GROCS Proposal
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"August 23, 1966"

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I. Abstract 2
II. Introduction 3
Time Scales 3
New Environments 3
Existential Significance 3
Emergence 4
III. Project Activities 5
IV. Process 7
V. Collaboration 8
VI. Learning Impact 8
VII. Participant Biographies 9
Additional Collaborators 10
VIII. Equipment, Materials and Technology 11
Equipment and Space Requirements 11
Realtime Data Sources 11
IX. Literature Review 12
Digital Media/Graphics Tools 12
Streaming Data or Hardware Interfacing Examples 12
Bridging Between the Sciences, and Sciences to Humanities 12
Aesthetic/Spacial Construction in Relation to Scientific Theory 14

Abstract

The intellectual barrier to even a surface level understanding of the themes and ideas in astronomy and cosmology are intimidating, and for many people the challenge lacks incentive. The scientific exploration of cosmic origins is far removed from celestial folklore of the past. This project aims to return astronomy to a position of cultural importance through the organized presentation of scientifically gathered data in a way that highlights the importance of spatial and temporal awareness beyond this planet. We aim to construct self-guided experiences that allow for a clear understanding of astronomical phenomena, and that integrate the participant's humanity with the project's composition, thus transforming the observer into an actor. As Mark Weiser writes, "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."[1] Astronomy gains meaning through personal contexts, and we will use visual and auditory aesthetic with technology to cement a connection between them. We target especially the accidental passerby, the person whose curiosity has not yet been piqued or has perhaps been doused. We will provide access to the hidden world that surrounds us so that participants may gain a deep appreciation for vastly disparate scales and find personal significance in our shared physical cosmology. Joseph Campbell claims that "Life has no meaning. We bring meaning to it."[2] This project is an effort to facilitate the infusion of meaning for the scientifically uninitiated. For the School of Art & Design's astronomy themed show in May and for the GROCS showcase we will deploy an interactive installation that engages both physically and virtually through a combination of digital and non-electronic media.

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1. Van Kranenburg, 10.
2. Osbon, 22.

Introduction

> "For those who have seen the Earth from space, and for the hundreds and perhaps thousands more who will, the experience most certainly changes your perspective. The things that we share in our world are far more valuable than those which divide us."
>
> — Donald Williams, USA[3]

At first glance, it is our scale and our immediate contexts that inform who we are. But, how do the complex processes on multiple, seemingly disjoint scales compare and even interact?

Time Scales

The human body fully replenishes its red blood cells every few days, while over millions of years, massive stars condense from cold ash and eventually erupt; they spew their dust and plasma into what will become a nursery for another million stars. These processes bookend one billion orders of magnitude, but both point to the self-regulatory and energy-sharing features of life. They also both speak to our origins — humans are bottom-up, hierarchical constructions of the same fundamental particles that compose our Sun and the containing galaxy. But, at each moment, don't we also see ourselves as a set of memories?

New Environments

Zooming past a massive spheroid, you are tugged toward it, but your speed quickly carries you away and then towards another nexus of impossibly bright lights. Whirling around this busy hub of agglomerating and differentiating masses, you realize you don't know where or *when* you are. Have you been sucked down a vein to a constricting human heart, preparing to blast you and replenished cells to the body?[4] Or have you joined the tide of daily commuters, who for all their jostling and chaotic motions, still fall into the bulk flows in the city's underbelly? Instead, you've happened upon a cluster of galaxies, whose dark matter has entrapped your own mass, and its stellar beacons your gaze. How does one begin to relate to this experience?

Existential Significance

As calm as outer space appears on film, and as removed from daily life as new findings in astronomy may seem, nothing physical is truly motionless or trivial; the subtlety is illuminated through relativity. We age quickly with respect to a family of stars, but the precise moments and location in which our star originated made all the difference in the Earth becoming habitable. Our galaxy will eventually collide with another nearby and at a relative velocity of nearly 1000 km/s (a non-negligible fraction of the speed of light). What bearing does that have for beings whose 100 km/hr car collisions mean the difference between life and death?

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3. English, 122.
4. Asimov.

Emergence

Colliding galaxies within clusters, interacting signal systems in the human body and cities all present complex dynamics driven by simple rules at different levels of complexity. Gravity is responsible for the attraction among massive particles, while emotions and social memes dictate the evolution of cities; these forces are washed over when the emergent characteristics of populations are considered. Do people, gravitating towards cultural city centers, behave like particles? Perhaps the study of complexity at mesoscopic scales will reveal a connection between the global and local realms.

As we traverse multiple scales and foray into different contexts, we can inform our local view and the development of constituent processes within us. A cyclic adventure through different contexts may alter our understanding. The underlying goal is to bridge global and local perspectives by highlighting aspects of the dynamic relationship between astronomy and human perceptions of existence.

Project Activities

To aptly bridge a gap between academic and public interest and between impossible and personal scales, we will employ new digital media tools integrated with traditional sculpture and design in an immersive environment. In this atmosphere, the accidental explorer will stumble upon state-of-the-art data and access it through his or her local perspective, but with tools that allow expansion to other contexts. We will incorporate substantial degrees of freedom so the participant can construct their own cosmic narrative, but one that connects to the physical cosmology common to all.

We have two classes of data sets that provide a scientific structure for different space-time scales. The first is comprised of simulated data[5] of the entire of cosmos and its statistically analyzed features. The second is a suite of data streams from realtime measurements of our solar system, like solar wind, satellite tracking, and lunar phases. Though these data have different origins, our team members have experience and expertise in working with each type; moreover, when viewed purely as numerical data, we need only consider them as information to be presented in the most suitable fashion.

Initially built for purposes of scientific inquiry, our 14 billion year simulation of the cosmos — complete with galaxy clusters measuring 1 million trillion times the mass of our sun - represents the state-of-art in reconstructing cosmic large-scale structure from basic physical principles. At our disposal are the physical properties of each cluster, including position, mass, thermal energy, etc.; each are essential tracers that scientists use to bridge theory to observations of the real world. Sophisticated rendering of these objects with each of these parameters will provide a first sense of the multidimensionality of our world to the fledgling observer, as well as a means for scientists to more fully explore the data.

Geared towards amateur exploration and opposite in apparent complexity, we will use simpler, but realtime streams of information. These sources take no computer processing time beyond an Internet download, but offer clear opportunities for relation to human scale. For example, we can track satellite movements in Earth orbit through a web application by NASA.[6] Through the University of Maryland, we also have access to solar wind data[7]. Rob van Kranenburg writes "There are no more humans, only information spaces."[8] By encouraging interaction with these ambient streams, we seek to relate personal space to this information space.

Several digital tools are ripe for integration within our overall scheme, of which multiple group members have proficiency or expertise. The UM 3D Lab provides several tools with which to render this data. We've met with Eric Maslowski of the 3D lab to begin exploring the CAVE; our computer graphics background will give us a strong bridge to testing the limits of this environment. Virtual realty will not likely be our final venue, but experimentation here will give the team a sense of the space we will create and the limitations and features of pure 3D immersions. Also, we have access to open source software (VISIT, S2PLOT) which enable even fledgling explorers to develop high-quality visuals. Google Sky provides another key framework for the mass access of both classes of data. Jiangang has already rendered his observed galaxy clusters and made them available

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5. Example data and visualizations - http://www.mpa-garching.mpg.de/galform/millennium/
6. NASA J-TRACK - http://science.nasa.gov/realtime
7. Solar wind data source - http://umtof.umd.edu/pm/
8. Van Kranenburg, 18.

as an addition to the Google Sky application. We will also explore the possibility of a collaborative universe creation computer game written in Java and Processing. Based on a true to life cosmic starting point, participants can manipulate galaxies and change the laws of physics on the fly. The creator can allow players to catalog and experiment with a shared universe (similar to the game, Spore[9]) while exploring scientific laws and theories of creation, order, and design.

For the more local solar system data stream, we plan to use one or more micro-controllers (such as the Arduino) in combination with Java programs and Python scripts running on a host computer to bridge the astronomical information space with that of the human. The host computer will use live data streams from the Internet to direct a suite of sensors and motors attached to the micro-controllers. For example, solar wind intensity can be streamed from the computer to an Arduino as a sequence of motor control commands. The motors can control a fan or water pump in tandem with the data. To encourage collaboration, the software and hardware schematics of anything we design over the semester will be released under an open source license, encouraging others to experience the cosmos even away from the installation. The start-up costs for an individual installation will be minimal. Arduino-compatible micro-controllers are available for under $25, and we will use off-the-shelf sensors and robotic devices to bring the pieces to life. All of the live data sources will be free and public resources. With the technical implementation details available, we will leave the aesthetic manifestation unwritten. Using the same code, such a solar wind display could be adapted to numerous control devices (e.g., fan, water pump, speaker). Rather than try to construct all of those possibilities, this project will focus on lessening the entry barrier for amateurs in any field.

As a final exhibition, we will develop an installation that showcases the multidimensional connections that exist within the data and between the cosmos and humans. It will address properties of time, space, mass, and how our perception of their context defines them. The participant will interact through an interface of new media that distills the astronomical into the personal. This will invoke a common parallel between our terrestrial and cosmic constructs, providing an initial platform for further discussion of the human/cultural aspects, as well as an understanding of the physical principles. Imagine an environment where star and human are equal in size, thus rendering them identical in their reproductive narrative; an environment where an understanding of the complex universe requires that you are only aware of your own existence.

Interaction can exist in a multitude of presentation formats, one being a linear hallway in analogy with the flow of time. A participant will walk through the structure and gather information on the history of the cosmos. At any time the participant may choose to further interact with the scientific data by signaling the interface via motion sensors or a touchscreen. The participant may superimpose a portion of the displayed graphic with themselves, thus providing the aesthetic component of connectivity between information and observer. This connectivity makes more interesting a previously difficult to understand subject, because it provides a lattice for mechanical adhesion as well as light, shadow, and space. Also, the explorer may choose to access more information about a subset of the hallway's timeline, and this facilitates the participant gaining further understanding of the scientific concept.

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9. Spore. Electronic Arts (2008).

Process

Each milestone acts a stepping stone with which we can iterate our objectives and methods of connection; each also provides a standalone element that addresses some of our questions.

- Deploy a mini-environment for each class of data in a public venue. These will be kiosks that allow passersby to observe and experiment with our data in two ways. Using a video camera or motion detector, we will glean the effectiveness and holding power of the display. This first step will give the project members a sense of how users will happen upon and interact with these phenomena.

    - The S2Plot, VISIT, and Google Sky software packages have already been applied to our cosmological data set; a computer terminal can be set up in any small space to allow for *ad hoc* explorations of our cosmic data. This step focuses on the user-to-data interaction. The user will be able to choose data sets, explore the astronomical images in multiple dimensions, and even make basic alterations to the data set. We are in the process of contacting malls, Apple Stores, and local coffee shops.
    - Implement a small physical device end-to-end — from an astronomical data stream to animated hardware.The principle technical challenge lies in information handling and scripting, rather than construction. Feedback from participants will be reflected the next aesthetic revision.

- Deploy a mini-environment that couples the two classes of data. This step focuses on the integration of the two-scaled data set, adding to the kiosk enhanced user-interaction element. We will assess the degree of equivalence between these data sets, perhaps using it as a link between the human impediment to conceptualizing larger scales.

    - Begin or continue work on the universe simulation game. Choose technologies and weigh feasibility.
    - Link visualizations in VISIT or S2PLOT with hardware, possibly porting them to more flexible graphics libraries and using streamlined, preprocessed data sets. Redesign earlier environments based on participant feedback, learn from collaboration.
    - Begin organizing documentation and code in a packaged form suitable for an open source release at the project's finish.

- Culminate into a larger scale environment to be displayed at DL-1, realizing the dimensions of time and space. Allow a participant walking down a muslin sheet hallway to control the passage of time in a projected particle visualization via their body movement. At either end of the hall, create an interface for manipulating the orientation, depth, gravity, etc., of a cube of particles.

Collaboration

Each piece of this project requires input from each of the unique collaborators. All aspects require scientific backing for data support, technical experience for implementation, and manufacturing skills for uniting each piece of the installation into a cohesive presentation.

In the interim period between the initial abstract and full proposal, the project gestated from two disparate ideas to a condensed, interdisciplinary experiment. Chris originally approached astronomical data like weather — ever present, but not always attention grabbing (e.g., The Weather Channel). He proposed ways of creating interest with new media technologies. Brian, Sasha and Jiangang originally intended to create sophisticated, multidimensional (using a space of physical properties rather than configuration space) digital visualizations with the possibility of including interactivity and fly-throughs that are more appealing to the non-scientist. John further distilled our objective during discussions about placing our data and scientific themes *within* the participant.

The combined teams have the diverse background required for an effective result; not only are we complementary in our perspectives and skills, but they overlap at various points, driving our cohesion. We each came to this with similar but non-equivalent goals and questions; for a moment it appeared that we might start to answer them for one another, but it has become clear that our understanding will emerge from joint inquiry. We are excited to have more input from the GROCS community over the semester to further widen the impact of our project.

Learning Impact

This proposal addresses the implementation of interpretive tools that couple traditional scientific data with public interest. The goal is to produce a coherent platform of information sharing that will be applicable within other avenues of academia, and also bridge the gap between those in and out of astronomical study.

This project will:

- Leave revisions of displays open to feedback from viewers
- Assist the scientific community directly by providing new tools and methods to share research results
- Perform public outreach to draw a crowd not already interested in the astronomic topics covered
- Provide a point of contact for multiple natural science fields (biology, chemistry, physics, etc.), as well as for the humanities (literature, philosophy, etc.)
- Encourage the sharing of our tools and installation by providing the software and hardware schematics under and open source license, in a concise packaged format with clear documentation (a online venue for technology support will also be considered)

Participant Biographies

Jiangang Hao is a fifth year PhD student in the Department of Physics, and has MA in Statistics. He works on developing algorithms to build largest ever galaxy cluster catalog based on the multicolor data from Sloan Digital Sky Survey. Jiangang works extensively on real astronomical data reduction and image processing, with special expertise on statistical modeling and discovering the hidden relations among multidimensional data. He also works on converting the galaxy cluster catalog into Google Earth KML files, making it easy for public access. He is a practitioner of various image processing software (such as Photoshop, GIMP and DS9) and has programming experience in IDL, C++, Python and MATLAB. Jiangang pursues the GROCS project as a tool for better visualization of multidimensional data, from which more hidden interconnections among the various dimensions could be uncovered. This will be extremely valuable for connecting the data and our existing theory about the formation and evolution of galaxies, clusters and the universe.

Brian Nord is a fifth year PhD candidate in the Department of Physics, and has B.A. in physics from Johns Hopkins University. He has contributed to our understanding of the physical world from the smallest scales to the largest, working in elementary particle physics and, more recently, computational cosmology. As an undergraduate, he searched for high-energy decays of fundamental particles at Fermi National Accelerator Laboratory, adding to our understanding of background signals in the resulting spray from particle collisions. Currently, his research focuses on the formation and evolution of large-scale structure; more specifically he wants to explain how information bias will pose a challenge to linking observed galaxy cluster spatial distributions to theoretical constructions of their evolution. Brian's recent effort has been to construct an observer's viewpoint within a one billion particle N-Body simulation, projecting from a God's-eye perspective to one that matches modern telescopes. His other research involves the design, construction, and usage of a test stand, with which he will characterize the largest thin-film interference filters ever to be constructed. For the Dark Energy Survey project, he is charged with ensuring that the high-precision filters meet specification and are capable of delivering science quality data for DES, which will take first light in 2010. Also at the University of Michigan, Brian has served as a GSI, Lead GSI, and curriculum developer for the physics department introductory laboratories. In these roles, he focused principally on coupling physical reality with ingrained unphysical perceptions; and on how to connect seemingly mundane introductory physics to real-world applications. He has programming experience in Python, Fortran, Labivew. Through the GROCS endeavor, Brian hopes to find more ways to bring intricate ideas into the conceptual vocabulary of non-scientists, and to explore methods and themes in fabrication and design.

Christopher Peplin is fourth year undergraduate in the Electrical Engineering & Computer Science Department in the College of Literature, Science & the Arts. His studies and work experience have focused on topics as wide as database management, scientific computing and software design. Recently, he has been working on the seamless integration of digital streams and concepts with the tangible. With rapid prototyping languages like Processing and Python, he hopes to embrace the new types of information and data processing power available, while removing lofty technology requirements. Chris is currently working at the Toyota Technical Center with a research and advanced development team on vehicle communications applications. His work at Toyota also attempts to better integrate computing, but in this case to make the driving experience safer and less distracted by the car itself. He hopes this GROCS project will help unite his undergraduate experience and direct his next level of academic study.

John Walters is a second year graduate student in the School of Art & Design with a BFA from the University of Nebraska, Lincoln. His sculptural work addresses the dual significance of human presence as a material entity in both micro and macro frameworks; an entity that occupies space and time while concurrently transforming its surroundings. Using the human figure as a platform for relative discussion, he juxtaposes the existence of energy inherent in all carbon-based material with the larger, more apparent systems of our contemporary, post-industrialized culture. He spent the past summer in Chile and Thailand conducting research that is two-fold in construct and deals with systems of management on both an industrial and individual level. The first trip was to examine the environmental and socioeconomic burdens of resource management in relation to copper ore extraction in Chile, the world's largest copper producer. Secondly, he visited a unique detoxification program at the Thamkrabok Monastery near the city of Phraputthabat in Thailand. This monastery helps individuals manage their addictive tendencies in regards to substance abuse. He combines these two very different avenues of research by drawing a direct correlation between copper and addiction management and the role these two subjects play within his interests as a creative practitioner. He envisions the GROCS project as a platform of further exploration into the complex systems that govern our existence as occupants of the earth.

Additional Collaborators

Oleg Gnedin is a professor of Astronomy at the University of Michigan. He specializes in galaxy formation and evolution, and structure simulation. He will provide scientific and computation support, as well as guidance in producing 3D visualizations that are scientifically relevant.

Sasha Muratov is 2nd year graduate student in the department of Astronomy and is advised by Prof. Gnedin. He will provide support and expertise in interpreting simulation data and rendering 3D visualizations.

Equipment, Materials and Technology

Equipment and Space Requirements

- Metal, woodworking shop and materials
- UM FabLab access
- Cluster time at the Center for Advanced Computing (public nodes may be sufficient)
- 3-5 Arduino-compatible micro-controllers, USB cables and extensions
- Small, inexpensive robotics and electronics parts (sensors, motors, wiring, etc.)
- Web camera for kiosk
- Table and display space for kiosks
- Moderately powerful computers for displaying visualizations
- Touch screen for user interaction
- 1-3 video projectors for time-manipulation installation

Realtime Data Sources

- SDSS SkyServer DR6 - http://cas.sdss.org/dr6/en/
- Realtime Satellite and Shuttle Tracking - http://www.n2yo.com
- Realtime Data Access Page - http://solar.physics.montana.edu/tslater/real-time/
- NASA J-TRACK and J-PASS Tracking Applications - http://science.nasa.gov/realtime

Literature Review

Digital Media/Graphics Tools

D.G.Barnes, C.J.Fluke, P.D.Bourke & O.T.Parry, 2006, Publications of the Astronomical Society of Australia, 23(2), 82-93.

Lawrence Livermore National Lab. VISIT. Computer Software. <https://wci.llnl.gov/codes/visit/>.

Swinburne University of Technology. S2PLOT. Computer Software. <http://astronomy.swin.edu.au/s2plot/index.php?title=S2PLOT>

Streaming Data or Hardware Interfacing Examples

Parsons, Allan, Duncan Wilson, Julie McCann, and Asher Hoskins. BOP-UK, What is the Creative Workplace?, 30 Nov. 2007, London, England. Building Awareness for Enhanced Workplace Performance. London: CSM Innovation.

> BOP gathered quantitative and qualitative data about the physical environment of an office, the use of space and the mood of the workforce. The toolkit of networked devices enabled the collecting, manipulating and displaying of both tangible environmental factors, for example, light levels, heat levels, noise levels and people's presence, and workforce reports on intangible factors, such as perceptions of personal energy levels, sense of well-being, stress and feelings of connectedness with others. (http://blogs.driversofchange.com/emtech/docs/Bop_booklet_portrait.pdf)

"Solar Thermal Organ." MAKE Blog. 08 Sept. 2008. MAKE Magazine. <http://blog.makezine.com/archive/2008/09/solar_thermal_organ.html>.

> An example of visualizing (actually "auralizing" in this case) data across disciplines. This prototype converts solar rays to sound.

"Umbrella Today?" Umbrella Today? <http://umbrellatoday.com/>.

> A site that condenses all knowledge of the weather down into one piece of metadata — do you need an umbrella today?

Van Kranenburg, Robert. The Internet of Things. Overview of Publications. Sept. 2008. Institute of Network Cultures. <http://networkcultures.org/wpmu/portal/publications/network-notebooks/the-internet-of-things/>.

> A critique of ambient networking technologies on Earth and the social implications of abstracting life and objects to their data sets.

Bridging Between the Sciences, and Sciences to Humanities

Asimov, Isaac. Fantastic Voyage. New York: Bantam, 1988.

> Asimov's rewrite of a film exploring scale of the human body and its inner workings.

Dennett, D.C. Consciousness Explained. Boston: Back Bay Books, 1991

Conway's *Game of Life* is uses by Dennett to explain constructs such as consciousness and free will. In our simulation, particles behave much the same as squares in the *Game of Life* and similar organic forms emerge like clusters.

Electronic Arts. Spore. Computer software. Spore. <http://www.spore.com/>.
A new game by Will Wright exploring evolution, the universe and diversity in biology.

English, David William. The Air Up There. New York: McGraw-Hill Professional, 2003. 122.

Fritjof, Capra. The Hidden Connections: A Science for Sustainable Living. Anchor, 2004
Capra uses scientific language and style to describe the tools employed by organic systems that give them characteristics of a complex system with emergent feaures.

Gilmore, Robert. Alice in Quantum Land. Springer, 1995.
Gilmore presents a conceptual discussion of the world and theory of quantum mechanics through the narrative of Lewis Carroll's Alice in Wonderland.

Greene, Brian. Icarus at the Edge of Time.
Intended for children, but accessible to all levels of non-scientist, Greene's retelling of the Greek tragedy is recast in a future where interstellar travel is possible. The young hero travels to the edge of a black to hole, but miscalculates his trajectory. Upon his return to Earth he finds it has aged far more than expected; his family and civilization are gone — generations having followed Einstein's arrow of time more quickly than Icarus did.

Johnson, Steven. Emergence: The Connected Lives of Ants, Brains, Cities, and Software. Scribner, 2002
The author makes connections between biological systems that clearly exhibit emergent characteristics and human populations. The example of ant colonies serves as a starting point to recount the history of the complex systems research which has had applications in computer science, biology, and now sociology.

Lightman, Alan. Einstein's Dreams. Vintage, 1994.
Einstein conceptualized many worlds with different laws of relativity and space-time. Lightman describes these worlds in a series of short stories, interspersed with historically accurate snippets of Einstein's discussions with friends and personal explorations.

Osbon, Diane K. Reflections on the Art of Living: A Joseph Campbell Companion. Harper Perennial, 1995.

"Powers of 10." Powers of 10. <http://www.powersof10.com/>.
A short film by Charles and Ray Eames that attempted to expand the way people thought about the world. Our project wants to continue the outward expansion with new media technologies.

Tyson, Neil D. Death by Black Hole: And Other Cosmic Quandaries.W. W. Norton, 2007.

Wilson, E.O. Consilience: The Unity of Knowledge. Vintage, 1999
Wilson notes a movement toward the recombination of the narrow tendrils of specialized scientific efforts into a synergistic understanding. The next step in the evolution of the human knowledge base will come through the unification of scales, viewpoints and technologies.

Aesthetic/Spacial Construction in Relation to Scientific Theory

Barratt, Krome. Logic and Design in Art, Science and Mathematics. United States: Design Books, 1980.

Barratt examines some of the key principles of design and shows how these also underlie much of what we know about art, mathematics, and science.

Hannah, Gail Greet. Elements of Design, Rowen Reed Kostellow and the Structure of Visual Relationships. New York: Princeton Architectural Press, 2002.

Hannah focuses on the manipulation of simple forms to address the creation of complex solutions to difficult design problems.

Mitchell, W.J.T. Architecture as Sculpture as Drawing: Antony Gormley's Paragone. Antony Gormley: Blind Light. The Hayward Gallery, London, 2007. <http://www.antonygormley.com/viewtext.php?textid=70&page=1>

Mitchell paints three portraits of Antony Gormly as demiurge, creator of a universe. First, as an architect, then a sculptor, and finally as a draughtsman, exploring the ability of a creative individual to cross traditional boundaries of space and time.