Association of American Geographers
Environmental Perception and Behavioral Geography Specialty Group
2003 Saarinen Student Paper Competition

"Camera motion and landscape: from information to perception and aesthetics"

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Abstract

The psychological human-landscape relations, conceptualized in terms of spatial knowledge, aesthetics and sense of place, are based in part on the perception and cognition of environmental information. The visualization and animation of landscape, conceptualized as a "view on the environment", can be used to access and manage environmental information to produce an enriched and enhanced experience of the visual resource of landscape, if suitable criteria of visualization design are formulated and adopted. This experimental study aims at verifying if variations in the trajectory of a virtual camera, manipulated in two conditions (high elevation/uniform and low elevation/terrain following), affect the viewers' experience of landscape. Computer-generated and animated sequences of various real-world landscapes are designed and shown to participants as landscape stimuli, and the responses are measured using a self-report questionnaire. The expected findings might lead to the development of the foundations of a cognitive theory of camera motion over the landscape, based on establishing how influential landscape animation design and, specifically, camera elevation are on landscape experience.

1. Introduction

The importance of landscape as a visual resource requires us to be aware of the nature of the human-landscape relations that are rooted in the perception and cognition of the environment. This study is generally aimed at developing a framework for a better understanding of, and access to, the visual resource of landscape. The framework considers in particular landscape animation, where the observer moves over a static landscape, as a useful method to manage the information present in the visual world within the context of a filmic or computerized representation. This paper is aimed at documenting a work-in-progress that entailed the development of a theoretical framework and the collection of preliminary data, in view of a forthcoming final thesis study.

The interest in dynamic visualization can be related to the relatively recent attempts to find novel and more effective methods of using increasing amounts of geographic data. Scientific visualization has brought forward the idea of “seeing the unseen”, an attempt at exposing the hidden properties of data, and extracting their information content through visual representation (Buttenfield & Mackaness 1991). Similarly, the “seeing the unseen” of landscape might mean the “exposure” of its visual resources. The process responsible for “exposure” arguably relates to the dynamics of observation, because it might involve the selection of particular views out of all the potential views in a scene.

The specific task of this study is to verify experimentally whether an exposure to different landscape information, provided by a computer animation of landscape, elicits different landscape experiences. In the experimental framework, the information available from the landscape varies according to two qualitatively different motions of a virtual camera over the landscape. Spatial knowledge, the aesthetics of landscape and sense of place are the elements used in this study to assess the nature of landscape experience to be tested experimentally.

A basic form of landscape information management, based on designing camera trajectories at different elevations, might constitute a good experimental perspective to approach the development of principles of landscape animation design. It might in fact provide evidence about how determinant is to choose one’s trajectory in the landscape to the viewer’s final experiences of landscape. In turn, this could lead to a general theory of camera motion over the landscape.

In summary, this study attempts to construct a framework that relates landscape information to spatial knowledge and aesthetics. Landscape information is managed through selective observation, a method also used experimentally. If we understand the link between experience and information, and we encode it in animation design principles, it would in turn allow us to consider the systematic study of landscapes for their visual documentation.

This document presents a literature review focused on spatial knowledge, aesthetics and sense of place, explains the conceptual framework of the study and illustrates the methodological aspects of the experiment, supported by a pilot study report and some final considerations regarding future thesis work.

2. Literature review

The Literature Review will consider in sequence the ontological properties of landscape (2.1), the theories of landscape aesthetics (2.2), and ideas about spatial knowledge (2.3) and sense of place (2.4). A review specifically focused on issues related to the perception and the cognition of the environment has been preferred to a broader literature base that originally included, for example, visual landscape design, cinematic aspects of visualization and ideas about the nature of landscape information. However, the theoretical core, useful in the interpretation of the experimental study, has been maintained.

2.1 Landscape

Landscape has been considered an elusive concept (Tuan 1979). The history of the term "landscape" begins in the 16th century when the Middle Dutch word "Landskip", at that time used to indicate the works of Flemish painters, has been translated into English (Lorzing 2001). "Landskip" referred specifically to a painting of a prospect involving elements like hills, woods, ruins, valleys, and towns (Shepard 1991). The derived term "Landscape" similarly refers to the definition of "view or prospect originated from one point of view" as given in the context of artistic painting in the 18th century (Cosgrove 1984).

The contemporary interpretation of the term "Landscape" took shape in the late 19th century as a portion of territory that is comprised in one view, including its objects in their pictorial aspect (Johnston et al. 2000). This transition signified the transformation of the term from the status of identifier of a representation to the specific content matter of such representation. Later it became attached to the cultural elements comprised in the view (Cosgrove 1984). Therefore the two levels of interpretation of landscape, the physical and the cultural, share the common context of "the view", a visual organizing principle utilized to select a portion of the environment.

The landscape concept overlaps in part with region and scenery, since it proposes two approaches of interpretation at the same time: landscape can be seen objectively as a domain and natural system necessary to organic life, but also as a scenery to contemplate from a viewpoint (Tuan 1979). Lowenthal (1961) defines landscape as "a way of seeing", which therefore has much to do with the viewer as with the viewed, a mediation of the external world through subjective human experience in a way that the concepts of region or area do not readily suggest. This mediation, carried out through "people's eyes" (Lowenthal 1966), means that the combination of objective and subjective takes place in the mind, or "in the mind's eye" (Tuan 1979).

Granö (1929) provides an interesting example of how the subjective/objective differentiation of landscape can be approached. He formulated a new discipline called "Pure Geography", in which the region was adopted as the basis of scientific investigation. In particular the regionalization process was decided by the subjective and perceptual experience of the individual, thus proposing an egocentric conceptualization of the environment. Visual, auditory and olfactory regions were referred to a perceiving observer, thus the subject's experience defined the object of study in the world

Even when we separate the two interpretations of landscape as a system and landscape as scenery, we are still using the common framework of the "view", inherited (as we have seen) from the original landscape painting definition. The "view" selects the visual data that we have to consider, affecting in turn our interpretations. Of particular interest here is the degree of change of the landscape experience as the viewing parameters change.

In summary, landscape is rather a "view on the environment" than just a physical entity, and it is based on the observation from a viewpoint, which is used to select the visual information. Using multiple viewpoints in sequence demand an extension of this definition by considering the exploration of other, more complex procedures of visual selection. The fundamental idea is that landscapes vary according to the procedure of visual selection being used: our interaction with the landscape (spatial, cognitive or aesthetical) might vary in an analogous way.

2.2 Aesthetics of landscape

In philosophy, aesthetics are the study of the meaning and the nature of art, but the term has a different meaning when applied to the environment (see Berleant 1992) or to media (see Zettl 1990). The study of the aesthetics of the environment finds a theoretical justification in the original interest of aesthetics for the natural world, even if historically only a few philosophers diverted their attention from art to nature.

Aesthetical experiences are, in part, the outcome of an innate human ability of relating with the environment, which depends on evolutionary considerations of adaptation; in part they depend on the human cognition of stimuli from the environment; and in part they depend on factors related to culture.

Appleton (1996) proposed Prospect-Refuge theory, according to which one likes or dislikes a scenery or landscape depending on biological considerations of survival. Prospect-Refuge theory is more specific than habitat theory and is dependent on the imagination and experience of the observer, as well as on environmental conditions. In particular the two situations of seeing and being seen are the fundamental building blocks of an aesthetical consideration of landscape. From an evolutionary point of view we have evolved by preferring those areas that afford prospect on the prey and at the same time refuge from a possible predator ("to see and not to be seen"). Landscape preference as suggested by Prospect-Refuge is not a conscious activity but in some ways it does underscore our sensations of pleasure in the landscape.

In Gibsonian terms, the Prospect-Refuge theory is a description of landscape in terms of prospect and refuge affordances, that is, the functional values of landscape (Hartig & Evans 1993). Gibson (1979) in fact suggested that the affordances of the environment are perceived by an observer by means of a process of direct perception that even preceded the process of classification. Although Gibson never specifically referred to aesthetics, he hinted at the concept of "higher order invariants" that arguably stem from the first-order perception of the environment. This suggests how aesthetics could in principle be conceptualized as a kind of higher order invariant making use of environmental information such as the affordances of the environment.

In summary, the variable land surface of Prospect-Refuge, with places to hide and prospects controlled by topography, finds aesthetical justification by means of an evolutionary preference for survival. Topographical features, when they control the observer's viewpoint, afford specific aesthetical reactions. Using this framework, landscape visualization, according to the relative topography of the viewpoint and the surrounding landscape elements, can then be linked to a particular aesthetical reaction.

Kaplans' theory of information processing is based on the idea that our preference for landscape depends on the kind of information processing that is necessary to perceive and relate with that environment. According to the theory, we have evolved by preferring those landscapes characterized by a particular balance between order and uncertainty, organized in factors such as coherence, complexity, legibility and mystery. An example of mystery factor is a deflected vista, such as a hilltop represented on a canvas, which suggests the possibility of obtaining a better view of the surroundings from the new viewpoint (Kaplan 1987)

	Understanding	**Exploration**
Immediate	Coherence	Complexity
Inferred or Predicted	Legibility	Mystery

Table 1- The Information Model of Environmental Preference (fr om Kaplan 1987)

Table 1 summarizes Kaplan's information model. The element that helps understanding in the immediate time frame is the coherence of the environment. When the observer is instead involved with the environment, such as during exploration, it is the complexity of the environment that engages aesthetically the individual. In case the observer is engaged in a prolonged interaction with the environment, the understanding effort is coupled with aesthetical satisfaction if the environment is legible, and, in case of exploration, if it generates mystery (Kaplan 1987).

Of particular interest in this context is the discussion related to the influence of culture and individual differences on a theory that promises a universal perspective on aesthetics, indicating aspects underlying the aesthetical experiences of all of us. Experimental results show that the cultural effect and the degree of exposure to previous information do influence landscape preferences, offsetting the expectations of the aesthetical factors discussed above. However what is considered invariant and fundamental across individuals is not strictly preference, but rather the adoption of the same determinant factors based on landscape information processing. The factors are only weighted differently according to the individual or the cultural group, but the fundamental assumption of considering aesthetics as information processing is not violated (Kaplan & Kaplan 1989). This suggests that landscape information processing might be used as a basic concept for reconciling evolutionary aesthetics with culture.

2.3 Spatial Knowledge

One aspect of this study is to assess the spatial knowledge of the environment that develops after exposure to animation. To achieve this goal it is important to discuss the nature of the process by which landscape information becomes spatial knowledge. The spatial experience of a landscape through the medium of animation might involve the development of a mental map or schema that includes visual memories of the appearance of the surface, the location of major natural landmarks and the shape of the topography, as well as the spatial relationships between the visual elements of landscape. Sholl (1996) suggests that while much animal navigation takes place without visual information by the process of dead reckoning, instead in human beings vision is a fundamental sense modality for spatial knowledge acquisition. In particular the invariant structure of the optic flow is important in the formation of survey knowledge, since it specifies object-to-object relations instead of the self-to-objects relations specified by the perspective structure. This idea results useful in establishing a link between visual information and spatial knowledge.

The second approach considers wayfinding to be a process deriving from the perception of the environment, without requiring the construction of cognitive maps. This ecological approach states that, while moving, instead of perceiving static snapshots of the environment that are later integrated into a cognitive map, we rather perceive the continuous optic flow and the invariants of the environment as they are picked-up over time. This allows us to acquire a holistic, higher order perception that is not dependent on the original viewpoints, and which also does not require the existence of a cognitive internal representation (Heft 1996). However, the contribution of cognitive factors is acknowledged in the sense that memory has a role in certain forms of spatial behavior that perception alone cannot explain (Heft 1983).

Each view and each path in the environment is unique, and we can distinguish in the perspective flow an alternation of vistas (a set of unhidden surfaces seen from a vantage point) and transitions (portions of a route where an occluded view replaces the current view), respectively characterized by a low magnitude and a high magnitude of change. This defines the temporal character of navigation on which perception is based (Heft 1996). This is important in landscape animation because it allows us to formulate the idea that spatial knowledge is a higher order perception of landscape when perceived within a temporal structure.

The ancillary effects of cognitive processes on perception might account for the influence of memory, experience and culture in spatial knowledge acquisition, storage and utilization. Cognitive maps might be considered as a representation of spatial knowledge rather than as a fundamental structure. This solution is interesting because it relies directly upon perception to explain spatial knowledge, thus presenting, together with the previous discussion on aesthetics, an occurrence of the fundamentally perceptual nature of landscape experience.

The animation used in this study can be classified as an indirect source of spatial knowledge, since it transmits spatial information indirectly through a pictorial representation, and it is contrasted with direct sources that involve apprehension of spatial knowledge directly from the environment via sensorimotor experience. While Montello et al. (in press) presents a comparison between direct experience and media such as maps and virtual environments, the characteristics of the sources of spatial information are also distinguished, so that it is possible to characterize the animation used in this study. Animation presents information in a dynamic stream; it requires sequential pick-up of information over a certain amount of time; it uses a terrain-level or aerial perspective; the symbols in it are realistic and iconic; the scale of viewing is reduced compared with direct experience; there is a high spatial precision in the spatial information; it contains redundant detail with respect to the one necessary for problem solving (a consequence of photorealism, consider also that detail might be irrelevant for spatial knowledge but not for aesthetics). From the basis of these characteristics it might be possible to evaluate the potential for spatial knowledge acquisition of the medium used in this study.

2.4 Sense of place

Sense of place is a vague umbrella concept incorporating many different aspects related to place. It combines the ideas of location, landscape and personal involvement in place, includes concepts of identity and attachment to an area and, overall, it offers a stronger unity than the region concept.

Muir (1999) addresses the issue of landscape and place in the broader context of landscape studies. Sense of place derives from two main factors: 1) the intrinsic personality of places which are visually striking and produce powerful images and 2) the emotional attachment to localities when considered as home settings. Landscape makes a substantial contribution to the sense of a place, and determines many qualities of it, including the character of the scenery. Yi-Fu Tuan (1975) proposes a scale of classification: at one end there are places that are remote from sensory experience considered as points in a spatial system; on the other end there are places eliciting visceral feelings and rooted in a locality.

The Sense of place for an area might vary with the view characteristics, such as the perspective of a traveler from the top of a hill versus a farmer in the valley below (Muir 1999), although there are few, if any, experimental studies investigating this aspect of topographically-dependent sense of place.

In this study the intention is to explore the aesthetical aspect of sense of place, and shift the attention away from its other cultural and memory-based components, which would probably require a different approach. Sense of place is considered to be the quality of a place when it is exposed to a particular landscape. In other words, the sense of place depends on the aesthetical characteristics of the visually accessible scenery. In this light it is rooted in aesthetics and, therefore, it is related (like aesthetics) to ecological perception.

3. Rationale of approach

3.1 Introduction

Three fundamental components of the psychological human-landscape relationships can be identified. The first, knowledge of the characteristics of the landscape, depends on the process of spatial knowledge acquisition, taking place during the exploration of the environment. The second element consists of the evaluation of landscape characteristics, and refers to the idea of landscape aesthetics. The third element is about our feelings towards landscape and is captured by the concept of sense of place.

These three elements are based on heterogeneous concepts, thus their investigation in combination might present methodological problems, such as considering affect and cognition at the same time, that are difficult to tackle in a single study. However, the approach used in this study makes the research problem conceptually more focused and manageable, while preserving the diversity of angles at which landscape is investigated. This research approach emphasizes the perceptual and cognitive dimensions of the human-landscape relationships.

The reason for emphasizing cognition comes from the idea that a fundamental layer of cognitive information processing might underlie spatial knowledge, aesthetics and sense of place. Therefore it is interesting to evaluate the proposed aspects of visualization primarily considering this layer.

Besides the cognitive emphasis, this study is also centered on aesthetics, which consists in the evaluative component of the human-landscape relationship. Spatial knowledge is considered here only as an auxiliary source of information about the human-landscape relationship, since the study is not designed to specifically investigate the process of spatial knowledge acquisition. It is nonetheless argued that having an insight into people's knowledge of the spatial structure of landscape might inform us on the extent and kind of information base used for their aesthetical evaluation of landscape.

Sense of place is instead considered in its cognitive and evaluative component, rather than in its specifically affect-based component of place attachment. Central in this context is the idea of landscape character (see below) and in particular the idea of distinctiveness and uniqueness of the information base contained in a landscape. This aspect of sense of place extends the scope of the concept of aesthetics while introducing more holistic and identity-based evaluations.

The following sections contain the specific details of the conceptual framework regarding aesthetics (3.2), spatial knowledge (3.3) and sense of place (3.4), together with ideas related to the choice of environmental conditions and trajectories (3.5).

3.2 Aesthetics

The idea of landscape aesthetics hinges upon an evaluative relationship with landscape that refers to the fundamental and very complex (although experientially simple) process of liking or disliking a scene. However it also includes a range of appreciative relations with the environment, such as for example interest and curiosity stemming from the visual properties of landscape.

Of particular interest to this thesis is the mystery factor described by Kaplan (1987) that specifically refers to the amount of promised information contained in a landscape view. In other words, promised information in a landscape originates from actual environmental information that indicates the availability of further information after a slight change in the vantage point.

This research aims at extending the concept of mystery suggested in the literature by considering the promised information effect generated by the occlusion of topographic forms. For example, a form of topographic mystery might be the effect of a foreground hill that, by means of occluding the view on the mountain beyond, actually generates an attractive view based on the promised information implicitly made available about the mountain. This form of topographic mystery is coherent with defining mystery as a condition in which some environmental information is promised by means of actual information cues in the landscape: for example, in topographic terms, a cue might be the highest tip of a mountain visible beyond the foreground landscape.

Prospect-Refuge theory by Appleton (1996) suggests the importance of the concept of visibility in the aesthetics of landscape. Prospects are specific locations in the landscape that afford a better visibility on the surrounding landscape, and therefore afford the viewer a more aesthetically pleasing view, for reasons supported by evolutionary considerations. This theory can be linked to a topographical view of landscape aesthetics because an ideal prospect might be a topographical high point on the terrain, such as a hill or a mountain, from which a satisfying view of the surroundings can be experienced. In the experimental design Appleton's (1996) hypothesis is used as a theoretical confirmation of the idea that topography has a direct influence on aesthetics. More specifically, a high elevation trajectory offers a more pronounced prospect than a low elevation trajectory, thus suggesting that preference might be granted to the former, for example being able to elicit a stronger impression of layout knowledge (as shown also by the pilot study, see below).

In informational terms the research question might be formulated as whether actual and promised information have an influence on landscape aesthetics, and in what ways. Actual information can be conceptualized as the environmental information expressed in form of perceptual invariants, such as the three dimensional information about landscape that is obtained from textural, lighting and perspective elements. Promised information is instead the environmental information that we are able to predict given an initial exposure to actual information and imagining a process of continued exploration of the environment. It is hypothesized that the perception of actual information and the unconscious formulation of promised information are linked by environmental cues, which consist in actual information having the role of "pointing to" other potential sources of information out of sight.

The experiment design dedicates a specific set of stimuli to the creation of environmental conditions that directly address the topographic mystery factor and more in general the dynamics of actual and promised information. It is also interesting to understand how specific cases of actual landscape information affect aesthetic perception. From a landscape visual design perspective it is suggested how aesthetically different it is to be located in a deep valley with respect to being on a plain or a ridge, for the sense of closure and scale of the surrounding environment, as well as for the limited visual range. By considering specific topographic forms it is possible to analyze specific cases of actual landscape information and the way different trajectories on the landscape might be able to elicit different aesthetical responses.

This study introduces dynamic animation to extend the methods of research normally employed to investigate landscape preference, which are traditionally based on the evaluation of static photographs of landscape. This is in line with the Gibsonian theoretical orientation in favor of natural perception in motion instead of static perception, and the interest for the effect of the motion picture on processes of perception (Gibson 1979).

The problem of measurement of aesthetical responses to landscape requires us to step back from the discussion and consider the strategies adopted in the literature. Research accounts illustrate the process of aesthetical evaluation as something captured by ratings of preference of landscape photographs. Landscape preference research is based on people's basic evaluations (i.e., like or dislike) of landscape, and on expert analysis of the stimuli in order to induct from the data the criteria used by people in their judgments. For example, the mystery factor discussed above is the result of an expert analysis of the stimuli, and it is assumed to be part of the unconscious strategy of the viewers of landscape. The approach used in this study is not only based on ratings of landscape preference as a main research tool, but also relies upon viewers' ratings of more elaborated variables, such as curiosity, visual balance, and complexity.

3.3 Spatial knowledge

The interest for spatial knowledge in this study is mainly related to the need of establishing a relationship between landscape information and aesthetical perception. In fact, investigating how spatial knowledge is acquired after exposure to a landscape animation is important to determine the extent of the information base used by the viewer to carry out her aesthetical evaluations.

In other words, as the viewer perceives the environment she develops an information base that is unconsciously processed during aesthetical perception. A way to assess the extent of that perceptual information base is to verify how it helped develop spatial knowledge. From this point of view, investigating the extent of spatial knowledge by means of analyzing its externalizations is like giving a different look at the landscape information that contributes to the viewer's cognitions and feelings. For example, knowing the level of detail of the viewer' memories of the spatial properties of landscape can be indicative of the things she noticed and that might have affected her aesthetical evaluations.

Another component of spatial knowledge is related to the spatial awareness of the characteristics of the viewer's trajectory. Being able to remember the type of trajectory in relation to the ground is an ability that can be related to the preference for the mode of landscape exploration used in an animation. In flight simulation there is great interest in modeling the way the pilot perceives the motion of the plane (Rolfe and Staples 1986). While their emphasis was on facilitating safer and more efficient flight, in our case it is interesting to study the perception of the characteristics of a trajectory as a factor that completes the experience of landscape in more general terms of self-motion awareness.

The methods used in this study to investigate spatial knowledge are based on self-report sketch maps of the plan and profile view of the landscape being viewed, and the plan and profile projection of the trajectory along which the exploration occurs. The sketch maps of the landscape contain the topographical structure of the terrain, including major topographic landmarks and landforms (see Methods below). While most spatial knowledge sketch-maps used in the literature refer to the built environment, drawing a sketch map of the natural environment is a less common task, especially when referred to a landscape lacking traditional navigation features, such as roads and nodes.

3.4 Sense of place

In the current theoretical framework of the thesis the concept of sense of place, when combined with aesthetics and spatial knowledge, completes the range of human-landscape relationships considered in this study. However, this study adopts the idea of considering sense of place as a concept similar to aesthetics.

The concept of sense of place has specific implications with respect to time and memory. According to the cultural tradition in Geography, sense of place is rarely acquired in passing (Yi-Fu Tuan 1975) and requires a long residence and deep involvement. From a temporal point of view it might not be similar to the quick evaluative aesthetical relationship with landscape, which instead operates in much shorter (although not instantaneous) time frames (for example see Kaplan's phases of understanding and exploration in information processing in Kaplan 1987). If sense of place is a cognitive concept then there might be similarities to spatial knowledge, assuming that sense of place is constructed in time in a way similar to a cognitive map of the environment. However, it might be argued that while a cognitive map of the environment starts to be built at a first exposure, in absolute temporal terms it takes more time to develop memories (in affective sense) and feelings of attachment to place.

The current experiment design, based on very short exposures to landscape (mostly 30-second sequences), does not allow us to examine the affective attachment dimension of sense of place, as the latter would probably not develop in that short period of time. In other words, sense of place cannot be included in full in the same experimental design together with aesthetics and spatial knowledge. However its similarity to aesthetics might be useful to capture part of the concept without radically changing the objective of the study.

The idea of landscape "character" is not only related to an appreciative (aesthetical) relationship to landscape, but also to an early form of attachment, better represented by sense of place. The viewer would probably establish the "character" of a landscape even after a short exposure, largely based on the environmental information present in the landscape.

In summary the proposed strategy is to explore the roots of sense of place in aesthetics by considering how the character of a landscape might be the first building block for a sense of attachment to landscape. The experiment design would be aimed at evaluating the initial aesthetical stages of sense of place development, without considering directly the latter in its full expression.

It is useful to develop self-report measures able to capture the aesthetical and cognitive component of sense of place, and in particular the idea of landscape character. Those measures are based on questions capturing uniqueness, distinctiveness, memorability, and how striking the scenery is, which all contribute to an assessment of a holistic dimension of aesthetics more similar to sense of place.

3.5 Experimental conditions – Trajectories

In the exploration of landscape there are certain perspective views that have the potential for triggering particular responses due to specific configurations of actual and promised information as suggested by the Kaplan's mystery factor.

The essence of this experimental study is to compare with each other trajectories that are very similar but still qualitatively different. In general the research question is to verify whether a slight variation in the viewing dynamics is able to influence significantly the aesthetical perception of landscape.

It is not a trivial choice to select the proper level of difference between trajectories in order for them to being still comparable (i.e. able to visualize the same landscape) but not so similar to be indistinguishable from each other. Also, designing qualitatively different trajectories means that we have to select examples of trajectories that have a particular meaning in the exploration of landscape.

The variable of camera elevation is the primary differentiating factor between trajectories used in this study. From a perceptual point of view, elevation influences the viewing perspective of the landscape, since the sizes of the textures change according to the distance from the ground, and objects tend to be seen vertically from above, thus exposing horizontal instead of vertical surfaces (for example, the crown of a tree versus a tree trunk). Camera elevation also influences the scale of the landscape because the visual elements of a ground view are represented at a larger size than those in a layout view, and in the latter case there is a larger portion of landscape being displayed at a given time.

From a cognitive point of view, a layout view from high above the ground might allow the viewer to have a different idea of the spatial structure of the environment, especially if compared with a ground view.

A similar difference can be found between perspective views and maps. Maps in particular have been studied to determine the strategies used to match a contour map with a three-dimensional representation of the same terrain. In the literature there are examples of the use of scale and orientation/viewing parameters variables to study the effects of spatial knowledge acquisition from maps (Taylor 1984; Eley 1992). They suggested that these variables have a strong influence on the cognitive processes of map reading. Therefore it can be hypothesized that camera elevation might have an influence on the process of cognition of landscape.

There are also other implications of the height of observation, for example the experience of seeing a city from the top of an observation tower, after being used to a ground perspective. The experience of a panorama seen from a height (Dubbini 1994) is probably based on the perceptual and cognitive implications of the visual perspective but certainly it suggests how important camera elevation is in influencing our experience of landscape.

From an aesthetic point of view, Prospect-Refuge theory by Appleton (1996) suggests the importance of visibility in landscape preference, and the role of topographical variations of terrain in affording different views of landscape. In this context the elevation of a camera is directly related to the characteristics of the prospect afforded by the viewer, and is therefore a major factor in landscape aesthetics.

For the reasons illustrated above, camera elevation can be considered as an important influencing factor on our experience of landscape, and therefore it is a variable of interest in this study. This variable is used in a more complex and qualitative way than its quantitative meaning of "meters above the ground", as it combines a component of absolute elevation, a specification of a relationship with the ground surface and also the type of vehicle being modeled (e.g. helicopter, small plane, person). The lack of a "pure" quantitative variable is compensated by the gain in qualitative differences that otherwise would not be captured by quantity alone.

In conclusion, the conditions in which the variable of camera trajectory is manipulated consist respectively of a low elevation flight that reflects the shape of the terrain (low elevation/terrain following), and a high elevation flight characterized by a trajectory without any vertical variations (high elevation/uniform).

4. Pilot Study

A pilot study has been carried out in June 2002 based on a preliminary version of the following "Methods" section. The participants were 14 undergraduate and graduate students (11 males, 3 females). The sample was considered sufficient for a pilot but not for a complete statistical analysis of results. The materials were composed of two animations (low elevation/terrain following and high elevation/uniform) representing a flight along a 3 Km segment across a system of canyons in central Santa Catalina Island

(CA). The main objective of the pilot was to test the experimental procedure, and in particular the adequacy of the computer animations in allowing the subjects to remember details to be later reported in the questionnaire.

Results indicate that the two experimental conditions (low elevation/terrain-following and high elevation/uniform trajectories) elicit different landscape experiences at a significant ($p<0.1$ and $p<0.05$) level in at least two close-ended questions, respectively suggesting that a low elevation/terrain-following flight stimulates less curiosity for newly revealed parts of the landscape and a weaker feeling of possessing navigational knowledge. The second result confirms the superiority of high elevation views for conferring at least an impression of layout knowledge, while the first result is in contrast with an idea of landscape that elicits more curiosity because it is revealed over time while advancing in a trajectory close to the ground. One could infer that a lack of information does not necessarily elicit curiosity, and the outcomes of the flow of information appear complex.

Participants seemed in general to be able to encode a good level of detail in their maps, even if the individual differences were substantial and stronger than the differences across experimental conditions. The maps have not been analyzed quantitatively yet, but it is possible to determine the variable extent to which the participants detected the characteristics of the experimental condition.

In summary the pilot suggests that the approach is feasible, the procedure is able to extract useful information and complex results seem to be produced, although the analysis and interpretation of some of the results appear difficult.

5. Methods

5.1 Design

The experiment design comprises a between-subject variable (camera elevation) in two levels (low elevation/terrain following and high elevation/uniform), and a within-subject variable (landscape stimuli) in five levels (see section 5.3.1 “Landscape stimuli”). The structure of the experiment is illustrated in Table 2.

Table 2 - The diagram shows the experimental design, consisting in a between-subject variable (camera elevation - rows) and a within-subject variable (landscape stimuli - columns).

	Landscape 1 Plain (Base)	**Landscape 2** Descending major landform	**Landscape 3** Ascending major landform	**Landscape 4** Flying over minor landform	**Landscape 5** Valley
Low elevation trajectory, terrain following	ANIMATION Stimulus 1 Low elevation	ANIMATION Stimulus 2 Low elevation	ANIMATION Stimulus 3 Low elevation	ANIMATION Stimulus 4 Low elevation	ANIMATION Stimulus 5 Low elevation
High elevation trajectory, Uniform	ANIMATION Stimulus 1 High elevation	ANIMATION Stimulus 2 High elevation	ANIMATION Stimulus 3 High elevation	ANIMATION Stimulus 4 High elevation	ANIMATION Stimulus 5 High elevation

5.2 Participants

The number of participants required for adequate statistical power is approximately equal to 40 in the between-subjects design. Participants will most likely be drawn from the University of California at Santa Barbara Geography 5 undergraduate research pool, based on course credit given in return of taking the test. Specifically selected subjects (e.g. professionals, artists, military personnel, etc.) are not warranted at this juncture, since a special relationship with the landscape is not researched at this point, and the extra cost might not be justified.

5.3 Materials

5.3.1 Landscape stimuli

The animations used as stimuli are designed using World Construction Set v3 by 3DNature, a Geographic Information System specifically dedicated to landscape visualization. The video sequences of landscapes are generated using real-world topographic data as a base. A series modeling and viewing parameters, such as land cover characteristics and camera trajectories, are then used to complete the design of the landscapes. Occasionally the topography is artificially altered (i.e., introducing lake beds) to achieve specific effects. Once the single frames along the trajectory are generated, a video animation is assembled. The duration of the animations is identical across conditions and equal to 30 seconds (900 frames).

The Conception Coast and Santa Catalina Island (CA) topographic datasets, constituted of Digital Elevation Model (DEM) files representing the altimetry of the landscape, are used in this study, because they offer a wide variety of topographic features, from extensive plains to major landforms useful in the experimental design. Vegetation and atmosphere, such as fog, haze, sky and clouds, are substantially varied across landscape type for ensuring a complete variety of the stimuli. Vegetation variety includes type of texture (trees, low vegetation, rocks), color of texture, texture density, and general distribution variety (including custom land-cover distribution). A series of additional landscape elements (such as lakes and streams) is introduced to make the landscapes interesting and heterogeneous. Topography varies according to a scheme that takes into account 1) potentials for promised information and 2) configuration of actual information. Each landscape is chosen to offer a meaningful comparative case for the two trajectories.

1) **Plain**. The base case is a flat plain with minor irregularities and no salient features around the camera.
2) **Major landform descent**. An expansion of the previous case consists of a terrain that varies with a downward trend (the descending side of a hill), intermediate irregularity, without occluding obstacles in front of the camera, and a simple visual structure
3) **Major landform ascent**. A case specifically concentrating on promised information consists of a camera moving towards a landform (a rather high and steep hill).
4) **Minor landform fly-over**. An investigation of the mystery factor and its relation to time leads us to consider a fourth case where the cameras fly over a small landform and pass it completely, completing the three phases of fly-by (approach, fly-over and fly-past).
5) **Valley**. Finally, a specific case more inspired to principles of landscape design requires the viewer to fly along trajectories in a narrow valley.

The following table contains an example of the frames of animation of the stimulus set N.3 (Ascending major landform) taken at the beginning and the end of the animation, using the low elevation and high elevation cameras. It can be noticed immediately that the two cameras present two qualitatively different views of the same landscape. The variety in the landscape is due to the different geomorphologic and land cover features being modeled (i.e., river, lakes, areas of burnt forest, areas of new growth). Frame 1 shows the difference between a low elevation view of the landscape and a layout view of the landscape. Frame 900 is useful also to compare a high mystery view (low elevation camera) to the corresponding layout view (high elevation camera). The high mystery view is due to the landform in the foreground that does not completely occlude the landscape in the background.

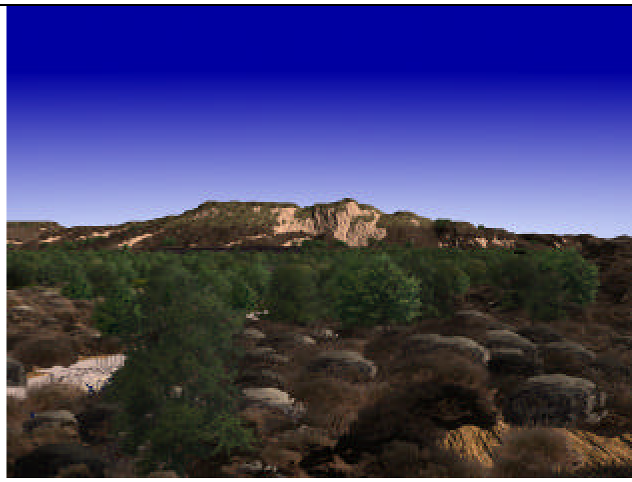
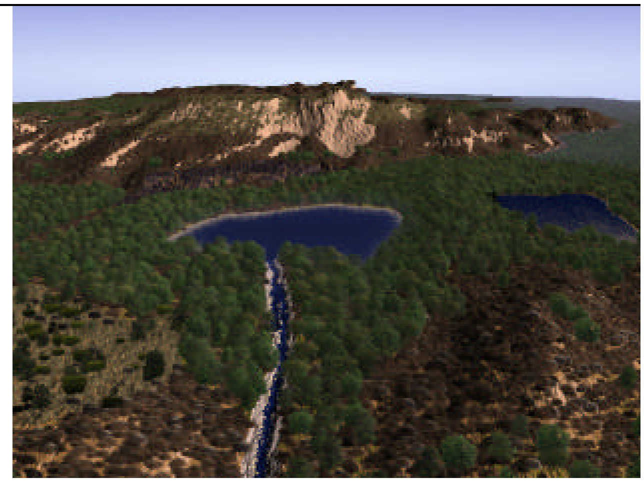
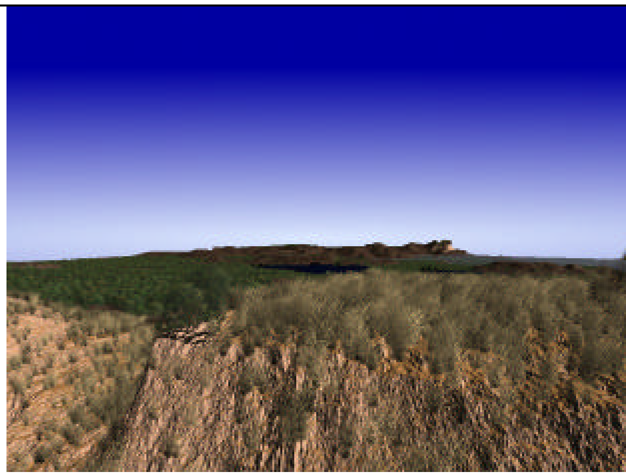
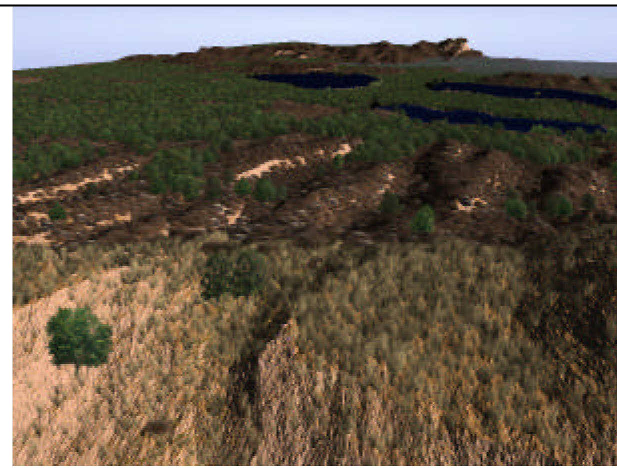
	Low elevation camera	**High elevation camera**
F R A M E **1**		
F R A M E **9 0 0**		

Table 2 - Rendering examples of the N.3 (ascending major landform) stimulus set, at the beginning and the end of the animation and according to low elevation and high elevation cameras.

5.3.2 Instruments – questionnaire

The responses to the five landscape stimuli described above will be recorded by means of a questionnaire. The testing strategy used by the questionnaire includes sketch maps, open-ended questions, and close-ended questions on a Likert or semantic differential scale. In particular the main aspects touched upon by the questionnaire will be:

- **Externalized spatial knowledge**
  - Plan view sketch-map.
  - Profile view sketch-map

    - Plan view trajectory sketch-map
    - Profile view trajectory sketch-map
    - Other knowledge-related questions (e.g., concerning land cover)
- **Aesthetics**
    - like/dislike of landscape.
    - like/dislike of trajectory
    - Other variables (e.g. curiosity)
- **Sense of place:**
    - **Character of landscape:**
        - Uniqueness.
        - Distinctiveness
        - Memorable/ not memorable
        - Striking/ not striking
- **Visualization-related questions**: (e.g. image quality, realism)

The results of the closed ended questionnaire questions will be analyzed by means of an analysis of variance that compares the two between-subject conditions and evaluates if the between-subject variance is higher than the within-subject variance of the sample. The sketch maps will be analyzed qualitatively as well as quantitatively by means of encoding to extract their information content. This process will include the counting of the features drawn and the evaluation of the degree of correspondence to a reference map. The open-ended questions will be analyzed qualitatively to obtain more details about the landscape experience of the participants

5.4 Procedure

The presentation interface will provide the participant with information screens and details about the experiment, leading to the display of the animation. The participants will be briefed that they will be presented with a movie of a fly-by over a landscape. It will be ensured that they will be ready to consider carefully the appearance of the landscape and the motion of the camera, without excluding a more general viewing.

The participants will be randomly assigned to the two conditions: low-elevation/terrain-following or high-elevation/uniform trajectory. Within each condition the subjects will be exposed to the five landscape stimuli according to a within-subject variable design. The order of display of the stimuli is completely randomized. Each stimulus will be shown three times, and after each group of stimuli the participant will be requested to complete the respective part of a questionnaire. The questionnaire will be provided on paper and the required coordination between screen and written instructions on paper will be ensured by means of reminders in the questionnaire and in the interface.

6. Expected results

The expected results are of difficult formulation due to the contrasting views offered by the literature. High elevation (layout) trajectories offer a clear prospect and are predicted to be liked more. On the other hand, a ground view offers, in some cases, a more complex pattern of actual and promised information and elements like secondary prospects that might have a role in aesthetical evaluation. One of the most interesting results would be to find out whether landscape preference is higher for a view from within the landscape or for a view from the "outside". Probably, a dominance of topographical mystery will produce the former, and a preference for the advantages of a layout view in terms of visibility will produce the latter.

In this study it would be interesting to measure how sense of place (or rather its cognitive-character component) varies according to different landscape information and viewing parameters. Due to the lack of evidence in these respects it is hard to come up with some theoretical expectations. However it might be argued that camera elevation influences sense of place for the same reason that a view from a valley floor is different from a view from a hill. Specifically, low elevation trajectories might be able to convey more of the character of a landscape, exposing the aesthetical components of uniqueness and distinctiveness more than a layout view of the landscape. The reason might be found in the way the landscape is visually articulated in the two conditions, resulting in a more ecological ground view and a more impersonal layout view. It could be argued that a ground view always communicates more sense of place than a layout view; however, as Burt (1995) pointed out, even maps might be able to communicate sense of place.

7. Summary and future work

The focus of this study is especially on the psychological human-landscape relations rooted in environmental perception and cognition. Spatial knowledge, aesthetics and sense of place might share a common cognitive underlying structure that is central to those relations and to the experience of landscape

The fundamental idea of this study is that it is possible to base a theory of camera motion over the landscape on the hypothesis of the existence of a close relationship between landscape information (that is, what is shown of the landscape) and experience (that is, the psychological response to the information). This hypothesis is tested experimentally by means of considering two modes of viewing the landscape, constituted of two camera trajectories at different elevations, which are qualitatively different but not radically dissimilar. The variable of camera elevation works as a high-order control on the information content of the landscape.

The results of the study might indicate whether the dynamics of observation affect the psychological response of people. In turn it would allow us to determine whether landscape animation design is a useful concept and, in specific relation to the main independent variable, whether camera elevation can be used as a primitive for animation design, and in what ways.

An important concept is also the visual structure of landscape, as discussed in terms of its effect on aesthetics and, in particular, the mystery factor. A possible future direction of research could be to formalize the concept of visual complexity as a property of the process of observation, and not as a geostatistical property of the landscape surface. It would then be possible to link the concept of visual complexity to a measure of psychological response.

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