings (Freyd, 1983; Babcock & Freyd, 1988, Dekay & Freyd, 1991).

How sensitive is the human viewer to nuances in human movement? Can those nuances be encoded in gestural marks in ways that are extractable by the viewer? I recently taught a class called "Perception and Drawing" at the University of Idaho, which combined current information about perceptual and neural processes related to vision with studio work in which students were encouraged to exploit that information. One of the modules on motion covered, among other things, Johansson's work on cycloid and biological motion (1973), and the handwriting perception studies of Freyd (1983). The studio component of the module made use of a live model. Because studies in biological motion have demonstrated that viewers are sensitive to deceptive movements like someone pretending to pick up a heavy object or throw a ball versus someone really performing those tasks (Sverker & Frykholm, 1983), we asked the model—a good sport—to do the same. For short poses (30 seconds to 1 minute) he pretended to perform actions like lifting and throwing and then really performed those motions. Afterwards when we put the drawings up for review, it was obvious to the entire class, which were

the pretend motion poses and which were the real motion poses (see Figure 1). I have been doing life-drawing ever since I could haul a portfolio up the steps to the life-drawing studio at the university where my father taught and I must admit that I would have been surprised to find that kind of sensitivity to human movement recorded even by experienced life-drawing artists. Yet most of the students in the class had never drawn from a live model and some had never had any drawing experience what-so-ever before the class.

I have been trying to demonstrate in this section that there currently exists a level of dialogue between the two disciplines, art and vision science, in which information and insights are shared in a way that moves beyond speculating why art can make us feel good or what makes a work aesthetically pleasing from a neural perspective. At the level of interchange, this trade in information begins to produce more tangible theories about visual processing and offers ways to connect multiple pieces of the puzzle of human vision at once. But to really move things forward, there needs to be a less haphazard, more concerted effort to merge the two disciplines. Art that is approached as a vision science and dialogue that is facilitated by common vocabulary and common methodologies would lead to a more productive collaboration. This is the third level, the level of convergence, which I will attempt to outline in the next section. It is a personal and therefore limited vision and still a work in progress. I am putting it forward in this paper in hopes that it will stimulate ideas about how the two fields, art and vision science, can be merged to create a distinct discipline.

The Convergence Level

To establish why the convergence level is necessary, I first need to answer what it is about image production and image manipulation that is so vital to the study of visual processing. After all, you don't have to be an artist to see, or to reflect about how you see, or even to hypothesize and design research to tackle deep and complex questions about vision. However, practice always surfaces issues that theory tends to gloss over. People who work with images, who manipulate images in order to communicate coherent visual information are bound to observe things in the course of their visual reasoning that go unnoticed by those who are not engaged in those pursuits. Few people would dispute that artists notice aspects of visual processing in the course of their production. And while natural curiosity and/or a desire for virtuosity can drive the art practitioner to explore the phenomena that crop up during production, there is no systematic way that this experimentation takes place. Nevertheless, practitioners of visual media will frequently experiment informally with images, producing observations, and reasoning out theories based on relevant background information.

Communication for these visual explorations is likewise informal. Results may be passed on to colleagues or may even find their way into the main stream of art theory, to be communicated via books and courses. But, in truth, there aren't many serious vehicles for transmitting this kind of information to a wider audience or for peers to theorize on the bases of these observed phenomena. In fact, in the art world, "Hey guys, I found this nifty effect and here's how you can do it" is usually considered the provenance of T.V. artists passing on kitschy technical advice to amateurs.

A systematized experimental method in visual production combined with a recognized method for communicating results would be the first step in creating convergence between art and vision science. And there is some precedence for systematic experimentation in the long history of art explorations. One notable example would be the meticulous studies of color interaction produced by Josef Albers and his students at Yale in the 1950s. However, Albers was not interested in merging research in the vision sciences with studio explorations. In fact he was adamant that it was unnecessary, even counterproductive for the person engaged in exploring color interactions to understand what might be happening at the neural level (Albers, 1975). On this point, I have to disagree with Albers. Excluding any information that might shed light on the process of visual perception seems like a pointless handicap. Since this paper is an argument for the inclusion of all information relevant to visual processing, my question is how can the methodologies of art and vision science be merged in a productive way?

One way would be to create a studio/lab. The perception and drawing course I mentioned earlier might provide a rudimentary map for how such a studio/lab could function. In that course, students were given current information about visual processing and then required to exploit that information in the studio. There exists no single text that presents this kind of information in a structure relevant to visual production but information can be effectively pieced together from a variety of sources. Aggregating and structuring the relevant material is not an insurmountable task and does not always entail building everything from the ground up. In the case of the perception and drawing course, certain sources were able to provide the majority of information for a given

module. For instance, the module on lines was taken in great part from Hoffman (1998) who provided an accessible summary of original research.

Assignments for the studio portion of the course varied depending on the material covered in lecture but every assignment required that students identify the perceptual cues they intended to manipulate and to keep a record of the observations they made during production. If, part way through a project, students decided that the variables they had chosen were not yielding results, they could introduce others but they were required to keep track of their visual reasoning and to explain to the rest of the class their evolving hypotheses. Midway through an assignment, there was a critique session so that students could observe what was emerging in the work of their peers and give feedback to each other.

Although this quasi-empirical approach in the studio produced some interesting artifacts and students improved their visual reasoning over the course of the semester, there were some drawbacks to the design of the course that impeded progress. The biggest impediment was student resistance to revising or creating multiple versions of a work. Most of the students were novice drawers so experimenting after the initial framework of the drawing had been laid out often had a high cost associated with it. Making substantial changes was seen as too risky and time consuming. Because of this, I think a better approach would be to make use of image production software—any or all that a student would choose to use. After all, current graphics software makes it possible for anyone to manipulate images and to do so in ways that were unthinkable thirty years ago. This does not mean that work made by hand could not be included; versions of hand-drawn work could be scanned and preserved electronically. Posting versions online

would make it easier for students to share the evolution of their work and explain why they chose given visual cues to manipulate. They might even make commentary on each other's work by directly manipulating copies of one of their classmates' versions.

The idea behind the studio/lab would be to encourage informed visual experiments—systematic explorations that would reveal promising avenues for future, more rigorous studies in the laboratory. In an ideal version, the researcher would be not only the "artist" exploring various visual phenomena but also the "scientist" who would take interesting results from the studio into the lab for further testing. An interim solution would be for studio/labs to explore visual processing through image manipulation and then make those results public so that vision researchers could pick up the trail. But for that to happen, there would need to be some recognized means for communicating results between disciplines.

I anticipate that the biggest resistance to the ideas I'm putting forward will come from people who may worry that a formal methodology will sterilize the art process. Would Pollock's gestural expressionism have been compromised if he had stopped every few minutes to note down observations about his "experiment"? Probably. But surely there is room to carve out a converged art/science discipline that doesn't impinge on any art processes that rely on spontaneity. In recent history, conceptions about art revolve around it being expressive and therapeutic—a form of entertainment and relaxation. What continues to go unrecognized is the power of art and image manipulation to facilitate reasoning. More than thirty years have passed since Arnheim (1969) challenged educators to, "understand that the arts are the most powerful means of strengthening the

perceptual component without which productive thinking is impossible in any field of endeavor." (p. 3)

Conclusion

In truth there is a continuum of degrees of interaction between the disciplines of art and vision science—not the arbitrary three levels I have defined for the sake of argument in this paper. But I have done so to highlight the benefits of working toward the convergence end of the spectrum where the nuts and bolts of visual production and visual reasoning can become integral to vision research. Visual experimentation—that is the informed and systematic manipulation of visual imagery—needs to be among those disciplines labeled as vision science. The proposal I have outlined here is only the roughest sketch of how a new discipline might look but the basic idea, that a methodology for systematic image manipulation needs to be constructed and that the results of visual imagery exploration need a legitimate form of communication, merits serious consideration.

Although Pollock's experiments with action painting are not what I mean by "informed and systematic image manipulation," the research by Taylor et al., (in press) relied on the image production of students to imitate Pollock's method so that it could be analyzed. Image production is a major key to understanding the visual process. Vision researchers know this. That is why so often research articles in the vision sciences begin with a nod of acknowledgement to the other side of the fence, the art side. The task now is to take down that fence. It's time to merge the disciplines.

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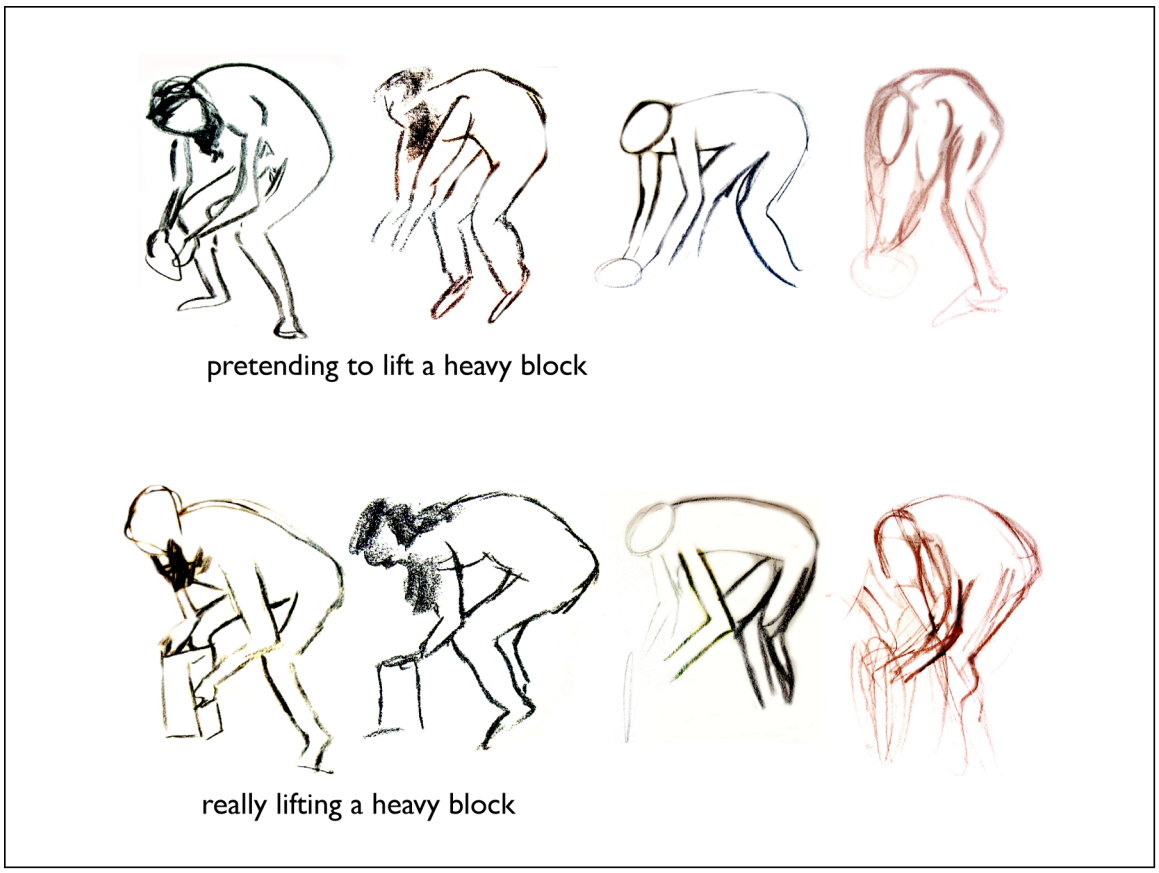
I wish to thank Margaret Sereno for drawing my attention to the fractal analyses of Jackson Pollock's work by Richard Taylor and his colleagues.

Figure Captions

Figure 1: Viewers demonstrate sensitivity to highly nuanced information from biological motion (Sverker & Fryholm, 1983). Here students drew quick sketches (30 sec – 1 min poses) of a model pretending to lift a block and then really lifting a block. Most of the students were novices to life drawing but all managed to record the nuances of the back arch and the elbow pressure on the knees.

Figure 1


pretending to lift a heavy block
really lifting a heavy block