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Art and the Default Mode Network

February 17, 2014 | Noah Hutton

A recent symposium presented by Columbia and NYU explored what happens in our brains when we're at rest, and why those same brain regions are crucial when we view art.

"It's not about merging disciplines," David Freedberg told a crowd gathered at NYU's Silver Center for Arts and Science last week, "it's about listening." Freedberg, an eminent art historian who serves as the director if the Italian Academy at Columbia University, was speaking about the alternately tense and productive relationship between the humanities and neurosciences. This is an intersection that he knows well: for nearly a decade, Freedberg has been collaborating with brain scientists— notably Vittorio Gallese in Parma, Italy, one of the discoverers of mirror neurons— but his comments dutifully acknowledged the turf battles that such interdisciplinary strivings continue to stir up, all too often hijacking productive dialogues and turning them into negative claims and calls for retreat back to party lines.

Freedberg went on, recalling a recent meeting with neuroscientist Edward Vessel of NYU, in which the two were discussing potential avenues of collaboration. Vessel mentioned some of his own recent work, which has probed a set of associated brain regions known as the default mode network, and its relationship to aesthetic evaluation of artwork. Freedberg hadn't heard of the DMN (as I hadn't either), and he recalled Vessel's blunt reply: "Then you're behind."

It didn't take long for Freedberg to catch up. He wisely made the default mode network and its relation to aesthetics and creativity the subject of the Italian Academy's annual symposium, jointly held last week by NYU and Columbia. In focusing on the DMN, an increasingly popular area of brain research, the symposium vaults Freedberg's Academy back to the forefront of the interdisciplinary dialogue around art and neuroscience—and the forefront is a familiar position: for nearly a decade, the Academy has organized symposia and supported the advanced research of scholars from the sciences and humanities alike, uniquely focused on fostering cross-discipline "listening" at every step. Past symposiahave included *Art and the New Biology of Mind* in 2006, which featured Antonio Damasio, V.S. Ramachandran, Semir Zeki, Margaret Livingstone and other heavyweights of the early days of

neuroaesthetics, and *Vision, Attention and Emotion* in 2008, which did indeed receive attention in the form of a column in the *New York Times*.

Despite its rise in popularity among brain researchers, the default mode network is surely an unorthodox choice for a symposium on neuroscience and its relation to the humanities: the scientific work on the DMN is still so young, and thus the interdisciplinary threads connecting science and art in this domain still few and far between. But it is a progressive choice, if only because the field of neuroaesthetics is in need of an injection of complexity. Looking back, the pioneers of neuroaesthetics mounted the findings from basic visual neuroscience, be it color processing in the retina to line and motion processing higher up in V1, to discuss hallmark works of abstraction and impressionism, and for good reason: these are some of the clearest findings that neuroscience can offer for discussions of basic aesthetic features of art. But as is intuitively felt by any interested in this work, the perception, evaluation, and creation of art involves so much more than basic sensory systems, and thus the new frontier of interdisciplinary work is approaching issues like embodied simulation (involving the motor system), emotional priming, and, in this case, the default mode network.

Many of the talks at the Italian Academy's symposium were necessarily definitional: what is the DMN? What regions are involved, and what does that indicate about function? Having coined the term himself and written seminal papers in the early 2000s elucidating its function, Marcus Raichle of Washington University's School of Medecine is considered to be the godfather of this field, and was to deliver the keynote address following Freedberg's introduction. But after health issues grounded Raichle in St. Louis, Bill Kelley of Dartmouth (a former student of Raichle's) filled in, and leaned on some eloquent video interview clips with Raichle to present a definition of the DMN.

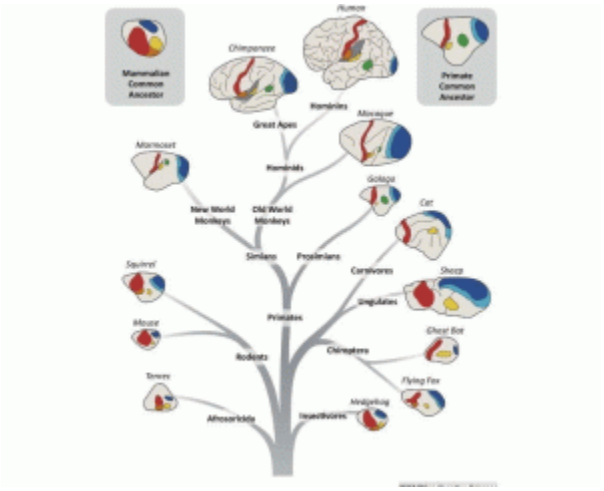
In one such clip, Raichle put it this way: "There is a paradigm shift going on. The focus has been on getting the brain to do things, rather than studying what it's doing all the time." In approaching the DMN, Raichle's musings demand we reorient our binary notions of *active* versus *inactive*, for with the DMN we find the omnipresent "baseline" brain, the parts that brain imaging studies always seek to cancel out so that the true point of "activation" can be seen.

So how to we approach a true definition of the DMN? It turns out a single definition is hard to reach, but broadly speaking, that we're talking about a network of regions in the brain which are most active in the moments when we aren't performing any outward-directed task. As Raichle explains, this "default mode" consumes most of the energy metabolized by the brain as a whole. It's an omnipresent, baseline state, but it is most active during the in-between moments when you're staring up at the ceiling, riding on the train, reflecting at the end of a long day– these moments seem to be tethered in study after study to activity in regions such as the precuneus, the anterior cingulate cortex, and the inferior prefrontal cortex, which are regions that have been implicated in authobiographical thinking, and in the relation of the self to other people, events, and planning for the future. But these are early days of understanding the behavior of this network, and those are large areas of the brain to be tossing around in any kind of explanatory way. Daniel Margulies (Max Planck Institute, Leipzig) and Felicity Callard (Durham U.) wisely delivered a comprehensive overview of the current definitional status of the field, and urged a more specific analysis of the subunits of the default mode network and their functional roles within the network as a whole. To ask if the anterior cingulated cortex is involved, Margulies offered as an example, "is like asking where the best coffee in the world is and being told 'Europe'. It is much more helpful to get

information at least on a country or a city, and that's the same as with functional roles of areas implicated in the DMN."

What seems to be clear is that when we engage in any kind of task that snaps us out of the familiar autobiographical background of our thoughts, this network dips in activity, inhibited by new regions that come online to deal with the outward behavior. As Bill Kelley told the audience at NYU's Silver Center, it's more and more seeming like the DMN could be the primary seat of personality, and that "differences in personality among individuals may manifest as differences in resting-state default mode network connectivity patterns." Yvette Sheline of UPenn added detail to this principle, relating findings from her work on depressive brains that reveal greater connectivity between default mode network regions involved in autobiographical thought and other regions involved in the judgement of others, suggesting a basis for the tendency of depressive patients to relate negative valuations to the self.

In addition to differences in personality, there is growing appreciation of the DMN as a major structural and functional leap from primate brains to human brains. Randy Buckner of Harvard could barely contain his enthusiasm for this line of work, telling the audience assembled the following day at the Italian Academy on Columbia's Morningside Campus that "we feel lucky to have stumbled on something so interesting. We have jobs for the indefinite future."



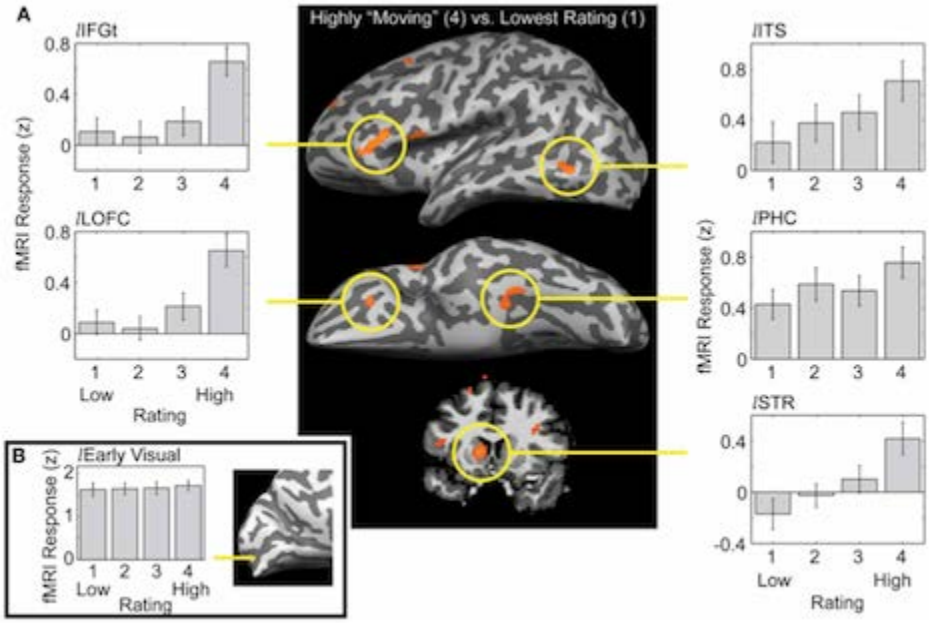
Buckner delivered a thorough and eloquent tour of human evolution that focused on the DMN's position in the evolution of the primate brain. It was the shift in attention from a full focus on the outside world to a split focus on external stimuli and internal world-modeling, Buckner theorizes, that accounted for the cognitive leaps that eventually separated modern man from his ape ancestors. Just look at how the physical proportions of the brain have evolved: primary sensory systems are about the same size in apes as in humans, but all of association cortex— including the prefrontal cortex, which usually gets most of the evolutionary attention— has expanded dramatically. Buckner believes the "nether regions" of association cortex are what truly distinguishes the human brain—folds upon folds of cortical sheets devoted to *nothing* in particular, tethered to no sensorimotor pathways, that can be sucked up during development— sometimes even decades into a lifetime— making them the hallmark of cultural learning. It's these reverberant circuits of association cortex that are wired to themselves which allow us to be flexible, highly plastic and adaptive, and which make up the bulk of the DMN, so that, as Buckner joked, "we can think to ourselves and worry all day."

Buckner's evolutionary tale brings us back to the present: what is research into the DMN revealing about the self, creativity, and aesthetics? The organization of the symposium, mirrored in the organization of this blog post, left any direct implications on art and aesthetics until the final talk, when Ed Vessel took the podium and worried that "the day has given us tools to tear his aesthetics work apart."

Vessel considers his work to be a step forward from the aforementioned "first wave" of correlational studies in the field of neuroaesthetics, which have looked at single areas of the brain reacting to familiar

works of art (this kind of work is what Anjan Chatterjee called “descriptive neuroaesthetics” in his recent book, *The Aesthetic Brain*). To move away from single areas and understand aesthetic response at a network level, Vessel has naturally latched onto the rising wave of DMN studies, curious about how aesthetic response might interact with the autobiographical, background brain.

To do this, Vessel devised an appraisal system for viewers to rate a wide range of artworks—from abstraction to portraiture and landscapes—while laying in an fMRI scanner (here is the paper, published in *Frontiers in Neuroscience)*. The participants were shown the artwork for a brief interval, then given four seconds to submit a rating on a scale of 1-4 of how powerful, pleasing, and profound they found the image. Vessel’s key finding is that for ratings of 1-3, the DMN showed fairly low activity, with subtle, linear increases as evaluations improved. But for ratings of 4, there was a dramatic, step-like jump in activity, as if the DMN fully “came online” for the highest aesthetic appraisals. At these moments, the sensory areas involved in viewing the art stayed online as well—a rare co-activation of two networks that usually exhibit toggling behavior.



Vessel described this step-like activation of the DMN during “4” ratings as a “signature” of aesthetic response, and argued that this activity supports the notion that the DMN is about self-referential processing, as in, “*I* love this painting.” Though further experiments may benefit from more specific rating scales (Vessel told me he’s now working with a sliding scale, where participants mark their response using the position of a horizontal slider rather than a fixed number) and perhaps be more conscious of the confounding effects of any kind of appraisal rendered in the scanner (perhaps participants should just be scanned while looking at artworks, then give their appraisals later when they’re out of the scanner, so that a reverse correlation can line up their appraisals with the brain activity they displayed upon seeing each work), the results are intriguing and do point towards the DMN’s central role in aesthetic response.

It's important to look at the conclusions from such a study, and to ask questions from the point of view of the humanities: what has this study told us about the way we view and evaluate art? Is there anything new to be learned about what happens in the brain at these moments? Though the peak aesthetic response did correlate with that tell-tale jump in DMN activity across subjects, Vessel's data reveals that there was very low agreement across subjects in their emotional responses to the paintings he presented them: people did not agree on their favorites. So one of the study's findings that Vessel announced to the audience was that "taste in art is highly individual, yet highly felt." Another conclusion he offered was that "art can feel strikingly personal." And, when it comes to the spike in DMN activity, that "self-relevance is an integral part of aesthetic experience." For someone coming at this from the humanities, the big takeaways still end up sounding like self-evident, intuitive truths known to the arts for eons. Vessel's conclusions, stated in this manner, sound like the findings of an alien society trying to come to terms with this thing humans do called "art." It would be prudent for researchers presenting their findings on aesthetics to have a lighter touch with their conclusions, if only to avoid the turf battles that so plague the current landscape. For researchers like Vessel, the results may speak volumes for the neuroscience of the DMN and its relationship to aesthetic appraisal; for art theory, these statements can sound like counting to ten.

The bottom line is that though the neuroscience of network-level activity like the DMN may still be far too young for any meaningful, novel contributions to aesthetics, the research must march on if we do eventually hope to break new ground. As David Freedberg offered in his conclusion to the symposium, "The humanities don't really know about what happens in the brain—we can just look at the results from neuroscience about aesthetics." So to avoid turf battles, the directive to the humanities might remain as Freedberg stated it: "look and listen," but to the scientist speaking to the humanist, we might say, "do tell, but tell us what we don't already know." For an emerging field of research into the default mode network, which appears to be a seat of autobiographical thought, the stakes for interdisciplinary dialogues may be higher than ever, and thus an awareness of domains– what they know and do not know, what they can offer and what they crave– is more important than ever.