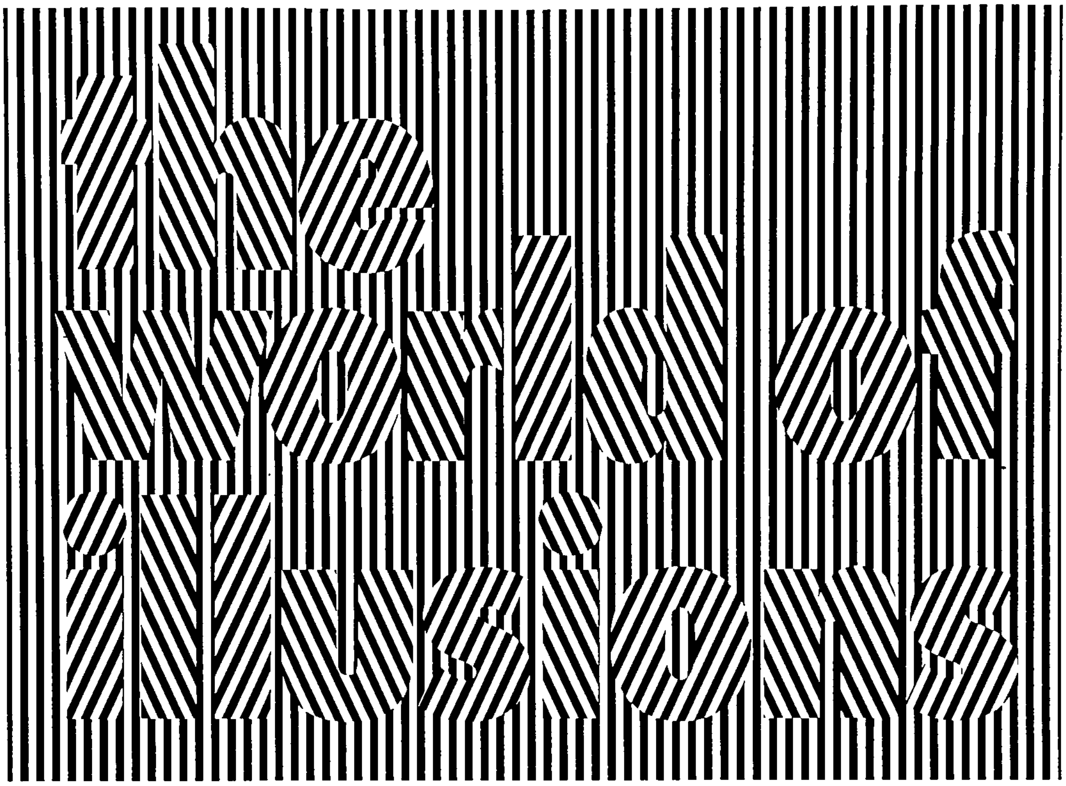

The World of Illusions

A Thesis Project submitted to
the Faculty of the College of Imaging Arts and Sciences
in candidacy for the degree of Master of Fine Arts.

Joel A. Rosen

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R·I·T Rochester Institute of Technology

Approvals

Chief Advisor:

Robert P. Keough ______________________

Date: 4-19-00

Associate Advisor:

James Ver Hague ______________________

Date: 4/19/00

Associate Advisor:

Marianne O'Loughlin ______________________

Date: 4-19-00

Chairperson:

Nancy Ciolek ______________________

Date: 5-8-00

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Joel A. Rosen

3/1/00
Date

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Determining Subject Matter

The development of the thesis project was supposed to begin with the selection of a subject. Making a selection proved to be difficult for me. I had many concerns about whether my topic would sustain not only my own interest throughout the development process but also the user's interest upon completion. I was also concerned with the relevance and usefulness of my project. After many fruitless efforts, I began to approach the problem from another angle. Rather than selecting a subject without any specific criteria and attempting to determine its suitability, I developed a list of goals that I felt the thesis project should meet. Armed with this list, I knew that I could confidently decide upon and remain satisfied with a subject for my thesis. Defining these objectives for the project was actually surprisingly easy. Particular aspects of these goals had been present in much of my work prior to developing the thesis project and new concepts and theories I was exposed to in both CGD and IT classes introduced new components to the list. On-going discussion with other CGD students, faculty and non-CGD participants of previous thesis exhibitions helped in clarifying less distinct aspects of the emerging vision of what my thesis would be.

A Teaching Component

The first goal on my list of objectives was to make my thesis project educational. Almost any thesis project would have some aspect of education within it. While often not clearly exhibited and directly intended, even games and purely artistic endeavors shed new light on their subjects and shared new ideas with their viewers. For me, however, the educational aspect had to be central to the project. Bringing new understanding of a topic to the user was critical to my definition of CGD (Computer Graphics Design). This is not to say that I believe projects less concerned with educational content and more involved with artistic expression are any less valid, they just were not what I felt my thesis project should be.

Informative

The goal of educating the user demanded a clearly defined and logical approach to whatever subject matter I ultimately chose for my thesis. Whether presenting new ideas or presenting well-known concepts in a novel way requires consideration and grounded analysis of the subject. Only after developing my own understanding of the subject matter could I expect to begin to teach the user about it. In order to educate the user, I would have to begin the process by educating myself.

Non-technical

Working with computers everyday and surrounded by people with similar interests, it is easy to lose sight of the rest of the world. Whether we admit it or not, we in CGD enjoy using computers. Outside the lab, this is not always the case. Choosing a topic involving purely technical issues was tempting, but in order for my thesis to be a success with people outside of the lab, I had to resist that temptation and select a non-technical topic.

Relevance

Perhaps the most critical concern throughout the thesis project for me was relevance. On many occasions, in review of many projects by other CGD students, I frequently arrived at the conclusion, "So What?" I felt that even if my topic was of interest to me, why would it be of interest to the user? Any purely personal interest could never survive this sustained scrutiny. My topic would, in some way, need to be as relevant and applicable to everyone as possible. It is impossible to assume that virtually everyone would be interested all of the time, but I wanted to make my project as relevant as possible to even the most ambivalent user. Presenting the information in simple, direct, compelling and entertaining ways would prove to be central to achieving this goal.

Relevance to CGD

While my topic needed to be of importance to myself (in order to sustain my interest through the development of the project), and hopefully of interest to the general public, the best possible subject would also have specific relevance to the field of computer graphics. Regardless of the subject, both the development of the project, and the final project itself would yield some insight specific to the field of computer graphics, but this knowledge would only be of a technical, procedural nature. A subject that explored some fundamental aspect of the human computer interaction (HCI) would be of much greater value to myself and to anyone interested in the field of computer graphics. Defining this objective for the thesis was particularly helpful in focusing my search for a topic. Even though I still had not settled on a topic, I had established criteria that would satisfy my personal goals for the thesis project. My project would need to explore the benefits and limitations of the computer as a teaching tool. Rather than simply using the computer to present the subject, the computer had to be a part of the subject.

The Computer as a Tool of Communication

Ultimately, the goal of all CGD students is to develop methods of communication that utilize new technologies. Developing a greater understanding of these technologies is critical to our ability to produce projects that are successful. My project would have to involve an understanding and demonstration of how the computer benefits and detracts from the development of new forms of communication.

Edutainment

Perhaps even more important than a relevance to the CGD community, the project needed to be relevant, educational and entertaining to the user. The single night showing of thesis , the "one night of glory", posed significant challenges. My initial feeling about the "one night stand" was that it did not allow serious viewing of our projects. They would be gone before anyone had a chance to delve into them and fully explore them. Attending the thesis show of the preceding year was very important to my development of a sense of what the thesis project should embody. It was clearly not an environment conducive to serious, thoughtful exploration of a project. In order for a project to be successful in this setting, the project needed to balance education with entertainment. It had to be not only thought-provoking and educational, but also easy and fun to use. In reviewing the projects from the previous year, within the scope of the thesis show setting, the most effective projects achieved the best balance of these demands. In my opinion it was better to err on the side of entertaining rather than educational. This perception might seem shallow, but I felt it more accurately reflected the reality of working in the commercial sector. Before you can teach someone, you have get (and hold) their attention.

Modular Construction

The thesis project represents the culmination of the education of the CGD student. Not only should the project represent an understanding of the nature of the field, it should also be the largest undertaking of the student's academic career. Developing a project of this size and scope accurately reflects the nature of work in the commercial sector. Throughout the courses preceding thesis, my projects gradually increased in size and scope. As I learned more about CGD and multimedia in general, I strove to become more efficient and practical about the underlying structure of my projects. Good design makes the most of the current level of technology to best present the content. It does not suffer because of the limitations of the technology. I felt that developing a modular approach to the thesis project would yield many benefits and teach me more about working in this way in the future.

Extensibility

Extensibility refers to the ability to efficiently add to or delete parts from a project through modular construction of the programming. The concept of extensibility is central to the work of programmers; however it is not to the artist. Like jigsaw puzzles with hundreds of unique pieces, works of art are often composed of countless inextricably interconnected unique parts, each existing solely within its place while relating to the whole. By contrast, digital media exists within a different paradigm where change is constant and expected. Experience in programming classes taught me that good design plans for and accommodates changes in stride.

Scalability

The large scope of the thesis project demanded that work begin on some portions of the project before the entire project was even fully defined in order to define the standards that subsequent components would adhere to. My initial proposal for the thesis project included demonstration of 12 to 15 illusions. Ultimately, the final number was 11, but in the time prior to thesis show, the number grew to as many as 15 and fell to as few as 8. Considering possible applications of the project beyond the immediate focus of the thesis show, I chose to design the architecture to accommodate later versions of the project. I envisioned versions of the project using fewer pieces for more focused applications, and larger versions using many more pieces as they were developed and incorporated into the project. These alternative versions could be also be easily presented on a variety of monitor sizes. Simply adding or removing connections to the modules from the main page is all that would be required aside from the development of the modules themselves.

Efficiency

Modular construction would also provide a way to easily reuse common elements throughout the project. Basic navigational and user interface structures would be built only once and then could be reused over and over again as needed in each module. Construction of the graphics, development and debugging of the Lingo code would all be simplified in similar ways as well. Working on smaller, discrete parts had several advantages; first it would be less demanding on the processing power of the computer; second, it would be less complicated for me to start and stop work on specific portions of the project without becoming lost or confused; finally, it would allow me to work much more efficiently over a long period of time by dividing the larger tasks into smaller more manageable parts.

Web Delivery

Unlike fine arts gallery shows that run for days, weeks or months, the CGD thesis show lasts for only one night. I was keenly aware of how limited an audience my project could reach during that short time. The amount of time and effort required to develop the project demanded a greater opportunity to be accessible to viewers. I felt that the best way to achieve this goal was to incorporate the development of some form of a web deliverable component to the project. However, locally presented, bandwidth intensive multimedia cannot be simply adapted to the limited bandwidth environment of the world wide web. Modular construction provided a way to deliver the core components of my project without requiring the high bandwidth available to the locally delivered CD-ROM version. The individual modules could be created with an awareness of being suitable for the WWW and then delivered over the Internet as discrete parts, downloaded in small portions as requested by the viewer.

Movie In A Window (MIAW)

The key to developing the thesis project in this modular way was MIAW. Early in my studies, I was made aware of MIAW and its potential but never had practical opportunity to test the benefits and discover pitfalls of its use. Developing the thesis project in this manner required accepting certain limitations in design and developing new skills in methods of multimedia construction. While I learned a great deal about the subject matter of my thesis, the single greatest area of education in the technical realm of the thesis project involved learning the techniques and mechanics of MIAW. More technical discussion of MIAW will be addressed later in this document.

Finally Selecting the Topic

Once the list of requirements was defined, choosing the topic became much easier. I was able to focus in on a subject, refine the idea and develop a vision of the final project. Subjects involving the visual arts quickly came to the front because of the goals of relevance to CGD and the users. My thoughts ran quickly through teaching concepts of art, to art history, and then to architecture. This led to interactive demonstrations of the concepts of three dimensional modeling and navigation through virtual space. This continued further to teaching the fundamental components of perspective, which turned back towards basic art theory. This related to the basic concepts of color theory, and the highly individual nature of color perception and ultimately to visual perception and illusions. Interest in the visual and psychological response to illusions had been a facet of much of my undergraduate work and earlier graduate projects. A chance viewing of a televised presentation of basic psychology and visual perception experiments opened my eyes to a new idea for the thesis project. Animated demonstrations in the program showed me a profoundly more compelling way of presenting this type of material. Finally selecting the topic of illusions was easily confirmed by researching the existing body of knowledge and seeing the vast potential for exploration.

Library Research

I began my research into the topic by looking at books in the Wallace library and Rundell library. Initial catalog searches uncovered a bounty of material. Utilizing a variety of keyword searches yielded titles in the areas of art and art history, the sciences of physics and optics, the field of psychology as well as books purely for entertainment. While the books that were based in the fine arts were personally interesting, they did not contain the direct presentation of the material that I was seeking for this application. The titles involved with physics and optics were generally too technical in nature, some containing little or no salient visual presentation. Some of the titles within the field of psychology also tended to become too technical and statistical, delving into biomechanics and neurology. However, there were several books that presented the material in the direct and simple explanatory nature I was seeking. These books formed the bulk of the research component of my thesis project. By comparing and contrasting ideas and theories in these texts, I was able to learn more of the psychological factors of perception and illusions that would become the basic explanatory component of the final project. The entertainment level books, while usually too simplistic or completely lacking in any scientific or explanatory content, often presented the best visual examples of the illusions.

Internet Research

After searching the libraries for printed material, I searched the internet for electronic material. I found many sites presenting material detailing specific illusions. Most of these examples were intended to present the technical skill of their creators, not for the purpose of educating the viewer. Many of these sites involved complex programming and detailed examples and explanations of particular phenomena. They were not intended as educational tools for the mainstream viewer. I also discovered a few sites from universities and museums that were presenting broader approaches similar to my intended project. These sites were both inspiring and discouraging. While similar in scope, they did not convey the material effectively in the interactive fashion that I felt would be the benefit of a multimedia format. These sites were very useful resources for content and ideas, but I felt that I could produce a project that offered a more direct learning experience. They were, however, far greater in scope and depth than I could produce working independently, with limited expertise and within the limited timeframe of the thesis project. Despite this realization, I did feel that at the time of my presentation, my project could contain more user interaction and direct visual response than these sites. I knew, however that like all work in this new field, with so many resources committed to development, my project would soon be outpaced. In the time since first discovering them, these sites have continued to develop in scope and use of interactivity.

Prior Experience

Once I had chosen my topic and begun to develop the project, I shared my ideas with faculty and colleagues. Those that had known me and my work prior to thesis and graduate work saw a common thread I had not considered. My undergraduate work in painting and printmaking was not specifically about illusions or perception. It was also not interactive. Much of it did, however, work within similar realms of interest. Many of my paintings explored aspects of perception and recognition. My printmaking often involved aspects of pattern development, color interaction and visual response. Most importantly, I approached work within the realm of fine arts as experiments that involved the viewers involuntary interaction and response to the visual presentation. One particular project involving changing pattern development in printmaking held potential for an interactive experience. While learning to develop interactive projects in prior coursework, I revisited this work and developed an interactive piece much as I had envisioned while creating the original printed work. This chain of related experiences had serendipitously laid a groundwork for developing and testing ideas much like those envisioned for the thesis project.

Designing the Interface

After the subject matter was determined and preliminary research begun, I started to develop the overall visual design of the thesis project. From the beginning of this process, certain components of the design were immediately apparent. Accommodating the modular architecture and minimizing distraction were the primary concerns of the design. Simplicity of the user interface and legibility were also of importance. Determining the best ways to accomplish these goals came through development and testing of designs and defining what approaches were appropriate for the project.

Metaphor vs. "Look and Feel"

The first and most important aspect of the design to be decided was the overall "look and feel". In keeping with the understood need to attain maximum user attention, I quickly ruled out the use of any sort of metaphorical interface. Navigation of complex information architecture can often benefit from the creation of a interface metaphor. By mimicking an existing mental model such as a map or a blueprint, the multimedia designer can create an information architecture more easily understood by the user. Creating and reinforcing this model for the user often requires developing a visual interface that contains imagery not directly related to the information presented. If the subject matter of the project and the design metaphor share common ground, the metaphor is more effective, easily supported and ultimately benefits the user ability to understand the organization of the project. Unfortunately, because my subject matter dealt with visual ambiguity, any metaphor could easily become distracting and confusing. For these reasons, I quickly determined that the use of any sort of visual metaphor as a critical component of navigation would not be successful. Instead, I would simply rely on a overall, clear and simple, unified visual style.

The use of a unified "look and feel" has the benefit of creating a visual impression upon the user that can influence their perception and attitude and even their mood. While a design metaphor relies heavily upon user experience, a "look and feel" approach does not demand as much of the user. Instead, it sets a tone by more subtle cues. The use of visual arrangement, typeface, color, sound, etc. all contribute to the "look and feel" by suggesting connection to previous user experience. Unlike the metaphor however, these cues do not demand fully understood user experience. They only draw subtle connections that influence the user's perception. The selection of the elements of the interface therefore demanded careful consideration.

Color

The first component of the interface I had to decide upon was color. One of the most drastic differences of computer based media is the use of color. In print media, the use of color is directly tied to the economics of the project. In multimedia, color is free. Well, almost free. Instead of restriction by budget, color use is restricted by bandwidth. The use of color on the WWW is constantly held in check by the limitations of throughput. In CD-ROM based projects, limits of storage space and video systems limit the amount of color depth available to the designer. Moore's Law of increasing processing power and constant improvements in all areas of computer hardware continue to ease these restrictions.

As I began to develop the individual modules, I quickly discovered that the illusions themselves were highly dependent upon the proper use of color and more importantly, contrast. One of the most critical lessons of the thesis project was coming into focus. Most of the illusions discussed in the texts were shown in black and white. I assumed most probably because of the budget constraints of printing, and the incorporation of the illustrations within the text. While these factors are most certainly true, the use of black and white was also far more effective for presenting the illusions as well. Even the entertainment focused, non-technical books presented the illusions in black and white. It quickly became clear to me that any other color scheme would be arbitrarily imposed on the interface and would potentially detract from the impact of the presentation of the illusions. I was initially disappointed to come to this conclusion. The richness of color in the world around me, in the projects being developed by classmates, was not mine to use. I knew that the stark contrast of black and white would be the most effective, but I was still disappointed. Early user tests soon confirmed the truth. This made me considerably more comfortable with the strictly limited color scheme. I also discovered that the limited palette aided in focusing the user on the material, pure white text held much greater attention than gray. Ultimately, there would be more color in the project, but it would be implemented only as needed. The limitations imposed also became somewhat of a freeing element. I would not have to agonize over decisions regarding color.

Typeface

Selecting a typeface was relatively a simple task. Foremost concerns were for legibility and readability on screen. A wide range of weights, italics and widths would be needed to accommodate all foreseeable text applications. Selecting typefaces is a highly subjective area. Describing their characteristics is not easily quantified. One can specify weight, slant, x-height, etc. but these do not capture the essence, flavor or "voice" of a particular typeface. Past experience narrowed the list and simply looking at specimens led to the final decision. Decorative fonts, lacking versatility and range of weights, were easily ruled out. Traditional serif fonts often lack on-screen readability in smaller sizes and tended to be "too old-fashioned" for the developing black and white modern style of the interface. Sans serif fonts, with extended range of weight remained. Any one of these would have been acceptable. I settled on Frutiger because it met all of the needed characteristics and it had the right mix of modern style and friendly curve.

Icons

Icons can be beneficial to the user interface if they are designed well and used appropriately. Icon design, like the use of metaphor, relies upon prior user experience to comprehend their meaning. If the meaning of an icon is understood, it can support and extend the interface design metaphor, extend the functionality of an interface design across language barriers and most importantly, aid the user in understanding functions that might be difficult or impossible to describe in only a few Arabic text characters. The drawback of icons is the complete reliance on common user experience and comprehension. If the user cannot understand the icon or if text labels are needed to aid comprehension, the icon is not serving its purpose and the entire program suffers as a result. I chose not to develop navigational icons for much the same reasons that I chose not to develop a design metaphor for the interface of my thesis project. The visually confusing subject material presented to the user would be ineffective in describing functionality. Instead, I chose to develop the architecture so that very little navigation would be needed, and I would use concise labels instead of icons as buttons.

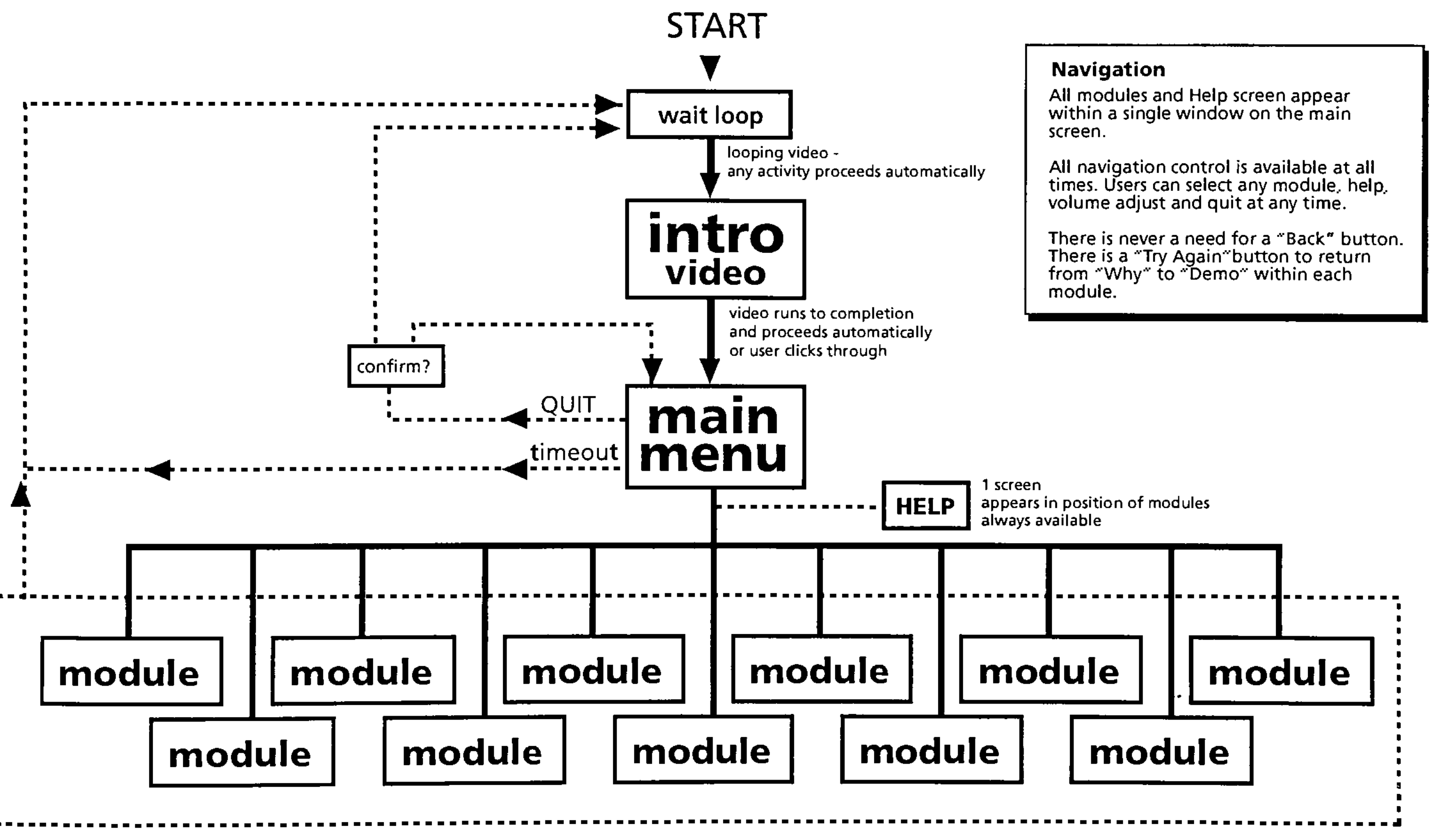
Text labels would indicate the available choices to the user for selecting teaching modules, help, volume control and quit on the main interface. Within each module, consistent labeling and location of navigation and control elements would allow the user to quickly learn how to navigate and effectively free them from actually reading and comprehending navigational functions. The largest array of choices on the main page involve the list of illusion modules. Icons could theoretically have been developed to indicate these choices to the user. Icons would not have eliminated the need for associated text descriptions. Many of the illusions demonstrated have formal titles based upon the names of early researchers credited with their discovery. These names are fairly universally used in the texts and provide a distinct (if not descriptive) name to associate with the illusion. Other illusions lacked formal titles but often have simple, universal descriptive names. I was aware of the language specific limitation of my project. All text explanations within the modules and the module titles on the main interface would need to be translated. Only a few remaining text elements could have replaced by icons. If the project was to be translated, the use of icons would save only a small portion of translation work.

Transitions

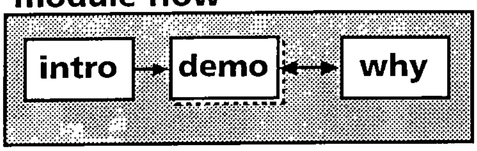
When designing the architecture and navigation, one is primarily concerned with the order that information will be presented to the user but it is easy to overlook the transitions between the screens of information. This sequencing greatly affects the user experience. Preliminary tests revealed a need to carefully consider these transitions. Text and design elements and user controls appearing and disappearing within the high contrast black and white interface were particularly abrupt, almost painfully jarring. The focused visual attention the project was designed to produce made the problem even greater. I found that quickly fading the elements in and out was far more pleasing and effective. In addition, by bringing elements on screen sequentially, I could easily and subtly direct the users attention to the appropriate areas. Developing this type of transition had a considerable drawback. The automated transitions available in Director do not include a simple fade. There is a "pixel dissolve" transition that was somewhat acceptable but it had two shortcomings. It was unpredictable in duration, depending on the processor speed of the machine the program was running on, and it was drastically different in appearance and performance from Macintosh to Windows operating systems. Rather than rely on this automated transition, I chose to develop a consistent use of the "blend" ink effect and change it over time with Lingo scripts. This presented more work and programming challenges than the automated transitions, but produced a much more pleasing visual effect. More detailed explanation will be presented in the individual module section of this report.

Navigation

Organization of information presented in multimedia can take many forms; straight linear progression like a book going in one direction from page to page; hierarchical tree structures like an organizational chart where information is nested deeper and deeper within separate branches; webs of many cross-linked connections; or hybrid combinations. Designers of information architecture take advantage of these systems to control and direct the user. In order to keep the navigational structure of my project as simple and easy to use as possible, I developed an hybrid architecture, one with almost no branching or hierarchy at all. From one main screen, the user can always have access to any area of the project. Use of MIAW allowed me to open the separate modules within a single small window on the main screen around it. In this way, the user is able to move from one module to another without requiring navigation out of the current module and back to the main list. Within each module, I consistently used a very short linear progress of introduction, demonstration and explanation. Once past the introduction, the user can pass back and forth between the demonstration and explanation sections. It is essentially impossible for the user to become "lost" within such a shallow structure.



module flow



Design of the Main Screen

Once the information architecture of the project was determined, I could begin to visual layout of the component parts of the project. This task primarily involved determining and mediating the physical spaces required by and available for each element of the main screen.

Resolution

The first decision involved the overall screen dimension. Historically, the standard size for multimedia projects has been 640x480 pixels, the resolution of a 15" monitor. As larger monitors become more prevalent, multimedia developers are starting to work with greater screen resolutions. However, if a project is designed for the larger monitor area, it becomes essentially unusable on a smaller screen. The educational computer market, a large part of the target audience for my project, tends to be the least funded and therefore using older and less advanced equipment like 15" monitors. Despite my desire to work with a larger screen resolution, I chose to not exclude even the most basic computer user from viewing it and developed my project for the smaller 640x480 screen.

My decision to use MIAW presented certain challenges, one of which was accommodating a variety of monitor sizes. The position of the window for the MIAW is determined in Lingo scripting based on the edges of monitor. When the program is run, it must check to determine the monitor dimensions (which can be any of a dozen or so, ranging from 640x480 to 1600x1200) and adjust to location of MIAW to the appropriate placement within the surrounding 640x480 screen layout, which is automatically centered within the monitor's dimensions.

An additional consideration in determining overall screen size was the web component of the project. The width of the web browser window can be set to be only slightly less than the width of the monitor, but it has a reduced height due to the additional navigation buttons along the top edge of the window. Within this reduced area, I wanted to retain as much look and feel of the CD-ROM version while still repurposing as much of the CD version as possible. This space limitation would ultimately, only affect my decision regarding the size of the illusion modules, as these components were the largest part of the project and the would be extremely difficult to resize for the web version. The animated rollovers for the list of illusions would not work within the limited bandwidth of the web version and would need to be recreated anyway. The universal controls; help, quit and volume controls, would not be included on the web version as well. Considering the web version early in the development process made the construction of the web version much easier in the long run by eliminating as much reconstruction as possible.

Module Size

Determining the module size was a critical design decision. All of the modules would need to be the same size. Changing sizes for modules would significantly complicate their development, the implementation of the MIAW, construction of the web version and ultimately detract from a unified design solution. Determining the final size involved seeking out the greatest variance in needs for the modules, even though not all the illusions had been designed (or even chosen at this point). Developing preliminary static designs helped to arrive at the final decision. Mockups at various sizes were made and tested on myself and other viewers to determine how large the illusions would need to be to be effective. Working outward from this window, to accommodate navigation and interaction controls, and design elements, I determined a range of functional dimensions from which to make the final , somewhat arbitrary size decision, 384-256 pixels.

The List of Modules / Rollover Buttons

While the final list of illusions remained unfinished until just before thesis show, the space allocated to the list on screen had to be determined in conjunction with the other components of the main screen. Test with typeface, font size, weight and colors helped determine the acceptable font size, based on readability and character definition at screen resolution. Working with a desired type specification and allocated space within the main screen, I was able to verify that the working list of illusion names would fit in the layout and how many items would fit vertically. This helped to finalize the list at 10 modules.

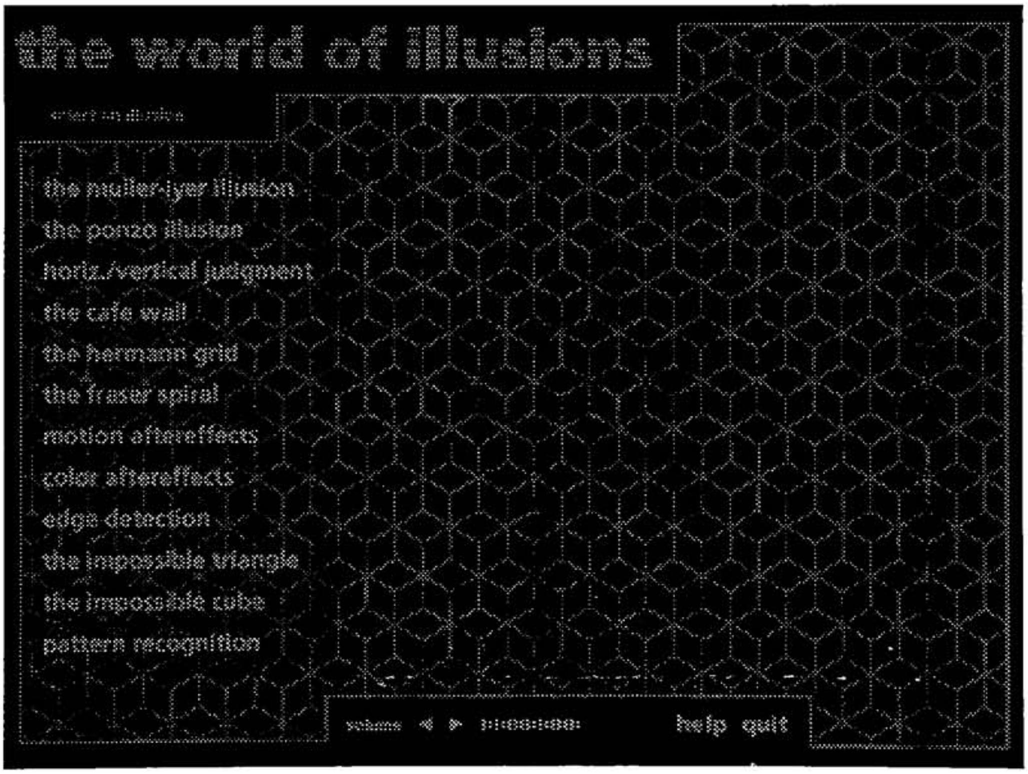
Help, Quit & Volume Adjust Buttons

These elements are grouped together because they share common value within the information architecture of the project. They are not associated with the subject content and are therefore located apart from the list of illusions. They are given less screen space in accordance with this reduced importance as well. While they are always available to the user, their relative importance (or unimportance) suggests that their screen presence should be as minimal as possible. I chose to allocate a small area at the bottom of the screen and to hide them from view, allowing the user to call them up simply by approaching their vicinity with the mouse. Arguably a controversial approach to the user interface, I felt that this disappearing act freed the screen from any undesirable distraction.

The Title Bar

The only remaining element for the main screen was the title bar. While not providing any interactive function, the title bar simply acts as a header element, containing the elements within a defined space.

Ultimately, the layout of the main screen became a balancing act between the space required for the module and the list of illusions. The title bar and universal navigation elements simply acted to fill out and balance the design. The visual appearance of the elements themselves would be determined in conjunction with demands of the elements of the modules.

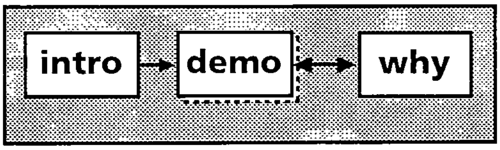


Building The Modules

Workflow

The design of the modules was derived from the initial linear workflow of introduction, demonstration and explanation. Each module would consist of these three sections and the all of the navigation and interaction controls would be consistent in appearance, location and behavior in all of the modules.

module flow



Each module's introduction screen consisted of 4 parts; a title element consistent with the title from list of illusions on the main screen, a brief text teaser about the illusion, a small illustration or animation of the illusion and the "try it" button.The central part of each module was the demonstration. These screens were the heart of the project, requiring the most research, development work and testing. Wherever possible, elements were reused for efficiency and consistency.The last part of each module was the explanation, consisting of a single title, "Why", a brief explanation of how or why the illusion works and a "try it again" button.

For all the modules, the illusion titles and the "Why" title were consistent in placement and font specifications. Similarly, all of the navigation buttons, "try it", "why" and "try it again" were consistent in placement and font specification. The allocation of space for the text elements in the introduction and explanation were designed much the same as the list of illusions, tests for optimal readability and maximum character counts were done. Once a font specification was arrived at, it was set and adhered to. Explanatory text elements were written and edited to conform to the type specifications and to fit comfortably in the allocated space. This strict limitation had the added benefit of forcing me to write directly and concisely, keeping the users reading requirements to an absolute minimum.

In addition to providing enhanced usability, this uniform structure and design allowed a great savings in development time. The first module was constructed as a template, with only introductory and explanatory pages containing only text placeholders and the demonstration page contained only the buttons to navigate through to the subsequent pages. The construction of this template was carefully considered and built as efficiently and cleanly as possible, as it would be reused for every module.

The Transitions

The greatest difficulty I faced in the construction of the module template was the specially developed sequential fade in and out of elements. The highly contrasted black and white design required subtle transitions to ease the sequential appearance and disappearance of elements on screen. The automated transitions built into Director would have been adequate for the project if it was only going to be run on Macintosh computers. However the fast dissolve transitions do not work well on the Windows platforms. I had to develop an efficient method of handling this effect because it would be used dozens of times throughout the modules. For example, on each introduction screen, 4 discrete elements appear on screen and subsequently disappear. I could have accomplished this by creating dozens of versions of each element, ranging from black to white and used a rapid castmember swapping effect to animate the illusion of a transition from black to white. This would have been the visually ideal solution but would have required vastly greater amounts of tedious castmember development time, much larger files size and potentially decreased performance time due to increased castmember loading times. (I did eventually use a similar animation effect elsewhere in the project, for the animated illusion title rollover effects and the windowshade effect for the help and quit buttons and volume adjustment controls.) So I had to develop another solution utilizing the castmember blend ink effects. Each individual element had to be placed on screen with a blend setting of 0 (transparent) and the blend setting then incrementally increased to 100 through a short repeat loop. This method was significantly more simple and efficient from a file management and storage space viewpoint. In the development phase, it presented several unexpected problems that required some extensive debugging. Once a consistent, reliable method was developed and thoroughly tested, I was able to automate the process in Lingo scripting and move forward with developing the interactive portion of the modules.

The Slider

The next critical element to be developed was the slider mechanism that would be the primary form of user interaction within the demonstration portion of the illusion modules. Sliders are basically an analog control to facilitate user interaction within a digital environment. Rather than a digital (numeric) adjustment method, the user is presented with physical representation such as a switch to move or knob to turn. These control mechanisms are merely illusions themselves, they are not actual physical elements. Instead, they provide a way to translate visually discerned change to digital information (numerical data) the computer can use to perform other functions. Sliders also seem to be fun to use. Interactive controls that provide tactile feedback to the user such as sliders that move with the mouse and buttons that appear to depress when clicked greatly enhance usability and therefore make the user experience more enjoyable and memorable.

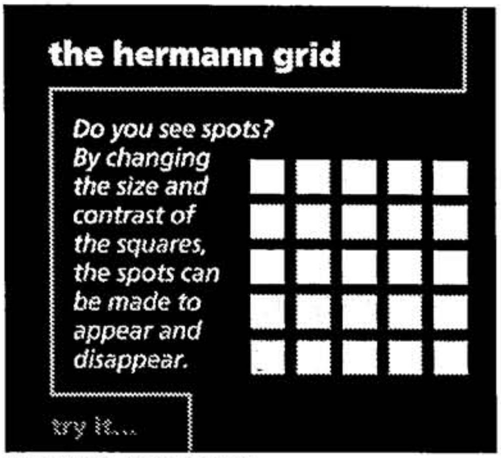
The consistent design of the modules demanded that I reuse my slider controls in many of the modules. Therefore, I needed to construct it in such a manner that it would be easy to adapt to many uses. If the slider mechanism is built intelligently, it also provides easily adapted pieces of information to the programmer, readily converted to many applications. In simplest terms, the slider mechanism works by restricting the movement of a object on the screen to a single fixed position in one axis and within an prescribed area along the alternate axis. For instance, a slider handle usually can move to the left and right, but not up and down. The position of the slider along the axis is continuously checked and recorded by the program and that numeric information can be passed along to other functions. In the case of my thesis project, I used that data to move, change the size of or change the opacity of other objects on screen. The slider used in the modules is permitted to travel a range of 200 pixels along the X axis (horizontally), starting at a point 40 pixels from the left edge of the stage (the visible area of the module). So the number recorded ranges from 40 to 240. This continuously recorded number is reduced by 40 and then divided in half to record a range from 0 to 100 in direct proportion to the movement of the slider . This number can then be further adjusted to provide a specific range for any purpose. For example, in the Hermann Grid module, this number is multiplied by .4, to provide a range from 0 to 40. This number is then used to set the height and width of each of the blocks of the grid, effectively scaling them individually, practically in real time, in response to the user's control of the slider mechanism.

Selecting the Illusions

The list of illusions was determined during the development of the screen design and module design. Research and planning for the design of the demonstrations took place as the technical issues were identified and resolved. Once these obstacles were overcome, work on the modules began in earnest and the knowledge and ideas from the research was put to use. Determining which illusions would be part of the project depended upon several factors. Popularity and familiarity of the illusion, whether it was well-known was important. Prior experience with the illusion would demand less of the user in terms of introduction and explanation, acting more as reminders than introduction of new concepts. Illusions that best benefited from user control, interactivity and animation were more interesting as well. It was important to find examples that could be seen in new, more revealing ways through computer presentation. I did not want to make a digital version of static examples that already existed in print media. Some of the illusions finally chosen were simple to design and develop, presenting no unexpected problem. Some were not, instead requiring rethinking, developing new approaches and in a few cases, giving up and eliminating them from the project. Developing the demonstrations required extensive testing on myself, friends and classmates to verify their effectiveness, experimenting with alternative methods of presenting the information and often some dumb luck in stumbling upon solutions to unexpected problems.

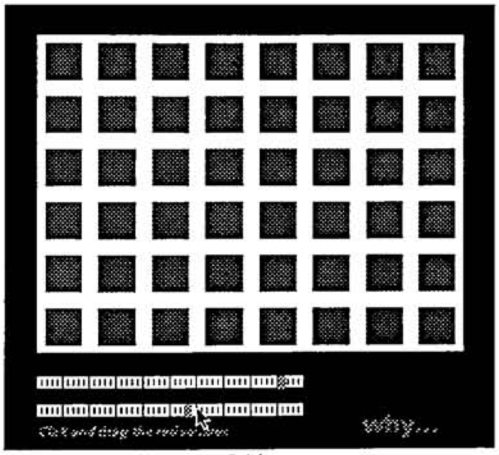
The Hermann Grid

I began the construction of the demonstrations with the Hermann Grid. Many of the design considerations for the entire project stemmed from the earliest tests of this illusion. I chose to start with this illusion because I was concerned that it would require the most screen area in order to achieve its effect. I discovered that only a few blocks of the grid were required but that more blocks worked better as long as they were large enough in relation to the space between them. Tests with varying numbers of blocks within a specified area helped determine the final



Intro screen - Hermann Grid

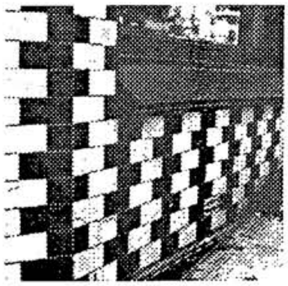
arrangement. The number of blocks was also restricted by the limitations of the program and computer processing time. Rapid response of the change height and width of the blocks as the slider was moved was critical to the users response to the interface. Initially the design of the interface included a white background, a three dimensionally styled slider mechanism and blocks that resembled 3D, faceted tiles. In addition to changing the size of the squares, the user could also change the color of the squares. Much of this design changed upon initial testing with users. The 3D styling was eliminated to increase the contrast and focus the user on the grid itself, not on the controls and screen design. The ability to change colors of the squares was removed later. Two factors drove this decision. First, certain colors were far more effective in creating the visual effect of the illusion. Combining this color effect with the varying size effect just clouded the user understanding of the demonstration. Secondly, the introduction of colors involved entirely arbitrary introduction of material not central to the concepts and only served to detract attention away for the illusion effects. During the testing for the different colors, I found that varying the contrast was more important than the color. Instead of providing multiple, arbitrary colors, I developed a second slider mechanism to change the contrast of the squares.



Demo screen - Hermann Grid

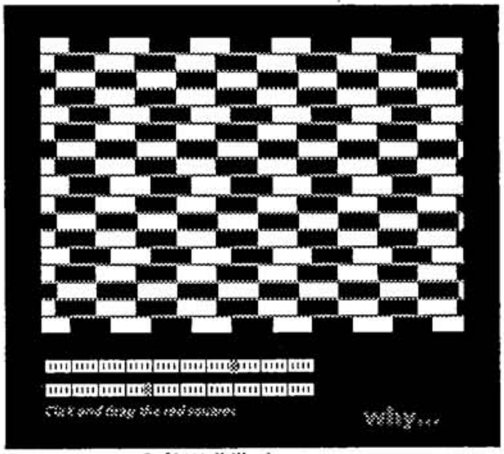
The conceptual approach to this demonstration was straightforward and fairly simple to develop. I was however surprised by the unexpected need for precision in developing the size of the blocks and spacing of them in the grid in order for the slider mechanism to control their range of size. I had not considered how much variation in size and spacing between the blocks would be desirable and how much calculation would be required to achieve it. The most surprising discovery of this demonstration was just how effective the presentation of some illusions on the computer screen could be. The projected light display of the monitor had far better results in creating the visual effect than the reflected light of printed examples. In addition, the interactive aspect of the demonstration allowed the user to achieve the effect incrementally, which enhanced the understanding and acceptance of the explanation of the illusion. The success of this first module confirmed much of my hopes and goals for the entire project.

The Café Wall



An actual cafe wall.

Following the successful tests of the Hermann Grid, I began development on the Café Wall. My plan for this demonstration was one of the first to be developed and I was confident of its success. The Café Wall demonstration built upon the controls developed for the Hermann Grid. The identical slider mechanism was used here again, my initial design called for a single slider to move one set of rows of blocks at one rate and a second alternating set of rows at a greater rate. After building and testing this design, I found that it was not as effective as I had hoped. Ultimately a second control was needed to move the alternating rows of blocks independently of the first. I briefly experimented with adding color controls like those initially in the Hermann Grid and found that here they were completely detrimental to the effect. I was surprised to discover that not only was the contrast of the block colors important, the middle gray tone of the horizontal "mortar" lines was even more critical to the successful creation of the effect. Any introduction of color was extraneous and undesirable. Experimentation with the range of motion helped determine the proper rate of movement in proportion to the slider movement. The actual range of movement was quite limited but was required to be so in order to provide adequately precise increments needed to allow the user to discover and test the limits of the illusion.

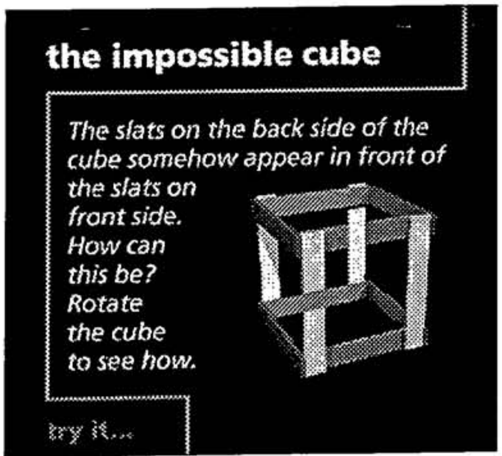


Demo screen - Café Wall illusion

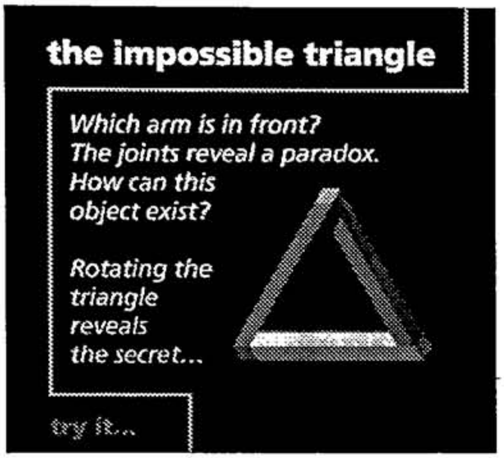
The basic parts of the Café Wall illusion.

The Impossible Cube and Impossible Triangle

These two illusions were developed together because they share many of the same concepts and technical specifics. The cube and the triangle illusions are composed of relatively simple three-dimensional models with critical portions removed, presented with the deliberate removal of any spatial cues of depth perception. In their final forms, the illusions only work from a single viewpoint. The models are positioned so that the edges of the deleted portions are precisely aligned with other parts of the models. The lack of spatial cues creates the ambiguity that completes the illusion In both demonstrations QTVR (Quicktime Virtual Reality) is used to allow the user to rotate the objects and reveal the secret of the illusions.

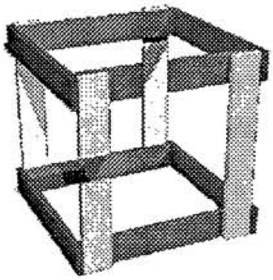


Intro screen - Impossible Cube

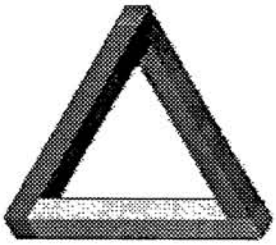


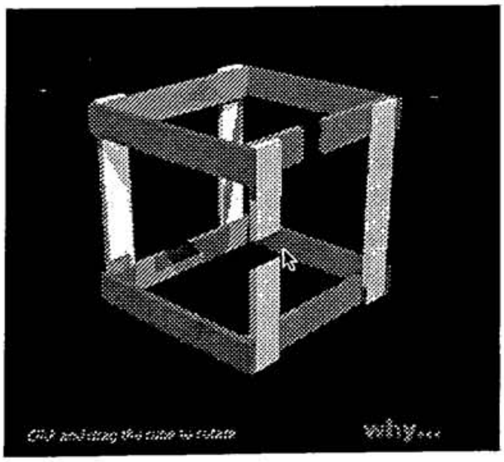
Intro screen - Impossible Triangle

The construction of the models began with study of photographs and drawings of examples. The cube is made of a 12 identical pieces arranged to form a simple crate. The exposed overlapping joints deliberately reveal the simplicity of the construction. The parts of the model are colored in the style of a simple child's toy. This systematic use of common colors for parallel parts aids the user's perception and interpretation of the spatial relationships of the models parts. The triangle is similarly constructed of 3 identical pieces but their arrangement, while not immediately apparent, is critical to the creation of the illusion. The three pieces are joined at right angles, forming a single zigzagging shape. The triangular shape seen in the illusion is created by looking at the model from an extreme angle. (This is difficult to describe verbally but easily demonstrated visually.) Again, simple color coding is used to reinforce interpretation of the relationships between the separate parts of the model.



While the basic construction appears simple, extremely exact modifications are needed to create the proper alignment of the deleted portions of the model and the camera. Making these modifications proved to be far more difficult than I anticipated. The removal of portions of the models have to be made in relation to the one exact camera angle and the model cannot be moved in relation to the camera during construction. Returning the model to the exact position would be practically impossible.



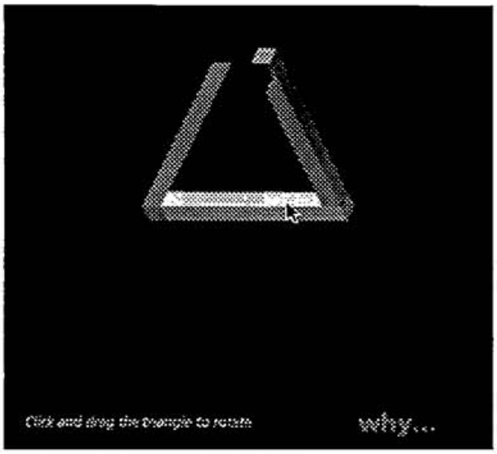


Demo screen - Impossible Cube

The illusion of the impossible cube works by removing portions of two pieces on the front plane of the model (closer to the camera) and revealing the pieces behind. The user is unable to perceive the revealed portions as being further away because of the deliberate removal of the spatial cues, (the visual overlapping of the parts and the convergence of perspective) and the spatial perception of the model becomes confused. In order to be seen as a three dimensional object, the cube is presented at an angle to the camera, revealing all of the planes to the viewer. The removal of the parts required for the illusion cannot be done by cutting straight across the parts themselves, but must occur along the line of sight of the camera.

The impossible triangle works in similar fashion. A portion of the model closest to the camera is deleted to reveal the part behind. Again, this deletion must be made along the camera's line of sight. In the final result, the frontmost piece appears to abut the backmost piece, and no cues of depth perception are available to establish the relative space between the parts.

The complications of construction comes from the limitations of three dimensional modeling software. Models can be viewed from orthographic points of view (front, top, side, etc.) or from camera viewpoints which can be positioned anywhere in the model's environment. Modification of the model can only be made from the orthographic views. Removing portions of the model would have required establishing the cameras line of sight from the orthographic viewpoint which would have been extremely difficult if not impossible. Additionally, the camera introduces parallax convergence. I quickly determined that the camera viewpoint would not work for this project. Orthographic views would allow me to make modifications from the line of sight and did not introduce convergence problems as well. The difficulty with the orthographic view involves maintaining proper orientation. Ideally, a model remains properly oriented within the modeling environment and specific angles of view are achieved through the camera viewpoint. Proper angles were critical to the illusions, but moving the models would make modifications very difficult because they would no longer be properly oriented to the orthographic views.



Demo screen - Impossible Triangle

I had no choice in accepting these limitations. I built the basic models and began to explore ways to work within the limitations. After making simple, inaccurate deletions, I attempted to adjust the models by moving individual points within the model. I expected this to be tedious, time consuming but ultimately effective. It was not. After hours of work, I found that I was achieving nothing near the level of accuracy required. I learned more about the program's features, but was not any closer to my goals.

I then tried to construct the deleted portions as separate objects, position them correctly and then "subtract" them from the model. This was slightly more effective, but still not acceptable. It did however lead in the right direction. The only way to make the precise deletion was to make it using the "subtract" Boolean function, allowing the computer to carry out the math functions rather than attempting them "by hand".

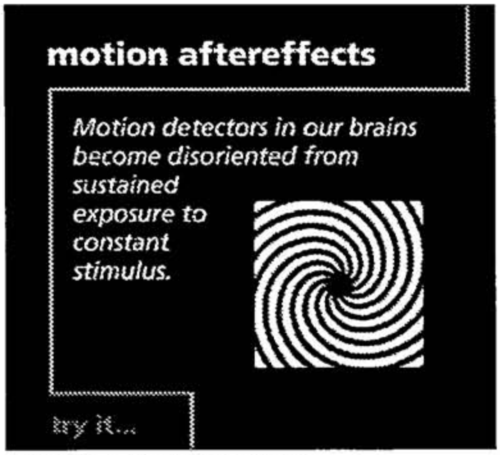
Working in a wireframe viewpoint, I built the basic models, rotated them to the desired point of view and created a new shape by following the contours of the overlapping areas as 2 dimensional shapes. I then extruded these shapes to create 3 dimensional pieces to subtract portions of the models. I moved these new pieces directly away from the viewpoint until they intersected the parts to be deleted and then used the Boolean subtract function to create the final model. Ultimately, a very simple solution but not an immediately apparent one.

Once the models were constructed, I proceeded to develop the QTVR Object (Quicktime Virtual Reality) files. A highly interactive technology developed by Apple, QTVR Object files allow the user to rotate an object. Technically, the QTVR file simply allows the user to rapidly move through a sequence of images. Typically, these images are made of an object as it is rotated at regular intervals around a central vertical axis. The greater the number of images, the smoother the rotation appears. The first QTVR files I made for the cube and triangle were composed of 36 images, at 10 degree intervals of rotation. This provided smooth uniform motion, rotating the models a complete 360 degrees. Testing the files revealed an interesting flaw, specific to the subject matter. While a complete rotation of the object was desirable, uniform intervals were not. The most interesting aspect of these images involves the changing alignment of the overlapping pieces of the models that create the illusion. The points of rotation where the illusion comes together demand shorter intervals so that the user has greater control over the rotation at these points. Rather than use uniform intervals, I used gradually lessening degrees of rotation at these critical parts of the sequence. The resulting QTVR files move slowly at first and more rapidly around the less critical viewpoints of the object.

The decision to use QTVR objects rather than simple animated sequences involved choices in usability. I could have used a continuously rotating series of images which would clearly reveal the illusion without requiring any input from the user. I could have made the changing sequence of image controlled through the use of slider similar to other illusions. While technically not much different from the QTVR, this solution appeared less intuitive because it required the user to associate the horizontal motion of the slider with the rotational movement of the object. Additionally, the uniform motion of the slider was not consistent with the varying rotation of the object. I chose to use the QTVR technology because of its superior intuitive interaction style but I knew that it would require some effort on the part of the user. As a compromise, I included some text below the images to help the novice user understand the technology. While not as aesthetically pleasing, this small portion of text helps assure a more successful user experience.

Motion Afterimage Effects

This module appears simple and straightforward but actually required the most work. Many seemingly insignificant aspects of the demonstration required careful planning, testing and revision before they were considered acceptable and effective. Interactive video presentation presented many challenges, but also assured greater success because of the greater ability to control the variables in the demonstration.



Intro screen - Motion Aftereffects

Motion afterimage demonstrations typically involve sustained exposure to a moving stimulus followed by exposure to a static image to reveal the neural phenomenon. Printed versions of the illusion require the viewer to cut out an example and place it on a turntable, stare at it for a defined period and then look at a static image. These examples involve severe impediments for the average user such as copying the example, locating a turntable (who has record players anymore?) and timing the exposure themselves without being distracted by the timing process. Additional uncontrolled variables include image quality of the printed example, lighting, viewing angle, speed of rotation, user focus on the center point and duration of exposure. Several animated examples found on the Internet did a better job with many of these variables but left others unresolved.

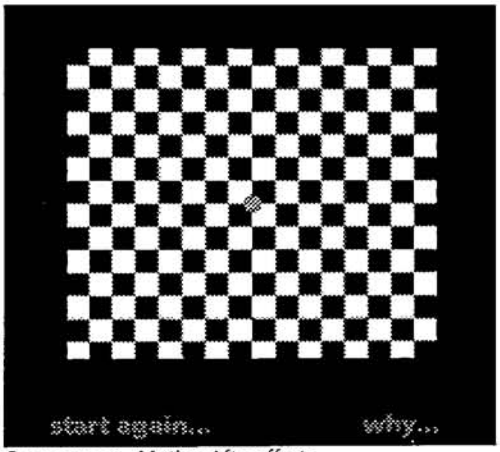

A test spiral design.

The first and foremost challenge was developing the ideal rotating spiral image. A wide variety of examples from books were studied. Variables included the number of rotations in the spiral, single spiraling line versus multiple interleaved lines, line thickness and spacing. Creating clean uniform geometrically perfect examples required learning new skills in drawing and image editing programs. Several variations were developed for testing. Animating the rotation of the examples introduced several new variables to be resolved, speed and direction of rotation, and number of steps in a single revolution. Combined with the additional visual effects of screen resolution and monitor refresh rate, determining optimum results became a complex series of trial and error requiring numerous iterations, revisions and repeated testing. Further complicating the test were issues of computer performance and image quality which affected the smoothness and speed of the animation. Particular combinations of the variables occasionally revealed unexpected and highly disturbing visual effects.

Demo screen - Motion Aftereffects

I encountered great difficulty producing satisfactory results because of the limited resolution of the computer monitor. The sharply defined edges of the spirals black lines appeared jagged on the screen. Anti-aliasing the edges (using intermediate shades of gray) eliminated the jagged appearance but softened the contrast of the graphics, diminishing the effectiveness of the demonstration. The increased color depth of the anti-aliased graphics also decreased processor performance resulting in choppier animation. The solution to this problem involved adjusting the angles of rotation and the size and frequency of the lines in the spiral. Extensive testing was required to achieve satisfactory results.

Once a suitable animation was developed, the next problem involved controlling the start, stop and duration of the animation. On-screen testing confirmed the often suggested duration of 30 seconds. Shorter exposures, combined with the normal wandering of focus did not provide enough stimulus, while longer duration made viewers impatient. As important as the duration itself was providing the viewer with some feedback during the animation without distracting them and drawing and holding their attention on the center of the spiral. I solved these problems with a small Quicktime movie 30 seconds in duration. The small pixel size and file size of the Quicktime move assured that it would run smoothly and consistently for an exact 30 seconds. The timer movie would begin when the user clicked the Start button and the program would wait for the end of the movie and then proceed to the next screen with the follow-up image for the illusion. I made the timer movie resemble a simple small clock face that winds down from 30 seconds to 0. I placed this movie in the center of the spiral to provide the user some feedback without causing them to look away from the center of the spiral.

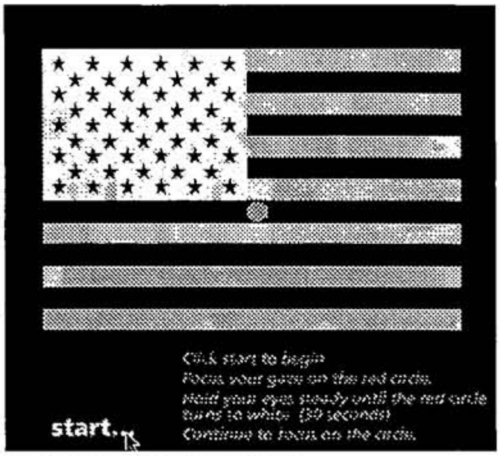


Demo screen - Motion Aftereffects

The follow-up image seen after the animated spiral could be anything, even a blank screen is effective due to the strong afterimage that remains on the retina after sustained viewing of a high contrast image. (Several instances of overlapping illusions occur throughout the program.) I wanted to create the greatest impression of the illusion so I chose a checkerboard pattern to emphasize the distortion created by the illusion. The consistent vertical and horizontal edges are quickly recognized and comprehended. The resulting variances between the known image of the grid and swelling curving image created by the spiral stimulus is quite pronounced and prolonged.

Color Afterimage Effects

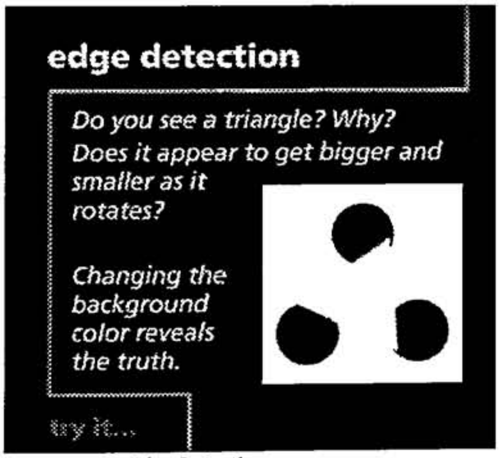
The color afterimage demonstration built upon the structure developed for the motion afterimage module. The same timing device was used as both timer and central focal point. The flag image used in the demonstration was a commonly shown example for several reasons. The flag's strong primary colors are particularly effective for the afterimage and the simple bold graphic patterns provide distinct solid areas of color. Initial tests using the colors of printed examples revealed a need to adjust the stimulus colors slightly because of differences in the qualities of projected light compared to reflected light. After the 30 second exposure, the flag image is replaced with a white shape with the centrally placed focal point. The red spot in the center was essential in providing the viewer a constant reference point so that the afterimage created on the retina was centered on the white space on the screen. I was surprised to discover that the illusion worked well on a black field as well, the afterimage generated a strikingly effective white value. However, I chose to use the white field for the demonstration because of a diminished ability to discern the red and blue areas in the black field.



Demo screen - Color Aftereffects

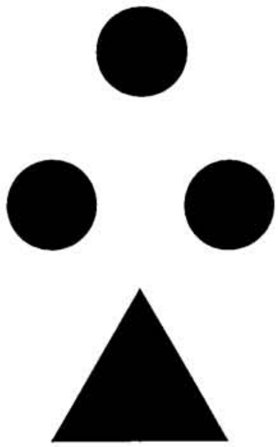
Edge Detection

The edge detection demonstration involves a white triangle on a white background, only made visible by the corner overlapping a black circle. As the triangle rotates, the corners are no longer visible and the triangle appears to become smaller, defined by the closest edges of the black circles. Presented in a static form, the illusion simply illustrates the basic concepts of the processing our brains do to resolve the image. Presented an a moving image, the dynamically changing perception of the triangle is startling. Confronted with this impossibility, the user's first inclination is to assume visual trickery, the triangle is actually changing size. To remove any doubt about the truth of the effect, I added a slider mechanism to allow the user to gradually change the shade of the triangle. When the triangle is changed to a light shade of gray, all of the edges become visible, edge detection processing is not required and the triangle no longer appears to change size as it spins.



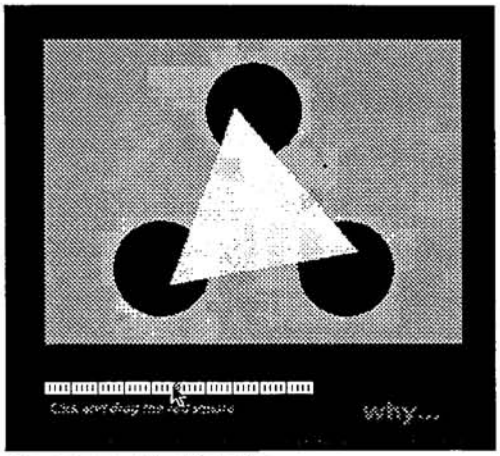
Intro screen - Edge Detection

Developing this demonstration revealed particular idiosyncrasies in Director that demanded novel solutions in order to make the illusion work. The fading in and out transitions (discussed earlier) I developed for the modules used the blend function to change the shade of objects from transparent to opaque, usually to a solid white in the case of the titles and graphics in the modules. I intended to use the function here to change the shade of the spinning triangle from a light gray to a pure white, providing the control of the shade to the user through the position of the slid-



The basic parts of the edge detection demonstration.

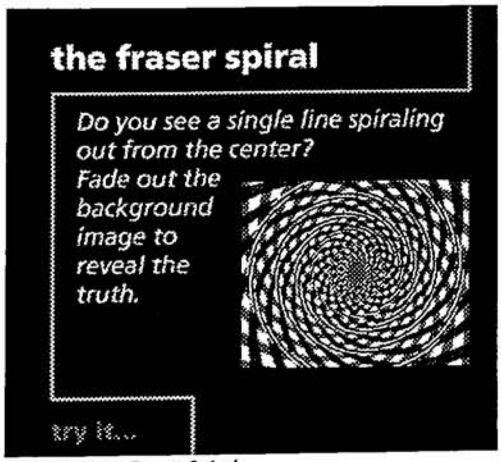
er. Two problems had to be solved. First, Director cannot allow absolute white objects The white text and graphic used in the modules are white areas bounded by black. Any white pixels of an object must be completely enclosed within colored pixels. Instead of pure white, I made the spinning triangle and the background object a very, very light gray. With no white object immediately adjacent, the gray would be seen as white. The second problem I discovered was that the blend effect would not bring to object to complete 100% opacity. Placing the light gray triangle over the light gray background revealed the flaw. While this slight difference would go unnoticed in most applications, it destroyed the effect of this illusion, an exact match of the color of the triangle and background was needed for the illusion to work. To accommodate this flaw, I created 2 identical spinning triangles, one of light gray behind another of a darker gray. Movement of the slider alters the opacity of the darker gray triangle from close to opaque to completely transparent. When the frontmost dark gray triangle is no longer visible, only the lighter gray triangle, over the black circles and light gray background is visible and the illusion works.



Demo screen - Edge Detection

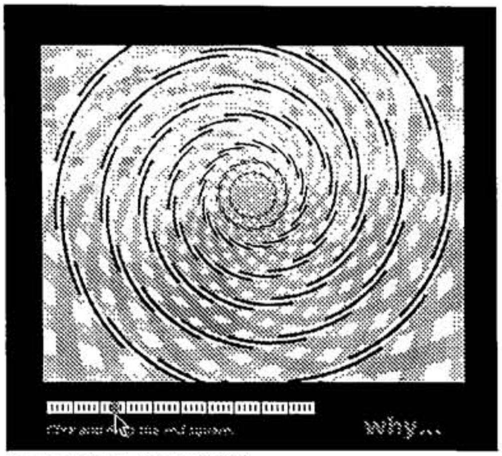
The Fraser Spiral

Lessons learned with the spinning triangle were put to use developing the demonstration of the Fraser Spiral. While not an animated presentation, my goal with this demonstration was to clearly reveal the effect of the background design on the perception of the concentric circles of the foreground. After studying examples and developing my own graphics, I attempted to use the slider mechanism and blend effect to change the opacity of the background image. Again, particular idiosyncrasies in Director presented obstacles to be overcome. The illusion requires the concentric circles to be made of interwoven black and white arcs. Director's inability to accommodate the unbounded white pixels presented a problem. I attempted to use the



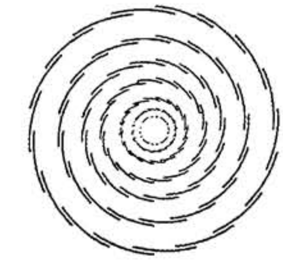
Intro screen - Fraser Spiral

Constructing the Fraser Spiral.



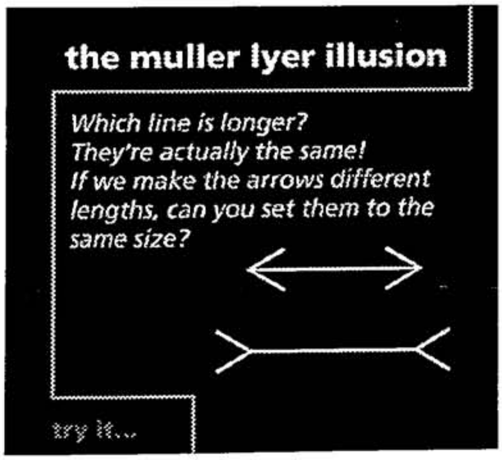
Demo screen - Fraser Spiral

light gray solution of the edge detection module, but found that jagged edges of the arcs would not allow the graphics to mesh perfectly. Under such close scrutiny, this was not an acceptable solution. Like so many other problems, the solution was very simple once I discovered it. Rather than create the concentric circles and background art as separate elements, I created two complete images. The first was just the concentric circles on a white background, bounded by a single pixel black square, the second image contained the background and the concentric circles, all bound by an identical single pixel thick black square. The second image is placed on screen in front of the first. The user controls the opacity of the second image with the slider mechanism. While the foreground image fades, it appears to be the background because the concentric circles never fade. The circles of the background image do not fade, they remain solid black while the rest of the image fades to white. A simple solution but it creates an effective demonstration of the difference between the perception and the reality of foreground and background elements.


The "trick" of the Fraser spiral

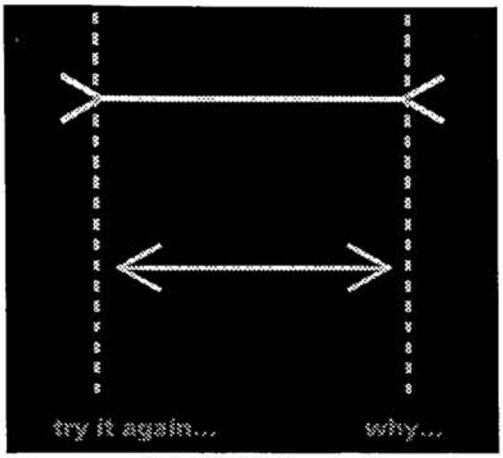
The Muller-Lyer Illusion

The Muller-Lyer Illusion is one of the oldest and most well-known illusions. People consider it one of the simplest, yet we still do not fully understand how it works. Everyone knows that the lines are the same size because of the illusion's popularity and frequent presentation. Despite this previous knowledge, the illusion still actually works. We still have difficulty determining the length of the lines. In order to bring a new respect for the power of this illusion, I developed a demonstration that forces the users to test their perception of the length of the lines. The user is presented with two lines. The bottom line is a fixed length. The user must move the arrow heads of the top line to match the length of the bottom line. The lines are then compared to reveal the results.



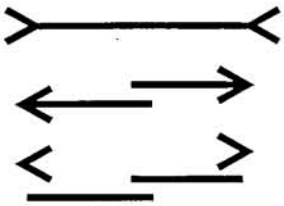
Intro screen - Muller-Lyer Illusion

Building the demonstration presented some unexpected challenges. Using a mechanism similar to the slider used in other modules, I created two arrow heads and lines that could be moved horizontally by the user within defined boundaries. The problem involved the length of the lines as the arrowheads were moved apart. Initial designs used arrows and lines as combined elements. When the arrows were moved towards the center of the screen, the lines extended beyond the end of the other



Demo screen - Muller-Lyer Illusion

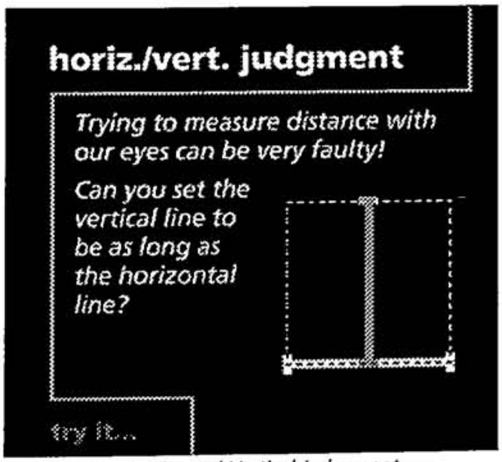
arrow. To prevent this, the lines would have needed to be much shorter and the length of travel greatly restricted. To resolve this problem, the arrowheads and lines had to be made as separate elements so the lines could be scaled in length independently of the arrowhead. Separate lines and arrowhead were needed for both the left and right sides. While horizontal alignment of the parts worked well, vertical alignment was erratic. Despite numerous attempt to resolve this, no entirely satisfactory solution was found.


The working parts of the Muller-Lyer Illusion. The left and right arrows are separate parts and are further divided into shafts and heads.

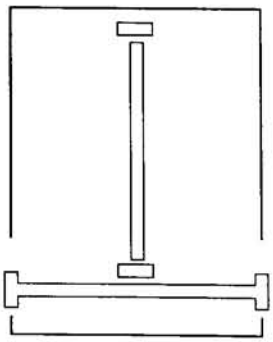
Another challenge was discovered during user testing. After the user adjusted the arrow lengths, parallel vertical lines were presented to demonstrate the accuracy of their attempt. When the lines were in place, the user could still move the arrowheads. I needed to find a way to lock the arrows in place. Particular behavior of elements in Director made this very complicated. I found a simpler solution by placing an invisible object in front of the lines. The use of an invisible object is helpful in interactive demonstrations in Director but it often also creates difficulties by preventing user access to particular elements. In this case, I used this trick to solve my problem. The arrows remain active but the user cannot click on them because of the invisible object in front of them.

Horizontal / Vertical Judgment

This module is really a derivative of the Muller-Lyer illusion and utilized much of the same construction techniques. Ultimately, this module was more successful because it did not have the same alignment problems of the Muller-Lyer demonstration. Instead of overlapping arrows, this demonstration used a fixed horizontal element and a movable vertical element. The vertical element was able to move up and down without requiring any scaling. The portion of the vertical element that extended below the horizontal element was simply hidden behind a black element placed in front. Similar tricks were used to create the bounding edges of the cafe wall illusion. This demonstration was also more successful than the Muller-Lyer because it was less well-known, appeared simple to do yet proved to be much more difficult. Users were consistently farther off-target with this test than



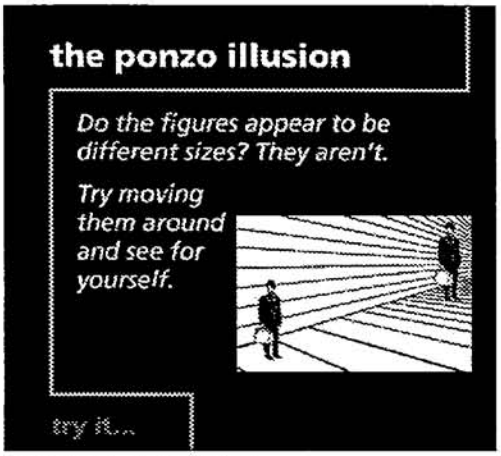
Intro screen - Horizontal-Vertical Judgement


The separate parts of the Horizontal-Vertical Judgement demonstration.

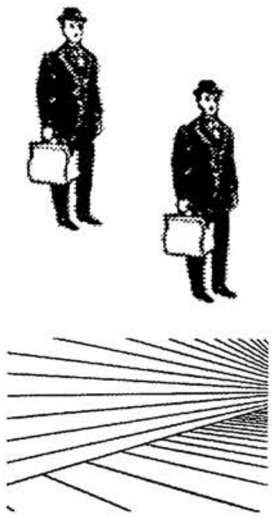
with the Muller-Lyer test. Fortunately, this increased inaccuracy proved to be more entertaining than frustrating to most users.

The Ponzo Illusion

This well-known illusion was the simplest to construct. Throughout the construction, I refused to use existing artwork from other sources. Examples were copied to study but all of the drawn elements were created by me. Pristine edges and pure tonal values, as well as many modifications for digital presentation prevented the use of scanned images any of the artwork as well. For the Ponzo illusion, I created my own background artwork, but I decided to use a scanned version of the figure. The scanned figure was more effective because it was recognized and considered "authentic" and therefore less subject to question as trickery. The scanned figure was slightly revised for digital presentation and two copies were made available for the user to reposition over the background. An invisible bounding box constrains the movement of the figure within the frame of the background. The freedom to move the figure anywhere within the space helps to demonstrate the illusion. The perception of the figure as smaller only occurs in the upper right corner where the convergence of lines suggest perspective depth.



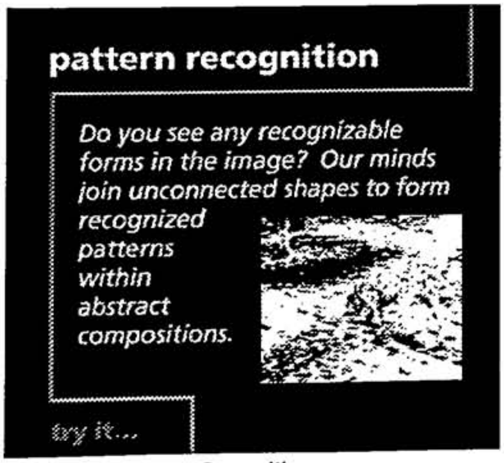
Intro screen - Ponzo Illusion.



The basic elements of the Ponzo Illusion.

Pattern Recognition

The last illusion demonstrates how we discern shapes through detecting patterns and how our visual perception has evolved to detect camouflaged objects. A seemingly abstract composition of black shapes on a white background contains the figure of a dalmatian dog. The spots of the dog's coat merge with the dark areas of the background. When the background shapes are concealed and only the dog's spots are seen, the silhouette of the dog is easily resolved, we "recognize" the pattern of the dogs body and legs. When the background is revealed again,



Intro screen - Pattern Recognition

The separate parts of the Pattern Detection demonstration.

the silhouette of the dog no longer disappears yet we can still discern the outline of the dog, we can continue to recognize the pattern of the silhouette as defined by shapes within it. Initially I utilized a slider to fade the background to reveal the dog's spots. Test users were unimpressed and failed to grasp the point. The focus of the user was on the changing background, not the unchanging figure of the dog. I removed the slider and replaced it with an unexpected rollover. when the user rolls the cursor over the dog, the background image fades away. When the user rolls off, the background reappears. No mouseclicks or click and drag function is required. The result is an almost effortless reveal and conceal effect. I used the same fading effect used for the text and graphic elements in all of the modules to avoid an abrupt visual change that would distract the user from the intended demonstration.

Putting It All Together

After finalizing the illusion modules came the job of assembling all of the parts into the final form. This task involved perfecting the implementation of the MIAW scripting to open the individual modules within the main interface, developing the navigation controls and building the help section, volume controls and opening introduction video segment.

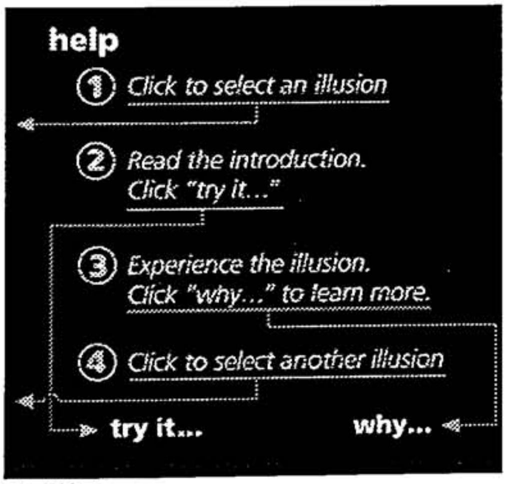
Implementing the MIAW

Determining the positioning of the MIAW was critical to the early development plans for the project. Once the modules were built, actually developing the code to access them from the main interface needed to be written. Positioning the window proved to be a simple matter of writing a script to determine the size of the monitor, determine the position of the stage within the monitor and then positioning the window according to these specifics. Testing the implementation of the script revealed an unexpected event. Each module was opened in exactly the same place. While not visible to the user, each movie remained open and occupied a small part of the available memory (RAM). Eventually so many modules were open that errors occurred when the RAM was completely occupied. Observing the "About this Macintosh" window during testing explained the event. This can't be considered a bug because the program is doing exactly what has been requested by the scripting. Once the explanation was clear, resolving the issue was simple. I added a command to each "open movie" script to close any other open windows before opening the specified one. Another simple solution once the problem was understood.

During testing, another problem with MIAW was discovered. A brief white flash occurred upon the opening of every new window. Numerous attempts were made to avoid or disquise this distracting "bug" with no success. Research in the technical libraries of Macromedi revealed that this flash was the result of a required screen redraw and was unavoidable. The discovery of this bug and its inability to be resolved caused me great difficulty. The development of the project as a whole was too far along to go back and start over from the beginning. Every module would have to be reconstructed as part of a single movie. Every lingo script would have to be checked and revised to accommodate its use in conjunction with all other scripts. While the screen redraw effect was undesirable, it did not affect the functionality of the the main interface or any of the mdules. The decison to use MIAW was based on its potential to provide a more flexible development environment. Ultimately, I decided that the incredible benefits ofMIAW outweighed its few drawbacks

The Main Screen Rollovers

Aside from the module window area , the most important part of the main interface was the list of illusions. This list was divided into individual graphic elements that would act as buttons to open the specified modules. The visual effect to identify the selected name was determined earlier in the design of the main interface but the actual graphics could not be built until the final list of names was determined. Once set, the construction of these graphics could be done. Early testing had shown that gray and white versions could be used to signify inactive and active states for the graphics. The entire list would be set in dark gray, and white versions of each name would appear when the user moved the cursor over the name, commonly called a rollover. Rather than simply switching from the gray to the white, I wanted to use a transition similar to the fading effect used in the modules. Simply fading from gray to white proved to be too subtle and not dramatic enough to hold the user's attention. Instead, I developed an interlaced horizontal line effect. While more complicated to construct, this effect was no more complicated to implement within Director. This type of animated transition represents the more embellished interface possible within multimedia applications and not viable for the WWW.

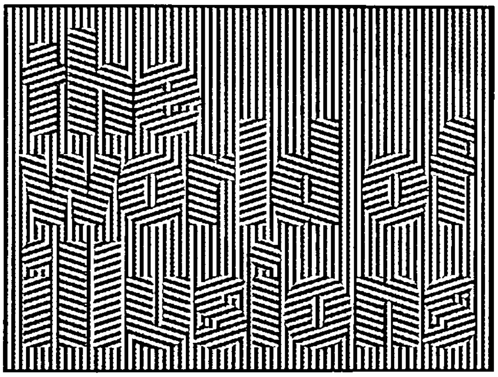


The Help Screen

I intended to use a similar transition effect for the help, quit and volume controls but testing showed that these elements were too small to work effectively. For these smaller controls, I developed a vertical transition resembling a windowshade like effect. The help, quit and volume controls also were hidden from view at the bottom of the screen until the user moved the cursor over the designated area. While this hiding of controls is contrary to some views of interface design, I felt that these less vital functions should be hidden when not in use in order to eliminate as much distraction as possible from the illusion demonstrations.

Help and Quit Screens

The implementation of a help screen was left for the end of the development process for two reasons. First, making a help screen that applied to all cases required the development of the modules before the help could be written. Second, the simple interface and short shallow architecture made the need for a help screen negligible. As a courtesy and a matter of completeness, I did make a simple help screen outlining the basic steps in navigating the program. I designed this help information to fit within the module display area. Implementing the help is basically identical to activating one of the modules. Any open window is closed when the help is activated and opening any module closes the help screen. The quit screen acts in similar fashion. Selecting the quit function displays a screen requiring a second decision by the user before quitting the program. While somewhat redundant and unneeded by more experienced users, this construct is an accepted standard for multimedia applications as it best accommodates the widest range of potential users.


The project title as shown in the Introduction video

Volume Controls

In the course of developing these control elements, I discovered that the simple solid black background was helpful in focusing user attention to the changing status of the controls. Greater user attention allowed me to use much smaller and simpler elements for the controls. The volume controls are elegantly simple, just 2 small triangles and a series of tiny rectangles to display the volume setting. Small details help to make user interaction more intuitive, the increase and decrease controls are hidden when these functions are not relevant. The decrease control is removed when the volume is at the lowest setting, the increase control is removed when the volume is at maximum.

The Introduction

Typically, multimedia titles include some sort of introductory section before reaching the main interface. While the separate modules are designed to function as individual self-contained units, some explanation of overall concepts needed inclusion in the project. Originally, this explanatory information was designed as two text segments that occupied the module demonstration area. In testing, I found that this text was considered too lengthy to be appropriate for the nature of the project as a whole, especially in comparison to the very limited text elements of the modules. As an alternative, I developed a short full screen video segment that included narration introducing the concepts covered in the introductory text. At the start of the program, this video runs automatically and then brings the user to the main interface. At any time during the video, the user can simply click anywhere on screen to move past the video and quickly go to the main interface.

Sound

One of the greatest benefits of multimedia is the addition of sound as an element of the presentation. For many subjects, the use of sound would be critical to the experience and its design and implementation would be a major component of the development of a project. My subject matter was entirely a visual experience. The use of sound would not be essential but only act in a supporting role. Initial versions of the modules included the usual interface action sound reinforcements on the buttons and rollovers. After lengthy debate, I finally chose to remove the sounds from the user actions because they quickly became redundant and distracting to the user.

Another role for sound in multimedia is acting as background sound to isolate the user from external distraction. This component was critical for my project, especially in terms of the presentation during the thesis show and the din produced by other projects and dozens of participants. Limited time and expertise with developing music required me to seek assistance from others to develop suitable music for my project. Use of existing music was unacceptable because of copyright restrictions. Furthermore, I felt that the use of existing material was not in keeping with the concept of the thesis project. The music for my project was developed by my classmate, Tony Bacchiocchi. I discussed my intentions and conceptual ideas with Tony and requested that he develop a short piece of music for me. He produced a computer generated "song" approximately 2 minutes in length. Simple editing in sound editing software allowed my to develop a continuous looping version of the music for implementation in the project.

The other use of sound in my project was narration during the introduction. The narration was recorded by myself, added to the program and set to run during the title video segment. During testing I discovered that the audio narration was difficult to discern over the background music. To solve this problem, I added scripts to the main program to reduce the sound level of the background music independent of the overall volume. When the video segment ends and the user arrives at the main interface, the sound level of the background music is restored.

Speakers and a sub-woofer were included as part of the hardware setup for thesis show to insure that the volume of the audio portions of the project would be adequate to allow the user to hear the narration and music over the noise of the audience and other thesis projects.

Time-out Function

Kiosk based applications, controlled by an unsupervised user, require a time-out function. The time-out function detects a defined period of inactivity and performs a specified function, usually returning to the beginning of the program. The time-out function for my project involved some specific specialized requirements. First, a time-out function usually detects a period of time without mouse clicks. My version of the time-out checks for periods of any mouse inactivity. Rather than requiring the user actually click on something, I designed my system to only require the user to actually move the mouse. After the defined period of inactivity which occurs if no one is using the program, the system checks for and closes any open modules. Without this specific action, the modules would remain on screen while the main movie returned to the beginning segment. Once the system returns to the beginning, the program performs a function to attract a user, running the introductory video without audio narration. I developed another script similar to the time-out script that checks for mouse activity during this waiting period. If no mouse activity occurs, the program does not proceed automatically from the video to the main interface and instead repeats the video segment. When mouse activity is detected, the system begins the audio narration and then proceeds to the main screen and the normal time-out function resumes. Despite all the care and effort exerted developing these scripts, they went entirely unused during the thesis show. The constant use by a line of interested users never allowed the system to time-out and return to the opening segment.

In addition, the quit function was actually disabled for the thesis show. If a user attempted to quit the program, the system simply returned to the opening screen and resumed checking for mouse activity.

The Web Version

After completing the CD-ROM based version of the project for the thesis show, I had some time remaining to develop the web version of the project. The modular construction made the basic construction of the web based version simple. A frameset was built, with three windows. The top window contained a title bar graphic based on the title graphic of the CD version. Below the title, two windows were set up, a smaller window on the left for the list of illusions and a larger space on the right for the modules. The animated rollovers of the CD-ROM version were not designed for implementation on the web. Simple rollovers that change color from gray to white were adequate and more suited to web implementation. The help, quit and volume adjust functions were not applicable to the web version and not implemented. The opening introductory video was also inappropriate for the web, so the original text versions were used instead in the opening screen display. When web users selected a module, it would be displayed in the same window, replacing the introductory text. Clicking on the title bar replaces the module with the introductory text. This feature is present but not made apparent to the user.

Limitations of Shockwave

Shockwave is an added functionality for WWW browsers that allows the use of Director files that have been prepared and compressed for web delivery, a process referred to as being "shocked" My intention with the web site was to simply prepare HTML files to accommodate "shocked" versions of the modules. This was a large part of the reasoning behind developing the modules in the first place. Initially, I expected the modules to be relatively simple Director movies. In the process of development, some of the modules became more complicated with the addition of Quicktime movies. I was surprised to discover that these Quicktime movies could not be included in the shocked versions and workarounds would have to be developed.

Modification of the Modules

Most of the modules did not include Quicktime movies and therefore did not require any modification. The afterimage modules, motion and color afterimage modules both contained the small timer movie. The impossible cube and impossible triangle involved QTVR movies. While not conventional animated sequences, they are technically Quicktime movies and utilize Quicktime compression algorithms. As a result, they would also need to be revised for the web version of the thesis project.

In order to eliminate the timer function from the afterimage modules, I developed an alternative method to achieve the same result. Instead of a Quicktime movie, I made 30 separate graphics and displayed them sequentially. A simple repeat loop in the scripting controlled the timing of the display. While functional for the Shockwave version, this solution had two disadvantages. The 30 separate graphics demanded more memory and therefore took longer to download. More importantly, the 30 separate graphics changing at 1 second intervals did not have the smooth motion of the Quicktime movie. More steps in the animation would have increased the file size and slowed the download times even more. Once constructed, second versions of the modules were made and "shocked" for the web site. Determining this solution for the web version was not difficult because I had already experimented with this timing method before developing the Quicktime movie that was used in the CD-ROM version.

A different solution was required for the impossible cube and triangle. While QTVR is not supported in shocked movies, it is supported in most newer web browsers (Netscape Navigator 3.0 and Microsoft Explorer 3.0) with the use of an additional plug-in from Apple. Rather than a Shockwave version of the module, I simply placed the QTVR movies directly within the web browser. For some reason still unexplained, I was unable to develop a QTVR version of the impossible triangle that would work within the web browser. Numerous versions were developed and hours spent unsuccessfully searching for a bug in the coding.

The Thesis Show

Preparation for Exhibition

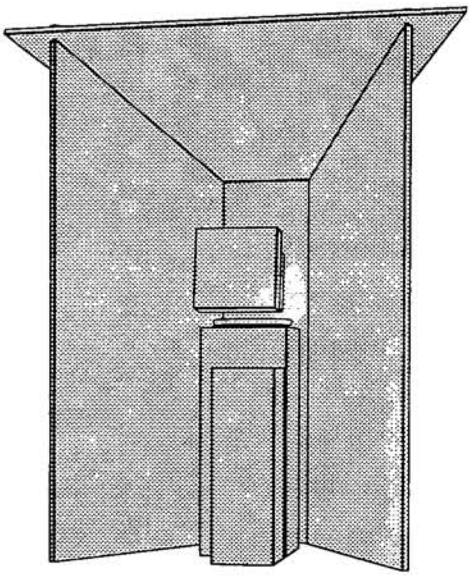
During the development of the software, I also developed a set of requirements for the hardware necessary for the presentation of the project during the thesis show. Throughout the development and testing of the illusions, I found that optimizing the viewing conditions greatly enhanced the effectiveness of the presentation. Two physical requirements were of the utmost importance, elimination of peripheral visual distractions and minimizing ambient light to increase intensity and contrast of the monitor display. Additional requirements involved proper ergonomics for the presentation, specifically the height of the screen and the surface for the mouse. Finally, accommodation needed to be made for proper sound reinforcement and storage of the computer within the enclosure.

Another factor in determining the needs for the presentation involved the user's perception of the project within the physical space and time of the thesis show. A computer sitting alone on a table would be ordinary and uninteresting. The numerous displays surrounding my own, competing for user attention made the need to generate interest and control the physical surroundings even more critical. By creating a defined space around the display and limiting access, a sense of mystery and importance was developed, heightening the curiosity and interest of the audience. My goal for the thesis show was to create a crowded line of users clamoring to get a look at and a chance to experience the program.

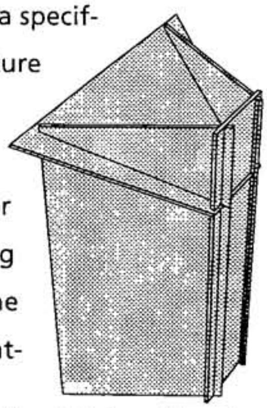
Several limiting factors were considered as well. The first of these was ease of construction, particularly the assembly immediately before the thesis show and disassembly after the thesis show. Storage space for the materials, the size, weight and complexity of the structure needed to be considered. Another limiting factor was cost. While the thesis show was important, the brief need for the enclosure made the expense a major consideration. Limited access to workspace, and tools for construction also influenced the design. Lastly, the amount of time available to be devoted to anything but the development and debugging of the software itself was extremely limited.

Designing the Enclosure

I began the design of the enclosure with sketches. I spent time in the Interior and Industrial Design studios, looking at examples of enclosures and computer displays. I was seeking the simplest solution to the problem. I decided that an enclosure that actually contained and supported the hardware would require too much in structure, materials and construction. As a alternative I determined the proper height for the pedestals, factoring in the height of the monitor base and found suitable existing pedestals in the Bevier Gallery's supply of display materials. Surrounding the pedestals, I needed to erect simple flat walls to isolate the display from the ambient and direct light and sound of the surroundings. I developed a simple design involving only 4 flat panels. Interlocking notches, fashioned after paperboard box designs allowed a method of extremely simple construction involving virtually no tools or hardware. A simple test model developed in a 3D modeling program let me look at the design from any angle. This work helped confirm the validity of the design. Slight changes in the dimensions and angles of the panels were made to accommodate the physical requirements for the pedestals and computer hardware. Specific dimensions for all of the parts were determined and a scale model was built from box board. The construction of the scale model revealed the areas of difficulty I would encounter with the actual display materials. The mechanical logistics of assembly of the large pieces would require a specific sequence of assembling the pieces. In addition, the structure would require some tensioning and reinforcement to remain stable. My design was not perfectly durable and sturdy, but it would be simple to build and modify as needed to work for the limited time of the show. The next task was determining suitable material from which to construct the enclosure. The material needed to be readily available in large panels, lightweight, rigid, easy to cut, paintable, and inexpensive. Discussion with instructors and lab technicians in Industrial Design led to Styrofoam insulating panels. Manufactured for home construction and remodeling, the ID department uses Styrofoam panels to construct models. The lab technicians provided invaluable knowledge regarding cutting, painting and assembling the material.



Front view of the 3D model for the enclosure.



Top right view of the enclosure model, showing the interlocking construction.

Construction of the Enclosure

I purchased several sheets of 1/2 inch thick 4'x8' blue Styrofoam from the local hardware store. Scale drawings were made from the computer model and the dimensions transferred to the flat panels. The pieces were carefully measured, checked and rechecked and then cut with a large razor. A partial assembly was done to verify the accuracy of the pieces and the validity of the structure. The relativity fragility of the material prohibited a full assembly. The pieces were carefully dismantled and given 2 coats of matte black latex housepaint. The afternoon before thesis show, the pieces were brought into the lab and assembled. Some minor breakage on non-critical areas occurred but was easily repaired. Two inch gaffer's tape was strategically applied so that the flexing of the panels created a rigid tension against the tape.

Pedestals

The pedestals were draped with thick black felt and placed within the enclosure and the monitor, speakers and mouse positioned. Initially, I intended to place the computer itself within the enclosure. Planning with the models revealed a potential difficulty with accessibility to the computer once placed in the enclosure behind the pedestals. An opening in the panels would have provided access but would have potentially weakened the structural stability of the foam panels. A small hole was cut in a side panel, hidden from view by the pedestals and cable run from the hardware within the enclosure to the computer set on a small platform behind the enclosure. A black panel with a window for the display area was cut and temporarily affixed to the front of the monitor.

The Exhibition Space

The selection of exhibit space was made months before the thesis show. I chose the space in the frontmost portion of the CGD lab for maximum exposure to the front door and for minimal exposure to the noise and distraction of the other exhibits. As my project developed, I realized that I would need to control the ambient lighting around my project. The black enclosure would obscure any ambient light from the back portion of the lab. No lighting was used in the front portion of the space except for the projected video of the project adjacent to mine. For the benefit of both projects, the windows open to the hallway were draped with opaque material to eliminate the unwanted ambient light from the hallway. The crowd of onlookers surrounding the exhibit helped to minimize the ambient light within the enclosure even further.

Conclusion

The thesis project proved to be a more challenging undertaking than I had anticipated. It was far more demanding and complex than any individual project I have ever worked on. The process of determining a topic and developing the content and presentation was arduous and draining. The completed presentation fails to reflect the amount of time, effort and mental energy that went into the construction of the project as a whole. Reviewing the steps involved and the myriad decisions made during the development presents a more realistic picture of the undertaking. The process of writing the thesis report has helped to reflect on and measure the successes and failures of the project.

I believe that my choice of subject and the approach to the presentation of the topic was very successful. The time and effort spent prior to actual production was well spent. The scope of the project outlined was reasonable and was fully realized in the thesis show presentation. The finished project accomplished the many goals set before production began. The production process challenged my skills, adding new areas of knowledge and reinforcing previous knowledge and experience. The integration of the component parts into the whole progressed without incident and produced a unified final project. The project was well received by the participants during the thesis show and ran flawlessly. Overall, I was very pleased with the final results of my work.

Certain aspects of the project were less successful however. The management of time and organization was occasionally ineffective and wasteful, forcing the use of less sophisticated solutions to problems or, in a few cases, failing to realize any solution at all. Changes in the technology during the development of the project presented new and better ways to do things, too late for me to incorporate them into the final project. The tightly defined scope of the project prevented finding new, unorthodox solutions and methods for presenting the content. Usability, efficiency and functionality outweighed the opportunities for creativity and embellishing the user experience. This self-imposed limitation has been a hindrance to my work before and since the thesis project. Awareness of this trait is the first step to overcoming it, each new project presents new opportunities to think in new and different ways. Having completed the project, I believe that the successes and failures of the project have made me a better designer and given me the resourcefulness to accomplish projects of greater scope and depth than I had thought possible before.

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On-line Resources

The Exploratory Science Centre
http://www.exploratory.org.uk/

The Exploratorium On-line
http://www.exploratorium.edu

IllusionWorks, L.L.C
http://www.illusionworks.com/

Counter-Rotating Spirals
http://www.sover.net/~manx/spirals.html

Mary Washington College Psychology Department
http://www.mwc.edu/~dmacewen/illusion.html

Ads On-line
http://www.ads-online.on.ca/illusion/directory.html

American Academy of Ophthalmology
http://www.eyenet.org/public/museum/discover.html