

Vector Aesthetics

Jon Phillips

The contribution of this paper is to create a general map of features of vector graphics in order to discuss cultural artifacts which could be described as having a vector aesthetic, across different media, both analog and digital. This is not a category killer or an end-all discussion on the subject, but rather a call to “pick up a shovel” and help fill in the blanks of this aesthetic sensibility. It is imperative to discuss this subject as the proliferation of global broadband connectivity (called “universal broadband” broadband by some) and saturation of mobile devices beckons for the use of a low data-rate graphical solution. Also, newer graphical window management systems, what many refer to as computer operating systems, like Windows, Macintosh, and Linux Desktops (Gnome and KDE) are converting to use a vector graphics meta-layer to describe their desktop windowing interface (think scalable windows, icons, dialogs, etc). This document is also written in support of the use of scalable vector graphics (SVG), an open World Wide Web Consortium (W3C) standard vector graphics XML format.

The intent of this paper comes from many encounters with artists and designers that resist to describe their work in anything but the purist sense of their media of choice. The limitation in using arcane lexicons, or specific jargon is viewed as a reductive hindrance in exclusion of a vast number of viewpoints which in the tradition of pluralism are generally lauded in order to work the kinks out of a “work-in-progress.” While defining a framework that bridges multiple media is also reductive if viewed as detached from the complexities of context, it is the privileging of this shared language that enables communication between various viewpoints from our entrenched critical positions that will make each person's work stronger; in order to communicate, we must make common to those that are a part of the discourse.

I espouse Jay Bolter and Richard Grusin's new media theory **remediation**, or the representation of one medium in another, as a central tenet of vector aesthetics¹. The remediation of the features in early cell animation mapped to graffiti in New York in the 80s and then has reverberated back onto contemporary motion graphics.

Another intention of this writing is a personal contribution to the community of contemporary artists and designers using vector-based applications, of which, Adobe Illustrator, Macromedia Flash and Freehand are the dominant tools. My personal goal though is to support the fledgling application, Inkscape, an open source scalable vector graphics editor, of which I am a developer. I feel that it is necessary to embed inside the application some linkages with design and art histories (Schaller 2004). While writing this paper I have been working on a tutorial for Inkscape which users can load and view various connections in order to inspire and contextualize their working practices (which is further reason to add to this discussion). It is important for users's to understand the lineage and context of their tools and how that affects what and how they are creating.

The **Vector Aesthetic** is a visual, technical and conceptual aesthetic typified by the features inherent in images using or being influenced by **vector graphics**, where vector graphics describes the use of geometrical primitives such as points, lines, Bezier curves, and polygons to represent images in computer graphics². It is used in

¹ Bolter, Jay David and Richard Grusin. *Remediation: Understanding New Media*. (Cambridge: The Mit Press, 2000), 45.

² My Vector Graphics definition is based on http://www.webopedia.com/TERM/v/vector_graphics.html because of the object-oriented reference. Similarly, my Vector Definition: [http://en.wikipedia.org/wiki/Vector_\(disambiguation\)](http://en.wikipedia.org/wiki/Vector_(disambiguation))

contrast with the term **raster graphics**, or bitmaps, which is the representation of images as a collection of pixels (dots) in computer graphics. To break down these definitions further still, **vector**, in a mathematical sense is defined as a "quantity characterized by a number (indicating magnitude) and a direction, often represented graphically by an arrow," while in physics and engineering it "most often refers specifically to an object that has a special relationship to spatial coordinates/directions." **Aesthetics** is that which is considered artistically beautiful or pleasing to a culture³.

Invented in the early 1960s, and published widely in 1972 by Pierre Bézier⁴, Bézier curves, or Bézier splines are polynomial parametric functions with vector coefficients⁵. They were originally used to design automobile bodies for car company Renault. The most important Bézier curves, the cubic type, are used in computer graphics and several imaging systems such as PostScript⁶ and Metafont for drawing "smooth" curves when joined into bezigons. Since their introduction, their implementation has expanded from an engineering solution to a graphical sensibility, thus redefining contemporary aesthetics. Coincidentally this conversion scaled in synchronization with the Doug Engelbart introduction of the NLS System (the introduction of the GUI), and the introduction of the Unix Operating System in 1969. The concurrent rise of both computer operating systems and graphical user interfaces made the human computer interface more easily used by people of various skill levels over time. The vector aesthetic, defined by the purity of the curve's discrete mathematical description, is not new. Rather, it is a remediation of styles, principles, concepts and logic from earlier art, design and engineering fields and movements. The precision of the curves, the boldness of the lines and the flatness of color fields of vector graphics moves beyond the analog visual aesthetic typified by the works of the Futurists, Constructivists, and Cubists through a more precise graphic design in a technological sense. Whereas earlier artists relied heavily on pre-Benjamin craft, the vector is reproduces closer to the mechanical rationalization of the Futurists. As technology improves, the consistency of the curve that can be mechanically generated on a computer becomes more and more precise, as floating point units move from 16-bit to 32-bit to now the more common 64-bit. In the transfer of technique, human to human's control over increasily more accurate machines, concepts from these artistic times were sampled and assimilated into the vector aesthetic. Of conceptual importance is the shift to a minimalism of mathematical representation through use of vector graphics as the impact of their discreteness resides in the simplified equations necessary to draw precise illustrations. In many senses, as time progresses, current indications show that the precision of computers is only increasing, and thus what is called precise today, is imprecise tomorrow.

³ Yes, this concept of aesthetics needs to be seriously expanded.

⁴ Bezier didn't actually invent Vector graphics, but rather first publicly announced the invention while working for car company Renault. Others developed the same mathematical construct, yet their companies held the scientific contribution back, treating it as a "trade secret" rather than a giving it to society. NOTE: Closed source concerns profiteering existed long before Microsoft.

⁵ Pierre Bezier. *Unisurf CAD*. (London: Butterworth & Co, 1986).

⁶ Adobe's EPS, AI, and PDF files are all based on Postscript (which uses cubic Beziers) while TrueType fonts use the simpler quadratic Bézier curves. Definition of Postscript: <http://www.cs.indiana.edu/docproject/programming/postscript/what-is-it.html>

The rise of the vector aesthetic is intertwined with the selection of Bézier curves and vector graphics as the foundation for the modern desktop publishing industry by Adobe and Apple in the mid-1980s. One year after the 1984 introduction of the Macintosh, Adobe Systems released the device-independent Postscript page description language. It provided a necessary standard at the birth of the Macintosh Plus, the first widely used graphical user interface, coupled with the killer-apps Adobe Illustrator and Aldus Pagemaker, and more importantly many thousands of highly productive people needing to accurately print their jobs.

The ultimate reasoning behind this framework has more to do with the increasing proliferation of vector graphics in other media. While much has been discussed about Flash graphics, animations and aesthetics by Lev Manovich in "Generation Flash," (2002) comic-master Stan Lee and others in *Flash Frames*⁷ and others simply through becoming Flash-artists (Josh Davis, praystation.com), there has not been an overview of works sharing the features of vector graphics across multiple-mediums. This writing includes movements and trends that have paralleled the development of computational vector graphics used in logo design, industrial design and signage, graffiti, street art, and current LA-based painting. I could also discuss cartoons, current games, and other design movements, but will save these for future iterations of this writing. Also, future additions to this talk should be: The Foundations of Vector Aesthetics: Earlier Media, Art and Design, Contemporary Media, Art and Design, and Remediation of Vector Aesthetics into other Media (Past and Present). This talk will be discussed in the following order: General features of vector aesthetics and the importance of this discussion.

General Features of Vector Aesthetics

As I look at artist's and designer's websites, the proliferation of flash as a dynamic decoration is high. Like Josh Davis, of praystation.com fame, a vector-master, similar others now have found a need for personal representation. Rather than simply displaying a dynamic intro flash animation, a decision that has been toppled over the last 3-4 years, his site now categorizes his Flash-based work into: web, print, broadcast, and installations. There is a need for a simple classification system to encompass Flash graphics, animation, street art, graffiti, stencil art, graphic design trends, contemporary motion graphics, data visualizations, and other contemporary (Spring 2004) graphical styles. After review of vector graphics and works that could be described as using the vector aesthetic, the following are five dominant features: 1) **Scalability**, 2) **Reproducibility**, 3) **Modularity** (object-oriented), 4) **Precision**, and 5) **Abstraction** (vectorization). Special care has been taken to not select features which pigeon-hole vector graphics through discussion of computer specific features such as file size, embedded meta-data, or file types. Rather, each is fairly broad and represent visual, conceptual and technical elements which comprise current vector graphics usage and the remediation of the vector aesthetic on pre-computer and pre-Bezier graphics which could be discussed using these same five features – a historical remediation.

Scalability is the ability to change the size of graphical elements both larger and smaller in proportion to the original. Subordinate to this feature is that content is not really lost in the transition of scales. On the digital front, file-size and extra computation for various scales is not a major performance hit. The conceptual importance of scalability of graphics allows them to be used on all manner of objects, screens sizes, or formats. The scale of images

⁷ Stuart S. Shapiro and Laurie Dolphin. *Flash Frames*. (New York: Watson-Guptill Publications, 2002).

are of all sizes on posters, industrial graphics, signage, airplane wings, downtown streets, and so on.

Look at a symbol like the McDonald's logo and how it is expressed at various scales consistently, yet conveys the similar information from different distances. While size does matter, especially in relationship to the surrounding context, compared to architecture supporting the logo, or the object that McDonald's is printed onto (cup or maybe a toy), the application of the same iconography acts as a controlled variable. In corporate identity, the consistency of representation promotes unity, and the isolation of scale rather than the randomness of interchangeable components allows for feature exploitation. Think *Citizen Kane*! Street and graffiti artists employ this in the real world with the idea of tagging, which on the simplest level has to do with using a paint marker to write one's handle (identity), wherever one can – the more difficult the reach, the better. The ultimate tag though for a graffiti artist is the top-to-bottom full-size tag. This takes the form of an entire subway car in NYC and London, or a massive wall⁸. Taki 183 is credited with starting graffiti in NYC with his simple handle being mapped to all manner of surfaces at different sizes. Since his creative act, a hip-hop Duchampian signature called a “tag”, all manner of faceless graffiti artists have taken to the streets to scale their tag. Works by loose-groups like Wooster Collective (<http://www.woostercollective.com/>) exemplify the scalability of the vector aesthetic in terms of visual representation (resampling and cloning). Scaling is of great importance for these forms in competition for public visibility because the actual concerns embedded within the images must consistently get larger if the artist is to gain notoriety among peers, or bring public recognition to a message (whether that be individual, collective, political).

Reproducibility is the ability to be (easily) reproduced. This is exemplified by the simplicity of graphics that usually accompanies the other features of vector graphics. Reproducibility is a graphical concept that is yet again expressed both digitally and conceptually. In the flat abstraction of current LA-based painting, as exemplified by Kevin Wingate's van paintings, which are all very similar conceptually and graphically, and which can be copied easily into other formats. In the art and design world, work like Takashi Murakami's Mr. Dob ("And then and then and then and then and then," 1995) figure and the wide availability of vector graphics on-line and posted in urban areas are highly reproducible. This is taken to the ultimate extreme with PDF file copies of graphics and file-sharing of popular media⁹.

It seems that the reproducibility of poster-based street art by Shepard Fairey (<http://www.obeygiant.com/>) and others is highly successful in urban areas. When a shop closes down, wooden planks encasing its front are covered with hundreds of duplicates of the same, or similar copied iconography. Also, note how commercial design, specifically the music industry, has co-opted this trend through postings by street teams of announcements of new artists, upcoming concerts and other commodified messages in privilege to the unwieldy public poster.

Modularity (object-oriented), is smaller parts, or modules which can be connected together to make up a whole. This concept has in the last 20 years received an injection from the computational ideology of object-oriented programming. Linux evangelist Eric S. Raymond (ESR), in his book, *Art of Unix Programming* says: "The only way to write complex software that won't fall on its face is to hold its global complexity down – to build it out of simple parts connected by well-defined interfaces, so that most problems are local and you can have some hope of upgrading a part without breaking the whole."¹⁰ This concept has been remediated by vector graphics (among other disciplines). While logos and symbology are the token signs in graphics, these icons make up larger images in

⁸ Martha Cooper and Henry Chalfant. *Subway Art*. (New York: Holt, Rinehart, and Winston, 1984), 17.

⁹ Using BitTorrent and <http://suprnova.org/>, specifically...

¹⁰ Eric Raymond. *Art of Unix Programming*. (New York: Addison-Wesley, 2004), 84.

current culture. The composite imagery of modern advertisements, street art and poster propaganda is dominated by modules composited to form a larger image¹¹.

The concept of modularity subsequently establishes how digital graphics are composed from smaller sized components which join into a larger connected whole. These small modules could be described as lightweight, or as Lev Manovich points out, vector graphics have an "unbearable lightness" [10]. He means this visually in terms of shades of colors and grays, but the same could be said for structural representation – morphologically speaking. The modules of vector graphics are structurally firm with bold hard outlines, yet maintain lightness with super-flat color surfaces that subtly gradate in color and contrast in a hyper-real California sunset-like moment. And, since computer-based vector graphics are discrete representation in memory, the operation of cloning the previous instance of a graphic is preferred rather than creating another copy of the original which takes up more memory and generally slows down an on-screen rendering. Thus, when viewing computer graphics using cloned symbols, it is the efficiency of their representation that has directly affected the countless times they are used in illustrations. The simple rendering speed trade-offs have back-propagated to learned usability.

The file format and description language XML actually encapsulate content within markup – html-like tags, another form of modularity. In the XML markup scalable vector graphics, or SVG, a rectangle is actually a tag that specifies a length, width and position, or the finite description of the on-screen rectangular graphical object. This is a discrete object which can then be combined with other primitives to make a more complex illustration. Its root is a modular tag which in combination with other tags, creates the desired whole.

In the analog world, icons and symbology are often called clip art, which are libraries of individual graphics (modules) which can be combined together to make a final composition. Check out the work of Neil Stuber (<http://www.neilstuber.com/>) whom builds his own library of clip art which he then combines together for various projects. This clip art is used as a visual alphabet, a glottographic language system, with which to construct more complex associations and assemble samples with pre-loaded meaning. The words make up sentences which makes up paragraphs of meaning in his work. This is highlighted now on-line in the Open Clip Art Library (<http://www.openclipart.org>), a user-motivated collection of graphics with rich meta-data embedded within the actual graphics that describe what is being portrayed.

As discussed earlier, modules are composed to make-up the gestalt of the image, thus implying a stratification of design. The specific operations used to combine these modules – overlapping, montage, arraying – are layered and many times can be repealed. Technically, the SVG vector file format is also represented hierarchically inside the computer, but more importantly, the conceptual significance of the stratification of the vector aesthetic implies cleanliness, durability, and then reflects back on the artisan of the original work. The young vector designer might combine elements in a chaotic mess and the more advanced user learns that each component of his or her design are actually conceptually integrated. Thus, the layering of lets say a combination of many blades of grass would be better represented in a group, grass rather than as several individually identified pieces.

Precision is accurate or exact measurements. This quite simply is both a visual accuracy – the hard-edged look – as well as in a technical sense, precision as implied by the creation of Bezier curves. Remember, these curvers were needed to consistently reproduce curvilinear surfaces for milling machines for Renault's car parts. Until the

¹¹ (QUESTION: What other computational concepts have been remediated back into design and popular culture with added meaning from our number one tool, the universal turing machine?)

invention and use of Bezier's polynomial functions, French curves and hand-chiseled models were used for much of 2d and 3d model making – far from precise! Imagine building a space shuttle that has 6 astronauts in it, millions of dollars in experiments, all that travels over populations of people designed without ultimate precision! In actuality, a space shuttle would not have been realized without the precision of computers and math necessary to make the 3D equivalent of Bezier splines on physical objects.

Motion graphics studio MK12's video work places in runtime the core features of the vector aesthetic, yet demo the accuracy and planned transition that vector aesthetics demands upon artists. The fluid motion of vector graphics is equivalent to following vectors from point A to point B. While in static 2D imagery, dynamicism is implied in the graphical variability of stroke width and layered structural complexity, vector-based motion graphics has a double logic of vectors. There is both a vector visual layer and a mathematical engine calculating vectorial movement and realtime collaging of graphical symbols.

Another brilliant example of the precision of vector-graphics is that while I'm writing this, there is a biologist next to me preparing his research by looking at his own data analysis consisting of vectorized data on a chart. While the initial data is discrete, it is extrapolated (abstracted) into a model which looks for the closest mathematical features, akin to the difference between a bitmap, the initial data, and the mathematical representation of a Bezier curve, the vector approximation of a bitmap.

In discussing precision, I will also quickly note the work of data visualizations created by the likes of Future Farmers, Lisa Jevbratt, and the work of Schoenerwissen whom all create abstract graphical representations of database fields (data mappings). I am not going to dig into their work right now even though their work is another section that needs to be written about. The application of vector aesthetics to physical data is something that happens with data-driven Flash graphics regularly now.

"**Abstraction** uses a strategy of simplification of detail, wherein formerly concrete details are left ambiguous, vague, or undefined; thus speaking of things in the abstract demands that the listener have an intuitive or common experience with the speaker, if the speaker expects to be understood.¹²"

The first four features of vector graphics seem to evoke a visual abstraction. Whereas a bitmap/raster image is trying to describe our world in desire to the reality perceived by our own vision, vectors seem to stylize reality in closer proximity to the actual concepts existing in our brain. While the reified symbolism of vector-based icons is a simplified aesthetic, the poetic abstraction, or larger metaphoric conceptual space connected with the icon is more general than the equivalent pixel-perfect rendition of an object existing in space because of less definition (implicit structure).

The style used is typified by a contrasty, heavily bolded boundary using mathematically precise lines. Whereas raster-based images give subtle gradations and textures in an image, the flat fields of colors with heavy lines maintain a sense of ideological boldness and power through aggressive visual layout.

Another sub-tenet of abstraction is **vectorization**. I am borrowing this term from normal graphic design work in which a real physical object, like a leaf, or a picture is scanned into a computer and then a program parses the bitmap representation of the file and converts it into a stylized representation of the original.

This happens literally in design continuously, as can be seen in hand-traced vectorization by Sike-Style (<http://www.sikestyle.com>). This also has happened over-time as represented by the progressive simplification and

¹² Wikipedia.org, <http://en.wikipedia.org/wiki/Abstraction>

vectorization of logotypes from the 19th century till present. The Shell oil logo typifies this concept in which the original company actually traded shells, but over-time merged with other trades and hence the shells, a stand-in for fossil fuels, is now abstracted to represent a larger corporate endeavor¹³. Ironically, the shell logo is a passified object that relates to our natural earth, yet exists as the unification of the Shell empire – a petroleum company which is far from nature¹⁴.

Importance of Discussing Vector Aesthetics Now

Flash has dominated the vector graphics scene on the web, but there are indications that this is shifting towards a new contender. Scalable Vector Graphics is a W3C (World Wide Web Consortium) standard file format and platform API¹⁵. For our discussion, the importance is that it is a flat text file format that uses XML. You can write it just as easily as you can HTML– in notepad! Also, Adobe has put its full weight behind this format and has a standard freely downloadable plug-in.

As broadband access increases, the amount of media (we're talking petabytes) piling up is only going to increase geometrically. The necessity for search engines, intelligent agents, and data-mining to help users find their needle in a haystack is becoming increasingly necessary. Google accounts for about 70% of the web traffic on my website, <http://www.rejon.org/>. Think about how many times you use Google to search for definitions, directions, images, plane tickets, hotels, etc. Quite simply, SVG is search-able and FLASH is not.

SVG has semantically described content which is search-able and definable, since it is an XML format. It is also becoming common practice to embed meta-data inside of an SVG file as described using the extensible meta-data platform, or XMP¹⁶. This meta-data is not just information related to the technical capture or file-only specifics, but keywords, descriptions and relationships that a user defines. The use of meta-data is going to be required for new ways to generate narratives (Harrell 2004), to define our relationships to others, and, for example, in order to find a picture in a shuffled stack of our inflating media archives. Think about how many photos you take now with a digital camera. How about how much video you record with a camera and never ever watch! Our overloaded personal media collection is our vanity. We have so much media that each collector could never fully experience it all in a lifetime¹⁷.

Quickly, I also want to mention that desktop window managers on Linux, Macintosh and Windows are moving to be vector based. While this is still in its early stages, the dominant Linux window managers already render their icons from SVG files. I am hypothesizing that the use of SVG is only going to increase in relationship (in parallel) to the rise of the Vector-based Desktop. This, coupled with Mozilla enabling SVG support in their browsers, along with many new cell phones using the open implementation of SVG Tiny, is only going to help the adoption of SVG as a standard.

My attempt at catalyzing the uptake of SVG takes form in this writing as being a developer on the project

¹³ History of Shell: <http://www.shell.com/home/Framework?siteId=royal-en&FC2=/royal-en/html/iwgen/who_we_are/history_of_shell/zzz_lhn.html&FC3=/royal-en/html/iwgen/who_we_are/history_of_shell/history_of_shell.html

¹⁴ Please note that other gas company logos have similar ironies like British Petroleum's corporate identity. <http://www.w3.org/TR/SVG/>

¹⁶ The Extensible Meta-data Platform description may be found online at: <http://www.adobe.com/products/xmp/main.html>

¹⁷ Marc Davis. "Garage Cinema and the Future of Media Technology" in *Communications of the ACM* (50th Anniversary Edition Invited Article) 40 (2 1997), 42-48.

Inkscape, a cross-platform open source SVG editor. This program hopes to become the W3C compliant SVG editor on Windows, Macintosh and Linux (Unices, really). By understanding the context within which I work as a developer as well as embedding a bulleted form of this document into the Inkscape interface I hope to encourage discussions of software beyond just technologically determined decision-making, but move to the forefront the visual and conceptual concerns the use of Vector Graphics.

Bibliography

Aesthetics and the Philosophy of Art – The Analytic Tradition, An Anthology, ed. Peter Lamarque and Stein Haugom Olsen. Oxford: Blackwell Publishing Limited, 2004.

Antliff, Mark and Patricia Leighton. *Cubism and Culture*. London: Thames & Hudson, 2001.

Bézier, Pierre. *The Mathematical Basis of the UNISURF CAD System*. London: Buttersworths, 1986.

Bézier, Pierre. *Emploi Des Machines A Commande Numérique*. Paris: Masson Et Cie, Éditeurs, 1970.

Callo, Max. *The Poster in History*. Middlesex, England: Hamlyn, 1972.

Castleman, Craig. *Getting Up: Subway Graffiti in New York*. Cambridge, MA: The MIT Press, 1982.

Cooper, Martha and Henry Chalfant. *Subway Art*. New York: Holt, Rinehart, and Winston, 1984.

Constructivism and the Geometric Tradition. New York: McCrory Corporation, 1979.

Crafton, Donald. *Before Mickey: The Animated Film 1898-1928*. Chicago: The University of Chicago Press, 1982.

Cushing, Lincoln. *Revolucion! Cuban Poster Art*. San Francisco: Chonicle Books, 2003.

Davis, Marc. "Garage Cinema and the Future of Media Technology" in *Communications of the ACM* (50th Anniversary Edition Invited Article) 40 (2 1997).

Flash Frames, ed. Laurie Dolphin and Stuart S. Shapiro. New York: Watson-Guptill, 2002.

Gilbert, Steve. *Tattoo History*. New York: Juno Books, 2000.

Harrell, D. Fox. 2004 (forthcoming). "Foundations for Active Multimedia Narrative: Semiotic spaces and structural blending." [online] San Diego: University of California, San Diego, Geisel Library, 2004. [cited May 20, 2004].

Available from the World Wide Web: (<http://www.cs.ucsd.edu/users/fharrell/publications.html>).

Harrison, Randall P. *The Cartoon: Communication to the Quick*. Beverly Hills, CA: Sage Publications, 1981.

Macdonald, Nancy. *The Graffiti Subculture: Youth, Masculinity and Identity in Lonon and New York*. New York: Palgrave, 2001.

Malone, Michael S. *Infinite Loop*. New York: Currency Doubleday, 1999.

Manovich, Lev. 2002. "Generation Flash." [online] San Diego: University of California, San Diego, Geisel Library, 2004. [cited May 20, 2004]. Available from the World Wide Web: (http://manovich.net/DOCS/generation_flash.doc).

Mount, Christopher. *Stenberg Brothers: Constructing A Revolution in Soviet Design*. New York: The Museum of Modern Art, 1997.

Nash, J.M. *Cubism, Futurism and Constructivism*. London: Thames & Hudson, 1974.

Pfiffner, Pamela. *Inside the Publishing Revolution: The Adobe Story*. Berkeley, CA: Peachpit Press, 2003.

Prautzsch, Hartmut, Wolfgang Boehm, and Marco Paluszny. *Bézier and B-Spline Techniques*. Berlin: Springer, 2002.

Raymond, Eric *Art of Unix Programming*. New York: Addison-Wesley, 2004.

Reid, Glenn C. *Postscript Language Program Design*. Reading, MA: Addison-Wesley Publishing Company, Inc., 1988.

Rickey, George. *Constructivism: Origins and Evolution*. New York: George Braziller, Inc., 1995.

Schaller, Christian. 2004. "SVG and its Path into the Linux Desktop" [online] San Diego: University of California, San Diego, Geisel Library, 2004. [cited May 20, 2004]. Available from the World Wide Web: (http://www.osnews.com/story.php?news_id=6460).

Shapiro, Stuart S. and Laurie Dolphin. *Flash Frames*. New York: Watson-Guption Publications, 2002.