Confocal Images and Visual Design

Lin Wang
Department of Design, School of Arts, Southeast University, Nanjing, Jiangsu 211189, China; College of Arts, Media and Design, Northeastern University, MA 02115, USA
Zhenyi Su
Department of Biochemistry and Molecular Biology, Medical School, Southeast University, Nanjing, Jiangsu 210009, China; Department of Cell Biology, Harvard Medical School, Boston, MA 02115, USA
Sophia Ainslie
College of Arts, Media and Design, Northeastern University, MA 02115, USA
Hui Chen
Department of Design, School of Arts, Southeast University, Nanjing, Jiangsu 211189, China.
Corresponding author. E-mail: chuidesign@163.com

Note: Lin Wang, Zhenyi Su, Sophia Ainslie, and Hui Chen contributed equally to this work and should be considered as co-first authors.

Abstract:
The laser scanning confocal microscope (LSCM) is developed from the conventional optical microscope, using a laser instead of a lamp for a light source. Confocal microscopy has several advantages over conventional optical microscopy, especially the capability to optically "section" thick specimens to get a clearer image. Specimens are labeled with one or more fluorescent probes to display distinct proteins, organelles, cells, or tissues. Some classic and non-classic visual design principles are reflected in these colorful confocal pictures, including repetition of certain elements, use of radiation, presentation of details, and application of light and shade. In the current paper, we discuss how confocal images convey these design principles by analyzing some representative pictures from confocal image competitions and give some examples of the application of these principles in visual design. Development of confocal technology opens another avenue for designers to find inspiration from nature and life, and re-construct their art works.

Keywords
- Laser scanning confocal microscope,
- Confocal microscopy,
- Visual Design,

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1. Introduction

The laser scanning confocal microscope (LSCM) is developed from the traditional light microscope, and uses a laser instead of a lamp for a light source, sensitive photomultiplier tube detectors (PMTs), and a computer to control the scanning mirrors and to facilitate the collection and display of the images[1]. In the LSCM, illumination and detection are restricted to a single diffraction-limited point in the specimen. This point is focused in a specimen by an objective lens, and scanned across it using a scanning device. Lights are captured by a PMT and built into an image by computer[1]. Specimens are usually labeled with one or more fluorescent probes, and different fluorescent probes may show distinct proteins, organelles, cells, or tissues. The main application of confocal microscopy in the biological sciences is for imaging either fixed or living tissues labeled with fluorescent probes. Compared with a conventional light microscope, the major advantages of confocal microscope are their ability to optically "section" thick specimens, elimination or reduction of background fluorescence away from the focal plane, and increased lateral and axial resolution[2].

Confocal images-based visual design is actually one form of Bionic design. It is well known that numerous design works and principles are from creatures. The bionic design is a design process selectively applying characteristics such as shape, color, texture, function and structure of plants, animals, and microbes[3]. Confocal microscope is a novel and powerful tool to unveil the ultrastructure of creatures in high resolution. From these colorful confocal microscope pictures, a sense of beauty is presented in well-organized cells, tissues, and organisms. Moreover, we also notice that some established visual design principles exist in these confocal pictures.

In the current paper, we selected some representative confocal images from award-winning photographs of the Nikon and Olympus photomicrography competition, and divided them into four major categories based on the design principles. These design principles consist of repetition, use of radial system, presentation of details, and application of light and shade. Furthermore, we also listed some examples in visual design, which can give readers a full understanding on the confocal image principles.

We hope this paper will engage the reader's attention and interest in confocal technology. Perhaps it can open another avenue for designers to find inspiration from nature and life, and re-construct their design or art works. Confocal images may include more design principles than listed in this paper. Readers can also discover their own design or aesthetic principles from confocal technology images.

2 Visual design principles from confocal images

2.1 Repetition

The major objects observed by confocal microscopy are cells or tissues of plants, animals, and microorganisms. The basic units of organisms are cells that appear round, oval, polygonal, star, and spindle. Confocal microscopy displays delicate and clear cell arrangements in tissues, among which different cell types, and different organelles could be stained with different fluorescence dyes and show different colors.

Repetition is the repeated display of certain visual elements in a design work, for example, repetition of colors, shapes, materials, character fonts, size, and pictures. Seen in the confocal images in Figure 1 repetition can be divided into two forms: repetition of identical shapes (identical repetition), and repetition of similar but varied shapes (non-identical repetition). Identical repetition can be a good way to attract greater visual attention by repeating the same element over and over. Non-identical repetition is not the simple and tedious stack of a design element, but it is the combination of these elements through changing size, proportions, and positions. Non-identical repetition is a useful way to express dynamism, contrast or transition in a scene.

As shown in Fig. 1A, the bamboo plant stem is composed of many round cells, which constitute vascular bundles (including xylem and phloem) and parenchyma. This structure is made up of a repeated single circle, but these circles vary in size, density, and color. Hundreds of circles form an ordered structure----vascular bundles, which further constitute the stem of the bamboo along with parenchyma. Similar structures are seen in Fig.1B. It shows the rhizome section of Convallaria sp., a species of Lily of the valley. A series of polygonal cells, with different thicknesses of cell walls, constitute the rhizome. Each repetitive element makes contact with adjacent elements, changeable light and shadow, thickness of outline, and size. Figure 1C displays the wood cross section, in which small oval cells compose a complex fabric network. Alternate application of small repetitive units, interspersed with big ones can create a layered visual effect. The in-vitro cultured mouse gut organoid is displayed by staining the nuclei with blue fluorescence dye (Fig.1D). This image indicates that repetition of certain design elements can be portrayed, not only in a 2-D manner, but also in a three dimensional space, which is achieved by flexible application of lights and angles. Taken together, repetition may archive a musical effect as repeated forms establish rhythmic patterns[4].

2.2 Radial design principle

Radial image is composed of a series of radiating lines emitted from a certain point. Radiating lines confer special status, rays were the attribute of gods and heroes, the hallmark of their supernatural power[5]. The use of radial elements will enlarge the visual regions, causing the eyes to focus on the periphery rather than on a single focal point or region. In other words, radial design increases the energy and the continuity of an image. It can also bridge different elements or images, and form an integrated design. Fig.2A shows the retinal flatmount of a mouse nerve fiber layer. Each neuron looks like a bright star and the adjacent neurons make contact with each other by radiating nerve fibers. Different radial units form a well-organized net, and a compelling design with multiple visual focuses. Fig.2B displays a hippocampal neuron receiving excitatory contacts, while Fig.2C shows neurons growing over astrocytes in a human stem cell embryo body. Radial lines are shown in both Fig.2B and Fig.2C. However, the radial styles are quite different. Only a few radial lines are seen in Fig.2B, but these lines have different lengths, widths, and levels. Contrarily, thousands of radial lines are emitted from a central region in Fig.2C, and they have similar width and hierarchy. These two radial patterns are good examples of expressing different emotions and moods via different patterns of line. Fewer, clear radial lines could express a rational and calm mood, but more vigorous and singular directional lines could express a more energetic directional force. In addition, the combination points (purple dots) and radial lines could create a more energetic and rich effect in comparison with only utilizing lines (Fig.2B). Fig. 2D shows a complex culture of murine embryonic brain cells, in which neurocytes and their synaptic structures are presented with blue fluorescence. Numerous radial lines extend out, making contact with each other, creating an Impressionist-like artwork, bringing to mind Vincent Van Gogh's Starry Night.

2.3 Detail principle

Designers can not only give the whole immediate impression, but also through using subtle details give hints of new hidden meanings, making their works more complex and compelling. Depicting detail can be one of the most important principles and golden rules in visual design. The more detail, the more appeal a design could have. Viewers tend to spend more time on more complex and multifaceted designs. Confocal microscopy is a sharp tool used to display the detail of organisms, tissues, or cells by scanning them layer by layer again and then merging them together. In Fig.3A1, we see dots or lattices on the damselfly eye from a common photograph, but we do not know what these dots or lattices really are. However, from a confocal image (Fig.3A2), we can clearly see crystal-like hexagonal lattices on the damselfly eye which from a new site. Some lattices are covered with fluff. If we continue zooming into this image, we can even see the composition of the single lattice and the receptors on the top of the fluff (Fig.3A3 and Fig.3A4). The same situation is seen in Fig.3B1-4. However, it seems harder to enjoy the aesthetic nature of the design in a Fig.3B1, (the photograph of common brine shrimp captured by camera), due to the lack of detail. But, once the confocal microscope is used (Fig.3B2-4), an engaging design is presented.

2.4 Light and shade principle

Light becomes evident through association with darkness or shade. Use of light and shade is an advanced and important principle for visual design. High contrast, high impact[5]. Introducing contrast of light and shade allows an image to come to life. In addition, it can be a means to express mood. Different light and shade relationships may give different feelings, such as hope, passion, contemplation, and despair or fear. Fig. 4A, shows a combination of the different strengths of fluorescent colors, combined with a black background, creating a mysterious and vibrant world. Without light contrast, we can't even see each cell. A similar situation arises in Fig.4B, but conveys a distinct scene and mood. It feels like a bird's-eye view of the city in a high building, in which the sun goes down, the sky becomes dark, and the stars emerge from the horizon. This image is also successful in expressing contrast of temperature, and a good example of combined use of lines and points. Moreover, light has a guiding role, which makes your eye focus on certain points or regions. Fig.4C displays the structure of a mammalian inner ear. With the guide of spiraling and curved lights, we enter into a "black hole" world of the inner of ear, which creates a sense of an infinitely extending. Therefore, proper use of light and shade is an effective manner for artists or designers to enhance the perception of shape, space and mood in their visual works.

2.5 The application of confocal image principles in visual design

As it is shown in Fig.5A, the background is composed of identical elements and they are repeated over and over again. In contrast, the different sizes of the circles in the poster seem to be a form of non-identical repetition. Fig.5B designed by Andy Warhol, a leading American figure in the visual art movement known as Pop Art. This print is another successful example of using repetition by mechanically repeating a singular image of a can to create a larger more compelling design. Fig.5C is a display of Marimekko products, a Finnish design company renowned for its original prints and colors since 1951. Marimekko fabric and products are featured using repetition of identical and varied shapes. In Fig.5D, the rays radiating from the Mickey Mouse head draw attention to the radiant smile, a technique used on the Chinese propaganda posters for chairman Mao. The radial elements used in Fig.5E direct the eye toward expansion and contraction, and express powerful energy. Fig.5F displays the MBTA subway lines of Boston with stations spaced according to scheduled travel time. The radial system in the map forms a well-organized net. Just like all roads lead to Rome, all lines lead to the Boston heart. As it is seen in Fig.5H, the design is a mixed portrait of several famous British personalities. From this poster, we can see a strange face, but we do not know what this face really is. However, if we focus on the detail of each part of the face, we can clearly understand the deeper meaning of the poster. The same situation is seen in Fig.5G, the initial impression of the poster is the number "2008", but if we zoom in this poster (Fig.5G1), we can find different sports man in the background. Fig.5I represents a poster for Stadt Theater Basel, a municipal theater. In the poster, the high-contrast of the hands and the gestures give the sense of drama in motion. Fig.5J is an example of the manner in which a sense of atmosphere can be conveyed. The lighting sequence unfolds gradually, creating calmness in the city. Deep blues establish a feeling of mystery and enigma, while the oranges and reds that follow give a feeling of warmness and hope.

3. Discussion and Conclusion

Line, shape, dark and light, volume and mass, color, texture, and space, are basic elements of visual design. Combined use of these elements and ingredients in an organized way leads to a successful visual design. Designers have raised some guiding principles, or suggestions, for visual design. For example, visual equilibrium of the elements, repetition of visual colors, shapes or lines in planned or random pattern, visual movement by directing viewers along edges, shapes, and colors, contrast and emphasis, and visual unity[6,7]. In confocal images, the most attractive feature is the flexible use of repetitive elements in a fluid manner. These similar repeated motifs, arrange together with subtle modification, the natural world including our bodies is extremely well designed, not only in function but also in form. The repeated form or design in the natural world has high visual cohesiveness and unity, which we can see through confocal images easily.

As we have discussed in Figure 2 and Figure 4, the application of radial lines and light contrast are effective ways to direct the viewer's eye, and a powerful tool to emphasize the focus of an image. As the radial lines connect different elements and units together, forming a new visual motif, it becomes evident that appropriate use of radial format will greatly enhance the unity of an artwork.

Confocal images display a structure and local part in an unprecedented high solution, which inspires the artists to pay more attention to details in the visual design process. Without details, it is possible to design a good graph, but with the introduction of details, a more vivid and lasting visual impact is presented to the viewers. Containing details arouse the interests of viewers for the second-round of exploration of a design work.

As a summary, confocal images are not only art works themselves, but design templates to guide more visual designs. Displaying repetition, radiation, detail, and light and shade are four major principles, or thoughts, from confocal images. Confocal images may include more design principles than list in this paper. In addition, principles in confocal images can not only direct visual design but also direct painting or other forms of art. Experts in different fields may get different inspiration~~s~~ and enlightenment~~s~~ from confocal images. It is known that arts originate from life. Confocal technology and images have opened a door for designers to learn from nature and life, and re-construct their artworks.

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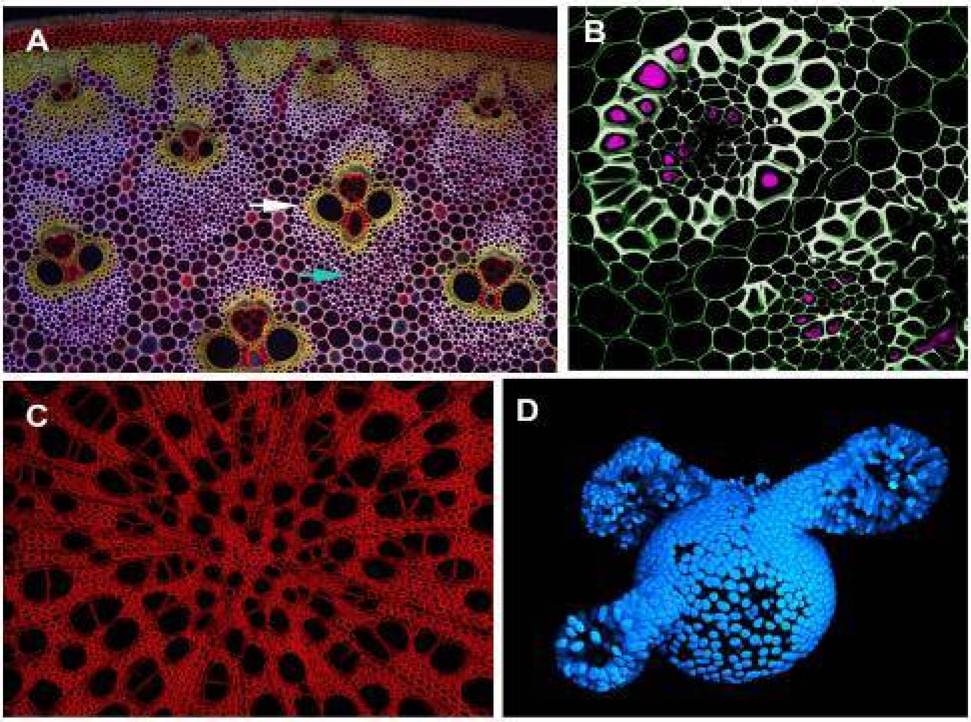

Figure 1. The representative confocal images indicating repetition as the first design principle.

A. A composite image of a bamboo plant stem. The white arrows indicate vascular bundles of a bamboo stem. In each vascular bundle, the big pores represent xylem, and the smaller circles, in yellow, surrounding the big pores, are phloem. The green arrows indicate parenchyma. This image was captured by Dr. Jim Haseloff (Department of Plant Sciences, University of Cambridge, Cambridge, UK).

B. The Rhizome section of Convallaria sp. (Lily of the valley). This image was captured by Dr. Guichuan Hou (Dewel Microscopy Facility, Boone, North Carolina, USA).

C. A cross section of wood. The net structures represent xylem of wood that are composed of fibrous tissues and vessels. This photo was taken by José R. Almodóvar (Mayaguez Campus, University of Puerto Rico, Mayaguez, Puerto Rico, USA).

D. The gut organoid of an in-vitro cultured mouse. Fragments of gut tissue were grown in-vitro and images were taken while they were alive to show cell motility. The nuclei of gut cells were stained with blue fluorescent dye. This photo was taken by Dr. Paul Appleton (Dundee College of Life Sciences, University of Dundee, Scotland, UK).

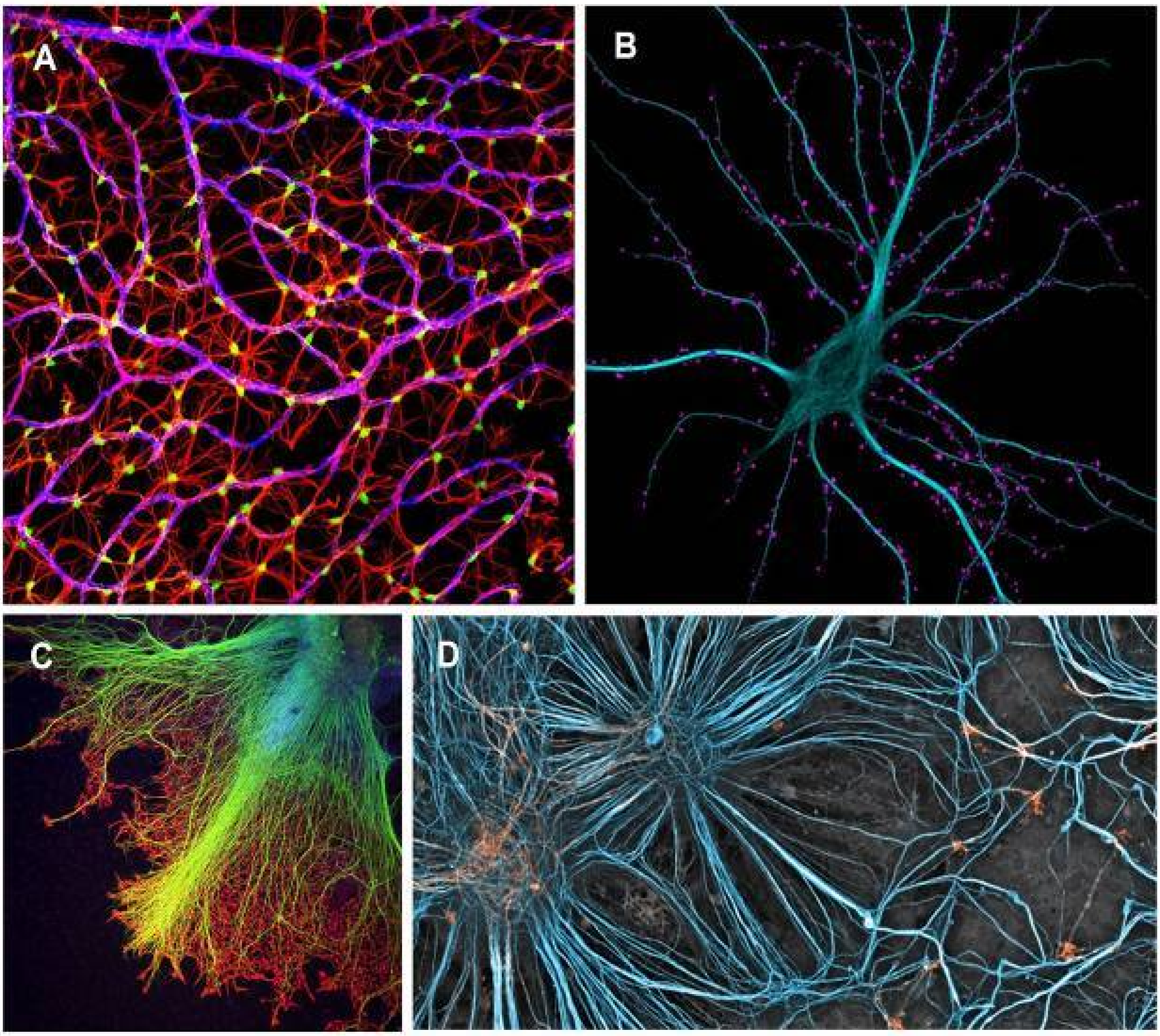

Figure 2. The representative confocal images for radial design thought.

A. Retinal flatmount of a mouse nerve fiber layer. Green fluorescence represents nuclei of nerve cells and red fluorescence represents nerve fiber. This image was captured by Gabriel Luna (UC Santa Barbara Neuroscience Research Institute, Santa Barbara, California, USA).

B. A hippocampal neuron interplaying with excitatory contacts. Dark green fluorescence shows a hippocampal neuron cell. Purple fluorescence shows the excitatory stimuli. This image was captured by Dr. Kieran Boyle (Institute of Neuroscience and Psychology, University of Glasgow, Glasgow, Scotland, UK).

C. Neurons surrounding with astrocytes in a human stem cell embryo body. Nerve fibers were stained with green fluorescence dye and astrocytes were stained with red fluorescence dye. This image was taken by Dr. Juan Carlos Izpisúa (Center of Regenerative Medicine in Barcelona, Barcelona, Spain).

D. Complex culture of murine embryonic brain cells. Blue fluorescence represents neurocytes and their synaptic structures. This image was taken by Dr. Andrew Woolley and Aaron Gilmour (University of New South Wales, Randwick, Australia).

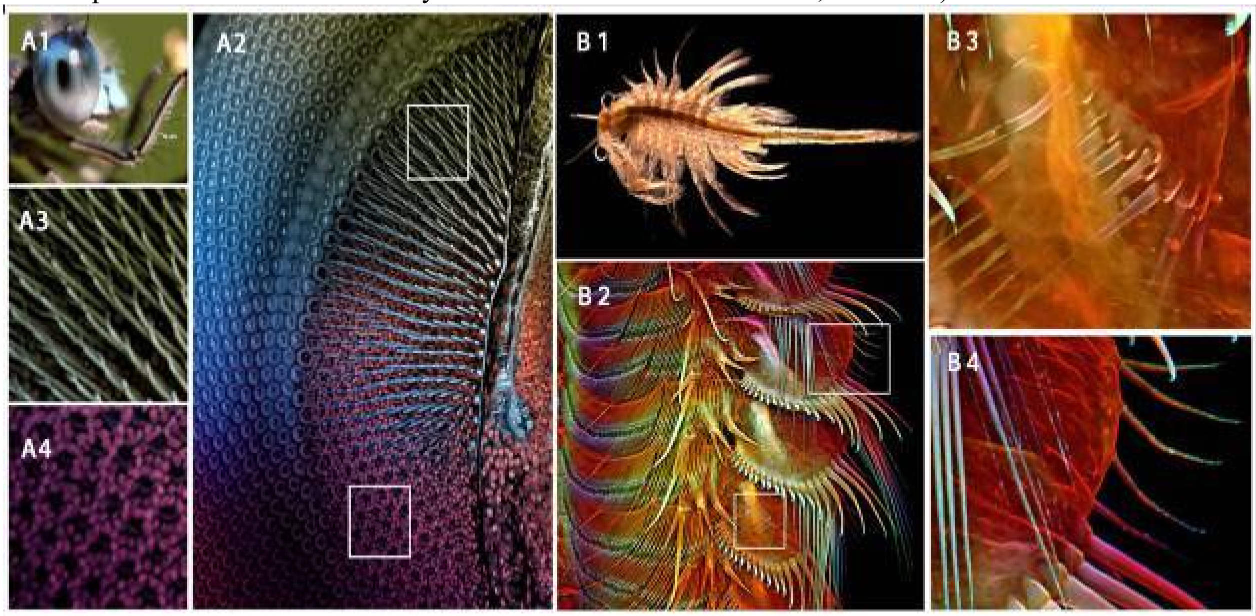

Figure 3. The representative confocal images for the detail design principle.

A1-A4. The different levels of a damselfly eye.

A1. Photograph of damselfly eye captured by camera.

A2. A confocal image of a crystal-like hexagonal lattice of a damselfly eye. This confocal image, was captured by Dr. Igor Siwanowicz (Max Planck Institute for Neurobiology, Munich, Germany).

A3 and A4. The white box indicates an enlarged image of the local parts of the graph.

B1-B4. Indicates different levels of a common brine shrimp.

B1. Photograph of a common brine shrimp captured by camera.

B2. A confocal image of the appendages of a common brine shrimp. This confocal image was taken by Dr. Igor Robert Siwanowicz (Janelia Farm Research Campus, Howard Hughes Medical Institute, Ashburn, Virginia, USA).

B3 and B4. The white box indicates an enlarged picture of the local parts of the graph.

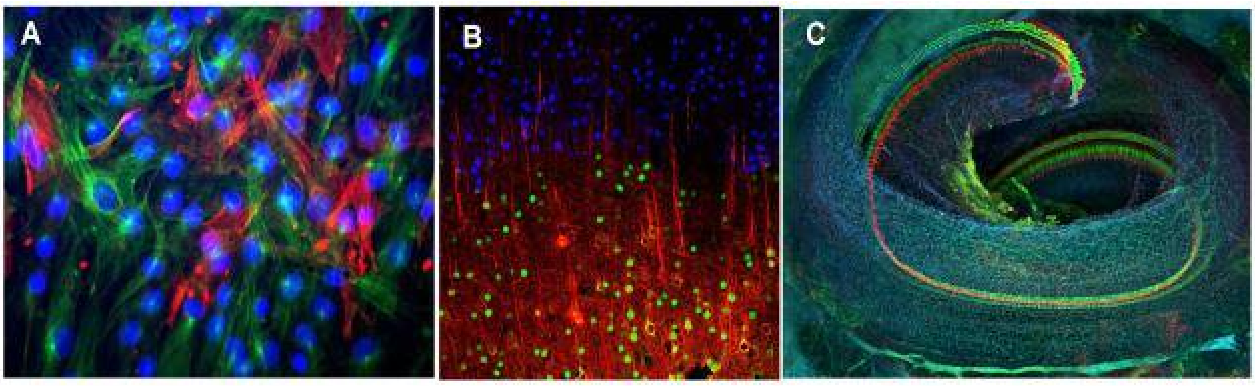

Figure 4. The representative confocal images for the light and shade principle.

A. Dissociated brain cells. Brightness of fluorescence reflects the abundance of certain proteins in brain cells. This image was captured by Eileen J. Kennedy (Verdine Research Group, Harvard University, Boston, USA).

B. Neurons of an adult mouse cerebral cortex. Neuron fibers in layer V were labeled with red fluorescence, and their nuclei were labeled with green. Nuclei from[5] other cortical layers were show in blue. This image was captured by Dr. Claudia Barros (Peninsula School of Medicine, Plymouth University, UK).

C. Structure of a mammalian inner ear. Different fluorescent colors show different parts of inner ear. Fluorescence intensity indicates the abundance of certain proteins in an inner ear. This image was captured by Mr. Glen MacDonald (Virginia Merrill Bloedel Hearing Research Center, University of Washington, Seattle, WA, USA)

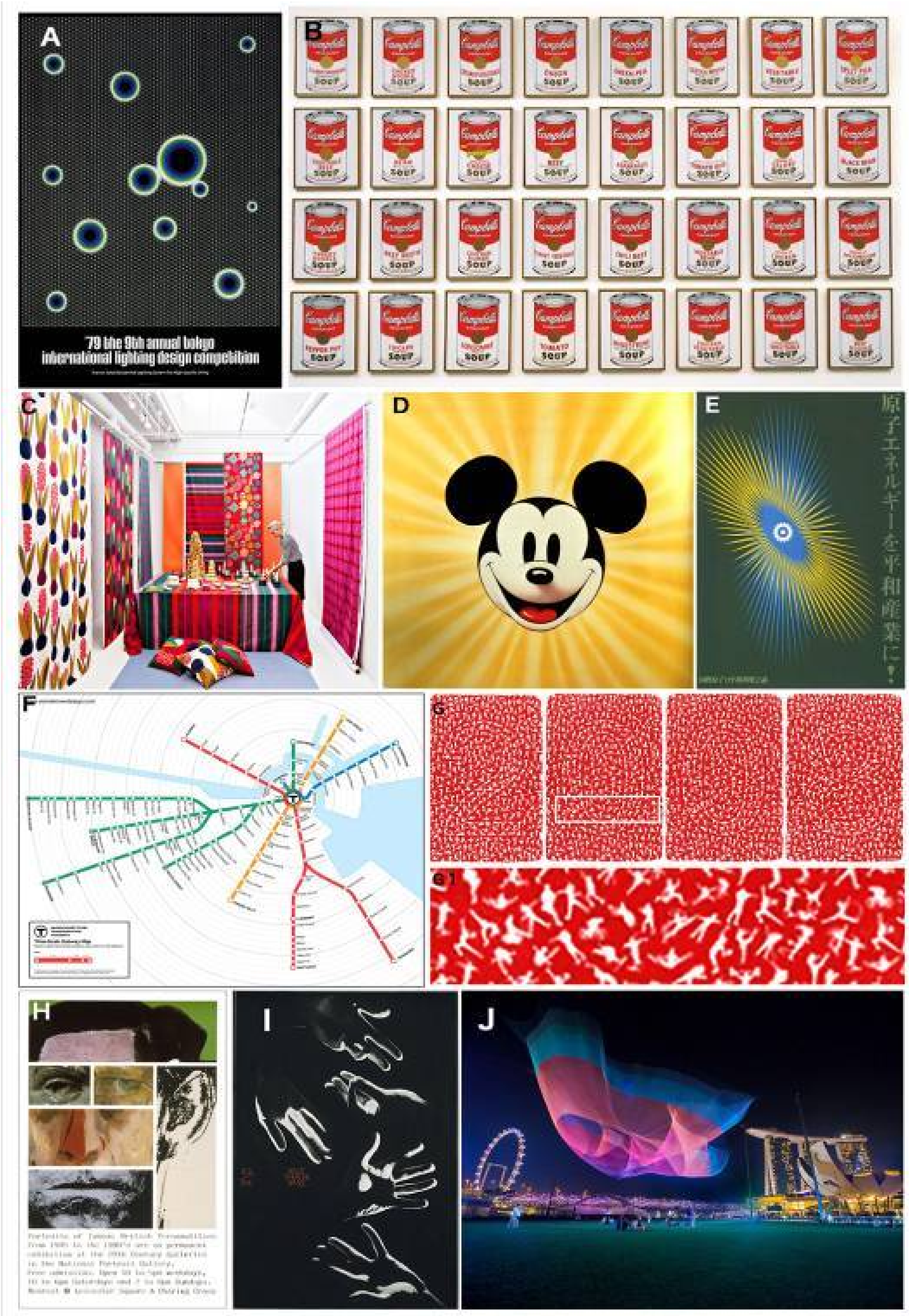

Figure 5. The application of confocal image principles in visual design.

A-C The application of repetition principle.

A. A poster for the 9th Annual Tokyo International Lighting Design Competition designed by Yusaku Kamekura, 1979 .

B. 32 Campbell's Soup Cans designed by Andy Warhol, 1962.

C. A image of a Marimekko Shop from the article “The Best Shops in Copenhagen, Stockholm, and Helsinki” written by Kate Maxwell.

D-F The application of radial design principle.

D. A poster of Mickey Mouse on his 80th birthday, 2008.

E. A poster for "Atomic Energy for Peaceful Industry" designed by Yusaku Kamekura ,1956.

F. Boston subway MAP designed by Stonebrown Design.

G-H The application of detail principle.

G. A poster for the Olympic Game in China designed by Hongshui Zhong, 2008.

G1. The white box indicates the enlarged image of the local parts of G.

H. A poster of the National Portrait Gallery designed by Alan Fletcher , 1990.

I-J The application of light and shade principle.

I. A Poster for Stadt Theater Basel designed by Armin Hofmann,1963.

J.'The Float' at Marina Bay, Singapore. Art: Janet Echelman, Studio Echelman Project Manager: Melissa Henry, Design Engineer: Peter Heppel Associates (Paris), Lighting Design: Martin Professional Pte. Ltd., Kurihara Kogyo Co., Ltd. Photography: Urban Redevelopment Authority (URA), Singapore, 2014.