

3D Interface Inspired by Constructivist Art Principles

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Abstract:

Concepts of form and space from the realm of art have in the past provided inspiration for designers seeking to explore new models for interface design. This paper is a conceptual evaluation that investigates issues encountered when the Constructivist art of Laslar Lissitzky, and his series of “Proun” paintings, are used to inspire and inform design decisions for a web browser history interface. Apart from producing some interesting interface features, this study illustrates the interesting relationship art has to interface and why some interfaces are more artistically appealing than others. This paper is part of a larger study that will result in a fully working web browser history interface.

The “Proun” series of paintings by Lissitzky in the 1920s have provided inspiration for many students of spatial form preceding the development of modernism. The pure abstract forms of Suprematism and De Stijl were rebuilt on the canvas in accordance to personal visions that were forming the Constructivist theories of the time. In a manner similar to that of Cubism, familiar shapes were re-combined to form unfamiliar constructions. The compositions of these Proun paintings were quite distinctive in the way that space, form and motion were used. The paintings were only two dimensional but invoked a strong sense of three dimensional (3D) composition and movement. When one looks at a Proun painting, one could easily envisage the composition as some sort of modern day, computer rendered interactive structure. This was the perception that provided this study’s departure point.

In order to provide a vehicle in which to test these design approaches, web history representation has been chosen. This choice allows the researcher to limit the amount of data to work with, as dealing with large amounts of data at this stage will impede progress, without helping to solve the central design criteria. Web history data also offers some unique visual representation ideally suited to this study. The art of Laslar Lissitzky, in particular the “Proun” series, provide an exciting model to apply to an interface, and present several some interesting questions.

- Can an environment based on abstract shapes provide successful cognitive mapping and orientation?
- Can abstract shapes maintain their cognitive associations as navigational and functional items?
- Do abstract shapes have any advantages over real-world literal metaphors?

To realise the significance of these questions, it is relevant to examine key aspects of Lissitzky’s art and theory.

Laslar Lissitzky’s Art & Space

El Lissitzky was a pivotal Russian artist working in the 1920s. With a series of paintings he called “Prouns”, he formed a bridge between the art and theory of the Suprematists, to that of the Constructivists. The term Proun is a Russian acronym for “Project for the Affirmation of the New”. His works and writings provide an opportunity to re-examine some of the principles about three dimensional space on a two dimensional (2D) surface.

Lissitzky created the Proun as an “interchange station between painting and architecture”. He saw himself not so much as painting, but rather as constructing. “I have treated canvas and wooden board as a building site, which placed the fewest restrictions on my contructional ideas.” (Lissitzky-Küppers, 1980). Lissitzky’s Prouns and his associated theory makes a significant contribution to how we see space and form within a 2D canvas. Lissitzky created self contained environments, that were both artistic and architectural, freely playing with perspective and projection, while still communicating form, scale, depth, and an impression of deliberate construction. His awareness of 3D spatial interaction is evidenced by such comments as: “We saw that the surface of the Proun ceases to be a picture and turns into a structure round which we must circle, looking at it from all sides, peering down from

above, investigating from below ... Circling round it, we screw ourselves into the space ... we stand between them and push them apart.”.

Lissitzky, professionally trained as an engineer, then an architect, consciously manipulates the architectural laws and concepts of environment. He skilfully uses many compositional techniques to invoke the sense of structures in space: perspective and orthographic projections, overlapping shapes, angled planes, sweeping curves, directional lines, and the careful alignment, or non-alignment, of strategically placed shapes. Baljeu (1966) describes Proun elements as: “They free themselves, so to speak, from the surface on which they are painted, in two directions: forwards out of the picture and backwards into the picture” and “invalidates the idea that the picture must have a vertical axis. ... the impression that a Proun constellation is weightless.”

Redefining object representation

Using the geometric tools from Suprematism, Lissitzky applied his architectural training and personal theories to give new meanings, and consequently, new functions to the shapes in his paintings. Once the painting space is explored, the functions are revealed. Some objects indicate scale, some give stability, others are visual anchors or directional indicators, leading the eye from one point to another. Although some of his works revealed their real-world origins with such titles as “Town” and “Bridge”, other paintings paid no such reference to the physical world. Instead, Lissitzky saw the environment as being created within the picture frame, and existing within its own right and within its own rules. “Proun is the creation of form (control of space) by means of the economic construction of material to which new value is assigned.” (Lissitzky-Küppers, 1980).

Lissitzky saw the elements of his paintings as “signs”. “A sign is a form through which we express phenomena”(Lissitzky-Küppers, 1980). He describes two types of sign: the first uses meanings that are agreed upon by all, as in the symbols used in a map. “...with these signs we have expressed what was already there in the world, what had already been built.” The second form of sign, however, is more complex. “A sign is designed, much later it is given its name, and later still its meaning becomes clear.” As the viewer learns the visual language, so they will understand the work. At the time this was an innovative concept. Lissitzky was asking the viewer to read spatial meaning to these otherwise abstract shapes. “Space until now has been projected on to a surface by a conditional system of planes (i.e. perspective). We began to move on the surface of the plane towards an unconditional distance. We multiplied the axes of projection in this rotation, we moved between them and separated them.” (Lissitzky-Küppers, 1980).

Lissitzky refers to the basic geometric building blocks, from which everything is constructed as “Plastic Elements”. His descriptions for these shapes includes how the depiction of them alters their representation. A cube viewed face-on is a square, whereas when viewed from an angle, it is a six-sided cube, of 3 dimensions, hanging in space, and dynamic.

Lissitzky aligned much of his spatial theory to that of science. In this, he believed that modern art had reached a comparable state to that of science. “Every form is the frozen instantaneous picture of a process. Thus a work is a stopping-place on the road of becoming and not the fixed goal. We acknowledge works which contain a system within themselves, a system which has not been evolved before the work started but has evolved in the course of it.” (Lissitzky-Küppers 1980). In this way, Lissitzky shows how his spatial thinking process can be seen as one of a designer, rather than an artist. He describes what is effectively a design process, using fundamental building blocks in order to solve the essential criteria, and over time solving the larger design problem.

Computer Data visualisation and Prouns

The associations Lissitzky presents between environment, viewer perception and interaction can be seen as synonymous with similar issues of virtual environment interaction. Lissitzky’s work demonstrates that environmental controllers such as landmarks and direction indicators need not be representative of real-world known objects, rather, they can be defined within the environment itself. This could imply that a virtual environment constructed of abstract objects may be as successfully navigable as one constructed from worldly objects. Furthermore, Lissitzky suggests that the interface learning stage can be stimulating and rewarding, and does not

necessarily need to follow expected paradigms. Lissitzky also suggests alternative pathways through a virtual environment; his roads through his virtual towns are not always straight, they may be curved, spiralled or angled.

Other studies – Visual Representation & Spatial Memory

The Data Mountain project by Robertson et al (1998) placed 2D thumbnail imagery onto a 3D perspective plane, in an attempt to leverage extra functionality for storage and retrieval from a browser's favourites list. The project was intended to establish whether 3D spatial cognition worked the same way in a 3D virtual environments as it does in the real world. Users were able to place documents at arbitrary positions on an inclined plane in a 3D virtual desktop virtual using a simple 2D interaction technique.

Their results showed that the Data Mountain had "statistically reliable advantages" (Czerwinski et al 1999) over the standard folder-list favourites mechanism used by mainstream Web browsers. It was also confirmed that thumbnail images, mouse-over text and spatial location memory each played a significant role. Data Mountain also described several interesting observations from a user satisfaction point of view, that are directly related to the 3D plane metaphor. Their users reported a favourable reaction to the informal, manual method of arranging files spatially, in their own personal manner. The users also demonstrated recall of file location by describing its location within the space. Storage times, retrieval times, and retrieval accuracy were reported as being reduced due to the users use of spatial memory recall.

Cockburn et al (2001), sought to isolate the perceived benefit of a Data Mountain like 3D space as a place to organise documents. Their study concluded that there was "no significant difference between task performance in 2D and 3D, but a significant preference for the 3D interfaces." Cockburn et al report that "Many users of the 3D interface also commented that the interface felt "natural" and "a good way to organise bookmarks". Equivalent statements about the 2D interface were less common."

It should be noted that designs based on the Data Mountain method place 2D thumbnails against a 3D static plane. Though this arrangement isolates issues for testing, it also reduces the role of 3D to a stacking device. It will be interesting to investigate a similar, though possibly broader range of 3D spatial issues. However, information from Data Mountain and other similar studies will be invaluable when investigating the Lissitzky influenced possibilities.

Appropriateness of 3D visualisation methods

Three dimensional visualisation offers a strong sense of environment. This sense of place is generally quite different from folders and desktops, and it would be of value to investigate some of the principles behind 3D environment design. Vinson (1999) offers guidelines for navigating virtual environments, taking cues from the use of landmarks in real environments. Several key criteria that have a possible relevance to the virtual nature in interface design can be summarised as follows:

- * a navigator's viewpoint may (happen to) not encompass the entire environment
- * landmarks provide key orientation and route navigation
- * landscape cues are not inherent in a virtual environment, and need to be deliberately inserted
- * users will transfer their navigation and cognitive mapping techniques from the real world to the virtual world
- * a user will compile information from several locations to form a mental image, or cognitive map, which will then be used increasingly to navigate the space
- * awareness of movement is less in a virtual environment than in the real world, including orientation and changes of direction

Citing Lynch's (1960) descriptions for real environments, Vinson describes five general types of elements and their functions: 1. Paths – channel for navigator movement, 2. Edges – indicate district limits, 3. Districts – reference point, 4. Nodes – focal point for travel, 5. Landmarks – reference point into which one does not enter. Without being too literal to the terminology used, these terms can aid us in the analysis and design of any environment that has any degree of "virtualness", or representational relationship to the real world.

Vinson also suggests that concrete objects, not abstract, are more memorable and make virtual environments easier

to navigate. However, the abstract forms he refers to are virtual abstract paintings. It is possible that these tests, the abstract paintings lacked uniqueness. It will be interesting to see if simplified, geometric based abstract forms have this same limitation. The fundamental requirement for a good landmark is uniqueness. Abstract objects are equally able to be unique, and so therefore may be equally successful as landmark items.

Vinson also describes cognitive distortions: spatial distortions brought about by incorrect cognitive mapping. For example, users will frequently portray north as being aligned with a main road, or some other main axis of a landmark. Darken and Sibert (1993) summarise how users use environment cues to organise the space, and to create a cognitive map of the environment. Static cues, and those able to be seen from all parts of the environment, provide the most stability.

The observations of virtual environment navigation behaviour shows us how users physically and cognitively manipulate their environments in order to apply sense and meaning to their interaction. Further insight may also be gained by examining briefly some of the visual city theories of Kevin Lynch (1960), that contributed to the landmarks concepts of virtual environment. With his book, *The Image of the City*, (1960) Lynch writes about the visual and social construction image of cities. He was concerned about the mental image people had of their cities, and what he called the legibility of cities. He describes how, in comparison to the legibility of a book, cities too are legible by use of districts, landmarks, pathways, and the overall recognisable pattern. He describes how the generalised picture of the environment is the product of immediate sensation and the memory of past experience, and these are used to interpret information and guide action.

It is curious that fundamental theories of environmental design can be seen as appropriate for interface design. This could imply that the computer interface is more than a place to open and close files, rather, it has now evolved into a complete environment, as graphics on the computer screen, and as part of a user's cognitive visualisation. It is then appropriate, that interface design could be approached as a form of environmental design, with all the implications and irresponsibilities of such. If we allow ourselves a brief analogy: a well designed adventure playground environment gives the children interesting and stimulating routes to the various activities. To get to the slide, a child may be required to cross a bridge, climb up spiralling stairs, and crawl through a tunnel. The interaction of the environment is just as educational and enjoyable as the activities themselves. One could say that the user experience is greatly enhanced by the design of the interface.

The Design Process

The first step of the design process was to gain familiarity with the visual devices commonly used by Lissitzky. This was, in effect, a deconstruction process of several of the proun paintings, (Fig. 1). It was hoped that this process would produce some insight into why the paintings evoked such spatial movement and intrigue. Perhaps the graphic devices used, that so successfully moved the eye in and out of the paintings, could be employed in the virtual space of folders and icons.

Lissitzky's work has already been thoroughly analysed from an architectural point of view. This particular study takes a slightly different approach, focusing more on object and eye movement within the space. All analysis was tempered with the criteria of how it could this be interpreted as part of an interface?. The elements within a selection of Proun paintings were isolated according to their roles, and given terms to describe their function. (Fig. 2)

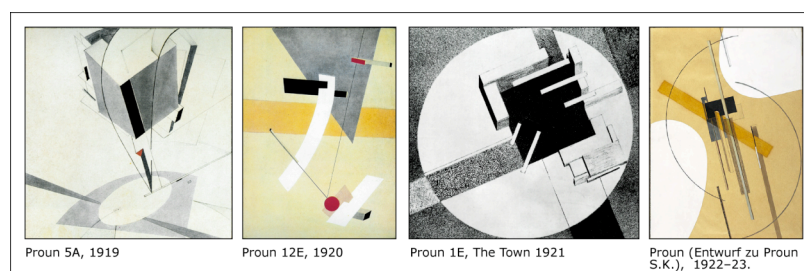


Figure 1: Prouns. (Lissitzky-Küppers, 1980).

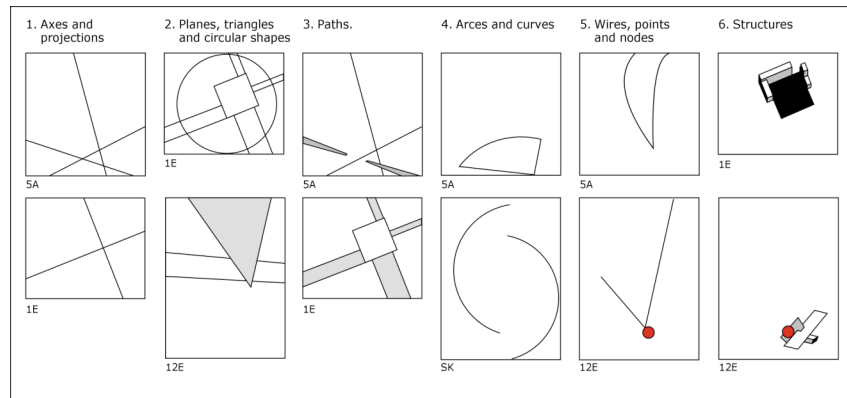


Figure 2: Identification of proun elements according to a design criteria.

1. **Axes and projections:** The prime axes and projections in a Proun provide the overall visual direction, and establishes the central planes of interest for the work. Axes intersect at a variety of angles, further increasing the visual dynamism. Various parallel projection types are used, at times, different types are used within the same painting.
2. **Planes, triangles and large circular shapes:** These are used to define boundaries, either as floors, walls or as background forms. These devices also function to provide scale, or to give visual limits to the environment, similar to the role of a horizon.
3. **Paths:** Paths provide visual road ways, giving direction into and out of structures. They may be straight or curved, and in some cases, are tapered, seemingly observing perspective. Often paths appear to float, with their connections to other shapes appearing very tenuous. Nonetheless, their presence provides a certain amount of temporary stability, settling the eye in this or that direction.
4. **Arcs and curves:** Curves, being a highly dynamic shape, add tension to static planed surfaces. Though not as stable as a plane, nor as dynamic as a wire, curved edges allow a plane to suggest movement, or at least to lead the eye from corner to corner.
5. **Wires, points and nodes:** The larger nodes provide static locators, from which wires frequently depart. These wires may move off the canvas, or they may end within another object, sometimes another node. These wires function as visual connectors between points. If a straight line is used, as in Proun 12E (Fig. 2), the connection is relatively static. If a curved line is used, as in Proun 5A (Fig. 2), the connection is dynamic, full of movement and tension. The curved line also has a stronger sensation of acceleration and depth. The colour red is often used for nodes, as if to draw attention to their function.
6. **Structures:** Constructivist than Suprematist, these structures are often found seemingly floating in space. Often a Proun painting is based around one of these structures, as in Proun 1E - The Town (Fig. 2). In other cases, simplified structures are combined with other forms. They appear to provide an anchoring function, perhaps a static location, from which spots and wires may travel from, as in Proun 12E (Fig. 2).

Lissitzky does not use conventional perspective projection. Instead he employs various parallel projection types, usually dimetric or trimetric. These types of drawing techniques are usually used in a diagrammatic role, to convey a shape's 3D qualities, while at the same time providing constant scale on all dimensions. This use of what is essentially a diagrammatic technique may suggest some solutions to representing the diagrammatic nature of interface.

Following the analysis stage, the first design experiments concentrated on building a Lissitzky type environment, and giving form to some of the principles arising from the analysis. In order to quickly realise design concepts, off the shelf authoring products were used. Initially a 3D authoring programme was chosen, AxelEdge by Mind Avenue. As the design approach moved away from perspective based 3D, Macromedia Flash was adopted.

It was decided that web pages would be represented by iconised screen captured views, accepting the value of iconised images as reported by such studies as Data Mountain. Four key criteria for interaction were identified:

1. How to represent the chronological sequence of web page encounters
2. How to allow for re-sorting by the user, using as much direct manipulation as possible
3. How to provide for storage of groups of pages

4. How to allow for intuitive retrieval of stored pages

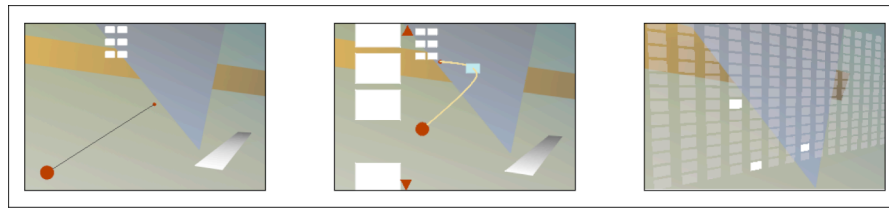


Figure 3 : Early designs

Early designs were essentially reconstructions of Lissitzky styled spaces (Fig. 3). These contained great visual appeal, as thumbnailed pages would speed off into the depths, along curved wires, towards distant shapes, where they would be organised into tidy stacks. This approach, however, contained significant flaws. Since the environment was built as a virtual space first, and interface considerations came second, the environment and the interface were not conceptually integrated. The space simply functioned like a virtual city, onto which iconised elements would move and hang, like so many lines of washing on washing lines. Though this direction would no doubt have produced a visually appealing interaction, this approach has already been explored in some depth, both practically, and conceptually in the entertainment industry, to a fairly high visual standard. Though the Lissitzky style would no doubt bring a different aesthetic, this direction, it was felt, was not really answering the central criteria of this brief. Another significant issue with this first design approach, was that this 3D styled environment inherited all of the issues of 3D way finding. Though this area had been examined theoretically earlier in the study, it had been decided not to explore true 3D navigation. Even so, some significant issues arose, that would have an impact on further progress.

First and foremost was the issues of Z-depth navigation, i.e., moving in and out of the environment, as opposed to simply moving up and down, (X and Y). Some initial solutions attempted to limit the effect. For example, instead of moving the camera in and out of Z-depth, the camera would remain fixed, and the pages themselves would fly up to the user, or away into the distance to be filed as needed. However, it soon became apparent that once numbers of pages grew, the filing area would become very cluttered, and some sort of zooming function would be required, so as to allow the user closer inspection.

As various techniques were explored, the fundamental issue of Z-depth navigation became very apparent. To require the user to move in and out, is to add another axis of navigation, and thus, another controller to the mouse, and another cognitive step for the user. This extra demand threatens to undermine a key interface principle, that of direct manipulation, where the user, as much as possible, is allowed to feel that they are directly manipulating the data. For example, when a user drags a folder across a desktop, they are conceptually moving the symbolised data (the folder) from to here to there directly. The indirect option is to use a command, or menu item, and the object is moved indirectly by the computer, not by the user. This principle, inherent in all WYSIWYG interfaces, is a fundamental principle to giving the user a sense of control, an almost tactile directness to controlling their data.

Whatever the problems, the zooming method also exposed some advantages. With zooming, the user retains the notion that the file is still “there”. The file is not hidden from view, it is not placed into a closed folder, it is not folded away into a list. Conceptually, the file is right there, in front of the user, though perhaps reduced in size to almost be unrecognisable. Informal tests at this time supported the value of this notion, and it is hoped that formal testing at a later date will support this hypothesis.

Many of Lissitzky’s Prouns included 3D constructed objects, often floating in space, that resembled floating buildings or structures. They are very deliberately placed, using orthographic projection techniques, and have a certain appeal when in contrast to the planar forms. It was supposed that much of the appeal of these forms lay in their unexpected appearance, and non-representational shapes. They were in effect “floating constructs” hanging in space, with two or all three axes angled to the viewing plane. This scenario has its counterpart in fine art, such as the surreal juxtapositions of Magritte. Floating mega-structures are also a recurring form in science fiction and fantasy. Without seeking to understand further the psychological appeal of floating structures, it was decided to reproduce the effect using the 3D modelling programme Alias Maya, with the help of some random positioning scripting. The results were surprisingly intriguing, as unique compositions were assembled on the screen in

immediate response to a button push from the user.

Though it was difficult to see how these shapes could be used in an interface, this design diversion was useful in two ways. Firstly it reinforced the initial appeal of floating 3D structures, and secondly, it demonstrated how a small amount of controlled random positioning could introduce surprise, without interrupting user control.

Surprise may not seem to be an ideal component of an interface, but when seen in the light of neurological reward behaviour, it may be one way to incorporate a mood enhancing effect, without being gratuitous. This is a design consideration not to be underestimated, as research confirms the link between emotion and cognition, (Damasio 1994). In particular, positive emotion can systematically affect cognitive processing and improve creative problem solving (Ashby et al 1999). The greatest neurological boost is received in response to the unanticipated reward, or the surprise reward (Holleram and Shultz 1998). This is the body's natural way of marking the best outcome, and setting up a memory, or somatic marker (Damasio 1994). As if to say "This was good, let's do it again". Any integrated design feature that can positively affect the user, without hindering function, will therefore add to the usability of the interface. It is therefore intended to implement a small amount of randomness to the stacking operation of thumbnails. It will be interesting to test users reaction to this – it is anticipated that some may feel an urge to "tidy-up" the carefully randomised stacks.

The second design phase

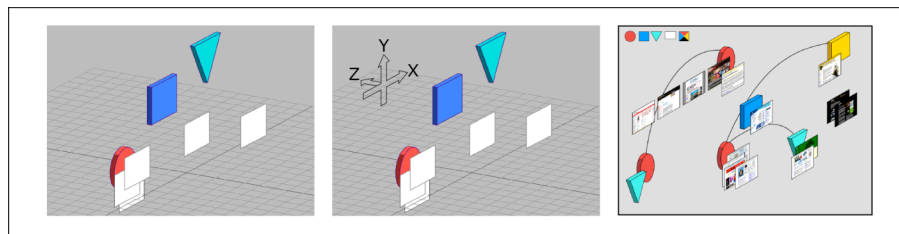


Figure 4 : Orthographic options

The second design phase saw a re-evaluation of the 3D perspective based environment. It was felt that perspective based 3D raised too many issues and threatened to move the study away from the central brief. The central brief was not about recreating a Lissitzky styled environment, rather, it was about integrating principles that were derived from his spatial theories. At this point of writing, the navigation and usability aspects of the orthographic model, or more accurately, the trimetric model, were in the initial stages of exploration. (Fig. 4). However, even at this early stage, several benefits have emerged:

1. As there is no diminishing Z-depth, there is no need for a zooming, Z-depth mouse control, thus reducing manipulation complexities and user cognitive load.
2. The illusion of 3 dimensions remains intact, thus providing 3 axes of movement, without issues of depth.
- 3 It is less complex to develop and test a prototype in what is essentially two dimensions.

Issues to be examined as the study continues:

1. What usability and cognitive differences does the orthographic model have to current flat plane 2D models.
2. Does the random element provide useful stimulation?
3. If a thumbnail size reducing option is provided, what visual effect does this have, being that the orthographic environment has no true depth? Will the size reduction appear to scale, or will it appear to move away from the camera, thus destroying the orthographic flatness of the space? Does this matter?

Conclusion

Using the design process as a means of investigation has proved to be extremely enlightening. The most significant issues identified were those associated with the perspective based 3D virtual environment. Paper prototyping had failed to identify many of these ramifications, in particular issues associated with user movement. The paper prototyping process would tend to illustrate the beginning and end points of a user movement, and easily overlook

the behaviour of the travel in between. As virtual environment principles warn, once the viewpoint of the user is changed, disorientation is a very real possibility. The degree of disorientation relies upon the speed and nature of the movement, the landmark nature of the environment, and to what degree the environment can provide world direction. This created some dilemmas. For example, file manipulation ideally requires fast interaction and feedback. However, this fast interaction within a virtual environment can be very disorienting. It soon became apparent, that the interface aims of the brief were conflicting with the way finding requirements of the environment. Though this work has contributed valuable information, to circumvent the many issues arising, an orthographic approach was adopted.

The orthographic approach also places the environment back into a graphic design context. When a designer decides to allow themselves to be influenced by a style, there is always the risk that the style will drive the design, which in this case, would have been inappropriate. The orthographic approach, being a strong visual form in itself, reduces the stylistic impact of Lissitzky, while at the same allowing key principles to be applied. This creates some very interesting dynamics, as the function of the Lissitzky objects are given a new visual form, and are placed into a different stylistic medium. It will be interesting to see if the perceived function of these forms still communicates successfully to the user. In the most recent iteration, several influences from Lissitzky are still evident, though the overall interface bears little resemblance to any Constructivist or Suprematist's aesthetic. Key aspects that have been retained are the use of abstract shapes as opposed to literal metaphors, the use of orthographic projection, the incorporation of unexpected compositions, and the use of curved wires and nodes to create connections between objects.

It is hoped that this project has demonstrated that the investigation of an art form can indeed provide useful direction and inspiration for the development of a contemporary piece of functional, usable interface design.

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