Raised On YouTube: Cultural Data Materialization Using Plants

Misha Rabinovich
Artist, Developer and Educator
155 Middlesex Street, Apt 3A
Lowell, MA 01852
mishawagon@gmail.com

See <www.mitpressjournals.org/toc/leon/49/4> for supplemental files associated with this issue.

Misha Rabinovich

ABSTRACT

Raised on YouTube **is an installation and game that grows plants using only the light of projected video and makes ecology legible as a multiplayer game. The challenge of finding the most nurturing video is crowdsourced online. As players watch a webcam feed of the plants surrounded by two-way mirrors, their computer power is diverted to photosynthetic video analysis. The system calculates the photosynthetic score for each video using a basic botanical model. The resulting shape and density of the plant grow bed serves as a data visualization of the energy patterns in the cultural stream. The system provides opportunities to reflect on the effects of long-term exposure to contemporary media and to imagine ecological possibilities of participatory culture.**

Living Off of Video

In 2012 I was working with the Everson Museum and the City of Syracuse to create a public art sculpture, which featured an aquaponics fish and vegetable garden in a shipping container. Research into grow lights led me to the realization that plants grow differently under different colors of light. This is due to two different types of chlorophyll; Chlorophyll A is mostly stimulated by purple and red light, and Chlorophyll B by blue and orange light [1]. Plants that are leggy or losing green leaves are not getting enough blue light, while plants that don't bloom are not getting enough red [2]. Witnessing the sunset or sunrise indicates that daylight color temperature changes throughout the day. Plants evolved to respond to the length of the day because it is a "reliable indicator of the time of year, enabling developmental events to be scheduled to coincide with particular environmental conditions" [3]. A calibrated light-and-dark cycle can kick plants into the reproductive stage. Plants evolved under a dynamic light source and developed phototropism (they move to follow the sun). It seems that lights flashing at specific frequencies can create higher plant yields [4]. "Electro-culture" gardening is replete with anecdotal evidence of gardening interventions using various energy waves. In 1992 Patrick Ready's installation *Radio and Beans* acknowledged radio as a material and not just a communication medium by showing the effects of media transmissions on the germination of beans. By situating the plants around a radio, television set, and other devices, the work reminds us of the "utopian desire to … harmonize relationships within the earth's ecosystem" [5]. Eventually it became clear to me that fostering an environment for the plants with this type of equilibrium was dependent on getting the frequencies right, especially the light frequencies. A 1:6 blue to red ratio worked well enough for the installation. However, after the basil shot up and flowered it became clear that the light was too red.

Calculating the ratios of light frequencies became the recipe for a sort of filter. This led me to an investigation of the effects on plants of different ratios of blue to red light using custom-made LED grow jars (Figure 1). Could we communicate with plants by feeding them light patterns over time and evolve the best patterns by trial and error? The 1995 *TV + Beans* installation by Garnet Hertz shed light on this question by exposing beans directly to the glow of a television suspended overhead (while also including a control group under more traditional lighting) [6].

  | Leonardo, Vol. 49, No. 4, pp. 342–349, 2016 doi:10.1162/LEON_a_01287

Figure 1. Two clover plants, originally the same size, were grown for 16 days in the summer of 2014. The left image shows the blue LED clover, bushy with short internodal distances. The red light clover on the right is spidery. (© 2013 Misha Rabinovich)

I restaged a version of this experiment by splitting a store-bought basil plant in half and putting one half under a window.

I isolated the other half from external light and projected my cell phone videos onto it using a 2,500 lumen projector. After two weeks the experimental basil seemed as healthy as—or maybe even more alive than—the control. Eduardo Kac's 1994 installation *Teleporting an Unknown State* [7] used a projector to germinate bean seeds using video streams of people pointing their webcams to the sky. Video has continued to evolve to become an efficient format for organizing light color information over time. Variegated video is available all across the internet, but what better source for video than YouTube, which is already ingesting hundreds of hours of video per minute [8] and pooling it all under a standard Application Programming Interface (API)?

Alchemy and Ethnobotany

Internet traffic is growing exponentially. Cisco Systems predicted that this year we will enter the Zettabyte era. Most of this traffic is video: millions of years of video are transmitted over the internet every month [9]. As an artist in residence at McGill University's Centre for Intelligent Machines, I collaborated with data scientist Yogesh Girdhar to use machine learning to distill films into summary montages [10]. Curating video for plants is decidedly simpler: it is enough to measure the amount of blue and red energy and subtract the green (Figure 2). Green light is reflected away by green plants because they have no use for it and producing it is a waste of energy. The difference between frames indicates motion and is also a good metric of light

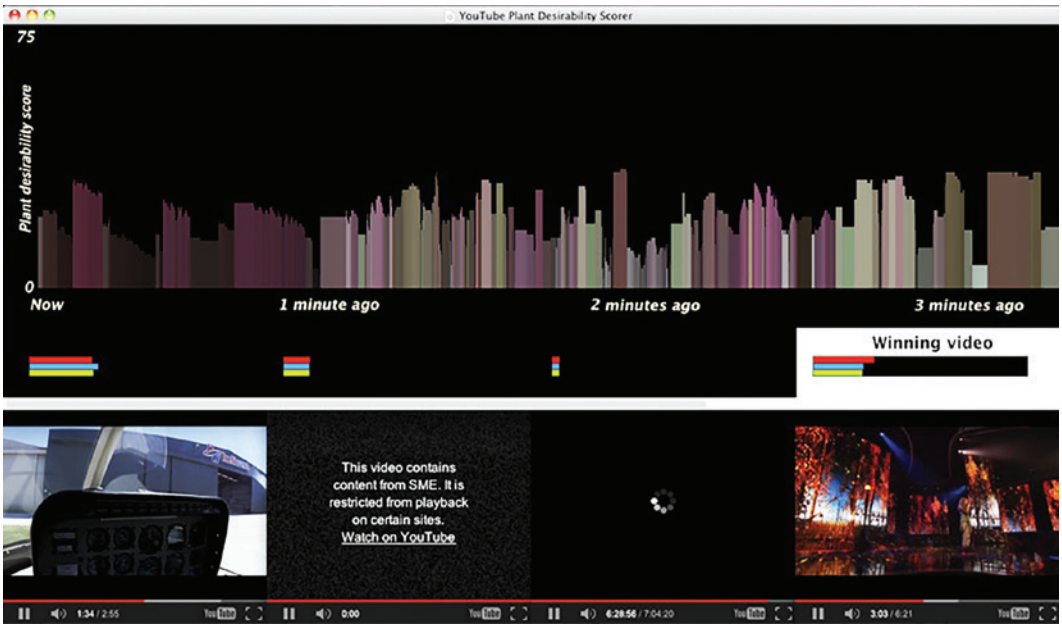

Figure 2. In the earlier version of the installation, four videos were evaluated in real time to create a projected remix. A graph displays the winning scores of the past three minutes. (© 2013 Misha Rabinovich)

dynamism, which seems to increase plant stimulation. It is best to normalize the score from 0 to 100 for readability.

*Photosynthetic Score = (Red + Blue - Green)*Motion*

As food, as medicine, as material, plants shaped the development of humankind. Humans have also shaped the development of plants. George Gessert describes the resulting variety of domesticated plants—from the ornamental to the mind-altering—as a "vast unacknowledged genetic folk art with a history stretching back a thousand years" [11]. However the Anthropocene is characterized by many other indirect and unintentional influences of humanity on plants. Artist Brigitta Zics has written about "instant affection technologies" which help people "achieve immersive states by self-observation and reflection." She used what I argue is an ecological approach of leveraging the "aesthetic linkage between the bodily state and the visual representation" in order to "produce a new body-awareness in the participant" [12]. Because ecology is so complex, it was important for me to pare down the inputs and outputs and tie the display to the plant bodies. The poetic juxtaposition of plants and YouTube video (yet another form of folk art) is an affectation technique that aims to produce a new ecological awareness. I started growing basil and white-stemmed pak choi using projected YouTube videos as the only source of light. It turns out that plants can be programmed by light patterns over time. Tiny seeds materialize into living data realizations. The shape of the grow bed coalesces over time to reflect the videos the plants have been "watching" (Figure 3). Videos that deviate from the default YouTube aspect ratio have black bars on the top and bottom or on the sides. The black bars of aspect ratio mismatches dwarfed the plants at the edges of the grow bed, and sometimes killed them. If most of the video is of talking heads, then the energy will be concentrated in the middle of the grow bed because central faces are well lit at the expense of a dim background. In this case, the grow bed will be tallest in the middle (Figure 4). Andrés Ramírez Gaviria wrote that functional data visualization communicates a message, while a data visualization artwork aims for a gut-level reaction [13]. *Raised on YouTube* doesn't just function as a visualization of video light frequencies and energy concentrations, but creates an emotional response in the viewers witnessing plants on video life-support.

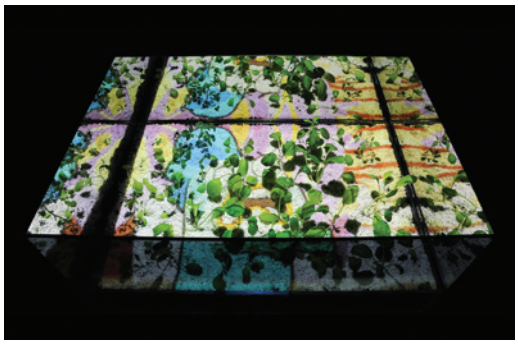

Figure 3. Basil and white-stemmed pak choi are grown with video as the only source of light. The two-way mirror box and white Perlite soil cover recycle the light from the projector and enhance the display. (© 2013 Misha Rabinovich)

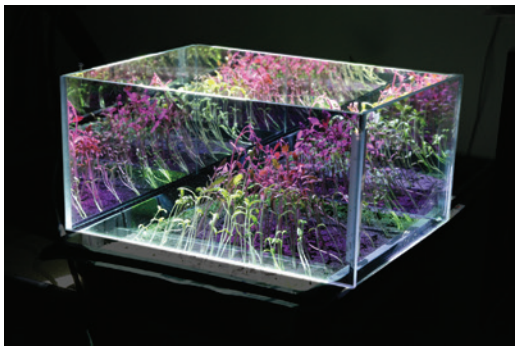

Figure 4. Tomato sprouts bend toward the center after being exposed to weeks of talking head videos from YouTube's educational recesses. (© 2013 Misha Rabinovich)

Creating the Installation

Stephanie Rothenberg's installation *Reversal of Fortune: Garden of Virtual Kinship* grows plants in a map-shaped grow bed and uses "water to visualize the flow of money" [14]. The project's activist bent is helped along by a correlation: money and water are two essential resources. The clarity of the relationship underscores the importance of a flowing economy. The project is

another example of what Wim van Eck and Maarten H. Lamers describe as "digitally controlled nurture of biological systems" that relates "external factors to nurture conditions" [15]. *Raised on YouTube* reveals the latent power in a subset of visual culture using more ambiguous mappings of inputs to outcomes. Artist Lindsey French's projects *Concert for Plants by Plants* and *Phytovision: Road Trip* connect people and plants to "produce stimulating effects that do not have to result in explicit understanding to constitute engaged cross-species interactions" [16]. In *Concert for Plants by Plants*, French used vibration sensors and WiFi to transmit the physical vibrations of a tree in Massachusetts into houseplants situated in a Chicago performance space. People sharing the space were left to speculate on what the plants were experiencing only from their perception of the barely audible vibrations. In *Phytovision: Road Trip*, French took a tree on the road and created a speculative video installation conveying what the tree might have "seen" during the ride. Similarly to how French demonstrates that "multiple ways of sensing or experiencing are both possible and valuable" [17], *Raised on YouTube* creates an opportunity to imagine the cultural experience from the perspective of non-human alterity.

Figure 5. *Raised on YouTube*: living plants, video projection, custom software, two-way mirrors, 10' x 2.5' x 1.5.' (© 2013 Misha Rabinovich. Photo: David Broda.)

Two-way mirrors helped me recycle the light of the projector and also created the illusion of a larger grow bed. A two-way mirror works by letting only enough light through for people to see inside (Figure 5). In a dark room, a projector shining into an open box made of two-way mirrors creates several arresting visual effects. The first is the infinity mirror effect caused by enough light being trapped and reflected inside the box. The plants appear to extend outward in all directions, inviting speculation on the use of projection farming on an industrial scale as a thought experiment on future ecologies. To quote Gaviria, an artistic information visualization "aspires to be conceptually transgressive, to reframe canonized structures.… [The] task is...not to resolve but to question or restructure issues...in a manner that is not possible through any other means, medium or cultural artifact" [18]. Jussi Parikka wrote that during the Anthropocene the "environmental expands from a focus on the natural ecology to an entanglement with technological questions" [19]. I used white perlite to blanket the soil and enhance the grow bed's capability of functioning as a video screen technology. David Latimer sealed an azalea garden in a glass bottle for 50 years and the plant survived [20]. His project removed all ecological inputs except light. *Raised on YouTube* deprioritizes all inputs except light, and goes further by repositioning "waste" videos often considered to be spam as potent energy sources. Even something as seemingly distant from "nature" as YouTube is subsumed into the ecological cycle, which can be read as a utopian act of erasing the concept of "waste." Arguably there was no such thing as waste before humankind. It was human culture that invented waste as something externalized from the life and death cycle, not biodegradable, something to be cordoned off due to poisonous effects. Growing plants with user-generated videos reveals the corporeality of data, or at least demonstrates that data has a direct influence over the material world. *Raised on*

YouTube manifests this influence and short-circuits the separation between information and material as well as "nature" and "culture."

Making the Installation Telematic

Ecology is hard to circumscribe because the connections keep extending outward. Influenced by an artistic and theoretical thrust toward the dematerialization of the art object, I yearned to have the system transcend physical space and extend outward through the internet. At first, the system was seeded with four starting videos and programmed to use the YouTube API's "related" feature to automatically spider out through user-defined folksonomies and find new videos. Several visitors to the Red Roots gallery in New York City who saw the installation wanted to try their hand at choosing the videos, so I decided to allow participants to submit YouTube links themselves. Eduardo Kac described the ability of telepresence art to reconcile cyberspace and physical space, to bridge the gap between "carbon and silicon" [21]. When it comes to elucidating ecology, some active participation is essential for demonstrating the power of human choice. Artistic telepresence, especially the type achieved by Ken Goldberg's *Telegarden* project from the mid-1990s was instructive here. "The user's control over 'what' and 'how' to see over the Web becomes more important than the image that mediates a glimpse and/or an action. This low resolution image becomes secondary compared to the definition of or access to other realities" [22]. Lacking the servers or budget to evaluate all of the potential submissions for their photosynthetic scores, I chose to crowdsource the evaluation.

The *Search for Extraterrestrial Intelligence at Home (SETI@Home)* is an excellent model for crowdsourcing processing because it entices users with fun graphics and a noble cause at practically no cost to said users. This is not some malware that runs in the background, slowing down the user experience, but a screensaver installed voluntarily by the user. Screensavers run when the computer is not being used. This is when *SETI@Home* downloads telescope data and looks for patterns which can be sent back to research headquarters. Similarly, *Folding@home*

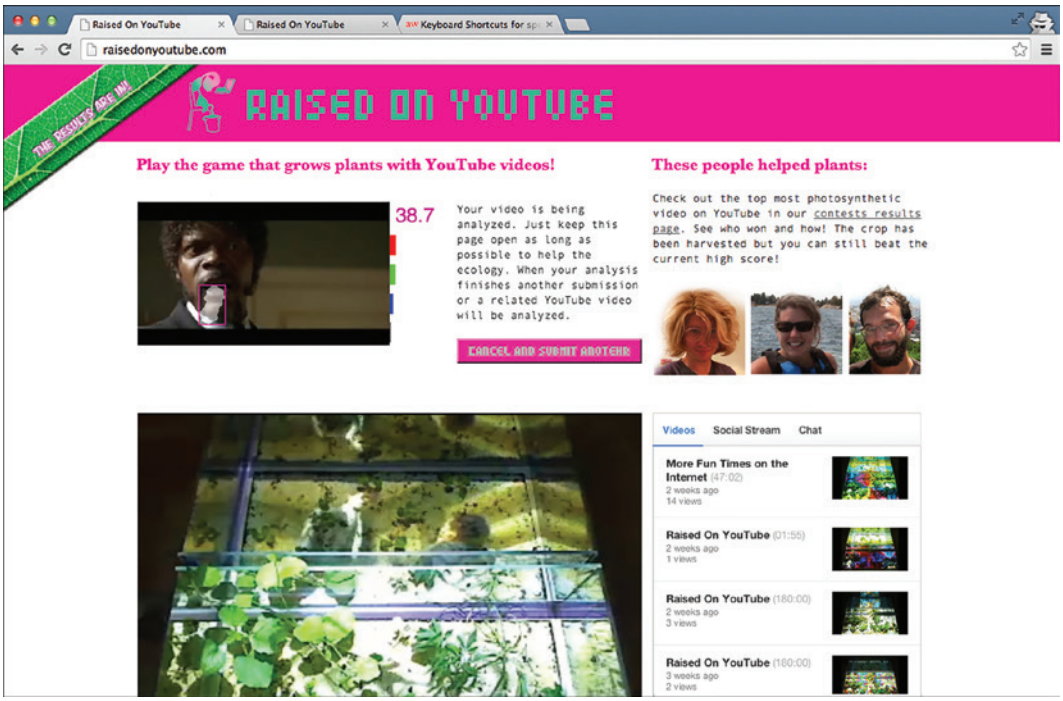

Figure 6. Players pasted YouTube video links directly into the website. To be eligible to win a prize, a player had to contribute computing power toward crowdsourced video analysis. (© 2014 Misha Rabinovich)

crowdsources the process of understanding protein folding. In the same way, *Raised on YouTube* gives people the chance to play ecology in exchange for making their processing power available as a shared resource. Users gave up some of their processing power only while the website was open (Figure 6), and they were incentivized to do so in several ways. Firstly, the website offered up a live feed of the rows of crops dancing under the dynamic light and sound of digital culture. Secondly, the players were not eligible to win until their submitted video was fully processed on the client side and score posted back to the server. Once their submission was processed and the score was sent to the database, they were also served previous video submissions that had not yet been scored (e.g. because the original submitter left the page too early). This amplified the network effect of processing so that the more people who visited the site, the faster submissions were analyzed, allowing the plants to receive better video more quickly. The system doesn't require installation of custom software but takes advantage of existing browser-based technologies, such as JavaScript and Flash, to run analysis in the background. The ActionScript Bitmap class opens up the access to the pixel data of each individual frame of video, which allowed for programmatic measurement of color energy and motion. I also created a custom Ruby on Rails backend and coupled it with the open-source youtube-dl Python library, which provides access to the raw video data syphoned off of Google's YouTube servers (Figure 7). The *ROY* server kept a live tally of submissions and showed the top videos ranked by photosynthetic score. Because the website compared submissions to one another, people could learn from each other.

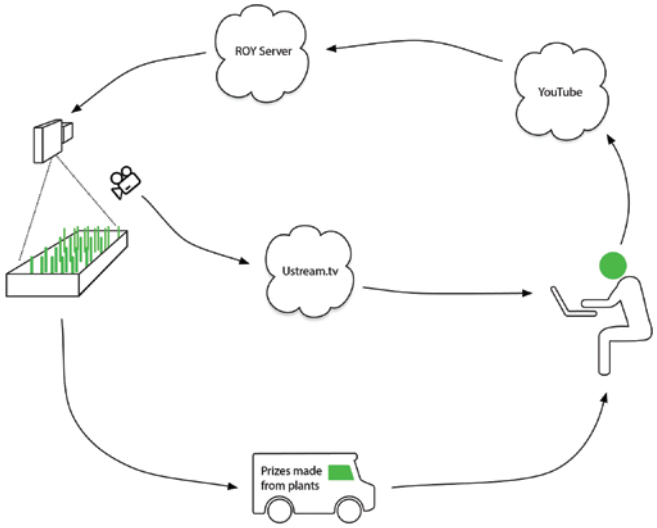

Figure 7. *Raised on YouTube* ecology diagram shown with a single user. (© 2016 Misha Rabinovich)

To bring the contest into the aesthetic dimension, I added a second identical grow bed which housed the same types of plants. The first grow bed was illuminated by the latest submitted video to date. The second grow bed was illuminated by a playlist of the top 40 hits submitted to date. The game experience benefited from this for a couple of reasons. The first was that a player had a high chance of seeing his or her submission appear on at least one grow bed almost immediately—even if the video was not well scored—which served as an instant reward to encourage further engagement. The second reason was to show what a difference highly photosynthetic videos made: the top 40 grow bed plants were bigger.

Outcomes

The telepresence version of the project was exhibited at the Arcade Gallery in the Los Angeles neighborhood of San Pedro in 2014, while also being broadcast via the internet. I received about 1,000 video submissions during the two-month run of the contest. The photosynthetic scores increased in bursts as players discovered whole genres of well-performing videos, with scores peaking in the mid-70s. Psychedelic eye-candy videos with lots of changing colors did well. Documentary videos of commercial grow rooms also did well, which is unsurprising considering how much time horticulturalists put into calibrating their grow lights. I continued to operate the website even after the main run of the contest was over and winners were chosen. In the spring

of 2015 I presented the project at the University of California San Diego and held a workshop with students. It was during this event that the most photosynthetic video to date (score of 79) was found: the video is called *My Girl's Reaction to Harvard Acceptance*. It is important to note that by this point the system ignored black bars during evaluation. This vertical video has a lot of excited movement and the reddish brick wall background surely boosts the score. I published the top 40 photosynthetic videos as a YouTube playlist to help people try this at home (Figure 8). One future direction for this research is the incorporation of sound analysis into the photosynthetic score. Research shows that specific genres of music [23] and sound frequencies of wavelengths similar to average leaf sizes can have serious effects on transpiration (plant "breathing") [24]. The Bemis Contemporary Art Center has invited me to continue this research in the summer of 2016 for their "Future of Food" theme.

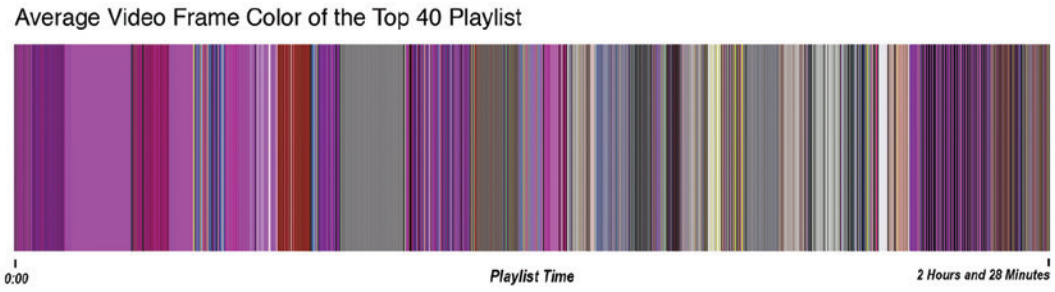

Figure 8. Visualization of the average video frame color over the running time of the Top 40 playlist as it stood at the end of the contest. (© 2015 Misha Rabinovich)

The ability of the grow beds to function as data visualizations creates opportunities to reflect on our exposure to user-generated culture. People relate to plants as living beings, and watching them become changed by this artificial light invites contemplation about the effects this culture is having on us. How are we changing under the influence of so much content? I hope that by making tangible these rather abstract data flows, the project stimulates appreciation for non-human players and provides an opportunity for reimagining ecology as an interspecies game.

Acknowledgment

This project was made possible with the support of Marylyn Ginsburg and Chuck Klaus and the help of Andrew Andkjar, Cooper Battersby, Caitlin Foley, Sunil Buster Kapila, Boryana Rossa, *ROY* Players, and Tom Sherman.

References

1. A.W.D. Larkum, S.E. Douglas, and J.A. Raven, eds., *Photosynthesis in Algae* (Dordrecht, Netherlands: Kluwer Academic Publishers, 2003), 120.
2. L. Baessler, "Red Light vs. Blue Light: Which Light Color Is Better For Plant Growth," Gardening Know How (2015), <www.gardeningknowhow.com/garden-how-to/info/red-light-vs-blue-light.htm>. Accessed June 3, 2015.
3. S.D. Jackson, "Plant Responses to Photoperiod," *New Phytologist* Vol. 181, No. 3, 517 (2009).
4. R.A. Nelson, "Chapter 5: Electro-Culture," *Hemp Husbandry*, internet edition (2000), <www.rexresearch.com/hhusb/hh5elc.htm>. Accessed January 11, 2014.
5. D. Augaitis and D. Lander, eds., *Radio Rethink: Art, Sound and Transmission* (Banff: Banff Centre Press, 1994), 72.
6. G. Hertz, *TV + Beans* (1995), <http://www.conceptlab.com/tvbeans/index.html>. Accessed March 19, 2016.
7. E. Kac, *Teleporting an Unknown State* (1994), <www.ekac.org/teleporting.html>. Accessed January 15, 2015.

8. M.R. Robertson, "300+ Hours of Video Uploaded to YouTube Every Minute," Reelseo (2014), <www.reelseo.com/youtube-300-hours/>. Accessed December 10, 2015.
9. Cisco, "The Zettabyte Era: Trends and Analysis" (May 2015), <www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/VNI_Hyperconnectivity_WP.pdf>. Accessed July 24, 2015.
10. M. Rabinovich and Y. Girdhar, "Gaining Insight Into Films Via Topic Modeling & Visualization," *Parsons Journal of Information Mapping* Vol. 7, No. 1, 3–5 (Spring 2015).
11. G. Gessert, "Notes on Genetic Art," *Leonardo* Vol. 26, No. 3, 205 (1993).
12. B. Zics, "Toward an Affective Aesthetics: Cognitive-Driven Interaction in the Affective Environment of the Mind Cupola," *Leonardo* Vol. 44, No. 1, 31–37 (2011).
13. A. Ramírez Gaviria, "When Is Information Visualization Art?: Determining the Critical Criteria," *Leonardo* Vol. 41, No. 5, 479–482 (2008).
14. C. Voon, "Growing a Garden According to the Economics of Philanthropic Crowdfunding," Hyperallergic (2016), <hyperallergic.com/261458/growing-a-garden-according-to-the-economics-of-philanthropic-crowdfunding>. Accessed January 12, 2016.
15. W. van Eck and M.H. Lamers, "Hybrid Biological-Digital Systems in Artistic and Entertainment Computing," *Leonardo* Vol. 46, No. 2, 154 (2013)
16. K. Anderson, "Object Intermediaries: How New Media Artists Translate the Language of Things," *Leonardo* Vol. 47, No. 4, 357 (2014).
17. *Ibid*., 356.
18. A. Ramírez Gaviria, "When Is Information Visualization Art?: Determining the Critical Criteria," *Leonardo* Vol. 41, No. 5, 482 (2008).
19. J. Parikka, *The Anthrobscene* (Minneapolis: University of Minnesota Press, 2014), 35.
20. D. Wilkes, "Thriving Since 1960, my Garden in a Bottle: Seedling Sealed in its Own Ecosystem and Watered Just Once in 53 Years," The Daily Mail (January 24, 2013), <http://www.dailymail.co.uk/sciencetech/article-2267504/The-sealed-bottle-garden-thriving-40-years-fresh-air-water.html>. Accessed April 13, 2016.
21. K. Goldberg, ed., *The Robot in the Garden: Telerobotics and Telepistemology in the Age of the Internet* (Cambridge, MA: MIT Press, 2001), 182.
22. L. Paraguai Donati and G. Prado, "Artistic Environments of Telepresence on the World Wide Web," *Leonardo* Vol. 34, No. 5, 438 (2001).
23. V. Chivukula and S. Ramaswamy, "Effect of Different Types of Music on *Rosa Chinensis* Plants," *International Journal of Environmental Science and Development* Vol. 5, No. 5, 431–434 (2014).
24. M.E. Collins and J.E.K. Foreman, "The Effect of Sound on the Growth of Plants," *Canadian Acoustics* Vol. 29, No. 2, 1–8 (2001).