THE AFFECTIVE AFFORDANCE OF MOTIONSCAPE

by

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Abstract

Visual artists and designers often employ the extensive compositions of visual forms and motion to construct abstract motionscapes. While abstract motionscapes are often employed for the evocation of affective experience in many recent interactive environments, little work has been done to correlate the two.

In this thesis research, two empirical studies were conducted to investigate how various fundamental properties of motionscapes influence viewer affective experience. Sixty university students were recruited to give self-reports on the affective experience of a number of motionscape primitives. Results showed that basic motionscape properties such as speed, direction, path curvature, shape, and scale, all had significant impacts on the affective experience of the tested motionscape primitives. The display conditions under which motionscape primitives were presented, were also found crucial for the motionscape expressiveness. Based on these findings, we envision the emerging principles and directions of the motionscape design for affective visualization within the interactive environments.

Keywords: Motionscape; Affective Visualization; Interactive Environment

In memory of my father

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List of Acronyms

AC	Affective Computing
AR	Augmented Reality
HCI	Human Computer Interaction
VE	Virtual Environment
VR	Virtual Reality

Glossary

Affect	In this thesis, we use the term “affect” and “emotion” interchangeably. And by affect we mean the affective experience that is evoked by an artifact or an environment.
Affective Affordance	Design theorists often appropriate the concept of affordance by referring to the possible functions that an artifact’s physical appearance implies. We propose the concept of affective affordance by focusing on the affective experience that an artifact evokes and its perceptual potential in communicating affective contents with its viewer.
Affective Experience	An affective experience refers to the conscious perception of one’s own emotional state. An affective experience can be evoked through viewing an artwork, interacting with an artifact, or navigating through an virtual environment.
Affective Visualization	Visualization that is not to represent statistical data, nor to quantify affects through graphical elements. The affective visualization is embedded in the graphical environment to communicate affective contents or to provoke affective experiences.
Interactor	The human being who interacts with an interactive artifact or environment. While HCI researchers often use the term “user”, we use “interactor” in this thesis as the artifacts and environments we discuss about are not usually to be used but to be interacted with.
Motionscape	Visual phenomenon constructed by the extensive and coordinate composition of enormous amount of abstract forms and their motions

Chapter 1.

Introduction

In nature, fields of motion can usually be seen in rain, snow, fog, herds of animals, schools of fish, or flocks of birds. Some common characteristics are visible in the above phenomena, that is, they are all comprised of a great amount of agents moving in coordinated organisms: flocking crows fly in identical speed and direction; countless snowflakes fall along similar wavy curves in a winter storm. Such phenomena in nature conceive a new type of landscapes, landscapes that are not constructed by rocks or earth but by the dynamic transformations of natural organisms. In this thesis, we term such dynamic landscapes as *motionscapes*.

In recent practice of visual arts and design, a similar type of motionscapes, which manifests itself in the massive but coordinated repetitions of visual form and motion, often resembles the motionscapes in nature. A great number of art works and design artifacts from fields such as kinetic art, abstract cinema, motion graphics, generative design, are notable for their shared creation approaches and expressive qualities. Notable examples of such artificial motionscapes can be found in James Whitney's computationally animated films, Saul Bass's motion title sequences, or Casey Reas's generative drawings. In works of such, motions of abstract visual forms are often extensively manipulated and composed, to further construct the more abstract artificial motionscapes (a greater range of examples of works of such can also be found in Russett & Starr, 1977; Pearson, 2001; Lima, 2011; Bohnacker et al., 2012).

In a range of recent interactive environments, abstract motionscapes have been pervasively employed in the visual presentation of such environments to evoke affective experience among the interactors. While affective expression is critical for the visual presentation of interactive artifacts and environments (Picard, 2000; Norman, 2005, 2009; Murray, 1998, 2012), theoretical works in visual arts and design (e.g. Youngblood, 1970; Moritz, 1998; Brougher, 2005) and recent scientific studies (e.g. Lockyer et al., 2011; Lockyer & Bartram, 2012) have revealed that motionscapes have rich potential to be employed as an expressive medium for the communication of affects.

However, affective expression through abstract motionscapes in the design space of human - computer interaction is so far an impressive alternative that arguably still lacks proper visual grammar. That is, while visual designers often rely on the evocative visual phenomena achieved by motionscapes to communicate affective contents or to evoke affective experience, little work has been accomplished to correlate the design of abstract motioscapes and the resulting affective expressiveness. Relevant theoretical works and empirical studies are still far from enough to comprehensively inform the principles and guidelines on the design of abstract motionscapes for affective expression.

1.1. Motivation

A noticeable characteristic of many motionscape works is the extensive and complex control over motions of massive amounts of visual components. Such heavy manipulation on visual motion often accounts for the affective expressiveness of many works that employ abstract motionscapes (Brougher, 2005). For instance, John Whitney, one of the first pioneer practitioners who largely employ motionscapes as expressive material, revealed that the extensive composition of motions of abstract forms was critical for his works to achieve evocative visual experience (Whitney, 1980). Fred Collopy also argued that motion should be a critical dimension of the design and creation of the abstract motionscapes (Collopy, 2000).

Motion has been considered as one of the most significant visual appeals in visual art (Arnheim, 1983, p. 304), and affective expression through motion has long been explored from fields of psychology (Heider & Simmel, 1944; Tagiuri, 1960), biological motion (Johansson, 1973; Laban, 1974; Dittrich et al., 1996; Pollick, 2001; Troje, 2002), animation (Thomas et al., 1995), performance (Dietrich, 1983; Maranan et al., 2013), video games (Milam et al. 2011; Milam et al., 2012), interface design (Bartram et al., 2003; Djajadiningrat et al. 2007), and information visualization (Bartram & Ware, 2002; Ware, 2004, p. 187; Ware, 2008). Recent studies also proved that motion, even when performed by simple forms and presented out of any context, has rich potential in expressing complex emotions and impressions (Bartram & Nakatani, 2009, 2010). However, as previous researches were mostly to examine motions performed by single or a small group of visual elements, fewer works have been done to visit the more extensive and complex composition of motions within motionscapes.

In response, this thesis research aims to address the above knowledge gap by providing empirical evidence on how simple abstract motionscapes contribute to the evocation of affective experience. This thesis devotes to study motion and its contribution to the affective expressiveness of motionscapes (and especially the abstract motionscapes created with the help of computational techniques).

1.2. Research Overview

In this thesis research, we designed and constructed a small collection of motionscape primitives that resembled the complex composition of visual motions that are commonly employed in recent motionscape design practice. We further employed these motionscape primitives as stimuli in two empirical studies and invited participants to self-evaluate how various affective experiences were evoked through viewing these primitives.

In so doing, we aim to provide evidence on how various affective impressions can be articulated through controlling motion properties in motionscape primitives. The motionscape primitives are generated through computational algorithms and to depict various structural motion patterns. Such motion patterns are designed to visualize motion properties including speed, direction, path curvature, scale, and the dynamic layout of visual motions. We expect different combinations of such motion properties will lead to different affective impressions and viewer interpretations. Through participant feedback with regard to the resulted interpretations, we aim to detect how each motion property is responsible for the impressions of motion, thus to contribute to the theories and practices of applying abstract motionscapes as a medium for affective expression.

This thesis is organized as follows. In the following chapter we give an overview of the previous efforts devoted to elicit motionscape aesthetic, and relevant research on motion's affective affordance. Instead of directly getting into motionscape, it starts with an introduction of the current affective computing research and practice. To study the motion aspect of the motionscape design, it is helpful to examine the established theoretical work and guidelines for the motion composition in fields such as abstract cinema, theatre direction, and more static visual mediums such as painting and graphic design. Many scientific studies on the expressive capability of motion also bring useful reference points. As we shall see, such practices and works have granted us perspectives to study the composition of forms and motion.

The third chapter illustrates the scientific approach applied by this research. A set of abstract motionscape primitives are designed and implemented to visualize several crucial motion properties of motionscape effects. And along with such primitives, an affect model to evaluate the visual aspects of interactive environment is proposed.

Two studies were conducted based on the motionscape primitives and the affect model. In the fourth and fifth chapter we report each study respectively, with each addressing different aspects of the motionscape design and presentation.

In the last part, the design implications generated from the two scientific studies are discussed. To give a concrete envision for the possible design scenarios, instances of the motionscape primitives applied in an virtual environment (VE) are also provided in this part. In the end, the limit of this study is addressed, thus to impose the possible direction of the explorations in the motionscape design and creation.

Chapter 2.

Background

2.1. Motionscape as Affective Expression

Many researchers have suggested that affective expression is a critical aspect of the visual design for the interactive environments. The need of affective expression for computational system is addressed and envisioned by a series of digital media theorists (e.g. Picard, 2000; Fagerberg et al. 2004; Murray, 2012).

According to Janet Murray, the experience of immersion is evoked when interactive environment constantly provides rich and affective feedback to its interactor (Murray, 2011). Rosalind Picard also suggests that enabling interactive systems to recognize and express affects not only enriches the experience of interaction but also helps user interact with the systems more intelligently (Picard, 2000).

While both Murray and Picard envisioned affect expression in computing systems achieved through verbal, gestural, or facial expressions of virtual avatars and the like, recent motionscape design practice and research has brought about alternatives to such approach. In this section we give examples of abstract motionscapes that are employed as elements of affective visualization in various fields of practice. The sample works discussed here are promising in their capability of communicating affects. In so doing, this part is to give instances on how abstract motionscapes can function as rich mediums for affective communication.

Figure 2.1 ***Genome Valence***
Note. Genome Valence. Interactive visualization by Ben Fry (2002)

Visual artists have long been exploring the possibilities of affective expression through the compositions of visual forms and motion. For instance, James Whitney was among the very few early visual artists who relied on the extensive and complex control of form, colour, and motion to approximate human inner minds and provoked powerful emotional experience among the audience members (Youngblood, 1970). Motion graphic design pioneer Saul Bass also appropriated similar visual language to communicate more articulated meaning and affects. In the title sequence (crafted by Saul Bass) to Hitchcock's horror classic *Vertigo* (1958), the mathematically manipulated motions and forms represent “the rational spiralling out of control” (Brougher, 2005). The title sequence was among the earliest adaptions of motionscapes in commercial cinema, and has since significantly influenced the motion graphic design within the contemporary visual media.

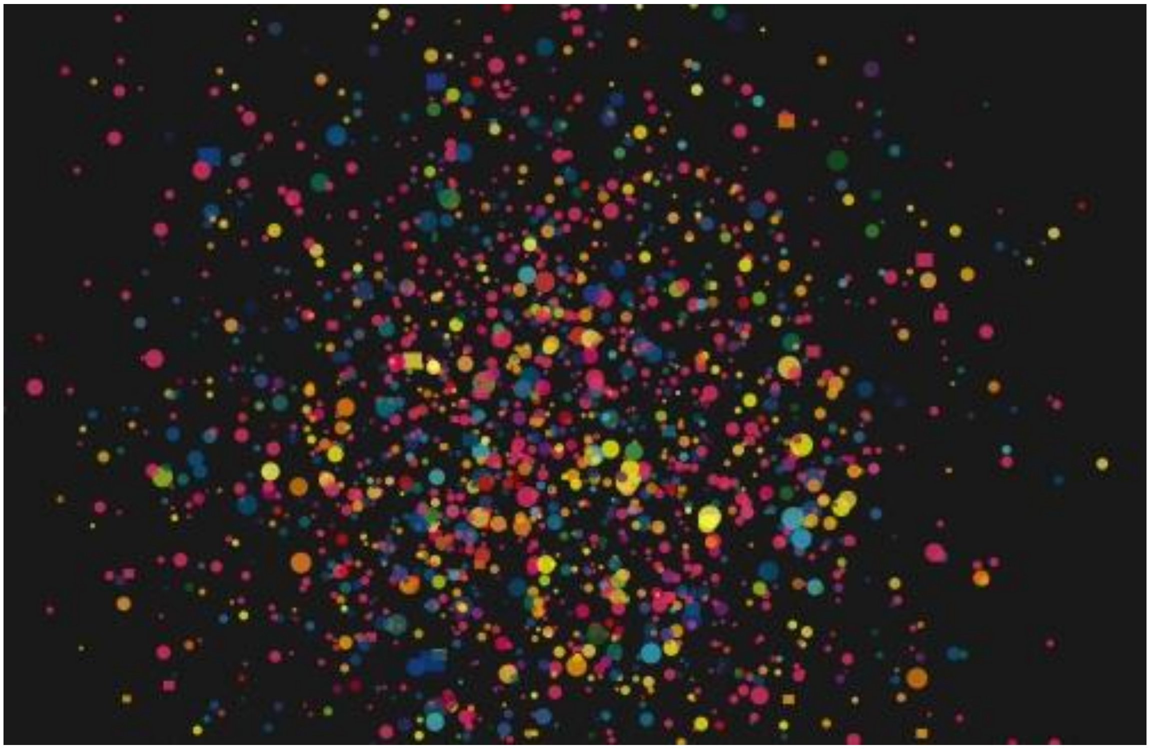


Figure 2.2. ***We Feel Fine***
Note. We Feel Fine. Online visualization (Harris & Kamvar, 2005)

Applications of motionscapes in recent interactive artifacts and environments are also usually designed to evoke affective experience or to articulate affective contents. For instance, Ben Fry's data visualization software *Valence* (Fry, 2002) is a good example of visualization project that resemble the motionscapes from field of visual art. Rather than presenting obvious data, Fry's application presents a “feel” for general trends: it functions as an “aesthetic context provider” by setting up the less obvious relationships between data elements (Paul, 2008).

Jonathan Harris’ and Sepandar Kamvar’s *We Feel Fine* (2005) is another visualization project that aims not only to provide the affective aesthetic context but also to visually represent affects. According to Harris and Kamvar, their online interactive visualization serves as “an exploration of human emotion, in six movements”. We Feel Fine searches a great number of online blogs for texts containing phrases “I feel” or “I am feeling” and created a great amount of animated particles representing such texts that are related to emotions (Harris & Kamvar, 2011). The visualization utilizes colour and size to visually distinguish the affects, while the rapid movements of the particles convey a sense of excitement and vividness, and make the presentation sophisticated and interesting (Simanowski 2011, p. 195).

In video game, the abstract motionscapes are not only revealed as the extensive explosions of star ships or traces of thousands of blades in a brutal battle; those motionscape visual effects implemented by abstract and surrealistic forms are also popular visual attractions. In a recent video game *Child of Eden* (2011), moving visual elements are flamboyantly rendered to depict specific impressions such as "passion" and “hope”.

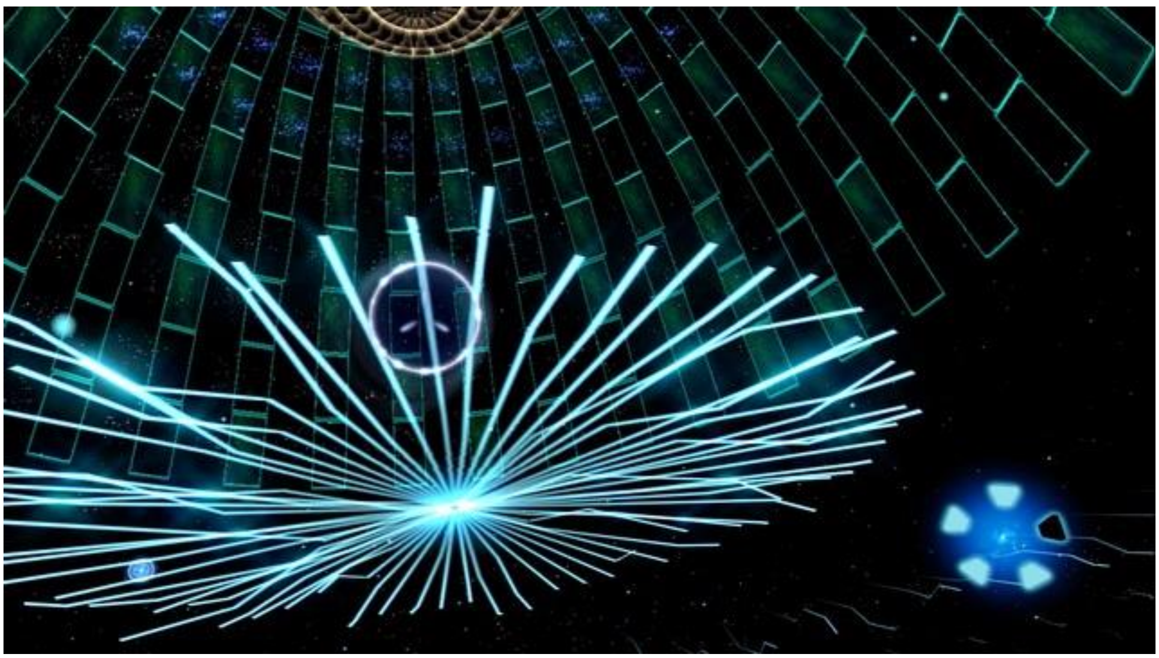


Figure 2.3. *Child of Eden* (2011)

In recent practice of interactive arts and installations, motionscapes are also often employed as expressive visual components and material. For instance, in *Starfield*, a large scale on screen interactive installation by Lab212 (2012), a simulation of cosmic space renders subtle movements of stars particularly to produce a calming atmosphere for its spectators. Newly emerged tangible computing techniques have also enabled artists to incorporate tangible objects into motion scape works. Design group *Squidsoup* (2012) use 3D arrays of LED lights to construct an “Ocean of Light”, where each LED's light intensity is responsive to the viewer's activity within the lighting environment.

Figure 2.4. *Starfield*
Starfield. Interactive installation by Cyril Diagne & Tobias Muthesius (2012)

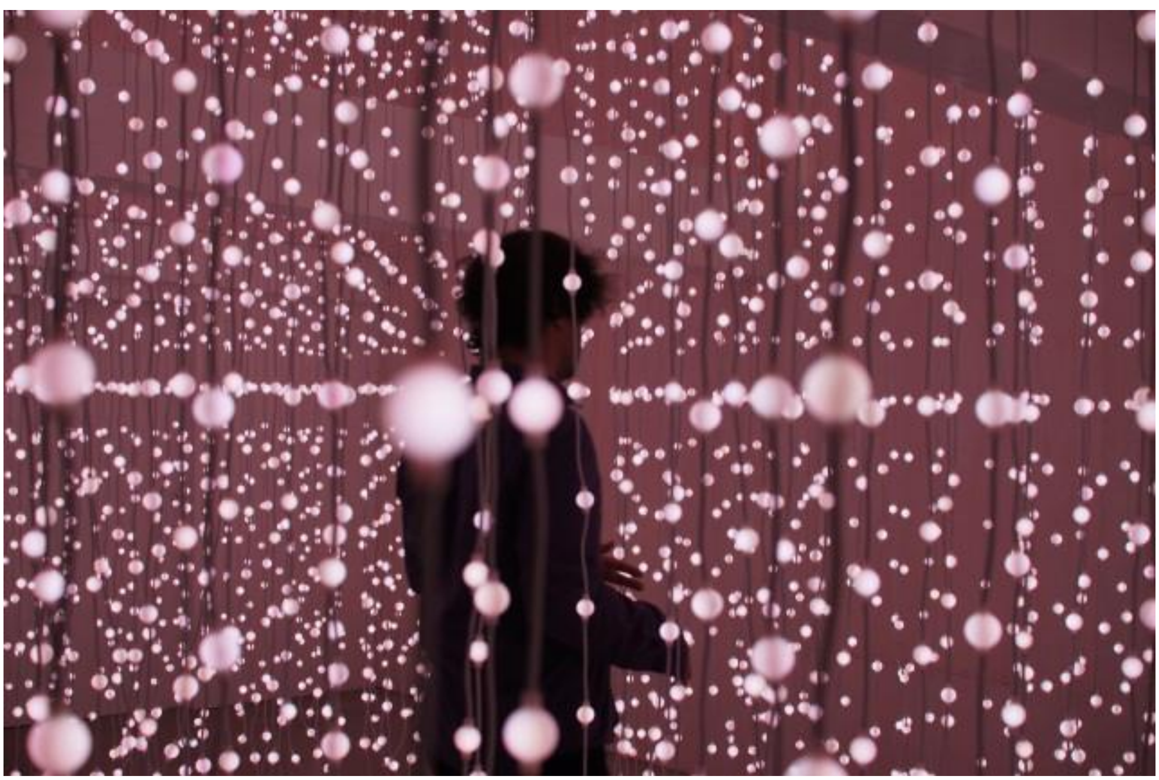


Figure 2.5. Ocean of Light
Ocean of Light. Interactive installation by *Squidsoup*. (2012)

Computational art works often receive the criticism that they are restricted by the functions and capabilities of the tools that are used to create them (e.g. Nadin, 1989; Holtzman, 1997; Shanken, 2009). Following this position, if the tool is to support the expression of personality, emotion, and experience, then understanding the tool's capability is essential to the artists. However, although visual designers often employ motionscapes to evoke affective experiences, researchers and theorists from visual design and perception seldom study the affective expressiveness of motionscapes. To address this research problem, we start with an overview on the recent researches on motion and affects. As motion has been revealed critical for the motionscape design and creation (Whitney, 1980; Collopy, 2000; Brougher, 2005), previous researches on motion therefore inform us on learning how motion in motionscapes contributes to the affective experiences of them. Along with this, previous affect researches also provide us perspectives on the understanding and measurement of the motionscape affective experiences.

2.2. Studying Motion in Motionscapes

2.2.1. Motion on Atomic Level

As motionscape involves the heavy composition and manipulation for movements of large amounts of agents, the essential elements that comprise of movements of individual visual elements within motionscapes are therefore crucial factors for the expressiveness of motionscapes.

But what makes motion evocative? What factors in motion make it capable of carrying so much affective contents? Previous studies devoted to study motion that are performed out of any context have revealed a fundamental set of such factors: speed, direction, path (line created by movement), area (use of space by the moving object) (Vaughan, 1997; Bartram & Nakatani, 2009, 2010). These characteristics reflected principles of applying motion in comics (McCloud, 1994, p. 118) and performance (Dietrich, 1983, Chap. 8), and were also proved to be significant affective contributors by a range of previous studies on the expressiveness of motion.

For instance, speed has been found an influential factor for motion expressiveness in the field of interaction design, animation and biological movements (Bacigalupi, 1998; Lassiter, 1987). In a general survey in motion within the field of visual art, Arnheim also suggested that speed can be perceived as indicator for weight, size, or force. In a study exploring the expressiveness of arm movement (Pollick et al., 2001), faster movements, or motion with greater acceleration and deceleration were usually interpreted as "energetic motions", and were also associated with more intense emotions such as anger, excitement, or joy.

Direction in motion is usually perceived as judgement of intention (Barrett et al.; Dietrich, 1983). In Arnheim's discussion regarding direction, the changes in direction also results in a change in viewer's attention (Arnheim, 2004). Direction can also elicit several meanings. For instance, downward motion is usually associated with negative impression, while upward motion is seen as positive. Motion towards right is usually perceived as forward, but moving towards left is more likely seen as moving backwards or losing (Bacigalupi, 1998).

Path curvature has often been found as an informative motion property. According to a study of single dot movements by Tagiuri (1960), a dot on screen that moves along straight lines is seen as "determined, aggressive, and purposeful", while curve paths are seen as "unhurried, unsure, or relaxed". Meandering paths are associated with impressions such as "immature, confusion, or curious". In addition, path that intersects itself is perceived as an "intense change and avoidance". Theoretical works from field of live performance also provide established guidelines for the changes of dancer positions on stage. For instance, John Dietrich discusses how theatre directors treat movements as line and form to evoke affective impressions. For instance, dancer moving in a straight path may evoke a feeling of strength, and moving in a curved path may evoke a feeling of naturalness (Dietrich, 1983).

2.2.2. Visual Composition: The Choreography of Abstract Forms

Affective expression through the dynamic composition of moving forms has been widely studied in fields such as abstract cinema, theatre direction, and graphic design. To study the motion aspect of the motionscape design, it is helpful to examine the established theoretical work and guidelines for the motion composition in fields of such.

In graphic design, spatial composition of graphic elements such as points, lines and forms are usually associated with the communication of messages and impressions (Wong, 1972, 1993). Similar sets of visual elements, when arranged based on basic layouts such as linear, radial, or spiral patterns, can convey various impressions of dynamic force and motion (Sausmarez, 2006).

More dynamic spatial arrangements and composition can be seen in theatre performance. According to Dietrich, the changes of the positions of a group of performers on stage may result in various expressions of moods and emotions (Dietrich 1983). For instance, performers moving away from a certain point on stage may render a sense of dislike or fear, while moving toward a point may represent desire and purposefulness.

Similar deliberate composition efforts are also visible in many motionscape works. In Whitney's many abstract cinema pieces, the manipulation of the on screen visual movements were specifically aimed to achieve an experience of the human inner mind (Moritz, 1998). For instance, in *Permutations* (1967), the optimal dots on screen moves in speeds and along directions independent from natural laws, while moving in their circular field. Such structurally composed actions therefore produces a phenomenon "more or less equivalent to the musical harmonies" (Youngblood, 1970).

Studies examining the emotional expressiveness of 2D motion textures (Lockyer et al., 2011, 2012) were useful to explore the dynamic layouts of abstract graphical elements. In these studies, large amounts of moving particles were manipulated by controlling their various motion properties and were organized in geometric primitive layouts. While motion factors such as speed, direction, path curvature were confirmed as significant factors for the affective impressions of motion textures, the dynamic layout of the motion textures, are proved to be pronounced for a variety of affective impressions.

2.3. Understanding Affect

According to Brenda Laurel (1990), interaction design for computational system had transformed from a concept just about user and software or hardware to a “concept including cognitive and affective aspect of user experience”. Enabling interactive systems to recognize and express affects not only enriches the experience of interaction but also helps user interact with the systems more intelligently (Picard, 2000). As the expression and recognizing of emotion has become an as equally crucial property as the system functions for completing basic tasks, constructing a conceptual model for the understanding of affects is especially useful for the management of the affective experience of a range of interactive artifacts and environments (Picard, 2000).

The exploration and construction of such model can be informed by the research on affect from cognitive science and psychology (e.g. Tomkins, 2008; Plutchik, 1982; Izard et al., 1984; Ortony et al., 1990; Ortony & Turner, 1990; Ekman, 1992). While researchers from such fields have provided insights on how affects should be categorized and measured, recent HCI researchers also expand and enrich the affect research in the design space of visualizations and HCI (e.g. Moere, 2007; Rodgers & Bartram, 2011; Picard, 2000; Calvo & D’Mello, 2010).

2.3.1. Basic Emotions and Affect Dimensions

Psychology and cognitive science researchers have attempted to categorize affects into a set of basic emotions. For instance, Tomkins proposed fear, anger, anguish, joy, disgust, surprise, interest, and shame as 8 basic emotions (Tomkins, 2008). Plutchik listed another set of 8 basic emotions as: fear, anger, sorrow, joy, disgust, surprise, acceptance, and anticipation (Plutchik, 1982). Although various sets of basic emotions are proposed within literature, only a few basic emotions are commonly agreed on. Ortony et al. summarized a range of emotional states addressed by previous researchers; among the list, fear, anger, sadness, and joy are four most common items among various studies (Ortony et al., 1990).

The basic emotion model is useful as it simplified the great complexity of the human affects by categorizing them under a small set of basic ones. But such efforts of categorizing human emotion into limited number of affects have been criticized by many researchers on the topic. For instance, Ekman summarized 9 essential characteristics of the commonly agreed on basic emotions, and suggested that emotions such as embarrassment, awe, and excitement, which share same characteristics with basic emotions should be included as potential basic emotions as well (Ekman, 1992). Ortony and Turner (1990) questioned the validity of the concept of basic emotions. They argued that the basic emotions were neither psychologically or biologically primitive nor "irreducible building blocks" for generating the "great variety of emotional experiences", as cognition theory had suggested that emotions are cognition dependent and contain cognitive components.

Instead of differentiating emotions based on basic categories, researchers also categorize affects through continuous dimensions. Among the many affective dimensions proposed, only arousal (calm and excited) and valence (negative and positive) are dimensions commonly agreed on (Schlosberg, 1954). Within the context of empirical study, self-reporting based on dimension is more reliable than that based on discrete basic emotions. In fact, the widely used self-reporting approaches are mostly based on the dimensional emotion models (Russel, 1974).

Whether affects should be categorized through discrete basic categories or through continuous dimensions has long been discussed by emotion theorists. Simply applying either of the two theories is problematic. On the one hand, descriptions of emotion is usually less reliable with respect to basic emotions than with respect to dimensions (Lang, 1984); on the other hand, despite that continuous dimensions such as valence and arousal are valid for most common descriptions of mood, the few available dimensions are not capable of covering all basic emotions (Picard, 2000). However, it is not our concern to decide which theory is universally applicable. Rather, the above two assumptions together serve as reference points to study the affective aspects of interactive artifacts and experience.

2.3.2. Affective Experiences of Interactive Environments

Picard, in her ground breaking book *Affective Computing* (2000), uses the term “affect” and “emotion” interchangeably. According to Picard, an affective experience “refers to all you consciously perceive of your own emotional state" (Picard, 2000). Despite the diverse usage and compounding meaning of the term affect, this thesis follows the definition given by Picard (2000). However, choosing Picard's perspective is not due to its accuracy but to its relevancy, as Picard's explanation on affect is a diverse one, which provides multiple useful reference points and can be adapted to explore the affective aspect of computational systems within digital media.

Picard's work is helpful as it guides us to understanding the need of addressing affective aspect of interactive artifacts and environments. Other AC experts also provide multiple perspectives to the topic. Calvo and D'mello have summarized main theories of emotion, eliciting that how emotion can be understood from the perspectives of physical activities, inner body chemical changes, cognition, and neural science (2010). According to Calvo and D'mello, different theories and models of affect research should be adopted by researchers in HCI based on the context of the research (2010).

Therefore, as the non-basic emotions are key to many particular domains of applications, simply relying on one universal affect model for all affective computing applications and practice will be problematic. Recent research has revealed that not only basic emotions should be emphasized, but also the non-basic ones (D'Mello & Calvo, 2013). Emotions other than basic emotions such as engagement, confusion, boredom, etc., are common in user interaction with computers. Particular emotions are relevant to particular applications and domains, and to study affective aspects of interactive systems we should select specific sets of certain categories of affects (D'Mello & Calvo, 2013).

2.4. Summary

Previous motion researches have revealed that a small set of motion properties such as speed, direction, path curvature are key contributors to the affective expressiveness of the motion performed by singular visual element. While the systematic manipulations on movements of individual components are essential to the creation of abstract motionscapes, the above motion properties are therefore key factors for motionscape design. Researches from visual design and performance also suggest that shape - the dynamic layout of the large amount of moving visual elements - is also influential for the affective experiences of motionscapes.

While the measurement of affective experiences are often based on the theories of basic emotions or basic affective dimensions, recent HCI researchers have suggested the measurement of affective experiences should not be restricted to the small set of basic emotions or affective dimensions that are commonly agreed on. Many affects that are not included as part of such affect models are also critical for the experience of a range of interactive artifacts and environments.

Chapter 3.

Approach

In previous chapter we've summarized that the fundamental set of properties of motionscape such as speed, direction, path curvature (line created by movement), scale (use of space by the moving object), and shape (the dynamic layout of moving agents within motionscape) are significant affective contributors by a range of previous studies in simple abstract motions. These previous findings therefore implied the motion properties that can be revisited in abstract motionscapes.

There are no doubt far more properties, factors, and dimensions of motionscapes other from the ones visited in this study. However, this thesis research has no intention to exhaust every possible motionscapes visible in the current visual design practice, nor to visually resemble any specific ones. For instance, although the motionscape phenomenon in nature are of interests by many artists and are widely employed as theme of their arts, the thesis won't discuss fog, rain, the movements of clouds and other motionscape phenomena in nature. Instead, we designed and constructed a small collection of abstract motionscape primitives. The motionscape primitives introduced here are constructed not as independent pieces of art or design artifacts, but to visualize the motion properties and dimensions within the motionscapes that are widely applied in recent digital visual media, especially those constructed and composed through systematic manner.

In the following, we introduce the abstract motionscape primitives employed by this thesis research. Specifically, we explain in detail how various fundamental motion properties are incorporated into and visualized through the design and construction of these motionscape primitives.

3.1. Constructing Motionscape Primitives

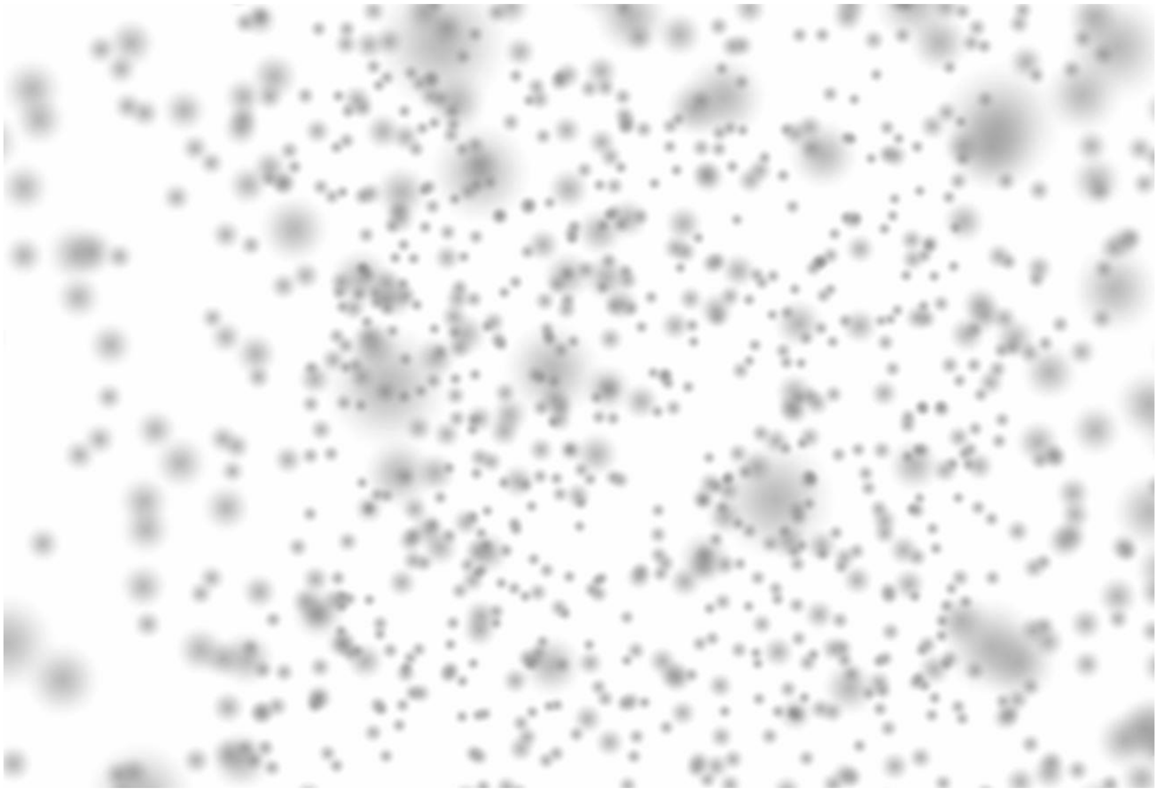


Figure 3.1. Spatial distribution
Note. Particles in a motionscape primitive are randomly distributed in a 3D Cartesian space

Instead of visualizing motion by animating single and simple on screen objects (an approach that is popularly adapted in previous scientific studies) the motionscape primitives were constructed through manipulating large amounts of moving particles on screen. And instead of distributing such particles on a 2D plane, we randomly distributed them in a 3D Cartesian space.

While such composition strategy was similar to that applied by abstract cinema artists such as the John and James Whitney, whose intention was to achieve the cosmic visual style, it is applied here as an approach to visually represent the visual complexity brought about by the computational creation methods. That we address the massive amount of visual agents is also due to the complexity of both creation approach and vieweing experience of the recent motionscape works. First, the computational methods bring about the complexity of manipulating agents of great quantity, which further leads to the complexity of interpretation for the viewer. We also aim to minimize the effects of visible forms resulted from the layouts of agents. All particles were blurred and half-transparent to decrease the intrusiveness of any single particle. Motion properties such as shape, path curvature, direction, speed and scale, were controlled to generate different abstract motionscape primitives. Variations of each of these factors are described in the following.

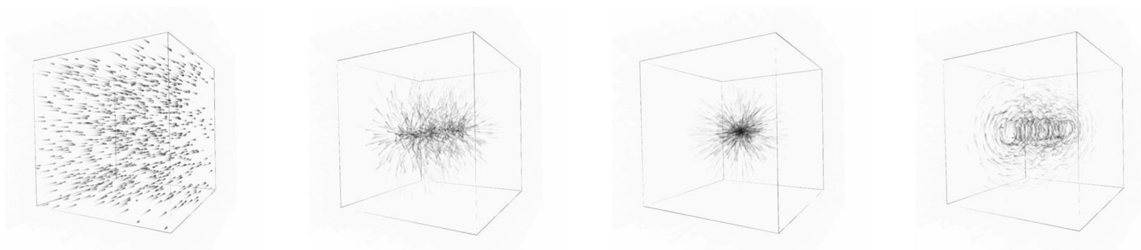
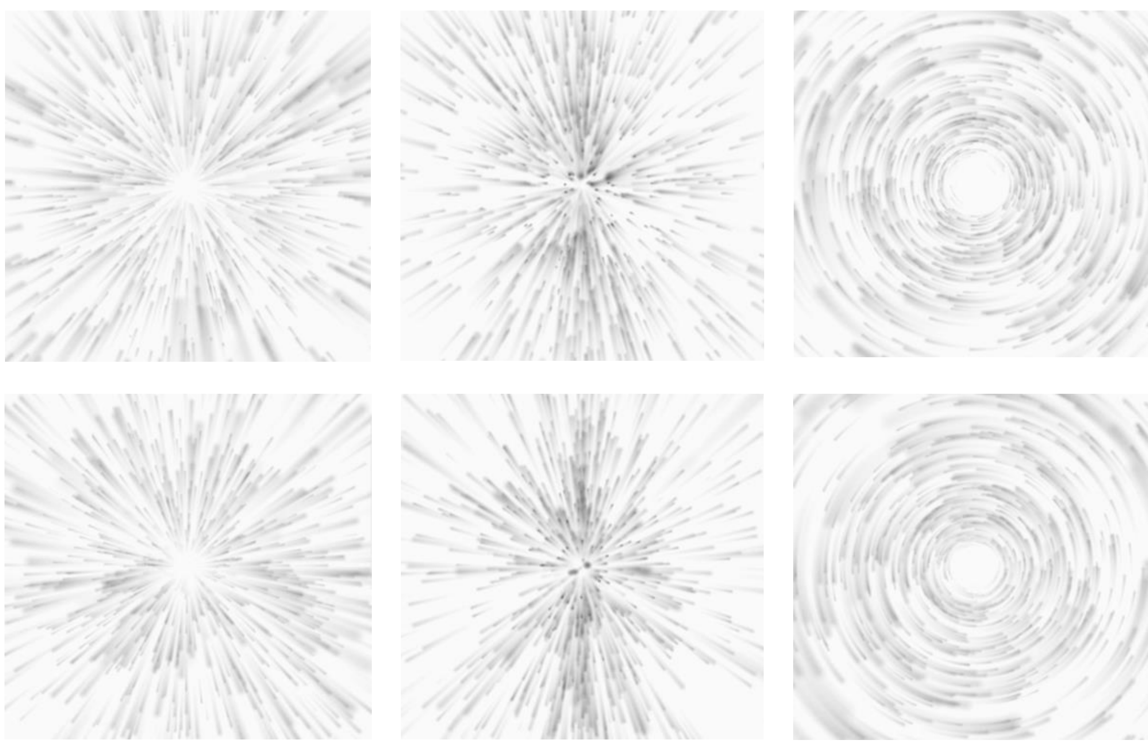


Figure 3.2. Shape
Note. From left to right: linear, radial, spherical, and circular motionscape primitives



(a) Inward and outward motions in a radial primitive

(b) Inward and outward motions in a spherical primitive

(c) Clockwise and counter clockwise motions in a circular primitive

Figure 3.3. Direction
Note. Inward (first row) & outward motions in radial, spherical and circular primitives

3.1.1. Shape

Figure 3.2 shows all 4 variations in shape of the motionscape primitives. These variations are: (1) linear primitives, in which all particles move in parallel paths; (2) radial primitives, in which particles move into or out from a central axis in space; (3) spherical primitives, in which particles move from all towards a center point in 3D spherical space; (4) circular primitives, in which particles move in circular paths about a central axis.

3.1.2. Direction

Two variations in direction are applied to radial, spherical, and circular primitives (Figure 3.3). In radial or spherical primitives, particles move inwards (sucking in) or outwards (radiating out) with respect to the z axis or the central point on z axis. In circular primitives particles move either clockwise or counter clockwise along z axis.

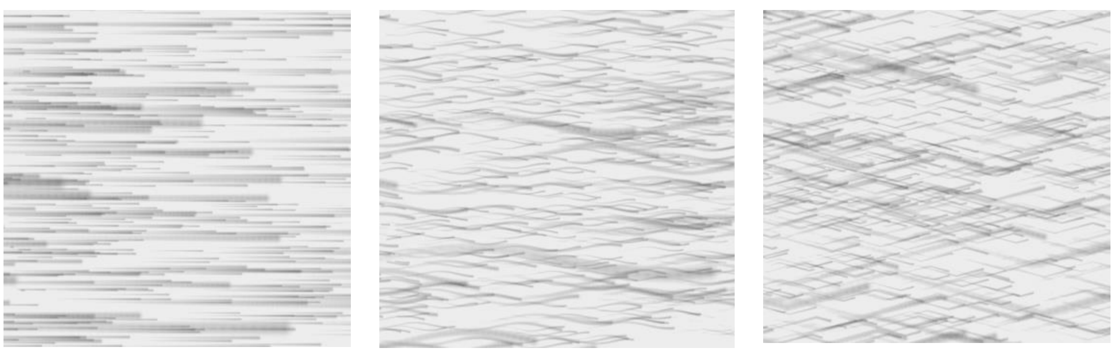


Figure 3.4. Path curvature
Note. Motions with straight, wavy, and angular path curvatures

3.1.3. Path Curvature

We incorporate three types of path curvatures into the abstract motionscape primitives. As shown from left to right in Figure 3.4, particles within three linear motionscape primitives are respectively controlled to move along straight, wavy, and angular path curvatures.

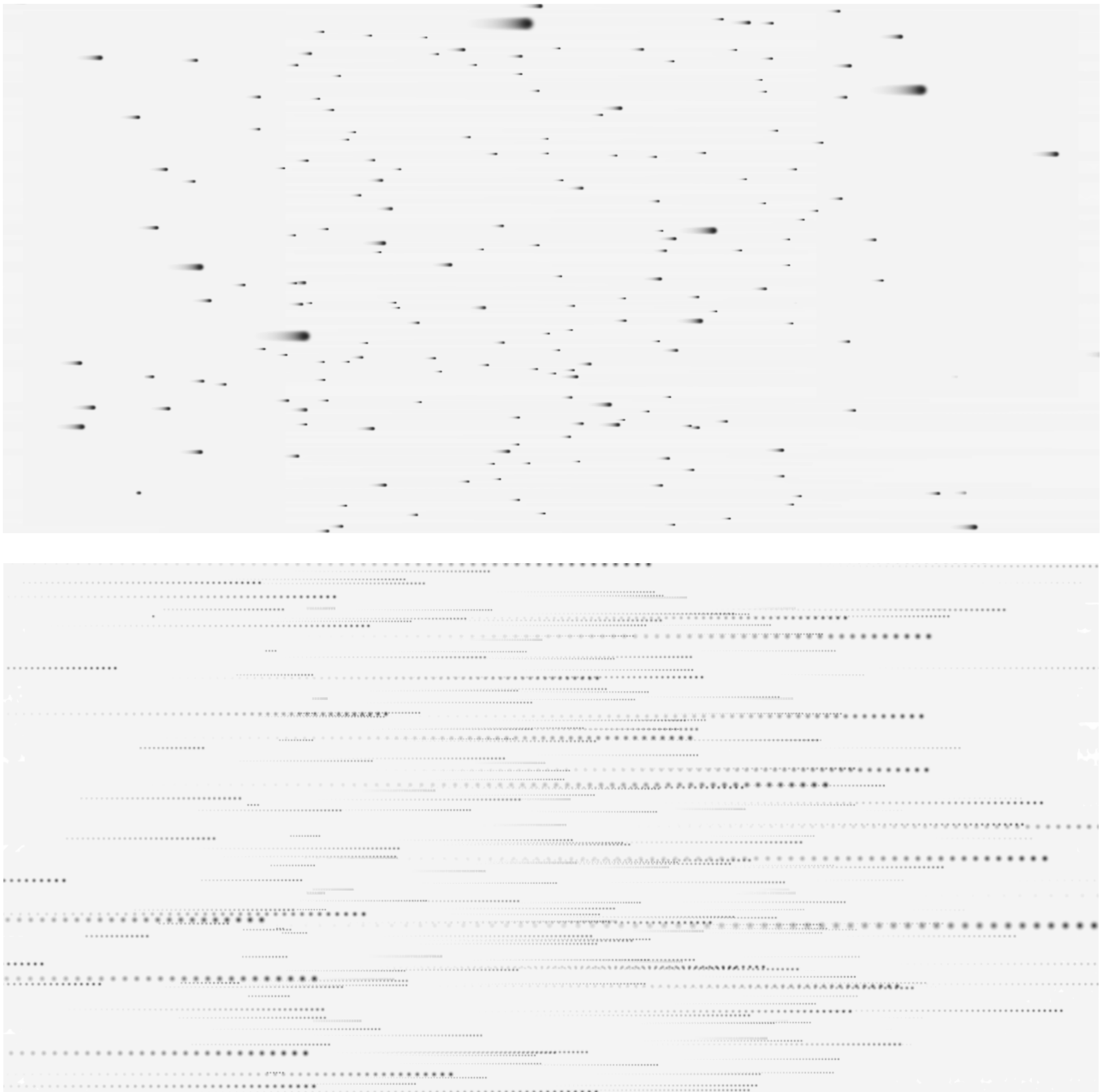


Figure 3.5. Speed
Note. Slow motions (above) and fast motions in a linear motionscape primitive;
traces are rendered to suggest speed

3.1.4. Speed

Particles in all motionscape primitives are manipulated to move in various speed levels. Figure 3.5 shows that particles within linear motionscape primitives move in both low speed (above) and high speed.

3.1.5. View Point

Variations in scale of the motionscape primitives can be achieved through controlling the position of viewing points in the space where the primitives are located. As shown in Figure 3.6, a spherical motionscape primitive can be either viewed from inside the motionscape space (above) or from an outside position.

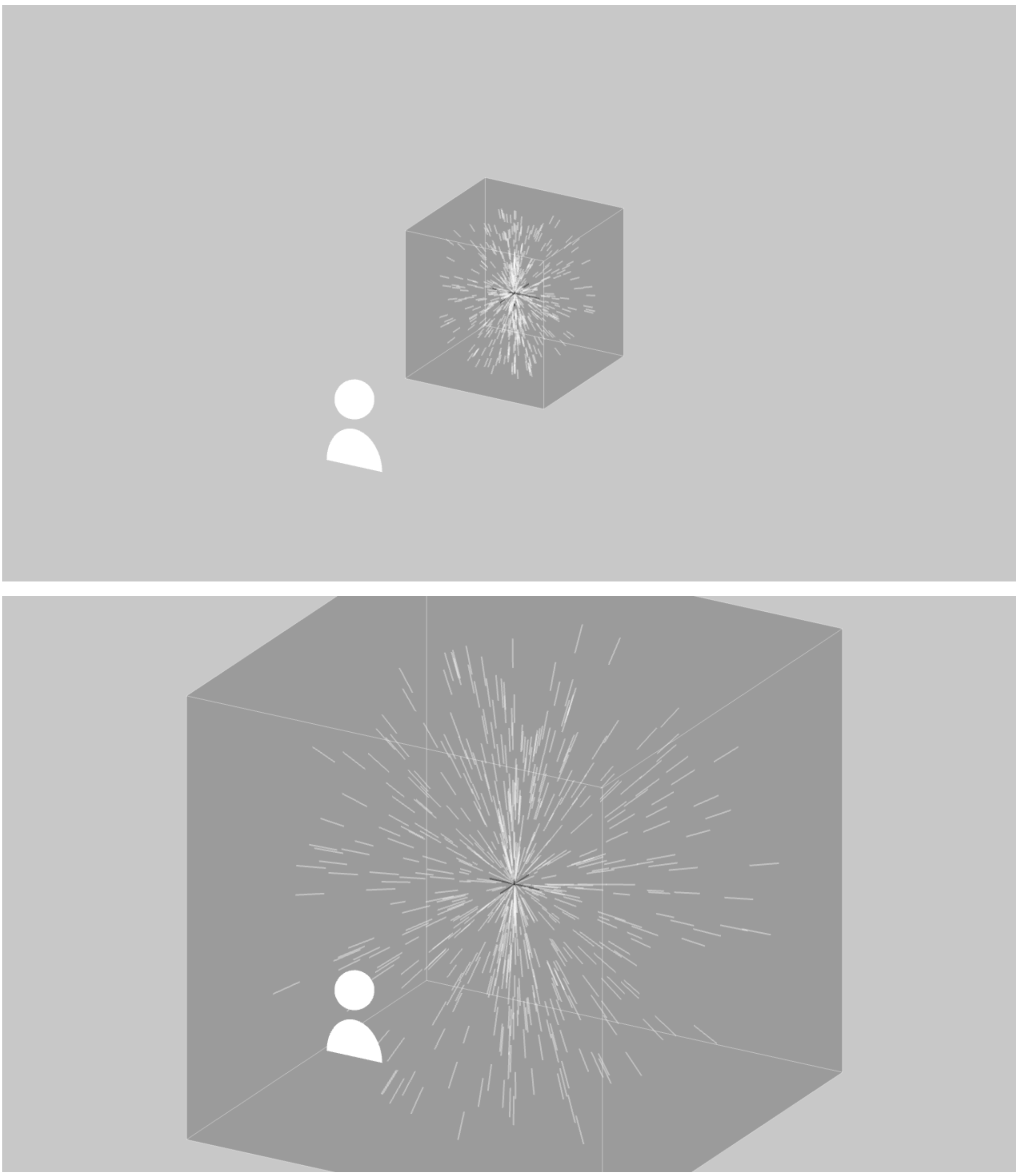


Figure 3.6. View point
Note. Spherical primitive viewed from outside and inside the space it is located

3.2. Affect Measurement

Following previous empirical studies devoted to affective expression through abstract motion (Bartram & Nakatani, 2009, 2010; Lockyer et al, 2011), in this thesis we employ an affect measurement model by focusing on the following five pairs of affects:

Valence (NP): Negative – Positive

Intensity (CE): Calming – Exciting

Interaction (AR): Attracting – Rejecting

Dominance (RT): Reassuring – Threatening

Urgency (UR): Urgent – Relaxed

While the first two pairs of affects Valence (Negative - Positive) and Intensity (Calming - Exciting) reflect the two commonly applied dimensions of valence and arousal in psychology researches (Schlosberg, 1954; Ortony et al, 1990), dimensions of dominance, interaction and urgency reflected affects that are core to the experience of many interactive artifacts and environments.

For instance, Norman suggests design artifacts need to constantly reassure users when they are working properly and also need to warn users when something is wrong (Norman, 2009). According to Kosara, the goal of visualization is usually to communicate a concern rather than to show data (Kosara, 2007). Examples of such affective affordance can be found in many software or application interfaces, and a notable one might be that the circular movement is usually displayed during loading (web contents, initiating applications, waiting), in this case the dot that moves in a circle is to reassure the user, to tell its viewer that the system is working.

Affective experiences on dimension of interaction are also critical for visualization and interface design, as the mechanisms of viewer attention are often of interest by the visual designers (Ware, 2004). Edward Tufte pointed out the friendly graphic “attracts the viewer and provokes curiosity” (Tufte, 2001, p.183). In this case, the affective experience of whether being engaged by the visual presentation should be recognized as another useful basic affect for the application of visualization.

Also, different from the other four dimensions regarding more emotional experiences, dimension of urgency implied more rational impressions for contexts such as real-time and supervisory visualizations (Lockyer & Bartram 2012).

Notably, the above 5 affective dimensions are not mutually exclusive, and cannot serve as comprehensive affects categories or dimensions to describe all possible affects. Instead, they are utilized to evaluate fundamental motionscape affective experience that are critical in general contexts of the visual design for interactive environments. The above affect model certainly cannot cover all affective experiences of recent interactive artifacts and environments; instead, the goal is to provide a small set of simple affective measurements to probe the correlation between abstract motionscapes and the evocation of affective experiences.

3.3. Overview of Studies

In the following two chapters, we report two empirical studies that investigated the affective expressiveness of abstract motionscapes. In both studies, we utilized the abstract motionscape primitives introduced in this chapter as stimuli and further investigated how various affective experiences were evoked by viewing such primitives.

In chapter 4, we present an initial study that investigated how four fundamental motion properties (shape, path curvature, direction, speed) contributed to the affective experiences of a collection of cinematographically presented motionscape primitives.

In chapter 5, we report a follow-up study that are comprised of two experiments. As we divided the motionscape primitives into two groups based on variations in shape, in these two experiments we examined linear and non-linear motionscape primitives separately. In addition, we also incorporated two stereoscopic displays along with standard non-stereoscopic screen to explore how variations in display conditions might influence the affective viewing experiences.

Chapter 4.

Cinematographic Motionscape Study

4.1. Motivation

The first study presented here is to probe the key affective motion factors within motionscapes. That is, the goal of this study is to probe the connection between key motion properties of a small set of motionscape primitives and fundamental affects critical for interactive artifacts and environments, especially for those with visual elements designed and implemented in three dimensional computer graphics.

While previous study (Lockyer et al, 2011) addressed motion's effect on simple 2D motion textures, motionscapes implemented in 3D – which are commonly applied in games, interface design, 3D visualizations, etc. – were not covered. Although such 3D motion effects are not usually presented stereoscopically but only implemented in 3D, they differ significantly from those implemented in 2D. Eliciting whether findings of previous studies are still applicable in 3D motionscape affects requires further exploration. This motivates us to take a further step by investigating 3D motionscape expressiveness.

It should be noted that motionscape primitives appeared in this study were only implemented in three dimensional computer graphics, but not presented stereoscopically. Such primitives were aimed to simulate popular visual effects in movies, 3D video games, software interfaces, visualizations, etc. that are displayed on non-stereo screens. In this study, we designed a quantitative study that explored the affective affordance of such 3D motionscape primitives, and further discuss the potential design principles implied from our findings through this study.

More importantly, by complementing with evidence on how the selected affective impressions can be articulated through controlling motion properties in abstract motionscape primitives, we aim to initiate the discussion on the possible design principles regarding the affective expressiveness of abstract motionscapes in general, which will further contribute to the visual grammar for the application of motion in a greater, yet more complex design space.

Research Question

Previous research in motion has suggested that motion can be studied by looking into various properties of it. But when motion is composed in greater complexity, as it is in motionscape, how such motion properties influence motionscape affects is therefore critical for the design and creation of motionscape.

Previous studies investigating such motionscape phenomena, has granted us promising methods to study the motion in motionscape. Among them, studies investigating simple 2D motion textures have revealed that 4 motion properties: shape, speed, direction, and path curvature to be influential factors for viewer affective experience (Lockyer et al., 2011, Lockyer & Bartram, 2012). Following this path, we raise our research question for this first study as follows:

> How do various motion properties contribute to the affective experience of motionscapes composed in three dimensional graphic?

4.2. Study Design

Previous studies have revealed that various motion properties are influential on motion's affective impression. This thesis chooses to revisit some of such motion properties and study their affective affordance that is yet to be explored in three dimensional computer graphics. In so doing, this study aims to provide a test on whether previous findings in simple motion would be consistent in motionscape.

4.2.1. Block Design

Four motion properties (shape, path curvature, direction, speed) were controlled to generate a series of motionscape primitives for this study. Variations of each motion property (independent variable) are shown in Table 4.1.

Table 4.1. Independent Variables

Shape	Speed	Path Curvature	Direction
Linear	Slow	Straight	Inward-Outward (Linear)
Radial	Fast	Wavy	Inward-Outward (Radial)
Spherical		Angular	Inward-Outward (Spherical)
Circular			Clockwise-Counter clockwise (Circular)

And with regards to the affective measurement, basing on the 5 previously introduced affect dimensions, we form our 5 pairs of affective ratings (dependent variables). These affective ratings are listed as follows:

Table 4.2. Dependent Variables

Valence	Intensity	Urgency	Dominance	Interaction
Negative-Positive	Calming-Exciting	Urgent-Relaxed	Reassuring-Threatening	Attracting-Rejecting
-100 – 100	-100 – 100	-100 – 100	-100 – 100	-100 – 100

All independent and dependent variables are listed in Table 4.1 and 4.2. A combination of 4 variations in shape, 2 variations in speed, 3 variations in path curvature and 2 variations in direction (for motions in each of the 4 shapes) led to 48 unique conditions (motionscape primitives). All conditions were replicated twice and displayed in randomized sequence to avoid first and second order effects. Therefore the whole experiment was comprised of 96 trials in total. In each trial, participants were instructed to enter their response (i.e. ratings for the affective impressions of the displayed motion primitive) to the 5 pairs of dependent affective impressions.

4.2.2. Hypotheses

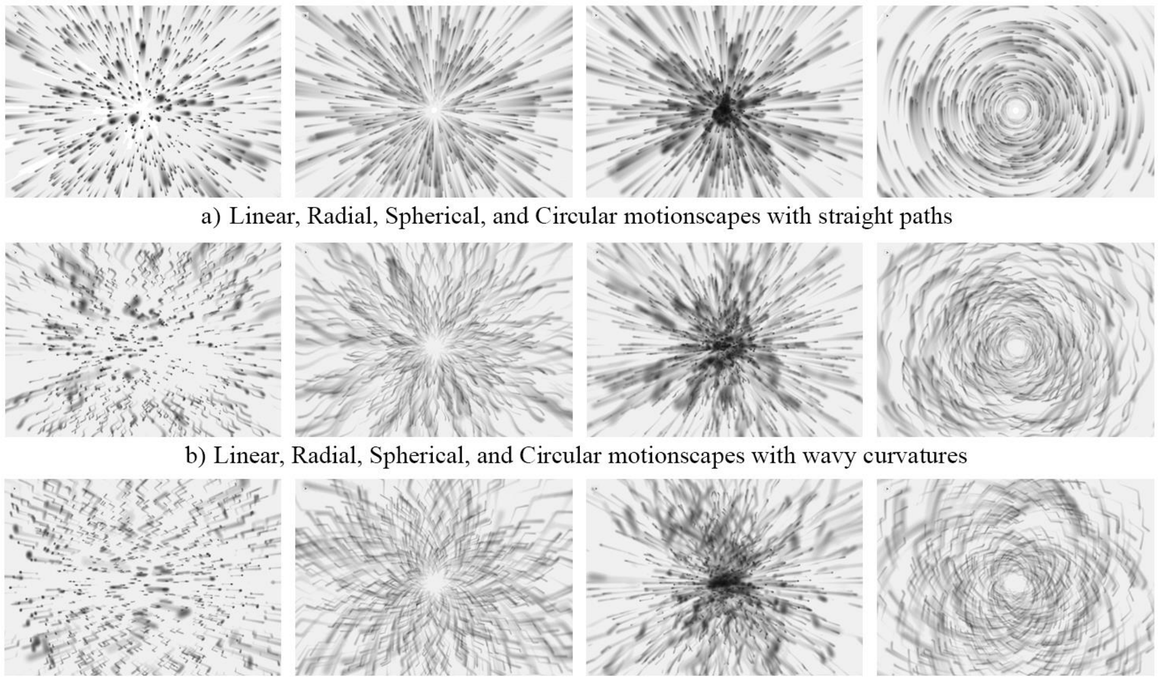
From previous studies we've learned that fundamental motion properties including path curvature, speed, shape, and direction are significant contributors to the affective impression of motion. Previous study in 2D motion textures (Lockyer et al., 2011) revealed that path curvature and speed had significant effects on affective ratings in multiple dimensions, whilst direction only had notable effects on ratings in valence (NP) dimension (in linear primitives) or in interaction (AR) dimension (in radial primitives). Specifically, we listed the findings that are closely related to this study as follows: (1) in linear textures, straight curvature were usually seen as more positive, calming, relaxed, reassuring, and attracting than non-straight (wavy and angular) curvatures; (2) motion textures with fast speed were perceived as more exciting, urgent, and threatening than those with slow speed; (3) inwards radial motion textures were rated as attracting, whilst outwards motion primitives were seen as rejecting.

These previous findings, along with results from our previous pilot studies with two participants, have led us to the following four hypotheses:

> **H1** (Path Curvature): Path curvature in linear motionscape primitives will strongly influence the affective ratings, where linear primitives with straight curvature will be seen as positive, calming, relaxed, reassuring, attracting, whilst those with non-straight curvature will be seen as opposite.
>
> **H2** (Speed): Speed will significantly affect ratings in intensity (CE), urgency (UR), and dominance (RT), that is, primitives with fast motions will be generally perceived as more exciting, urgent, and threatening than slow ones.
>
> **H3** (Direction): Direction in linear, radial, and spherical motionscape primitives will significantly affect ratings for interaction (AR), with inwards being perceived as attracting and outwards being perceived as more rejecting. In circular motions, direction will have an effect on ratings in valence (NP) dimension.
>
> **H4** (Shape): Circular motionscape primitives will be perceived as highly negative.

4.3. Method

4.3.1. Stimuli



a) Linear, Radial, Spherical, and Circular motionscapes with straight paths

b) Linear, Radial, Spherical, and Circular motionscapes with wavy curvatures

c) Linear, Radial, Spherical, and Circular motionscapes with angular curvatures

Figure 4.1. Stimuli
Linear, radial, spherical and circular primitives with all 3 path curvatures

In the experiment, all motionscape primitives were shown to viewer from orthographic view in linear perspective, with x axis and y axis parallel to screen's edges along width and height, and with z axis perpendicular to the screen. Therefore, all (1) linear primitives were manipulated to move parallel to z axis, (2) radial and (4) circular primitives were attached to z axis, and (3) spherical primitives were located to a point on z axis.

Figure 4.1 shows motionscape primitives with all 3 different path curvatures. While in figure 4.1a all particles move along straight paths, they were also manipulated to move along wavy (Figure 4.1b) or angular (Figure 4.1c) path curvatures.

Two variations in direction were applied to motion primitives in each shape. In (1) linear primitives particles moved along z axis either inwards or outwards with respect to the screen's plane; in (2) radial or (3) spherical primitives particles moved inwards (radiating out) or outwards (sucking in) to the z axis or the central point on z axis; in (4) circular primitives particles moved either clockwise or counter clockwise along z axis.

Particles in all motionscape primitives moved in either slow speed (1 voxel per second) or fast speed (5 voxels per second).

4.3.2. Apparatus

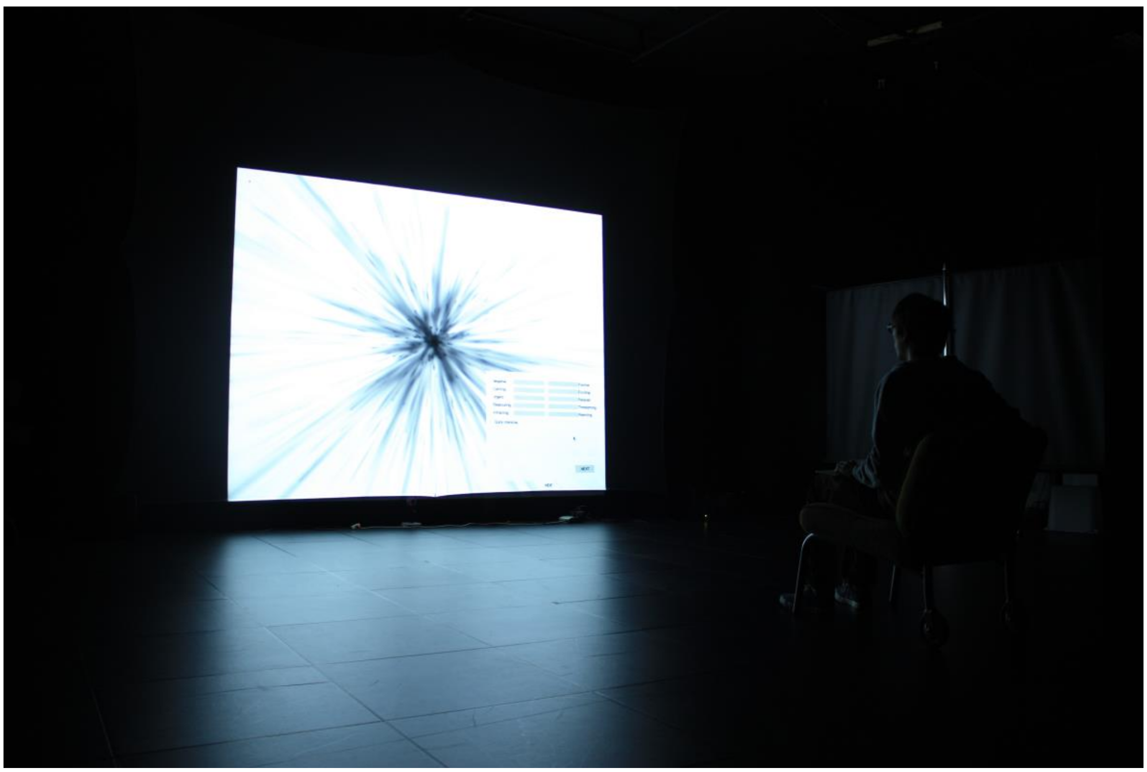


Figure 4.2. Experiment Set-up

Figure 4.2 shows the set-up of the experiment. Motionscape primitives were projected on to a canvas screen at a 60 frames per second with 1280 × 960 resolution. The projection on screen was left as the only lighting source in the experiment room; the projection size was adjusted to 2.8 m × 2.1 m. Participants were seated in a chair 3.6 m in front of the screen and provided with a mouse and a keyboard to enter affective ratings and comments.

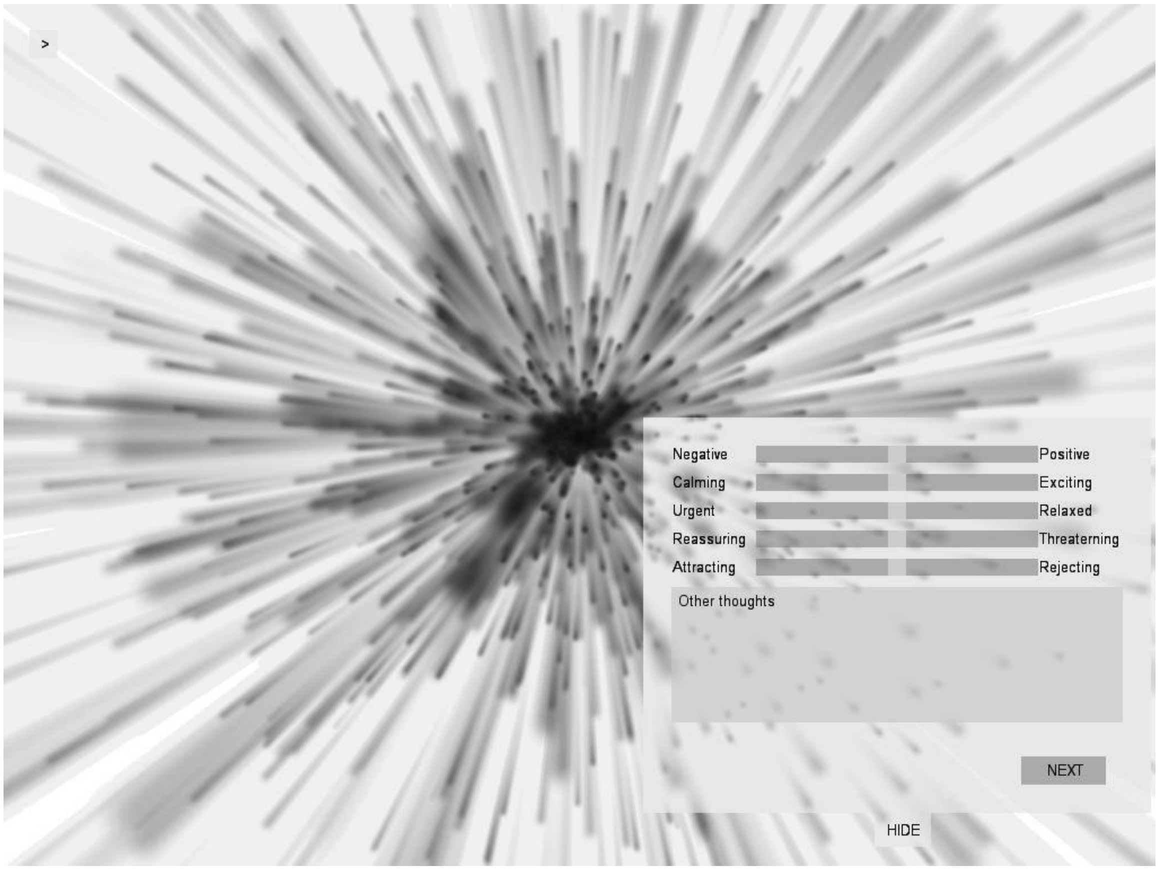


Figure 4.3. Interface for Affect Measurement

Above the animated motionscape primitive, a 400 × 350 pixel window was displayed on the down right corner of the scene. The window provided five sliders to enter the affective ratings and a text field to write down other comments (Figure 4.3). Each slider represented one affective rating and was scaled from -100 to 100, with negative value representing the affective rating labelled on the left and positive value representing the opposite rating on the right. The default value of each slider was set to 0, thus all our five pairs of affective impressions were initially rated as 0 (representing neutral). Participants could further drag the sliders to each side, as a result, the entered value represented the intensity of the corresponding affective impression. For instance, if a participant rates certain motionscape primitive on the dimension of intensity and assign a high positive value for exciting (e.g. 90), the affective impression of this motionscape primitive is thus interpreted as strongly exciting. Also, when a participant evaluates the affective ratings independently, the value will represent the intensity (value) of that affective rating. For instance, if a value of 20 on the interaction dimension is chosen, the affective rating will thus be interpreted as slightly rejecting.

The window could be hidden or shown by clicking the check box labeled as “HIDE”, while it had to be set to visible whenever participant responses should be entered. When the grey button (labeled as “NEXT”) was clicked, the current motionscape primitive would fade out until the screen was left blank, then a new one would fade in (each transition took 2 seconds) and stay till the button was clicked again.

4.3.3. Procedure

After a 2-participant pilot study, 12 university students were recruited to the formal study (5 women aged from 20 - 44 and 7 men aged from 21 - 36). All had normal (or corrected-to-normal) acuity and with no knowledge of the research questions or hypotheses of the study. Participants were either paid or granted standard course credits upon the completion of the study.

Training

At the beginning of the first session of each experiment, an introduction was given to each participant. At this stage, 4 basic motion primitives of each shape (linear, radial, spherical, and circular) with medium speed and straight path curvature were displayed in sequence to help the participant get familiar with the motion primitives. Along with each sample motion primitive, the window for affective ratings and commenting were also displayed. We explained the meaning of the affective ratings along the 5 sliders, and instructed the participant to enter their affective ratings through our interface.

All sample motionscape primitives were different from those in formal trials, and no ratings or comments entered during the introduction were recorded. Once the participant was ready, the formal trials would began and all participant input would be recorded.

Formal Task

Once the participant went through the training session and stated ready for the following formal experiment, the participant would be directed to start the formal conditions. The participant was instructed to evaluate each motionscape primitive using affective rating by dragging the corresponding slider and to input any thoughts and comments in the text box below the ten affective rating sliders. The participant was encouraged to rest when any negative symptoms occurred. All participants completed both sessions of our experiments within 1 week, and each session averaged 45-50 minutes for each experiment. After the formal tasks, an informal semi-structured interview was conducted for feedback and further ideas with regard to the experiment. All participant inputs were recorded and stored and copied in encrypted hard drives and an encrypted web server. One participant reported fatigue and motion sick during his first session of the experiment, while no other participants reported any discomfort caused by either the motionscape primitives or set up of the experiment space.

4.4. Results

We began our analysis by using a four-way ANOVA of all 4 motion factors (shape, speed, direction and path curvature) for all 5 affective ratings.

Our statistical analysis model (General Linear Model) had 4 within-subject factors (i.e., shape, speed, direction, path curvature). Shapiro-Wilk tests revealed that the sample was not significantly deviated from normality. Mauchly's tests were performed to detect violations of the assumption of sphericity. When the assumption of sphericity was violated (i.e. $p > .05$), we employed the Huynh-Feldt correction to produce a valid F-ratio. And results suggested that the participants' responses largely varied among primitives with different shapes. Post hoc analysis with Bonferroni adjustment indicated that almost all 4 variations of shape differed from each other significantly in their effects on affective ratings.

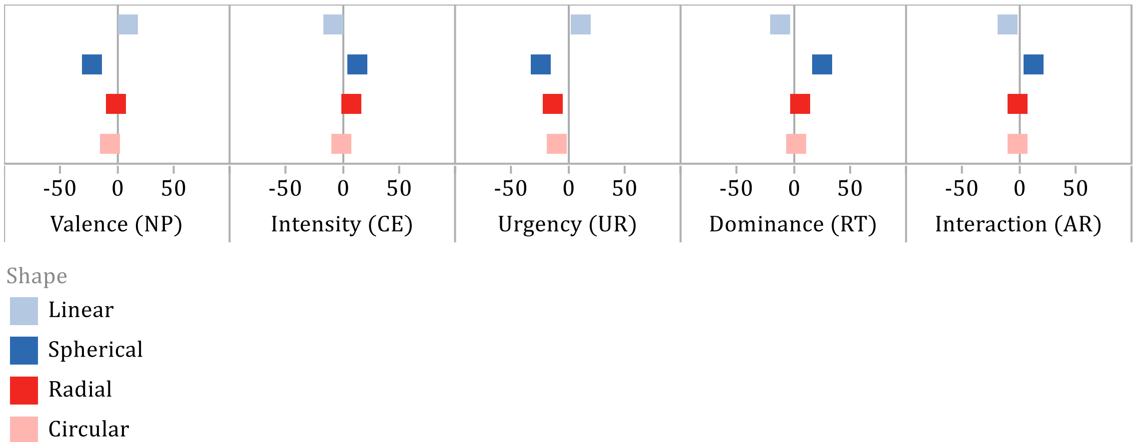


Figure 4.4. Means of All Affective Ratings by Shape

Post-hoc test revealed spherical primitives were perceived significantly different from linear primitives. While spherical primitives were in general seen as negative (-22.85), exciting (14.07), urgent (-23.48), threatening (26.17), and rejecting (13.11), linear primitives were more positive (9.75), calming (-8.79), relaxed (11.84), reassuring (-11.73), and attracting (-9.29).

Table 4.3. Main Effects of Shape on All Affective Ratings

Valence (NP)	Intensity (CE)	Urgency (UR)	Dominance (RT)	Interaction (AR)
$F(3,33) = 7.377$, $p = .001$	$F(3,33) = 19.390$, $p < .001$	$F(3,33) = 20.087$, $p < .001$	$F(3,33) = 16.343$, $p < .001$	$F(3,33) = 5.163$, $p = .005$

However, although both radial and circular primitives differed significantly in at least one affective rating with linear and spherical primitives, no significant difference in their effects were detected through our post-hoc test. As suggested in Figure 4.4, these two factors (radial and circular) yielded similar neutral effects on all 5 affective ratings (Figure 4.4).

This finding had led us to further conduct 5 three-way ANOVA tests for all affective ratings among speed, curvature and direction on each of the shape primitives. In the following sub sections, we will group the results by shape. That is, rather than reporting the effects of speed, direction, and path curvature among all motion primitives in general, we will discuss effects of these 3 factors in each shape primitive separately. Figure 4.5 to Figure 4.8 provide overviews of the results, showing mean affective ratings by curvature, speed, and direction (Table A.1 lists significant main and interaction effects). In the following subsections, we further discuss each significant factor in turn.

4.4.1. Linear Primitives

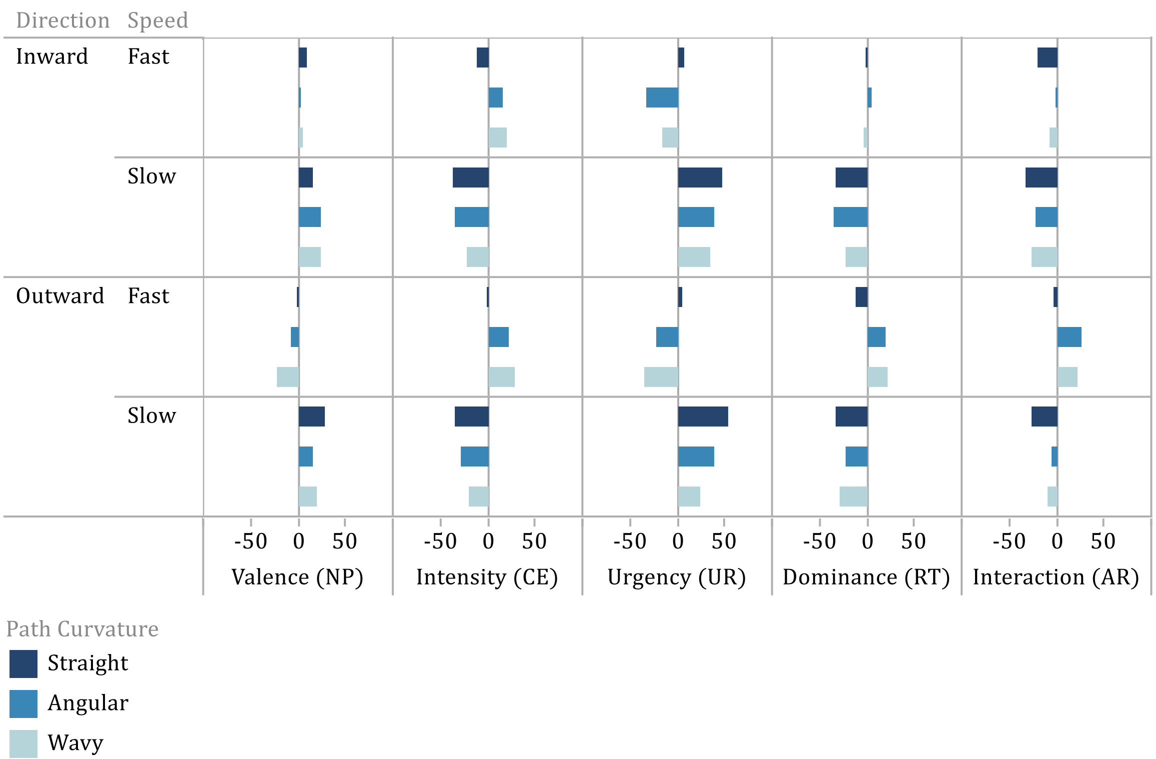


Figure 4.5. Means of All Ratings of Linear Motionscape Primitives

Speed had significant effects on all five affective ratings. For valence (NP) ratings, post hoc analysis using with Bonferroni adjustment indicated that affective ratings of slow motions (*Mean* = 21.91) were much higher than those of fast motions (*Mean* = -2.40). i.e., slow motions were rated as positive, while the fast motions were rated as neutral or slightly negative. Urgency (UR) ratings followed a similar pattern with regards to speed's effect: slow motions (*Mean* = 39.33) were seen as very relaxed, while fast motions (*Mean* = -15.64) were seen as urgent. In intensity (CE) ratings, slow motions (*Mean* = -29.70) were rated as significantly more calming than exciting fast motions (*Mean* = 12.12). Dominance (RT) ratings have slow motions (*Mean* = -29.05) rated as reassuring and fast motions (*Mean* = 5.6) rated as slightly threatening. In interaction (AR) ratings, slow motions (*Mean* = -20.96) were more attracting compared to fast motions (*Mean* = 2.39).

Path curvature also has significant effects on intensity (CE), urgency (UR), and interaction (AR) ratings (Table A1). Post hoc analysis for intensity (CE) indicated that straight motions (*Mean* =-21.08) were rated as more calming than angular motions (*Mean* =-6.56), and more neutral than wavy motions (*Mean* =1.27). Notably, here wavy motions did not significantly differ from angular motions. Urgency (UR) ratings had straight motions (*Mean* = 27.91) rated as relaxed, while angular motions (*Mean* = 5.42) and wavy motions (*Mean* = 2.2) were rated as neutral. In interaction (AR) ratings, straight motions (*Mean* = -21.14) were seen as more attracting than wavy motions (*Mean* = -0.99) and angular motions (*Mean* = -5.72).

Direction in linear primitive was highly significant for interaction (AR) rating only. A post hoc analysis of directions indicated that inward motions (*Mean* = -18.77) were generally rated as more attracting than outward motions (*Mean* = 0.20).

4.4.2. Spherical and Radial Primitives

Speed, in both spherical and radial primitives, was again a significant contributing factor for all 5 affective ratings. In spherical motions, while slow motions (*Mean* = -5.76) were rated far less negative than fast motions (*Mean* = -39.95). Intensity (CE) ratings had slow spherical motions (*Mean* = -11.53) rated as calming and fast motions (*Mean* = 39.67) rated as very exciting. Urgency (UR) ratings had slow spherical motions (*Mean* = 9.60) rated as relaxed, while fast spherical motions (*Mean* = -56.57) rated as highly urgent. In interaction (RT) ratings, slow spherical motions (*Mean* = 4.53) were more reassuring compared to threatening fast motions (*Mean* = 47.81). In spherical primitives, slow motions (*Mean* = -3.21) were rated as slightly attracting, whereas fast motions (*Mean* = 29.43) were rated as rejecting.

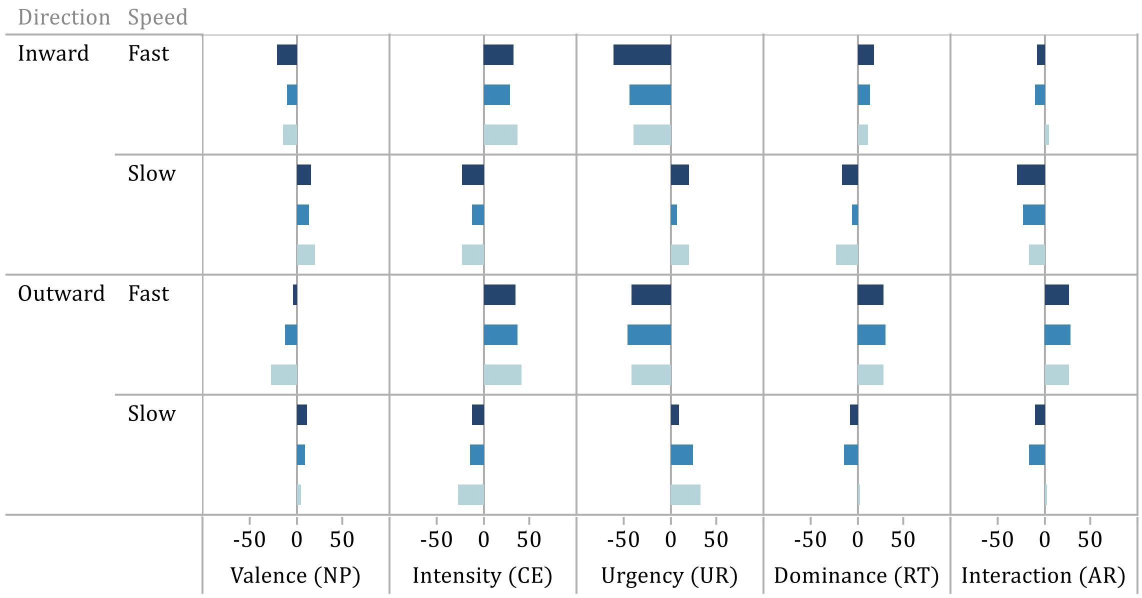


Figure 4.6. Means of All Ratings of Radial Motionscape Primitives
Note. Colour legend is same with Figure 4.7

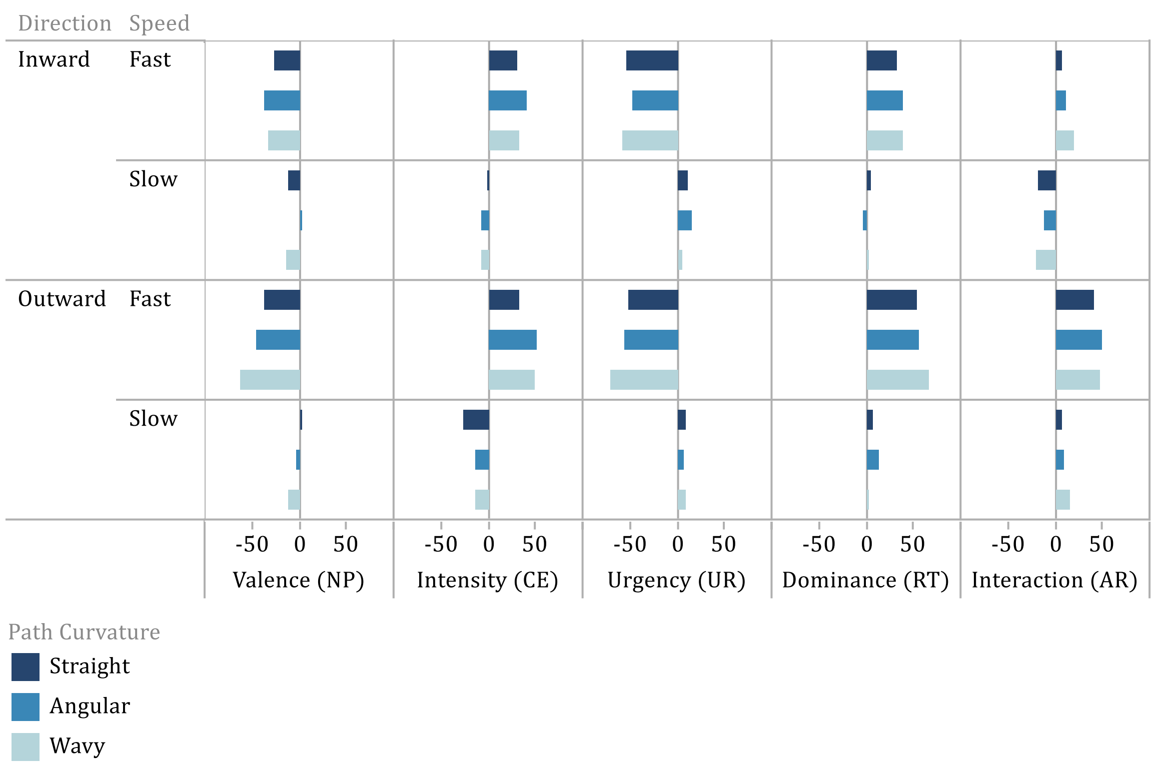


Figure 4.7. Means of All Ratings of Spherical Motionscape Primitives

Affective ratings for radial primitives were consistent with spherical primitives with regard to speed: slow motions were rated as positive (*Mean* = 12.67), relaxing (*Mean* = 18.99), calming (*Mean* = -17.93), reassuring (*Mean* = -10.52) and attracting (*Mean* = -15.12), whereas fast motions were rated as negative (*Mean* = -14.08), urgent (*Mean* = -44.93), exciting (*Mean* = 35.53), threatening (*Mean* = 21.63), and rejecting (*Mean* = 11.79).

Direction also yielded significant effects on dominance (RT) and interaction (AR). In dominance (RT) ratings, inward spherical motions (*Mean* =19.12) were less threatening than outward spherical motions (*Mean* = 33.22). In interaction (AR) ratings, inward spherical motions (*Mean* = -2.31) were rated as attracting, while outward spherical motions (*Mean* = 28.53) were very rejecting.

Again radial primitives followed a similar pattern with regard to direction's effects on dominance (RT) and interaction (AR) ratings, with inward motions rated as reassuring (*Mean* = -0.15) and attracting (*Mean* = -13.12), and outward motions rated as threatening(*Mean* = 11.26) and rejecting (*Mean* = 9.79).

Notably, path curvature, either in spherical or radial primitives, did not have significant effect on any of our 5 affective ratings.

4.4.3. Circular Primitives

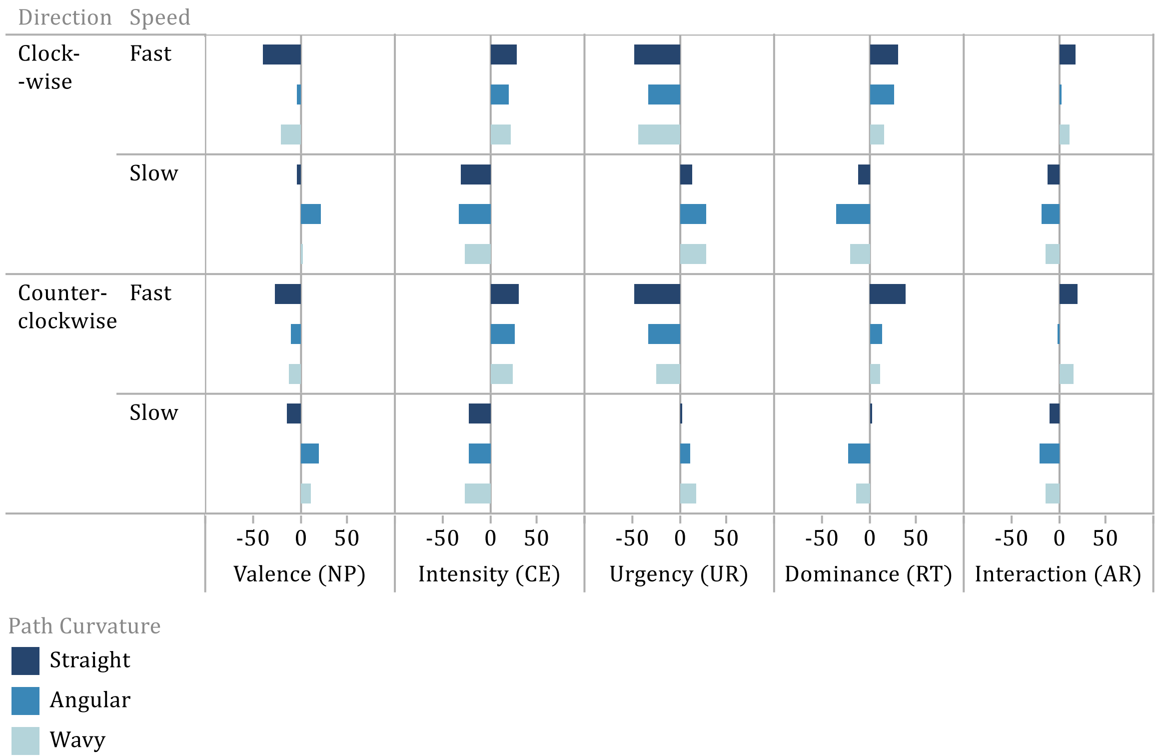


Figure 4.8. Means of All Ratings of Circular Motionscape Primitives

Speed in circular primitives, had similar effects as it yielded in ratings for linear, radial, and spherical primitives, on all five affective ratings. Slow circular motions were rated as slightly positive (*Mean* = 6.41), relaxing (*Mean* = 17.09), calming (*Mean* = -26.71), reassuring (*Mean* = -16.34) and attracting (*Mean* = -14.23), whilst fast circular motions were rated as negative (*Mean* = -18.24), urgent (*Mean* = -37.74), exciting (*Mean* = 25.36), threatening (*Mean* = 23.11), and rejecting (*Mean* = 11.21).

Path curvature was highly significant for valence (NP), urgency (UR), and interaction (AR) ratings. Valence (NP) ratings had straight motions (*Mean* = -20.80) rated as more negative, comparing to ratings for angular motions (*Mean* = -7.02) and wavy motions (*Mean* = -3.97). Interestingly, Urgency (UR) rating for curvature in circular primitives was opposite comparing to that in linear primitives. And here straight (*Mean* = -19.71) motions were rated as more urgent than wavy (*Mean* = -5.11) and angular (Mean = -6.16). In interaction (AR) ratings, straight motions (*Mean* = 15.56) were seen as rejecting, wavy motions (*Mean* = -1.26) and angular motions (*Mean* = -4.16) were generally seen as neutral.

4.5. Discussion

One of our main purposes of this study is to test the validity of the results from previous studies on two dimensional motion textures. Through this, we aim to compare the affective experience evoked by 3D motionscape effects on a level of simple motion properties, thus to both foster guidelines affects suggested from our previous studies and detect new possible principles in the design space in 3D.

With this in mind, our hypotheses in this study were developed largely as a reflection of our previous findings. And in this section, we summarize and report key findings retrieved from results, and provide analysis of such results with respect to each of our hypotheses.

4.5.1. Speed

Speed had significant effects on all our 5 affective ratings.

From separated 3-way ANOVA and post-hoc tests for linear, spherical, radial, and circular primitives, we found that slow motions yielded significantly different responses than fast motions. We detected a clear trend that slow motions were generally perceived as positive, calming, relaxed, reassuring, and attracting, whereas fast motions were seen oppositely as negative, exciting, urgent, threatening, and rejecting. Therefore, our hypothesis (H2) regarding speed is supported.

These results fit previous findings regarding 2D motion textures, where speed yielded similar effects – as it did in this study – on intensity (CE), urgency (UR), and dominance (RT) affective ratings. In addition to this, results of our study also showed strong effects of speed on the other two affective ratings: valence (NP) and interaction (AR). While previous studies in 2D motion textures implied that speed can be manipulated for impressions on intensity and dominance dimensions, the findings here suggest that speed also has potential on valence dimension. That is, as slow motions are usually associated with more positive (or less negative) affective impressions comparing to fast motions, the use of visual elements with high speed should be limited for motionscapes that are aimed for positive impressions.

4.5.2. Direction

Direction is a significant factor for affective ratings on dominance (RT) and interaction (AR) dimensions.

As direction in linear primitives was controlled to vary between inwards and outwards screen, we did not expect similar effects of direction on valence (NP) dimension in our hypothesis (H3). Therefore, we group linear, radial, and spherical primitives together, as they all share similar variations in direction.

Results from linear, radial, and spherical primitives showed that direction was highly significant in interaction (AR) ratings: outward motions were rated as more rejecting than inward motions in each of the above shape primitives. The detected effects of direction of such primitives on interaction (AR) ratings were consistent with our previous findings in 2D motion textures. However, in circular motions, we did not detect any significant effect of direction (clockwise – counter clockwise). These led us to partly accept H3, with the hypothesis regarding direction in circular primitives being rejected.

What we did not expect or state in our hypothesis (H3), was the effects of direction in radial and spherical primitives on dominance (RT) ratings. In both radial and spherical primitives, inward motions were perceived as more neutral than outward motions, which were generally seen as highly threatening. This finding is opposite to the results of our previous study in 2D motion primitives, where we found all radial primitives in 2D were rated similarly on dominance (RT) dimension regardless of direction.

4.5.3. Path Curvature

Path curvature, in linear primitives, had significant effects on intensity (CE), urgency (UR), and interaction (AR). Linear primitives with straight curvature were rated as more calming, relaxed, and attracting than those with wavy or angular curvatures. These fit our previous findings with exception only in valence (NP) and dominance (RT) ratings, which path curvature did not have significantly effects on. Not surprisingly, in radial and spherical primitives, no significant effect of path curvature was captured. This is again consistent with our previous findings. Thus, we accept H1, as in linear primitives path curvature still contributes significantly to 3 of the 5 affective ratings.

One interesting finding retrieved from this study is, that in circular primitives path curvature yielded opposite affective ratings than it yielded in linear primitives on urgency (UR) and interaction (AR) ratings. Straight motions, which were found to be relaxed and attracting in linear primitives, were rated as negative, urgent and threatening among circular primitives. In circular primitives, those with non-straight path curvatures were generally perceived as neutral in all the following three dimensions: valence (NP), urgency (UR), and interaction (AR). This finding regarding path curvature is quite inconsistent with the current practice and applications of circular motions. As in web and interface design circular motions are commonly applied as indicator of loading or translating progression, it is not radical to conclude that circular motions are generally seen as neutral, or at least not negative, exciting, urgent, threatening, or rejecting. Although our study was designed to investigate motion's affordance in motion scape, we suspect similar effect of path curvature in circular motionscape will also apply in circular motions in general. While this is still a guess, it is a reasonable one. And this hypothesis raised here suggests a series of future test to elicit how circular motions should be designed in its different applications in various contexts.

4.5.4. Shape

Shape, along with speed, is another significant factor that affects all of our 5 affective ratings.

User affective ratings significantly varied between spherical and linear primitives. Spherical primitives were generally rated as negative, exciting, urgent, threatening, and rejecting, linear primitives were more positive, calming, relaxed, reassuring, and attracting.

As we did not detect significant difference between radial and circular primitives through our one-way ANOVA, we concluded that they yielded similar effects. And as reflected from Figure 4.4, both shape primitives were rated as neutral in general, which rejected our hypothesis regarding circular motion primitives (H4).

Spherical primitives received highest ratings (in terms of intensity) in all 5 affective ratings among all 4 shape primitives, we therefore focus on spherical motion primitives at this part of the discussion. This finding reveals the strong potential of applying spherical and linear primitives for affective impressions. While spherical primitives were rated as highly negative, exciting, urgent, threatening, and rejecting, a general implication for visual artists and designers is clear: where the listed impressions are intended, spherical motion primitive will be a legitimate candidate visual element to consider.

4.6. Summary

While previous studies in motion have detected a range of affective factors simple abstract motion and motionscapes composed in two dimensional space, our study proves some of such motion properties (speed, direction, path curvature, and shape) are still significant affective motion properties for motionscape primitives that are implemented in three dimensional visual space.

Through this study employing a selection of motionscape primitives, the roles of the key motion properties are summarized below:

Shape has significant main effects on all 5 affective ratings. Spherical motions were perceived significantly different from motions of other shapes: spherical motions were seen as negative, exciting, urgent, threatening, and rejecting. Linear motions were seen as positive, calming, relaxed, reassuring, and attracting. No strong effects were detected for Radial and Circular motions.

Speed has significant effects on all 5 affective ratings. Fast motions are seen as more negative, exciting, urgent, threatening, and rejecting than slow motions.

Path curvature was not detected as significant main effect, but it has interaction effects with shape (linear and circular, but not radial and spherical) on NP, CE, UR, RT (but not on AR). In Linear motions, straight motions were seen as more positive, calming, relaxed, and reassuring than non-straight (wavy and angular) motions. In Circular motions, straight motions were seen as negative, urgent, threatening, and rejecting. No significant difference was found between wavy and angular motions.

Direction only has an interaction effect with shape on AR ratings. In linear and spherical motions, inwards motions were seen as more attracting than outwards motions. In radial motions, motion sucking in were seen as more attracting. Direction doesn't have any effect on circular motions.

Chapter 5.

Stereoscopic Motionscape Study

Through the first motionscape study we gave an initial attempt to probe the connections between key motion properties within motionscape and multiple affect dimensions that were critical to affective visualization. However, several limitations also became visible as the study proceeded; each implied the aspects of motivations for a second motionscape study.

5.1. Immersion, Motion and Affect

5.1.1. Screen and Scale

The motionscape primitives appeared in the first study was to create an affective visual experience through projecting large scale motion stimuli in an experiment environment resembling cinema or gallery space. The goal of such set up was to enlarge the motionscape's effect and therefore to detect the possible subtle effects contributed by its various motion aspects. The visual stimuli in the study were also created to resemble the works of motionscape aimed for immersive experience. That is, the motionscape visual effects in such works were intended to take the screen space and to let the viewer immerse in the abstract visual presentation. This trend of such applications of motionscape is visible in a range of visual art and design practices, thus it was natural that we followed it by employing the cinematic set up in the first study.

However, this approach only implied limited scenarios or instances on how motionscapes could be applied. Other possibilities and directions can be imposed by considering the variations in the levels of immersion and scale of motionscape presentation, thus brings about two following problems:

First, not all applications of motionscape are intended for immersive experience. In a range of interface design scenarios, motionscape visual effects are popularly rendered locally rather than taking full screen space. Since the variations in sizes and types of the screens significantly affect the affordance of the interactive artifacts (more in-depth surveys on this topic can be found in Mondloch, 2010), it is reasonable to consider other variations in display options of motionscape (such as desktop computer monitor, stereoscopic screen, and VR set-up).

Second, the experience of immersion isn't only result in the size of screen, but also the “depth”. That is, while two dimensional screen is often short in its stereoscopic presentation, displays that are capable of delivering three dimensional presentations increases the level of immersion by eliminating the boundary between viewer and screen (Manovich, 2002). Therefore, employing stereoscopic display will likely influence the affective experiences evoked by the displayed subject. What this means to the abstract motionscapes is unclear: on the one hand, motionscape works implemented in tangible forms are rare; on the other hand, motionscape's effects are seldom involved in current VR research or similar surveys incorporating stereoscopic displays.

5.1.2. Linear vs. Non-linear

Motionscape with linear dynamic layout (shape) was found to significantly differ itself from ones with non-linear shapes. As linear primitives and non-linear ones are constructed differently based on variations in their dynamic layouts (i.e. Linear, circular, radial, spherical), other motion factors could be therefore interpreted differently. Among the motion properties explored in previous study, direction was a factor significantly varied in primitives with different shapes. As a result, its effects on affect ratings could be hidden by the effects from shape.

5.1.3. Affect Measures

The 5 affect measure dimensions used in the previous study were constructed based on semantic differential scales and could not be exclusively selected. Therefore, on each affect measure dimension, participants were only allowed to give ratings for the affective impression that was located on either the left or right side of that dimension. However, participants often stated that they experienced two affective impressions on the same dimension at the same time. In this case, the affective ratings could not represent or reflect their actual responses with regards to our 5 dependent affect dimensions. Therefore affect measurement protocol should be modified so that ratings for both affective impressions on each dimension could be recorded.

5.1.4. Research Question

Based on the above findings revealed from the first motionscape study, new research questions are raised:

> How will basic motion properties of linear and non-linear motionscape primitives contribute to their affective expressiveness?
>
> How will the affective affordance of motionscape be influenced by the immersive experience brought by stereoscopic and VR display conditions?

5.2. Study Design

Table 5.1. Experiment Allocations

Linear Motionscape Experiment	Non-linear Motionscape Experiment
VR Group	VR Group
Desktop 3D Group	Desktop 3D Group

The lessons learned from the previous motionscape study led us to several changes in our study design.

First, we designed two experiments to further explore the affective expressiveness of linear primitives and non-linear primitives separately. That is, while one experiment was to investigate only linear motionscape primitives, the other experiment devoted to study spherical and spiral primitives. And in both experiments we continued to investigate basic motion properties (i.e. speed, direction, path curvature) introduced in the first motionscape study. Along with such motion properties, we incorporate a new property, view point, to study the effects of the scale of the motionscape primitives

Second, as a response to the limited display conditions provided by previous motionscape study, we employed two stereoscopic displays along with standard non-stereoscopic screen in this study. In each experiment, we divided our participants into two independent groups: while all participants were requested to view motionscape primitives through standard non-stereo display, in each group participant were either assigned to view motionscape primitives through an immersive VR display (VR group) or through a desktop 3D display (Desktop 3D group).

Finally, as shown in Table 5.2, we divided each of the 5 previous affect dimensions into 2 independent differential scales. That is, previous affects that were on the same dimension were paired and represented by 2 sliders. Therefore, participants in this study were able to enter ratings for both affective impressions on all 5 affect dimensions.

Table 5.2. Affective Ratings

Valence (NP):		Intensity (CE):	
Negative	Positive	Calming	Exciting
0 – 100	0 – 100	0 – 100	0 – 100
Urgency (UR):		Dominance (RT):	
Urgent	Relaxed	Reassuring	Threatening
0 – 100	0 – 100	0 – 100	0 – 100
Interaction (AR):			
Attracting	Rejecting		
0 – 100	0 – 100		

Note. On each affect dimension there are two affective ratings, producing 10 dependent variables for this study

5.2.1. Block Design

All independent variables for both linear and non-linear motionscape experiments are listed in Table 5.3 (with Table 5.3a. listing independent variables for the linear motionscape experiment and Table 5.3.b listing independent variables for the non-linear motionscape experiment).

Table 5.3. Independent Variables

View point	Speed	PC	Direction	Display
Inside Outside	Slow Fast	Straight Non-straight (Wavy)	Upward Downward Inward Outward	Stereo (VR/Desktop) Non-stereo

a. Independent variables for linear motionscape study

Shape	View point	Speed	PC	Direction	Display
Spherical Spiral	Inside Outside	Slow Fast	Straight Non-straight (wavy)	Inward Outward	Stereo (VR/Desktop) Non-stereo

b. Independent variables for non-linear motionscape study

As stated in the previous section there are too many factors for a single experimental study. We split these factors into two parallel studies on the dimension of shape, as we already know shape is a strong effect. Thus this study used a between-subjects approach. That is, we conducted two experiments to investigate linear and non-linear motionscapes separately. And both studies comprised two independent within-subject groups (i.e., VR and Desktop 3D groups). These studies were run with different participant sets but were drawn from the same user population.

In linear motionscape experiment, for both VR and Desktop 3D groups, a combination of 2 viewing points, 2 variations in speed, 2 variations in path curvature, 4 variations in direction, and 2 rendering methods (stereo or non-stereo) led to 64 unique conditions. While in non-linear motionscape experiment, for each sub group a combination of 2 motion shape, 2 speed, 2 path curvature, 2 direction two view points and 2 display methods (non-stereo vs. VR or non-stereo vs. Desktop 3D) led to 64 unique conditions.

We used a fully repeated-measures factorial design that all participants (12 of each sub group of each motionscape experiment) were to experience every experimental condition. All conditions were presented to each participant twice and were displayed in randomized sequence. Therefore the whole experiment was comprised of 128 trials in total. The experiments were then divided into two sessions where motionscape primitives were either displayed under stereo or non-stereo display condition. Therefore, in each session participants were instructed to enter their affective ratings for each of the 64 trials with regard to the 10 dependent affective impressions.

5.2.2. Hypotheses

The first study has revealed that path curvature, speed, and direction are significant factors for the affective impression of linear motion primitives. While path curvature and speed had significant effects on affective ratings in multiple dimensions, direction was only detected to have strong effects on ratings in valence (NP) dimension.

In the following listed are the findings that are closely related to this study as follows: (1) PC: in linear primitives, straight curvature were usually seen as more positive, calming, relaxed, reassuring, and attracting than non-straight (wavy and angular) curvatures; (2) Speed: motion primitives with fast speed were perceived as more exciting, urgent, and threatening than those with slow speed; (3) Direction: inwards motion primitives were rated as attracting, whilst outwards motion primitives were seen as rejecting.

> **H1** (Viewing condition): Stereo motions will generally have stronger affective rating results than those yielded by non-stereo motions. And VR set up will yield the strongest affective ratings.
>
> **H2** (Shape): Spherical motions will be generally rated as Negative, Exciting, Urgent, Threatening, and Rejecting; while spiral motions will be generally rated as neutral for most affective impressions, except that it will have a strong interaction effect with direction (inward spiral motion will be perceived as more attracting than other combinations of shape and direction).

H3 (Path Curvature): Path curvature in linear primitives will strongly influence the affective ratings, where primitives with straight curvature will be seen as positive, calming, relaxed, reassuring, attracting, whilst those with non-straight curvature will be seen as opposite.

H4 (Speed): Speed will significantly affect ratings in intensity (CE), urgency (UR), and dominance (RT), that is, fast motions will be generally perceived as more exciting, urgent, and threatening than slow ones.

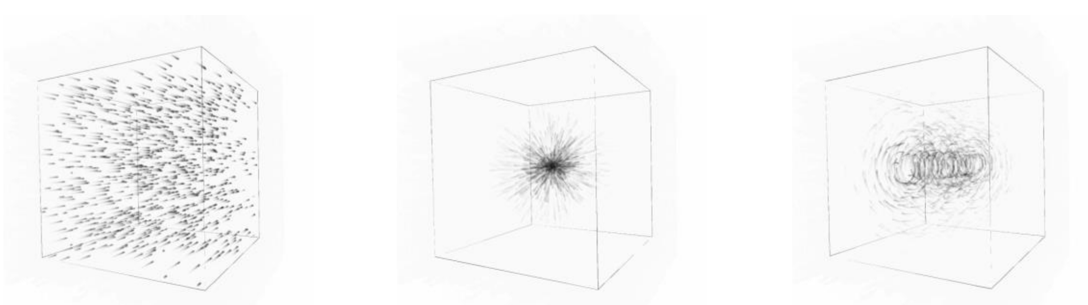
H5 (Direction): Direction will affect ratings for interaction (AR) and valence (NP), with inwards being perceived as attracting and outwards being perceived as more rejecting. And upward motions will be perceived as positive while downward motions will be perceived as negative.

H6 (View point): Motions displayed in full screen (with participant virtually inside the space of particles) will receive higher ratings for intensity (Exciting), urgency (Urgent), and dominance (Threatening) than those displayed with participant virtually outside the space of particles.

5.3. Method

5.3.1. Stiumuli: Motionscape Primitives

In both experiments, all motionscape primitives were again shown to viewer from orthographic view in linear perspective, with x axis and y axis parallel to screen's edges along width and height, and with z axis perpendicular to the screen. All spherical primitives were located to a point on z axis, while all spiral primitives were attached to z axis.



(a) Base linear primitive (b) Base spherical primitive (c) Base spiral primitive

Figure 5.1. Base Motionscape Primitives

In linear motionscape experiment, 4 variations in direction were applied to the linear primitives: (1) inward and (2) outward, particles moved along z axis either inwards or outwards with respect to the screen's plane; (3) upward or (4) downward, particles moved upwards or downwards along the y axis.

In non-linear motionscape experiment: 2 variations in direction were applied to motion primitives of both shapes (spherical and spiral): in spherical primitives: particles moved outwards (radiating out) or inwards (sucking in) to the central point on z axis; in spiral primitives: particles moved clockwise, either inwards or outwards along z axis.

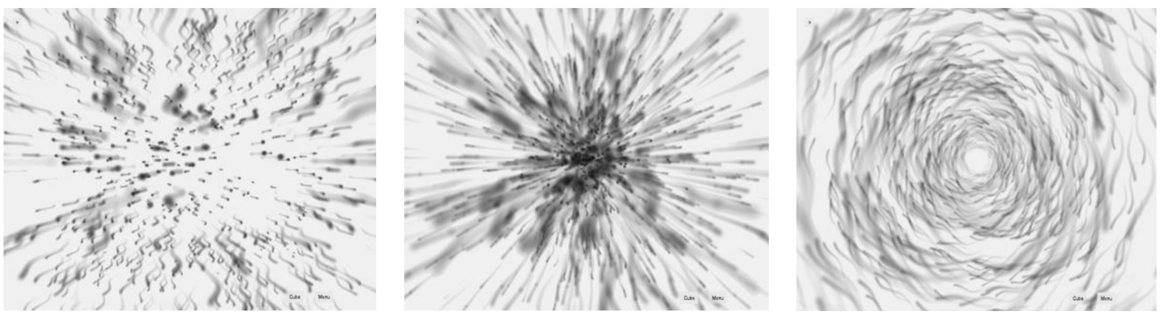


Figure 5.2. Wavy path curvature
Note. Linear, spherical, and spiral primitives applied with wavy path curvature

Figure 5.2 shows the variations in the shape and path curvature controlled in both the linear and non-linear motionscape experiment. In Figure 5.2, particles in linear, spherical, and spiral motionscape primitives were controlled to move along wavy path curvatures.

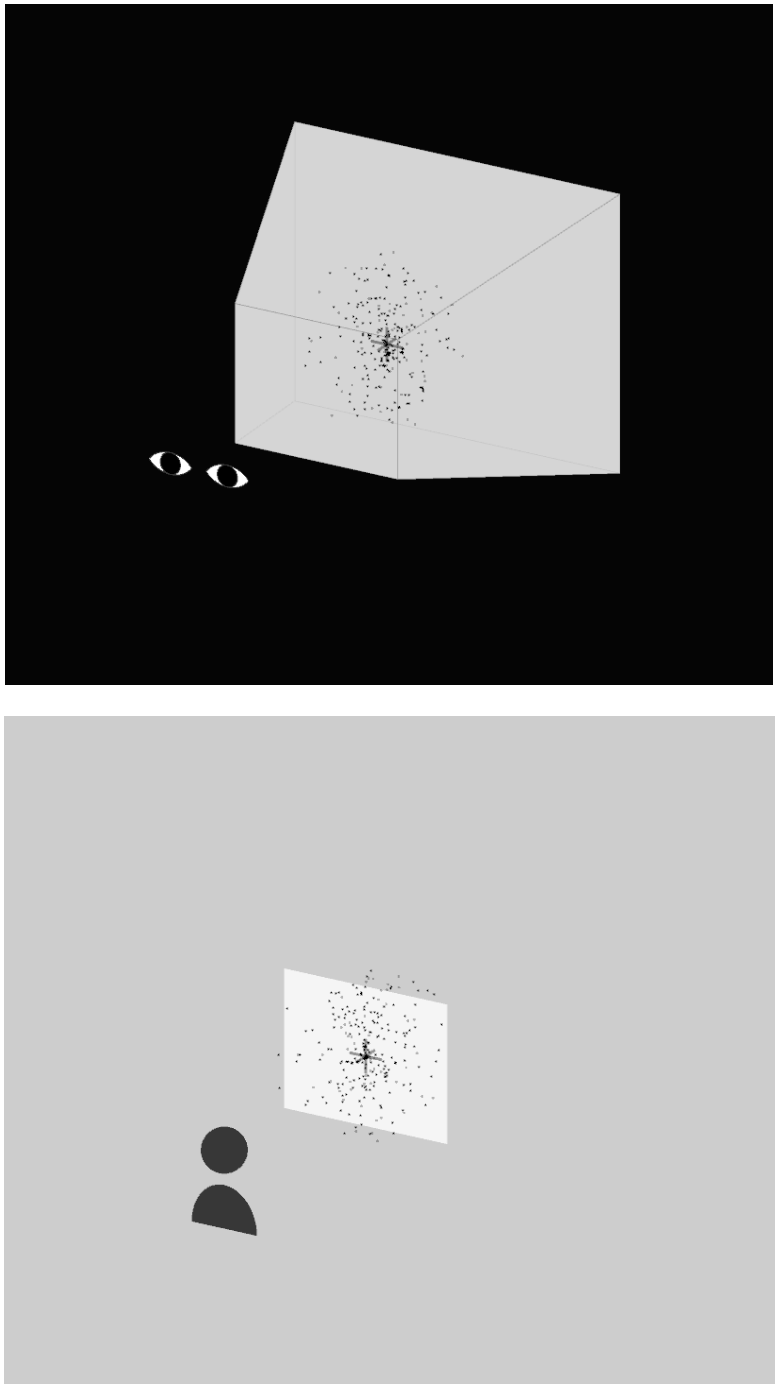


Figure 5.3. Stereoscopic Display
Note. The above images resemble the spectatorship intended by the VR set-up (above) and desktop stereo display

5.3.2. Apparatus

Display

While the previous study employed canvas screen and darkened experimenting space to achieve an experience of immersion, this study took a further step into the three dimensional computer graphic world by incorporating both a standard desktop stereo monitor and through a display designed and customized for Virtual Reality applications.

Both stereo displays were incorporated in this study in order to achieve a spectatorship in which the viewer sees that the particles within motionscape move around/through her or that they are positioned in a cube/sphere placed in front of her. Figure 5.3 resembles the spectatorship intended by the set up employed by this study.

Affect Measurement

As shown in Figure 5.4, an affect measurement window was positioned on the up right corner of the screen. In this study, we re-implemented the affect measuring window from the first study. Every row representing the affect dimension (the same dimensions applied in the previous study reported in chapter 4) is comprised of two sliders, with each represening one of the two opposite affective impression on that dimension.

The input method was similar as that in the previous study. Again each slider represented the intensity of affective rating listed above the slider and was scaled from 0 to 100, with default value set to 0 (meaning the represented impression was not evoked at all by the motionscape primitive). Just like previously introduced measuring sliders in first study, participants could further drag the sliders to grade corresponding affective impression of the displayed primitive, only that the participant was requested to evaluate both affective ratings on the same row (affect dimension) independently. The value would thus represent the intensity (value) of that affective rating. For instance, if the rejecting slider on the row of interaction dimension is dragged to 20, the affective rating will thus be interpreted as slightly rejecting. Again, the window could be switched on and off by clicking the "HIDE" check box, and had to be set on when inputting the affect measurement. Upon the completion of the current condition, participant could continue to the next condition by clicking the grey button labelled as "NEXT". Then the current motion primitive would fade out in 2 seconds until the screen was left blank, and a new one would be revealed in another 2 seconds.

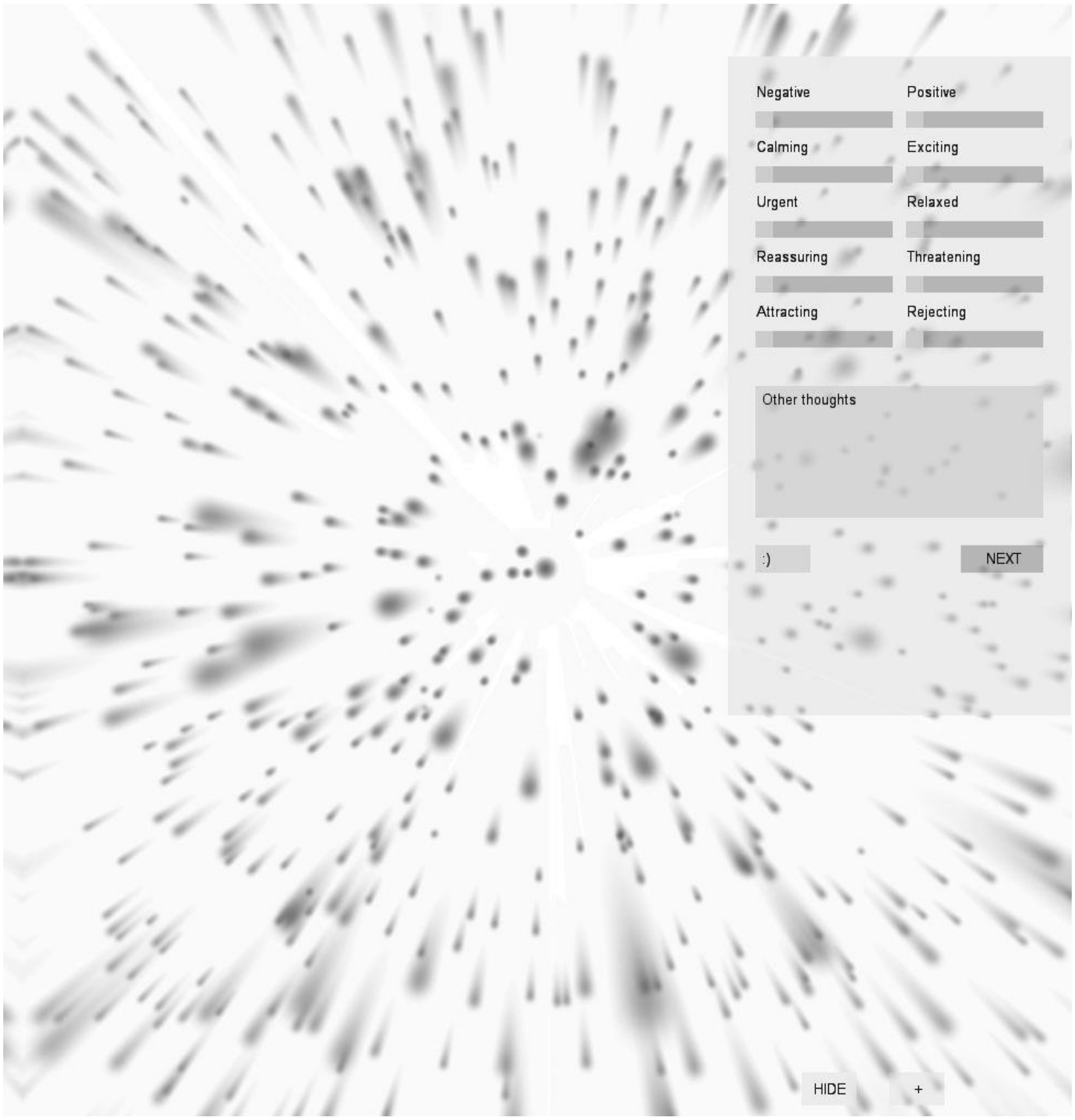


Figure 5.4. Affect Measurement
Note. The window were arranged as such: ten sliders were positioned on the upper side of the window with each slider representing one affective rating; and a text field for participant comments on current displayed condition

5.3.3. Procedure

48 university students were recruited to participate in this study (26 women aged from 19 – 29 and 22 men aged from 21 – 33). Participants were either paid or granted standard course credits upon the completion of the study. All had normal (or corrected-to-normal) acuity and were with no knowledge of either the research question or the hypotheses.

Participants were equally assigned to the linear motionscape experiment and the non-linear motionscape experiment. Participants in each experiment were then divided into two groups, with 12 assigned to view motionscape primitives in VR display and the rest 12 viewing standard desktop stereo display. Participants from both groups, in each experiment, were also assigned to view same set of primitives on regular screen, with the sequence of viewing conditions randomized.

Training

At the beginning of the first session of each experiment, an introduction was given to each participant.

In linear motionscape experiment, (8) linear motion primitives that move in 4 directions (upwards, downwards, inwards, and outwards) with medium speed and straight path curvature were displayed.

In non-linear motionscape experiment, (4) spherical and (4) spiral motion primitives that move in both directions (inwards, and outwards) with medium speed and straight path curvature were displayed.

All motions were shown both in full screen and partial area of the screen in sequence to help the participant get familiar with the motion primitives. Along with each sample motion primitive, the window for affective ratings and commenting were also displayed. We explained the meaning of the affective ratings along the 10 sliders, and instructed the participant to enter their affective ratings through our interface. All the sample motionscape primitives were different from those in formal trials and no ratings or comments could be entered during the introduction were recorded.

Formal Task

Once the participant went through the training session and felt ready for the following formal experiment, the participant would be directed to start the formal conditions. The participant was instructed to evaluate each motionscape primitive using affective rating by dragging the corresponding slider and to input any thoughts and comments in the text box below the ten affective rating sliders. The participant was encouraged to rest when any negative symptoms occurred.

All participants completed both sessions of our experiments within 1 week, and each session averaged 45-50 minutes for each experiment. After the second session, an informal semi-structured interview was conducted for feedback and further ideas with regard to the experiment. All participant inputs were recorded and stored and copied in encrypted hard drives and an encrypted web server.

5.4. Results

For both linear and non-linear motionscape experiments, we analyzed the data obtained from VR group and Desktop group independently. That is, each group was treated as an independent within-subject experiment. Our statistical analysis model (General Linear Model) for the linear motionscape experiments had 5 within-subject factors (i.e. display, speed, direction, path curvature, and view point). And for non-linear motionscape experiments, the analysis model had 6 within-subject factors (i.e. display, shape, speed, direction, path curvature, and view point).

We performend Shapiro-Wilk test of normality for the data obtained from both sub groups (VR and Desktop 3D groups) within both experiments (linear and non-linear motionscape experiments). Shapiro-Wilk tests revealed that the sample was not significantly deviated from normality. Mauchly's tests were performed to detect violations of the assumption of sphericity. When the assumption of sphericity was violated (i.e. $p > .05$), we employed the Huynh-Feldt correction to produce a valid F-ratio.

We began our analysis by using a five-way factorial ANOVA of all five factors (speed, direction, path curvature, display, view point) for all 10 affective ratings for the linear motionscape experiment, and a six-way factorial ANOVA of six factors (shape, speed, direction, path curvature, display, view point) for the non-linear motionscape experiment. Results from each experiment are reported respectively in this section. And for each experiment, we start with a report of the motion properties (independent variables) found significant for the affect ratings (dependent variables), and continue on to state the interaction among these motion properties.

5.4.1. Linear Motionscape Experiment

Main Effects

Display

As shown in Table 5.4, display was found to have little influences on affective ratings in this experiment.

Table 5.4. Significant Main Effects of Display

Exciting	Urgent	Rejecting
$F(1,11) = 7.196$, $p = .021$	$F(1,11) = 8.829$, $p = .013$	$F(1,11) = 5.727$, $p = .036$

Note. Significant main effects of Display on Exciting, Urgent, and Rejecting ratings (VR Group)

In VR group, stereo display only has slight amplification effect on Exciting, Urgent and Rejecting (as shown in Table 5.4 and Figure 5.5). Motionscape primitives that displayed in the VR stereo display (*Mean* = 24) were rated as more exciting than displayed in the standard screen (*Mean* =20), and were considered to be more urgent when displayed in the VR stereo display (*Mean* =32) compared to the standard screen (*Mean* = 27). Rejecting ratings followed a similar pattern with regard to display: motionscape primitives displayed in the VR set-up (*Mean* = 28) received higher rejecting ratings than displayed in the standard screen (*Mean* = 24). No significant effect from display was found in the desktop group.

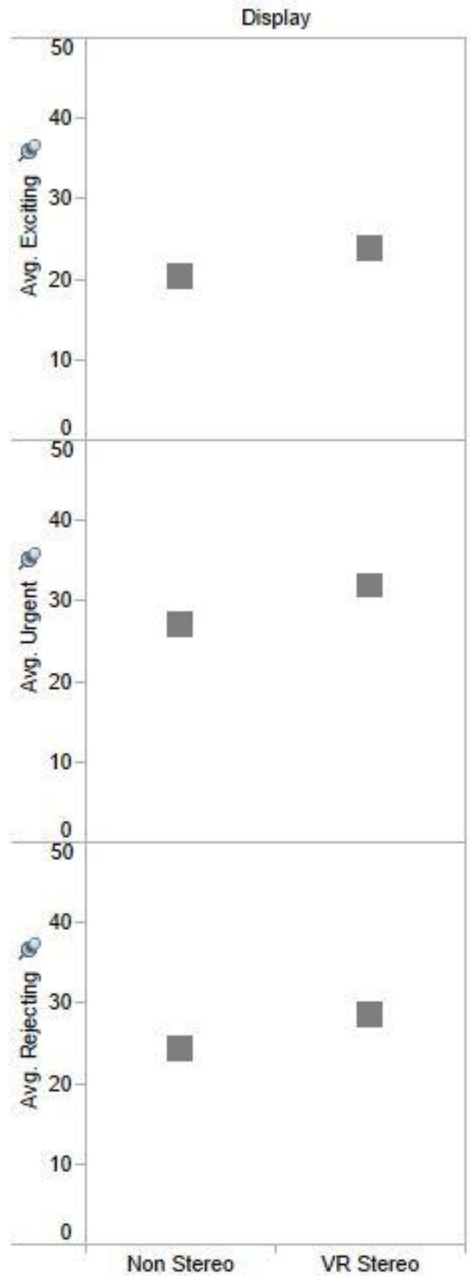


Figure 5.5. Mean affective ratings by display in VR group
Note. Only affective ratings that display has significant main effects on are presented

Speed

Speed was found to yield significant main effects on most dependent variables in this experiment (Table 5.5). Figure 5.6a and 5.6b show mean values of all affective ratings from both VR and Desktop groups.

Table 5.5. Significant Main Effects of Speed

VR Group		Desktop 3D Group	
Negative	Positive	**Negative**	**Positive**
$F(1,11) = 36.284$, $p < .001$		$F(1,11) = 19.296$, $p = .001$	$F(1,11) = 6.922$, $p = .023$
Calming	**Exciting**	**Calming**	**Exciting**
$F(1,11) = 91.950$, $p < .001$	$F(1,11)=28.803$, $p < .001$	$F(1,11) = 42.780$, $p < .001$	$F(1,11) = 33.137$, $p < .001$
Urgent	**Relaxed**	**Urgent**	**Relaxed**
$F(1,11)=95.018$, $p<.001$	$F(1,11)=80.761$, $p<.001$	$F(1,11)=58.137$, $p < .001$	$F(1,11) = 28.791$, $p < .001$
Reassuring	**Threatening**	**Reassuring**	**Threatening**
$F(1,11) = 47.206$, $p < .001$	$F(1,11) = 51.035$, $p < .001$	$F(1,11) = 23.336$, $p = .001$	$F(1,11) = 21.493$, $p = .001$
Attracting	**Rejecting**	Attracting	**Rejecting**
$F(1,11) = 5.003$, $p=.047$	$F(1,11) = 46.358$, $p < .001$		$F(1,11) = 11.938$, $p = .005$

In the VR group, speed had significant effect on most affective ratings. Motionscape primitives applied with fast speed were seen as more negative, exciting, urgent, threatening, and rejecting; while those with slow speed were rated as more calming, relaxed, reassuring, and attracting. There was a strong effect of speed in calming/exciting judgments, with slow linear primitives (*Mean* = 42.49) rated as significantly more calming compared to fast primitives (*Mean* = 6.14) and significantly less exciting (*Mean* = 6.86) than fast ones (*Mean* =37.15). Slow linear primitives (*Mean* = 38.35) were rated as more relaxed than fast primitives (*Mean* = 4.93), while fast primitives (*Mean* = 52.62) were rated as highly urgent compared to slow ones (Mean = 6.15). Slow motions (*Mean* = 34.14) were more reassuring compared to fast motions (*Mean* = 8.80) and less threatening (*Mean* = 6.78) than fast motions (*Mean* = 32.47). In desktop group, similar to results from VR group, speed again had significant effects on most affective ratings: slow primitives were rated as more positive, calming, reassuring, and relaxed, while fast motions were rated as more negative, exciting, urgent, threatening, and rejecting.

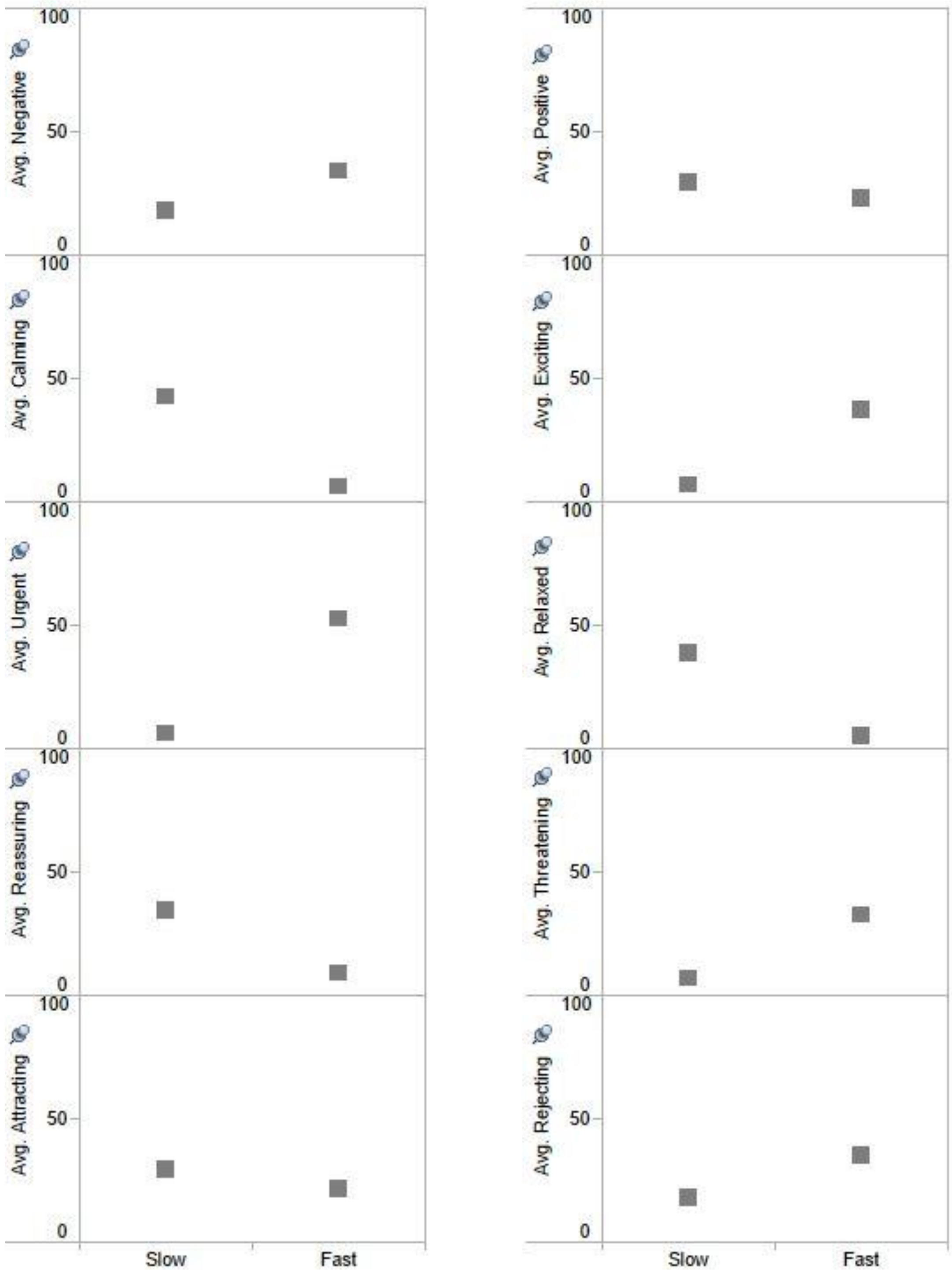


Figure 5.6a. Mean affective ratings by speed in VR group

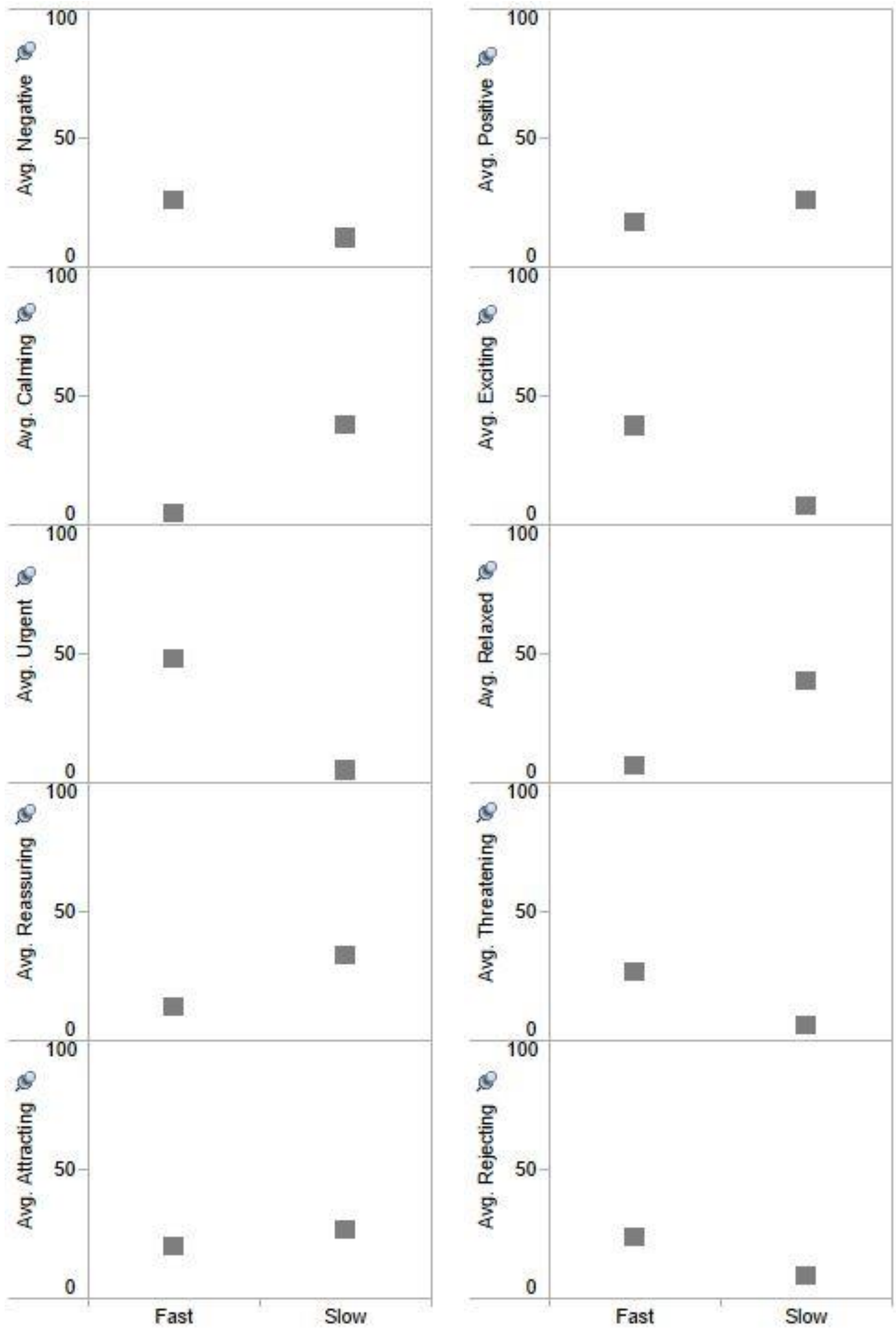


Figure 5.6b. Mean affective ratings by speed in Desktop group

Figure 5.6. Mean Affective Ratings by Speed

Path Curvature

As shown in Table 5.6 path curvature was found to have strong influences on a range of affect ratings on motionscape primitives.

Table 5.6. Significant Main Effects of Path Curvature

VR Group		Desktop 3D Group	
Negative	Positive	Negative	Positive
$F(1,11)=5.455$, $p=.039$	$F(1,11)=14.873$, $p=.003$	$F(1,11)=10.738$, $p=.007$	$F(1,11)=6.590$, $p=.026$
Calming	Exciting	Calming	Exciting
$F(1,11)=11.734$, $p=.006$		$F(1,11)=19.694$, $p=.001$	$F(1,11)=15.017$, $p=.003$
Urgent	Relaxed	Urgent	Relaxed
$F(1,11)=39.474$, $p<.001$	$F(1,11)=13.211$, $p=.004$	$F(1,11)=37.551$, $p<.001$	$F(1,11)=14.534$, $p=.003$
Reassuring	Threatening	Reassuring	Threatening
$F(1,11)=12.394$, $p=.005$	$F(1,11)=19.474$, $p<.001$	$F(1,11)=14.255$, $p=.003$	$F(1,11)=21.047$, $p=.001$
Attracting	Rejecting	Attracting	Rejecting
$F(1,11)=14.666$, $p=.003$	$F(1,11)=11.264$, $p=.006$		$F(1,11)=9.778$, $p=.010$

In the VR group, motionscape primitives with non-straight path curvature were seen as more negative (*Mean* = 30.56), urgent (*Mean* = 34.15), threatening (*Mean* =24.12) and rejecting (*Mean* =31.27) than straight motions (*Mean* =21.34, 24.62, 15.129, and 21.43). In addition, non-straight motions were also less positive (*Mean* =21.06), calming (*Mean* = 20.94), relaxed (*Mean* =18.15), reassuring (*Mean* =18.04) and attracting (*Mean* = 20.74) than straight motions (*Mean* = 31.32, 27.70, 25.14, 24.91, and 29.92).

In the desktop group, non-straight motions were seen as more negative, exciting, urgent, threatening and rejecting, while straight motions were considered as more positive, calming, reassuring, and relaxed.

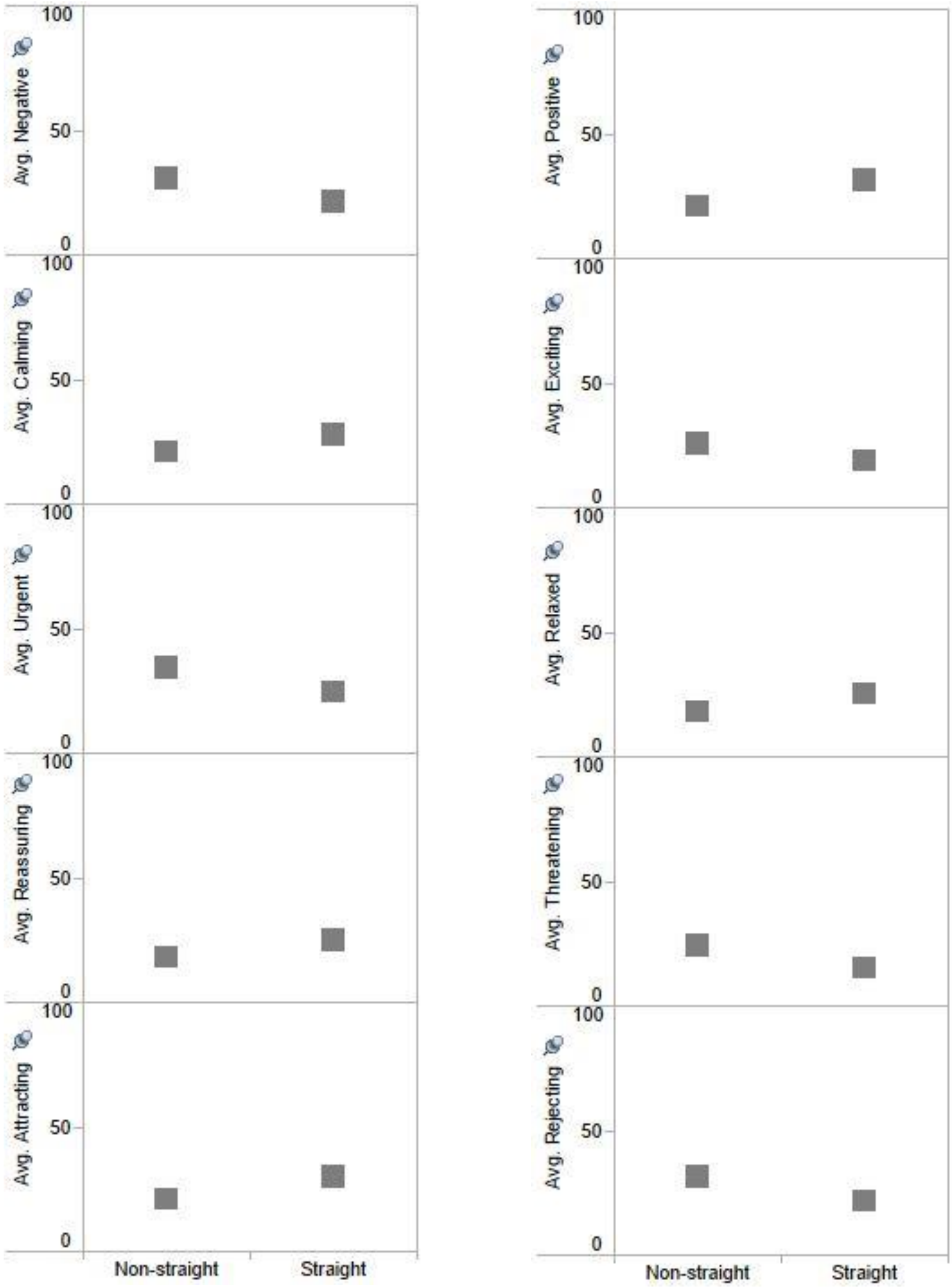


Figure 5.7a. Mean affective ratings by path curvature in VR group

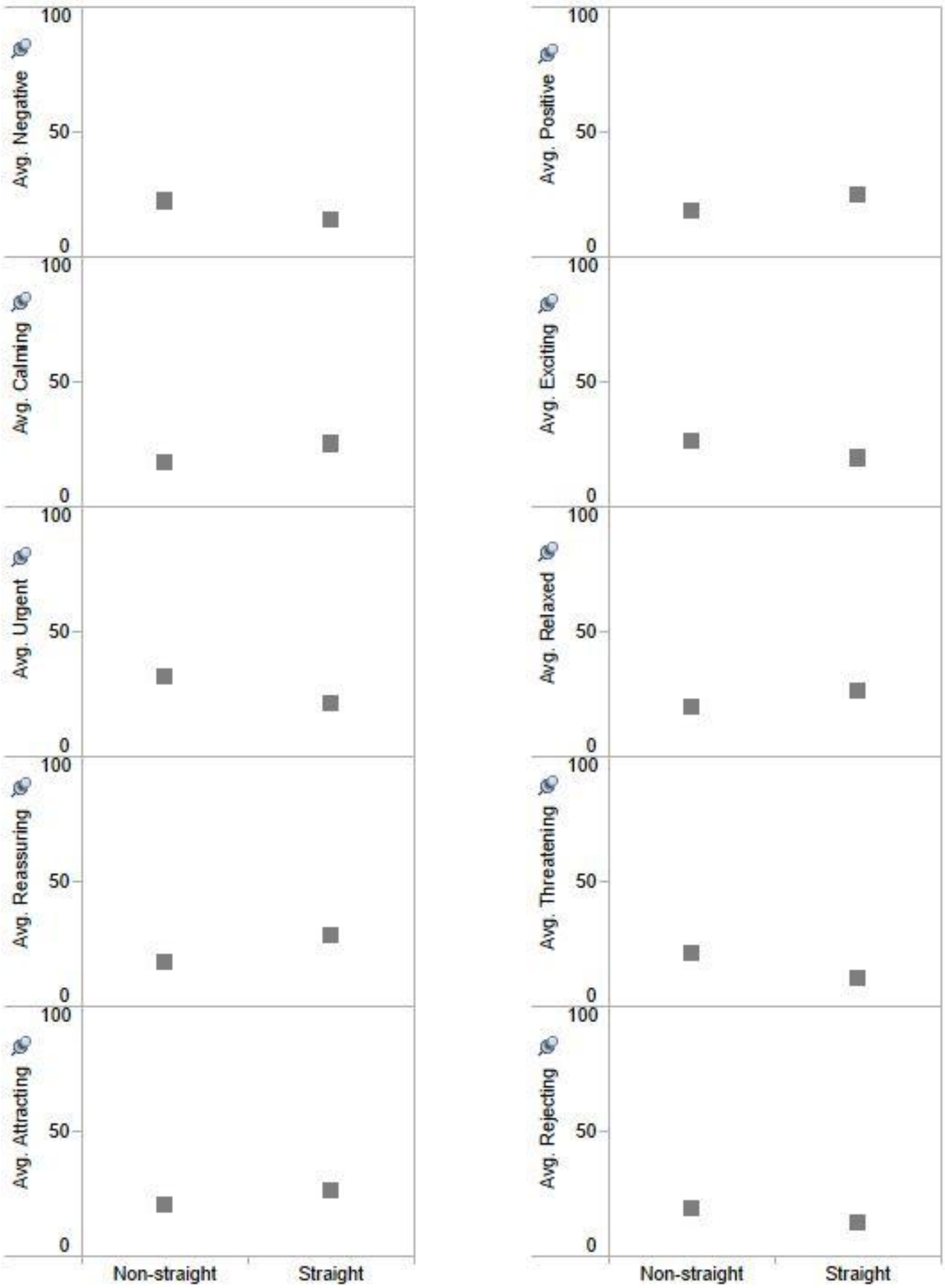


Figure 5.7b. Mean affective ratings by path curvature in Desktop group

Figure 5.7. Mean Affective Ratings by Path Curvature

Direction

Table 5.7. Significant Main Effects of Direction

VR Group		Desktop 3D Group	
Negative	**Positive**	**Negative**	**Positive**
	$F(2.065,22.712)=5.185$, $p=.013$	$F(1.653,18.186)=3.972$, $p=.044$	$F(2.132,23.451)=3.858$, $p=.033$
Calming	**Exciting**	**Calming**	**Exciting**
	$F(3,33)=5,423$, $p=.004$	$F(3,33)=4.789$, $p=.007$	$F(3,33)=9.045$, $p<.001$
Urgent	Relaxed	**Urgent**	Relaxed
$F(1.778,19.559)=8.246$, $p=.003$		$F(3,33)=5.533$, $p=.003$	
Reassuring	**Threatening**	**Reassuring**	**Threatening**
	$F(1.821,20.0263)=3.779$, $p=.044$	$F(3,33)=4.303$, $p=.011$	$F(3,33)=7.913$, $p<.001$
Attracting	Rejecting	**Attracting**	**Rejecting**
		$F(3,33)=3.811$, $p=.019$	$F(3,33)=6.187$, $p=.002$

In VR group, a post-hoc analysis revealed that upward linear primitives (*Mean* = 39.31) were considered to be more positive than downward (*Mean* = 14.53) linear primitives. Upward motions (*Mean* = 25.96) were more exciting than downward motions (*Mean* = 19.31). Upward motions (*Mean* =33.36) were more urgent than downward motions (*Mean* =26.41). Outward motions (*Mean* = 26.32) were generally seen as more threatening than inward motions (*Mean* = 14.60). In desktop group, direction's effect was found as more significant. Post-hoc tests revealed that direction has similar effects as those found in VR Group on positive, exciting, urgent and threatening ratings. And as shown in Table 5.7, direction has significant main effects on all affective ratings except Relaxed. Downward motions were considered as more calming (*Mean* = 23.00) than upward motions (*Mean* = 18.98), and less exciting (*Mean* = 20.69) compared to motion primitives that moved in upward direction (*Mean* = 26.79). In addition, upward motions were seen as more positive (*Mean* = 27.42) and less negative (*Mean* = 14.25) than downward motions (*Mean* = 14.60 and 25.79). Outward motions received higher reassuring ratings (*Mean* = 27.09) and less threatening ratings (*Mean* = 10.49) than inward motions (*Mean* = 20.96, 20.90). In this group, direction also has significant effects on Attracting/Rejecting ratings. Inward motions (*Mean* = 28.37) are seen as significantly more attracting than outward motions (*Mean* = 19.96); whilst outward motions (*Mean* =20.67) were seen as more rejecting compared to inward motions (*Mean* = 10.31).

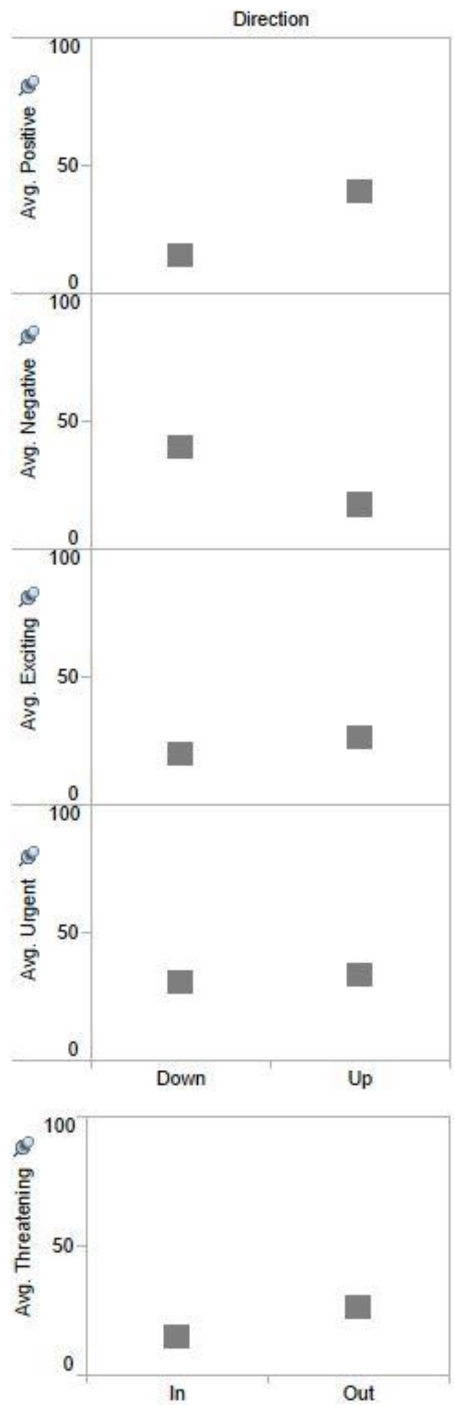


Figure 5.8a. Mean affective ratings by direction in VR group

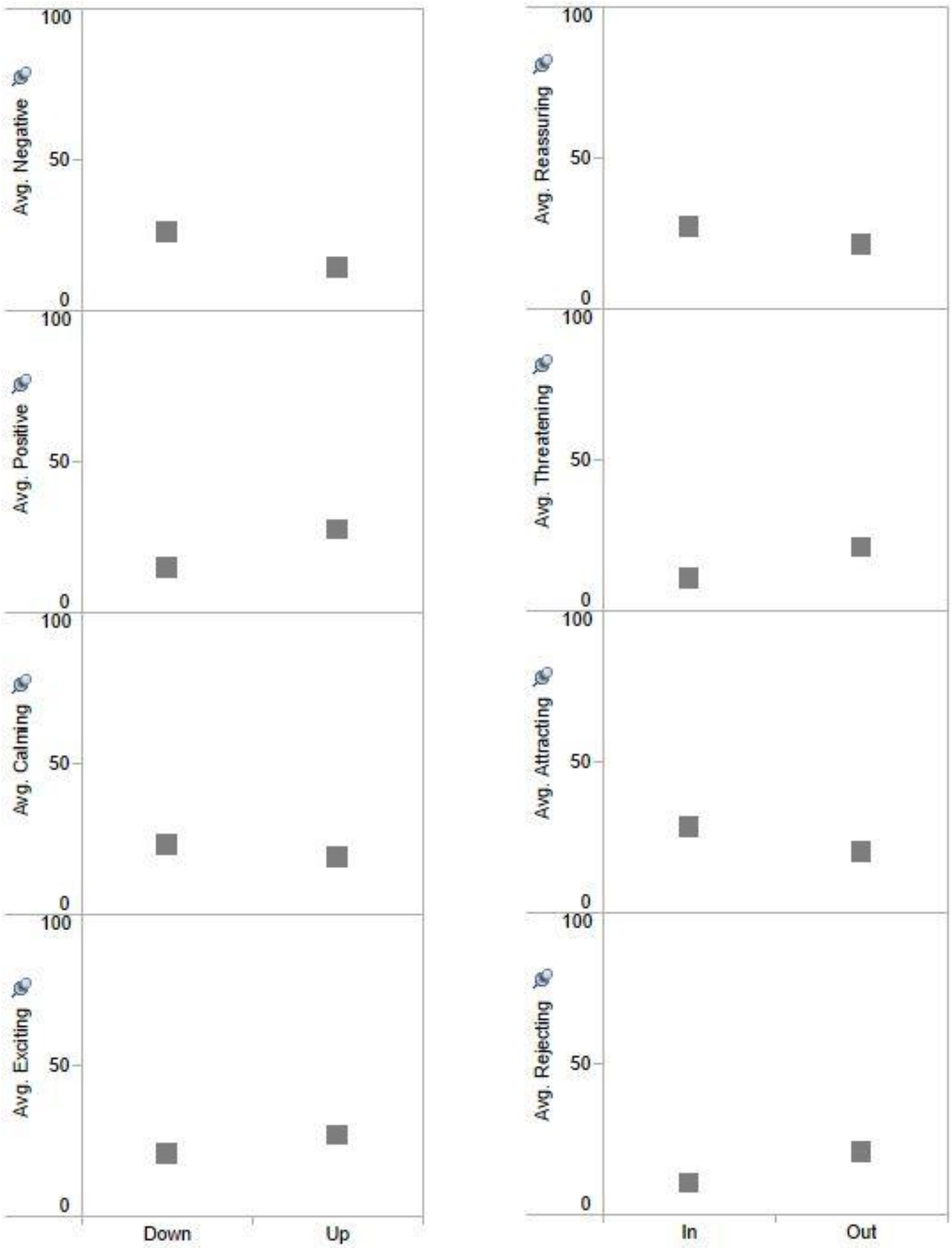


Figure 5.8b. Mean affective ratings by direction in Desktop group

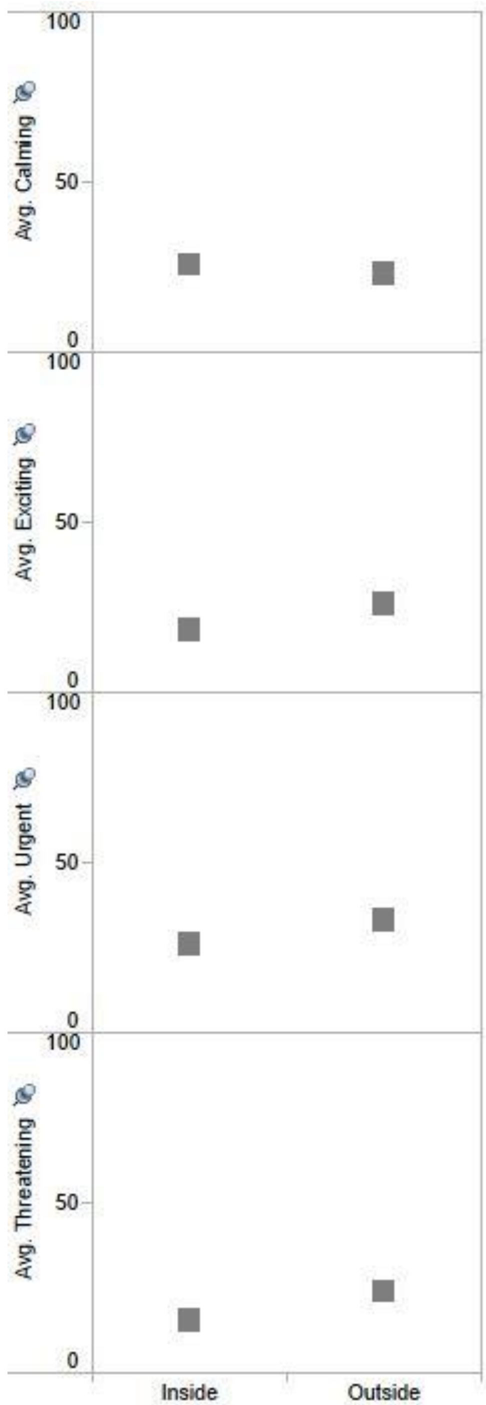
Figure 5.8. Mean Affective Ratings by Direction

Viewpoint

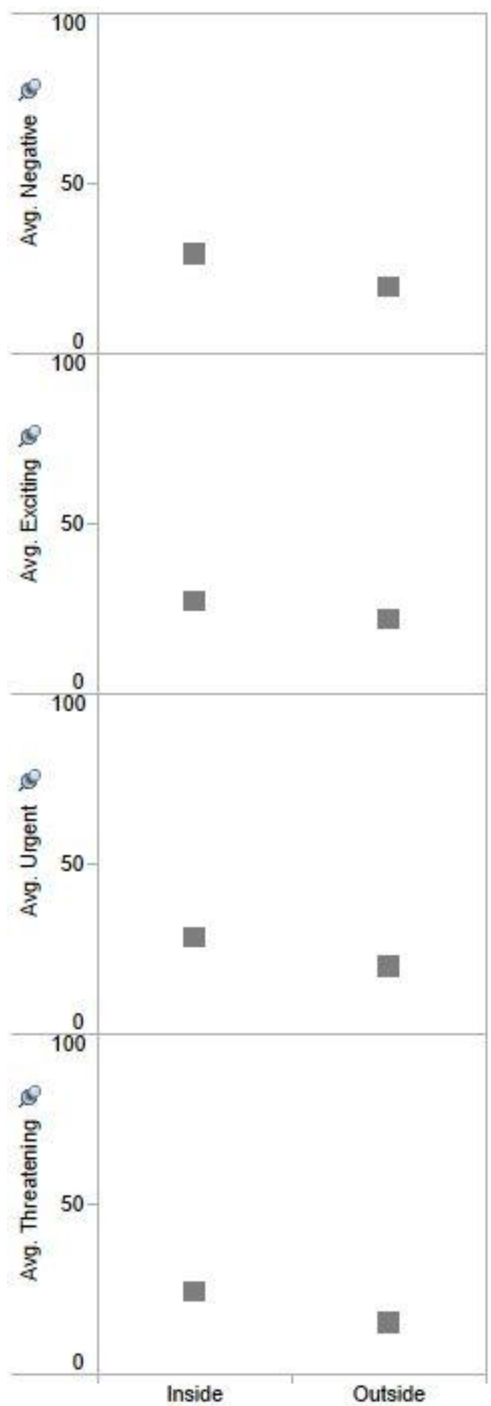
In VR group, view point had effects on calming, exciting, urgent, and threatening ratings (Table 5.8). When viewed from an inside point of view (*Mean* = 25.64), motions were seen as more calming than from outside (*Mean* =23.00). Motion viewed from inside (*Mean* =18.30) were also less exciting than viewed from outside (*Mean* = 25.71). Motions were rated as more threatening from an outside view point (*Mean* = 23.81) compared to an inside view point (*Mean* = 15.44). Urgent ratings were also generally higher when viewed from outside (*Mean* =33.00) than viewed form inside (*Mean* = 25.772). In desktop group exciting, urgent, and threatening ratings followed similar patterns as the previous group in regards to viewpoint: motions viewed from outside were seen as more exciting (*Mean* = 26.687), threatening (*Mean* = 19.000) and urgent (*Mean* = 29.589) than viewed from inside (*Mean* = 18.822, 13.177, and 22.764). In this group, motion primitives were rated as more attracting from an outside view point (*Mean* = 25.452) compared to an inside view point (*Mean* =2 1.013).

Table 5.8. Significant Main Effects of View Point

VR Group		Desktop 3D Group	
Calming $F(1,11) = 5.782$, $p=.035$	**Exciting** $F(1,11)=28.840$, $p < .001$	Calming	**Exciting** $F(1,11)=24.069$, $p<.001$
Urgent $F(1,11)=16.221$, $p<.002$	Relaxed	**Urgent** $F(1,11)=16.427$, $p=.002$	Relaxed
Reassuring	**Threatening** $F(1,11)=21.740$, $p=.001$	Reassuring	**Threatening** $F(1,11)=10.834$, $p=.007$
Attracting	Rejecting	**Attracting** $F(1,11)=5.519$, $p=.039$	Rejecting



(a) VR group



(b) Desktop group

Figure 5.9. Mean Affective Ratings by View Point

Interaction effects

Speed * Path Curvature

In both groups, speed and path curvature have interaction effects on ratings of most affect dimensions.

Table 5.9. Interaction Effects of Speed and Path Curvature

VR Group		Desktop 3D Group	
Negative	**Positive**	**Negative**	Positive
$F(1,11)=11.476$, $p=.006$	$F(1,11)=5.302$, $p=.042$	$F(1,11)=16.942$, $p=.002$	
Calming	Exciting	Calming	**Exciting**
			$F(1,11)=5.553$, $p=.038$
Urgent	Relaxed	**Urgent**	Relaxed
$F(1,11)=24.046$, $p<.001$		$F(1,11)=21.444$, $p=.001$	
Reassuring	**Threatening**	Reassuring	**Threatening**
$F(1,11)=15.141$, $p=.003$	$F(1,11)=27.850$, $p<.001$		$F(1,11)=24.798$, $p<.001$
Attracting	**Rejecting**	Attracting	**Rejecting**
$F(1,11)=10.516$, $p=.008$	$F(1,11)=12.797$, $p=.004$		$F(1,11)=15.453$, $p=.002$

In VR group, speed and path curvature have interaction effects on Negative, Positive, Urgent, Reassuring, Threatening, Attracting, Rejecting (No significant effects on Calming/Exciting); while in desktop group, the interaction effects were detected in Negative, Exciting, Urgent, Threatening, Rejecting.

In general, motionscape primitives with non-straight path curvatures are rated as less Positive, more Exciting, more Urgent, Threatening, and Rejecting than those with straight curvature are rated. But the difference between the two path curvatures is greater when particles within primitives move fast. That is, Speed amplifies the effect of path curvature.

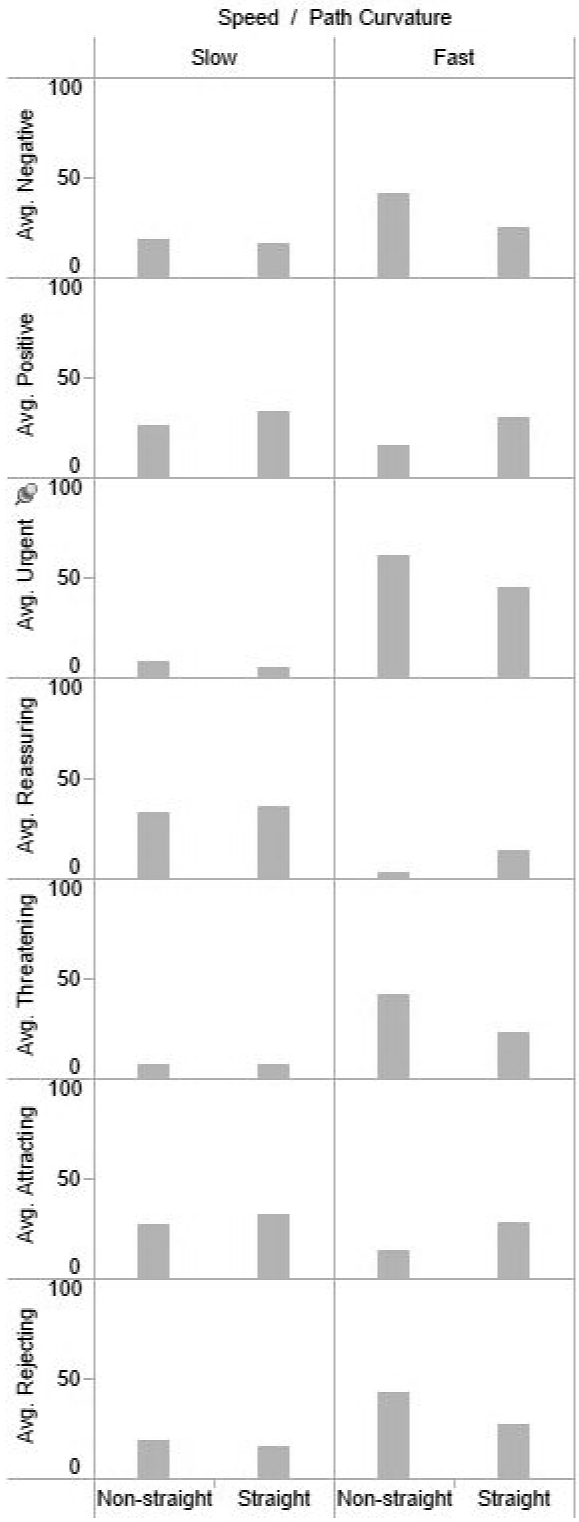


Figure 5.10a. Mean affective ratings by speed and path curvature in VR group

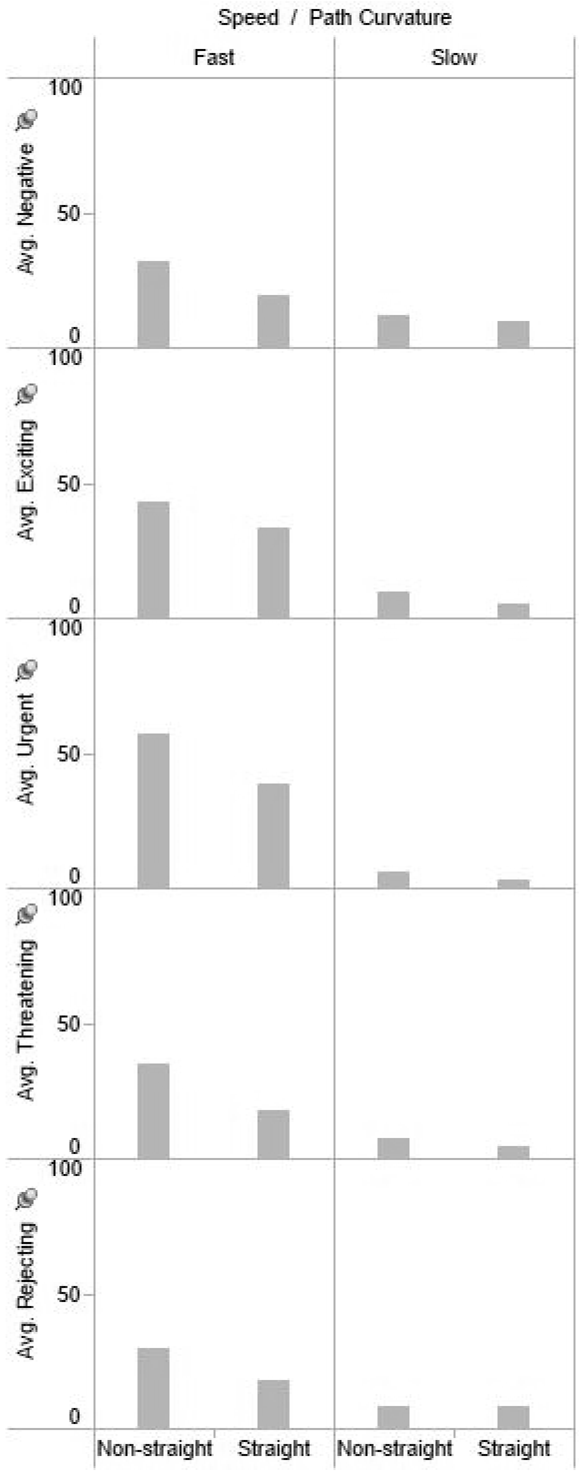


Figure 5.10b Mean affective ratings by speed and path curvature in Desktop group

Figure 5.10. Mean Affective Ratings by Speed and Path Curvature

5.4.2. Non-linear Motionscape Experiment

Main effects

Display

Table 5.10. Significant Main Effects of Display

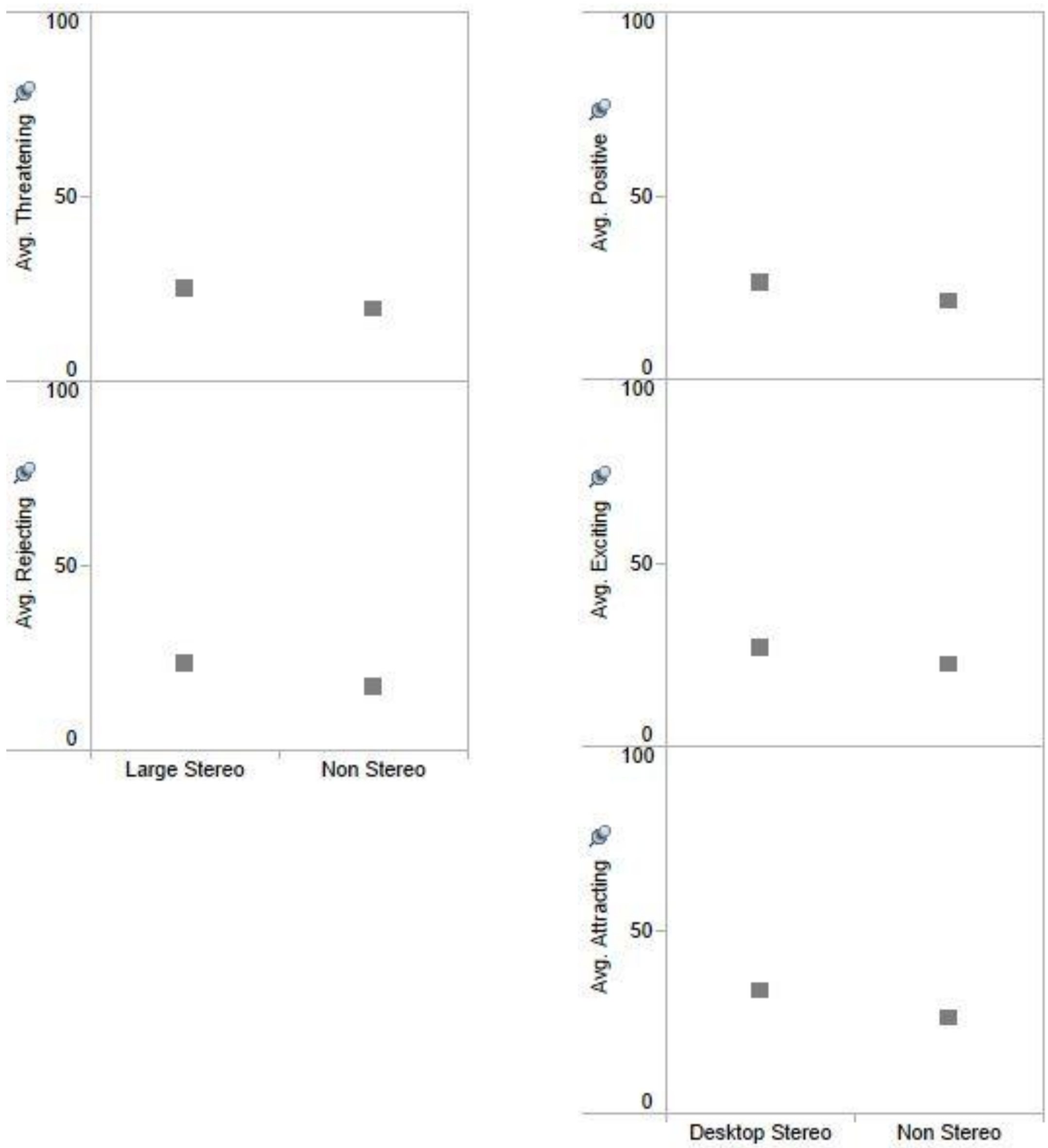
VR Group		Desktop 3D Group	
Negative	Positive	Negative	**Positive** $F(1,11)=5.014$, $p=.047$
Calming	Exciting	Calming	**Exciting** $F(1,11)=4.823$, $p=.050$
Reassuring	**Threatening** $F(1,11)=6.825$, $p=.024$	Reassuring	Threatening
Attracting	**Rejecting** $F(1,11)=8.615$, $p=.014$	**Attracting** $F(1,11)=13.151$, $p=.004$	Rejecting

Display has effect on certain ratings, but not consistent between two groups. In VR group, stereo motions were seen as more threatening and rejecting. In Desktop group, stereo motions were generally seen as more positive (this was surprising), exciting, and attracting.

In VR group, the stereoscopic display slightly amplified threatening and rejecting ratings. Motion primitives received higher threatening ratings when displayed in the VR set-up (*Mean* =24.95) than in the standard screen (*Mean* = 19.62). Motion primitives that displayed in the VR set-up (*Mean* = 23.43) were also rated as more rejecting than displayed in the standard screen (*Mean* = 17.03).

In desktop group, stereo motions were generally seen as more positive, exciting, and attracting. Motion primitives that were viewed on desktop stereo display received higher positve (*Mean* = 26.16), exciting (*Mean* = 26.75) and attracting (*Mean* = 33.39) ratings than those were viewed on standard screen (*Mean* = 21.14, 22.08, and 25.78).

One notable difference between display's effects in the two groups is: motions displayed through immersive VR setup were seen as more rejecting than through standard non-stereo screen (*Mean* = 23.42 against *Mean* = 17.03), but motions in Desktop 3D monitor were seen as more attracting than non-stereo primitives (*Mean* = 33.39 against *Mean* = 25.78).



(a) VR group (b) Desktop 3D group

Figure 5.11. Mean Affective Ratings by Display

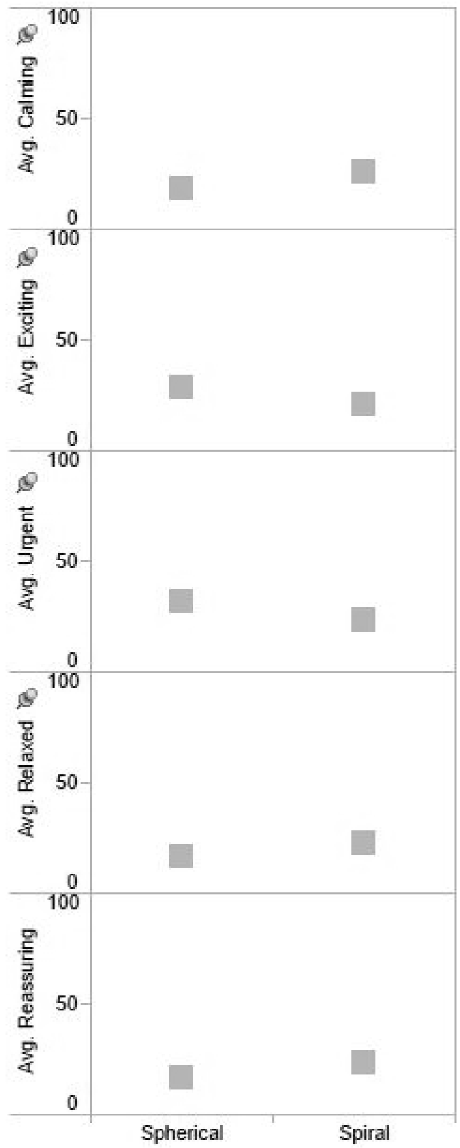
Shape

Table 5.11. Significant Main Effects of Shape

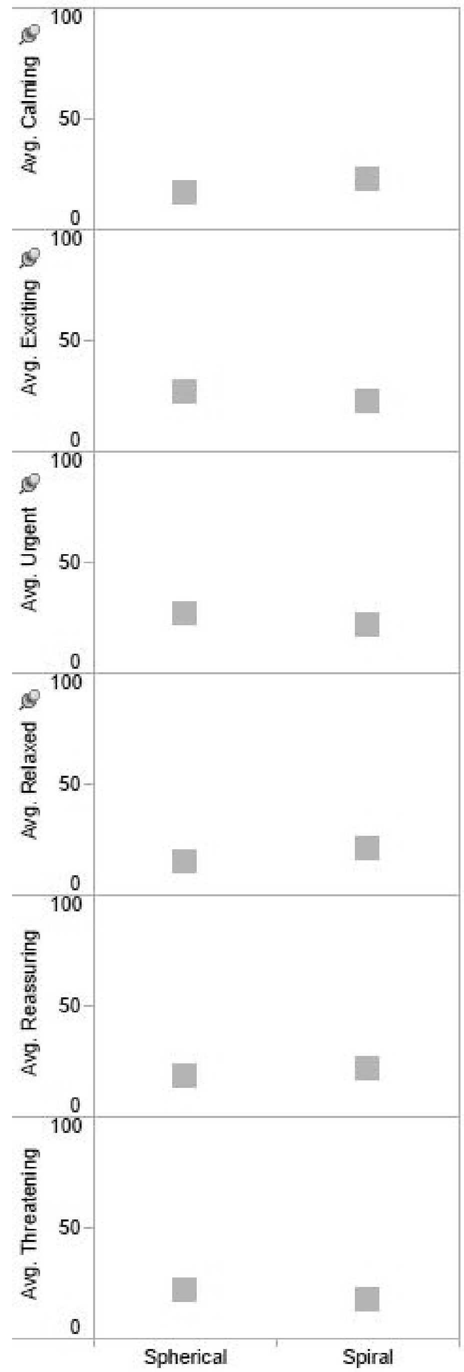
VR Group		Desktop 3D Group	
Calming	Exciting	Calming	Exciting
F(1,11)=23.411, *p*=.001	*F*(1,11)=21.471, *p*=.001	*F*(1,11)=11.093, *p*=.007	*F*(1,11)=14.576, *p*=.003
Urgent	Relaxed	Urgent	Relaxed
F(1,11)=15.225, *p*=.002	*F*(1,11)=10.261, *p*=.008	*F*(1,11)=9.657, *p*=.010	*F*(1,11)=8.478, *p*=.014
Reassuring	Threatening	Reassuring	Threatening
F(1,11)=11.244, *p*=.006		*F*(1,11)=4.826, *p*=.050	*F*(1,11)=10.451, *p*=.008

In VR group, shape of motionscape primitives was a significant factor for calming, exciting, urgent, relaxed and reassuring ratings. Spherical motions received higher exciting (*Mean* = 28.52) and urgent (*Mean* = 32.13), ratings than spiral motions (*Mean* = 20.80 and 23.31). Spiral motions were rated as more calming (*Mean* =25.75), relaxed (*Mean* = 22.734) and reassuring (*Mean* = 23.07) than spherical motions (*Mean* = 17.90, 16.81, and 16.40).

In desktop group, Shape was a significant factor for calming, exciting, urgent, relaxed, reassuring, and threatening. Spherical motion primitives were usually more exciting (*Mean* = 26.45), more urgent (*Mean* = 26.45), and more threatening (*Mean* = 21.90) than spiral motion primitives (*Mean* = 22.38, 21.47, and 17.47). Spiral motions were rated as more calming (*Mean* = 22.12), relaxed (*Mean* = 21.47) and reassuring (*Mean* = 21.81) compared to spherical motions (*Mean* = 16.16, 15.21, and 17.95).



a. VR group



b. Desktop 3D group

Figure 5.12. Mean Affective Ratings by Shape

Speed

Speed produced significant main effects on almost all affective ratings (Table 5.12). In VR group, fast motions were again seen as more negative (*Mean* = 34.42), exciting (*Mean* = 39.13), urgent (*Mean* = 47.21), threatening (*Mean* = 33.92) and rejecting (*Mean* = 25.98) than slow motions (*Mean* = 14.44, 10.18, 8.22, 10.65, and 14.47). The reverse is also true, that slow motions were more positive (*Mean* = 30.57), calming (*Mean* =34.52), relaxed (*Mean* = 31.89), and reassuring (*Mean* =28.79) than fast motions (*Mean* = 18.67, 9.13, 7.65, and 10.68). This result was consistent with the previous studies.

In the desktop group, fast moving motion primitives were again seen as more negative (*Mean* = 34.22), exciting (*Mean* = 37.89), urgent (*Mean* = 39.51), threatening (*Mean* = 30.08) and rejecting (Mean = 25.14) than slow motion primitives (*Mean* = 14.49, 10.93, 8.40, 9.28, and 14.00). Motions primitives that moved slower were rated as more calming (*Mean* = 33.35), relaxed (*Mean* = 30.70) and reassuring (*Mean* = 28.84) than fast moving motion primitives (*Mean* =4.93, 5.13, and 10.91). This was consistent with results from previous studies. Although slow motions recieved higher positive ratings (*Mean* =29.60) and attracting ratings (*Mean* = 33.17) than slow motions (*Mean* = 17.70, and 26.01), these results were insignificant statistically (*p* >.05).

Table 5.12. Significant Main Effects of Speed

VR Group		Desktop 3D Group	
Negative	**Positive**	**Negative**	Positive
$F(1,11)=33.420$, $p<.001$	$F(1,11)=22.178$, $p=.001$	$F(1,11)=14.156$, $p=.003$	
Calming	**Exciting**	**Calming**	**Exciting**
$F(1,11)=65.279$, $p<.001$	$F(1,11)=61.050$, $p<.001$	$F(1,11)=25.200$, $p<.001$	$F(1,11)=28.018$, $p<.001$
Urgent	**Relaxed**	**Urgent**	**Relaxed**
$F(1,11)=107.099$, $p<.001$	$F(1,11)=42.019$, $p<.001$	$F(1,11)=35.071$, $p<.001$	$F(1,11)=19.409$, $p=.001$
Reassuring	**Threatening**	**Reassuring**	**Threatening**
$F(1,11)=49.181$, $p<.001$	$F(1,11)=52.378$, $p<.001$	$F(1,11)=9.916$, $p=.009$	$F(1,11)=15.887$, $p=.002$
Attracting	**Rejecting**	Attracting	**Rejecting**
	$F(1,11)= 6.991$, $p=.023$		$F(1,11)=6.221$, $p=.030$

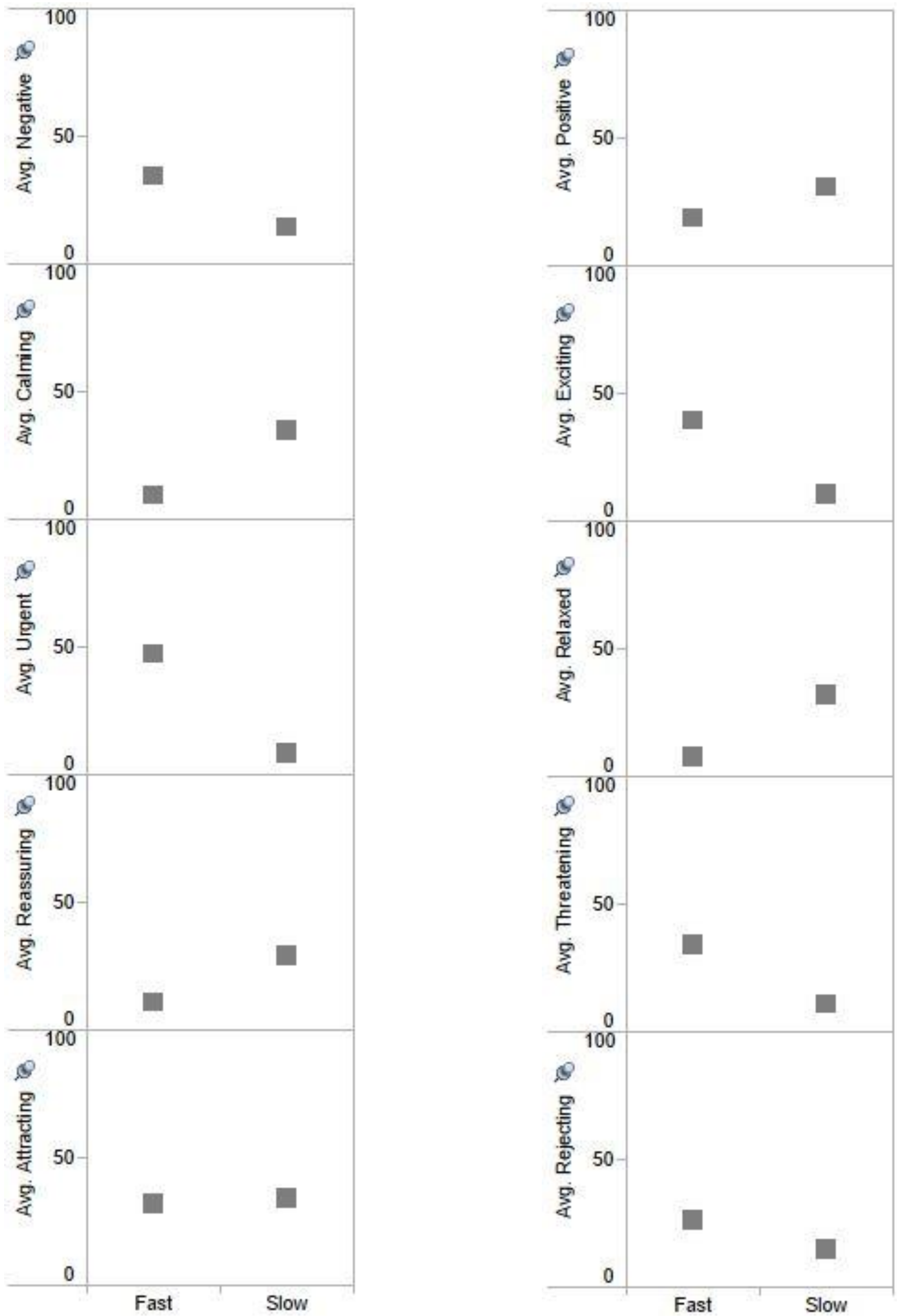


Figure 5.13a. Mean affective ratings by speed in VR group

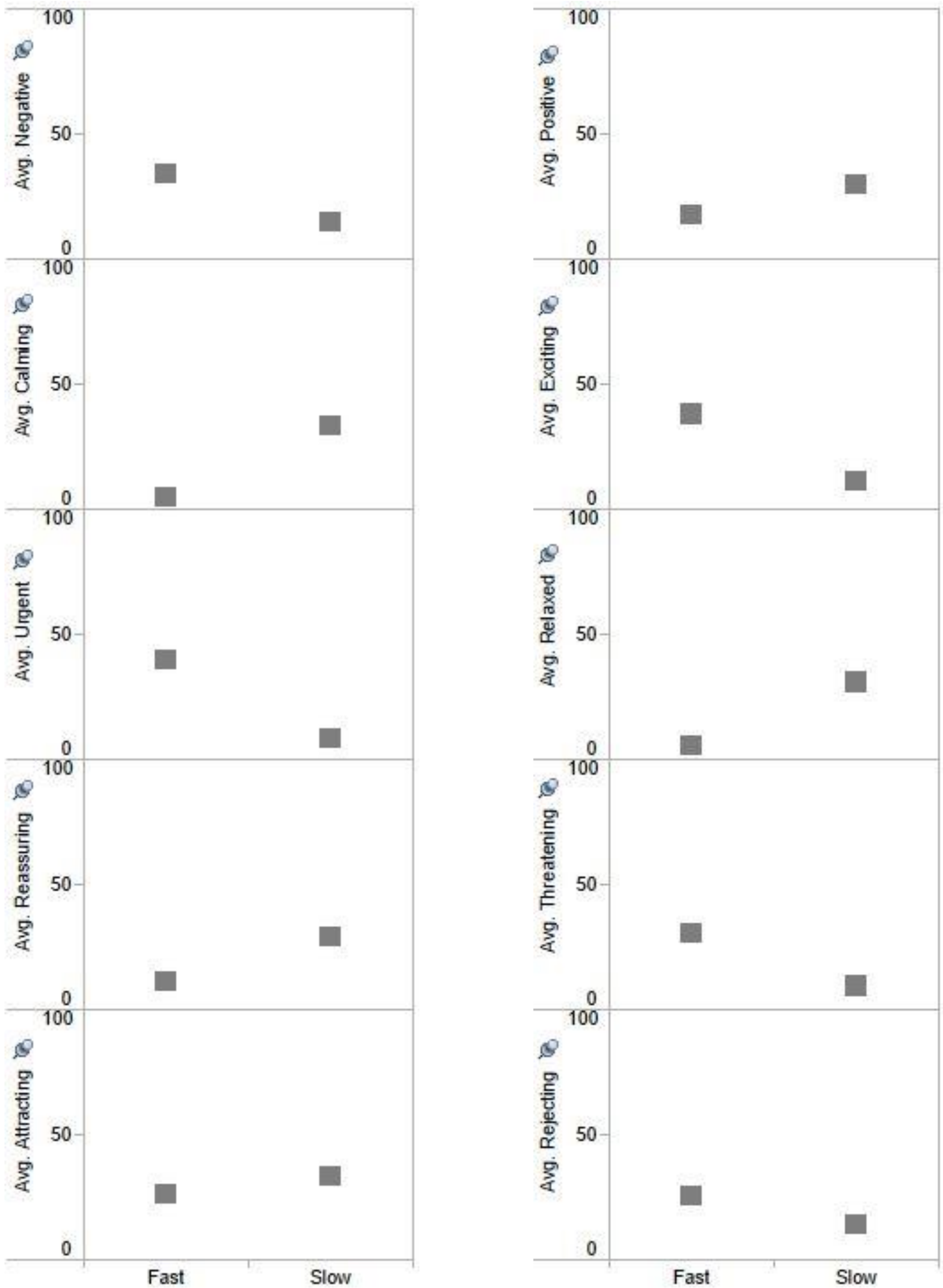


Figure 5.13b Mean affective ratings by speed in Desktop 3D group

Figure 5.13. Mean Affective Ratings by Speed

View Point

The effect of View point was similar to that found in linear motion study. Again inside view point amplifies Exciting, Urgent, Threatening ratings. In addition, motions viewed from inside were also seen as more negative (this was not the case in linear motions).

Table 5.13. Significant Main Effects of View Point

VR Group		Desktop 3D Group	
Negative $F(1,11)=49.958$, $p<.001$	**Positive** $F(1,11)=19.043$, $p=.001$	**Negative** $F(1,11)=8.981$, $p=.012$	Positive
Calming $F(1,11)=15.708$, $p=.002$	**Exciting** $F(1,11)=15.648$, $p=.002$	Calming	**Exciting** $F(1,11)=11.226$, $p=.006$
Urgent $F(1,11)=89.356$, $p<.001$	**Relaxed** $F(1,11)=26.066$, $p<.001$	**Urgent** $F(1,11)=63.886$, $p<.001$	Relaxed
Reassuring $F(1,11)=19.128$, $p=.001$	**Threatening** $F(1,11)=41.405$, $p<.001$	Reassuring	**Threatening** $F(1,11)=21.421$, $p=.001$
Attracting	**Rejecting** $F(1,11)=13.212$, $p=.004$	Attracting	Rejecting

When viewed from outside point of view in VR group, conditions were seen as more positive (*Mean* = 30.08), calming (*Mean* = 25.69), relaxed (*Mean* = 23.72), and reassuring (*Mean* = 24.20) than outside view point (*Mean* = 19.16, 17.96, 15.83, and 15.27). Motion primitives viewed from inside were considered as more negative (*Mean* = 34.46), exciting (*Mean* = 30.48), urgent (*Mean* = 36.35), threatening (*Mean* = 33.68), and rejecting (*Mean* = 25.99) than from outside (*Mean* = 14.40, 18.84, 19.07, 10.89, and 14.46).

In desktop group, motionscape primitives that were viewed from inside were rated as more exciting (*Mean* = 27.06), urgent (*Mean* = 28.30) and threatening (*Mean* = 24.19) than from outside (*Mean* = 21.77, 19.61, and 15.17). In addition, when viewed from inside view point (*Mean* = 29.30), motion primitives were also seen as more negative (this was not the case in linear motions) than outside view point (*Mean* = 19.41).

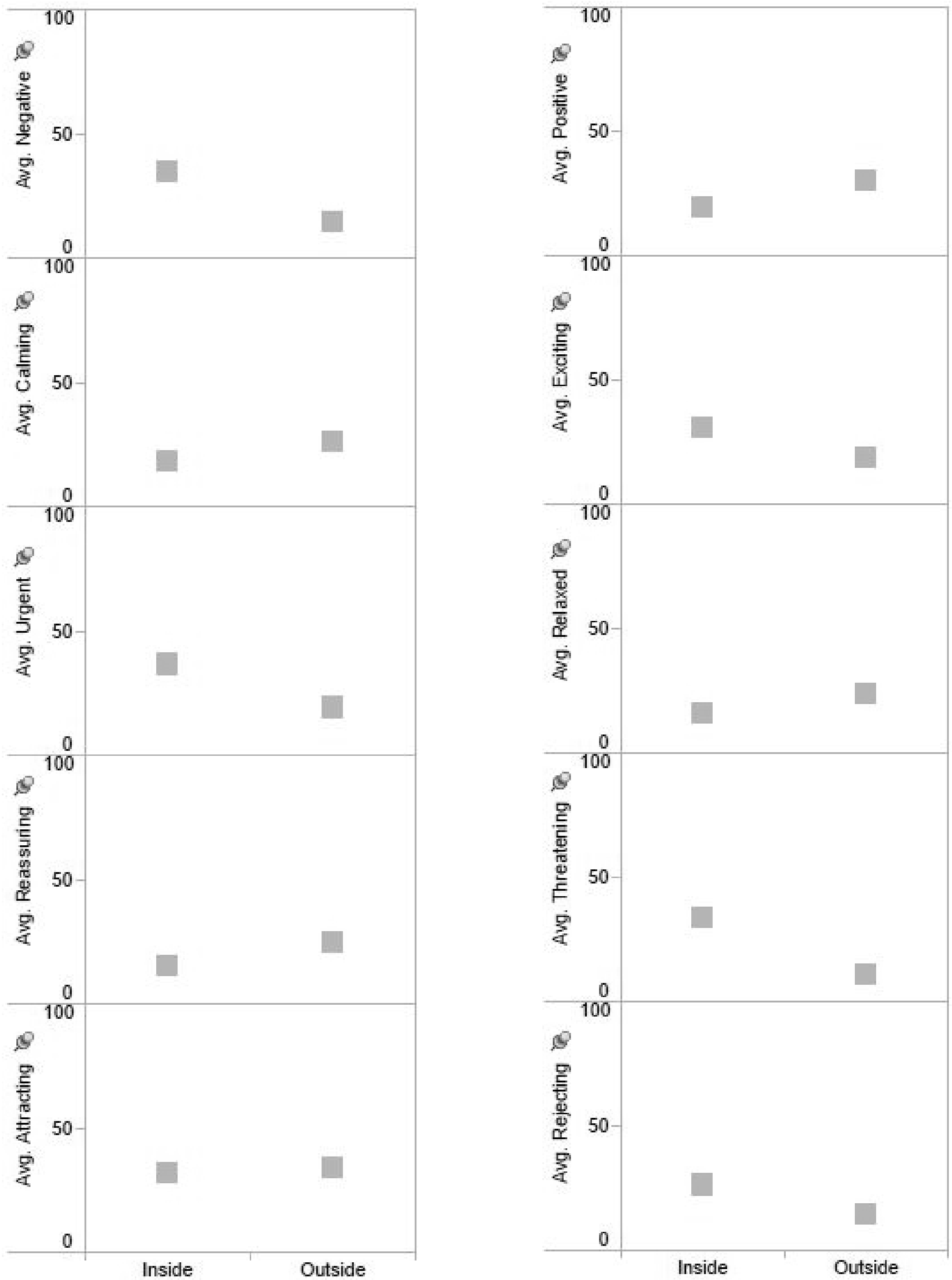


Figure 5.14a. Mean affective ratings by viewpoint in VR group

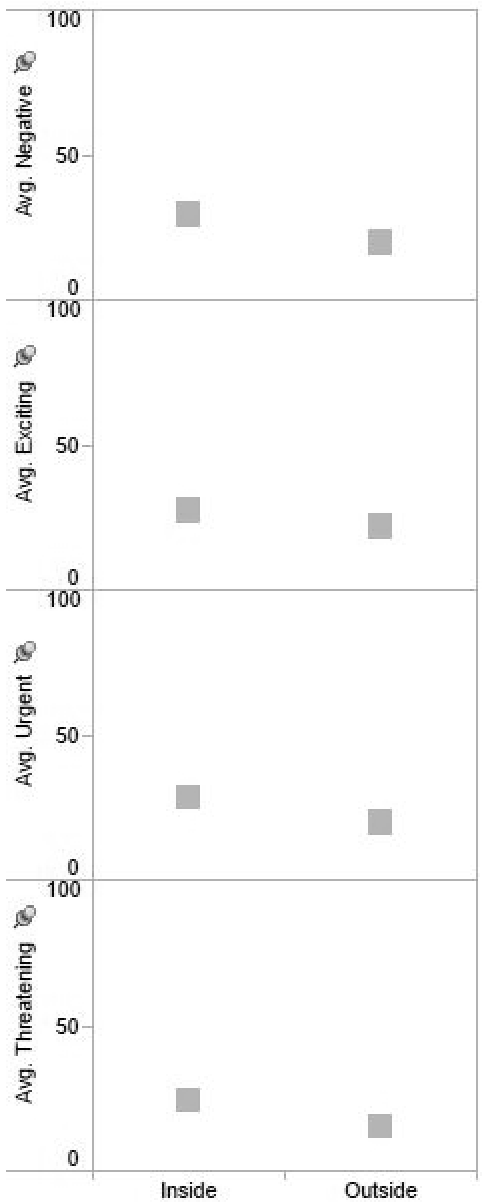


Figure 5.14b. Mean affective ratings by viewpoint in Desktop 3D group

Figure 5.14. Mean Affective Ratings by View Point

Direction & Path curvature

Direction and path curvature were revealed to have little effect in this study. Direction was only detected to be significant in VR group: outward motions were more threatening than inward motions. No similar effect was detected in SS/NS group, one possible reason being the less immersive visual experience.

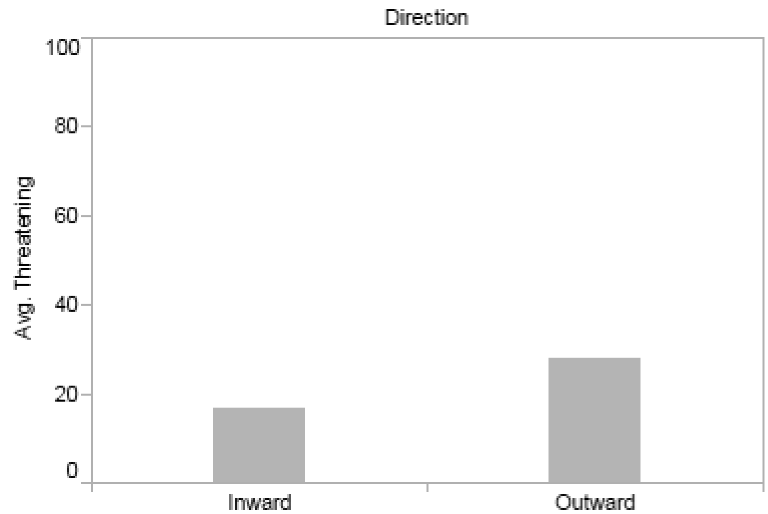


Figure 5.15. Mean Threatening Ratings by Direction in VR group

In Desktop 3D group path curvature has some level of effect on threatening, where non-straight motions were generally seen as more threatening. Straight motion primitives (*Mean* = 21.54) received lower threatening ratings than non-straight motion primitives (*Mean* = 17.83).

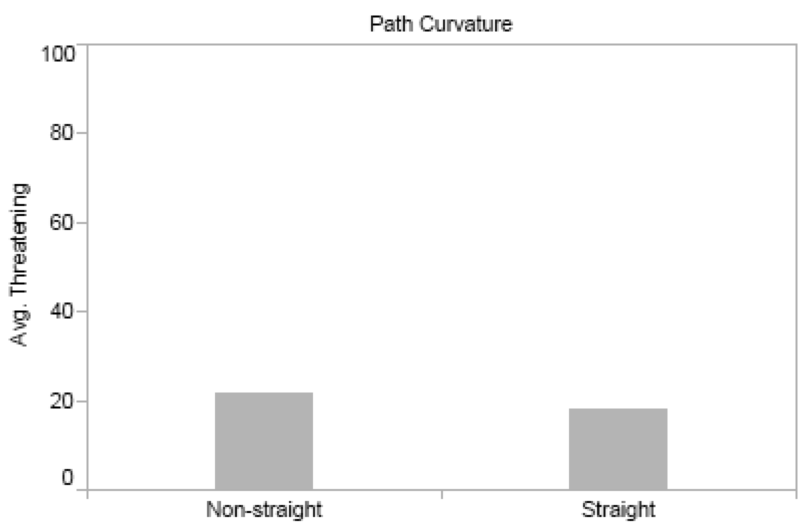


Figure 5.16. Mean Threatening Ratings by Path Curvature in Desktop Group

Interaction Effects

Speed * View point

Speed and view point have interaction effects on multiple affective dimensions in both VR group and desktop group. In both groups, View point amplifies the effects of speed on ratings of most dimensions. While fast motions are usually seen as more intense than slow motions, the difference between fast and slow motions is more pronounced within the VR group, when viewers are virtually among particles than they are outside the space of the motionscape.

Table 5.14. Interaction Effects of Speed and View Point

VR Group		Desktop 3D Group	
Negative $F(1,11)=30.419$, $p<.001$	**Positive** $F(1,11)=11.026$, $p=.007$	**Negative** $F(1,11)=7.008$, $p=.023$	Positive
Calming	**Exciting** $F(1,11)=7.451$, $p=.020$	Calming	**Exciting** $F=10.368$, $p=.008$
Urgent	**Relaxed** $F(1,11)=19.362$, $p=.001$	**Urgent** $F(1,11)=17.038$, $p=.002$	Relaxed
Reassuring	**Threatening** F(1,11)=19.367, p=.001	Reassuring	**Threatening** $F(1,11)=12.943$, $p=004$
Attracting $F(1,11)=6.603$, $p=.026$	**Rejecting** $F(1,11)=18.701$, $p=.001$	**Attracting** $F(1,11)=6.603$, $p=.026$	Rejecting

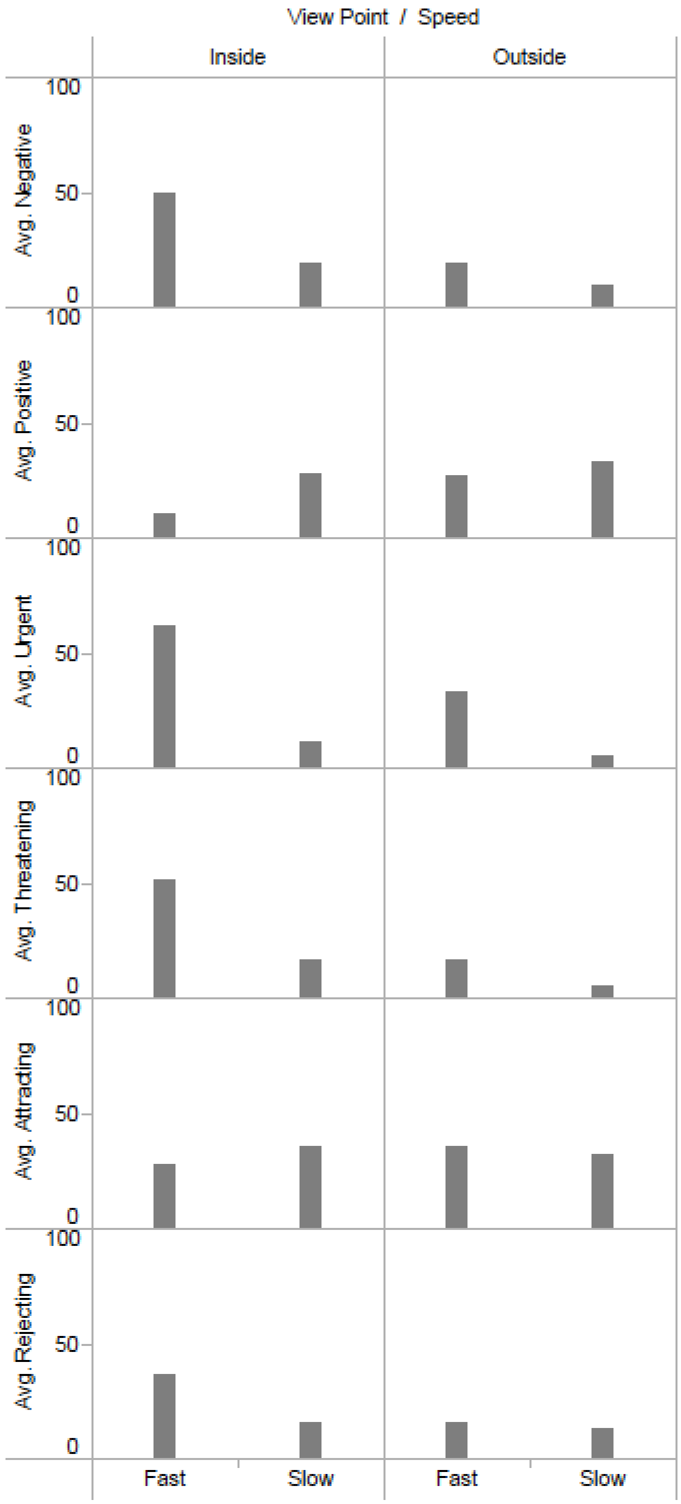


Figure 5.17a. Interaction effects between speed and view point, VR group

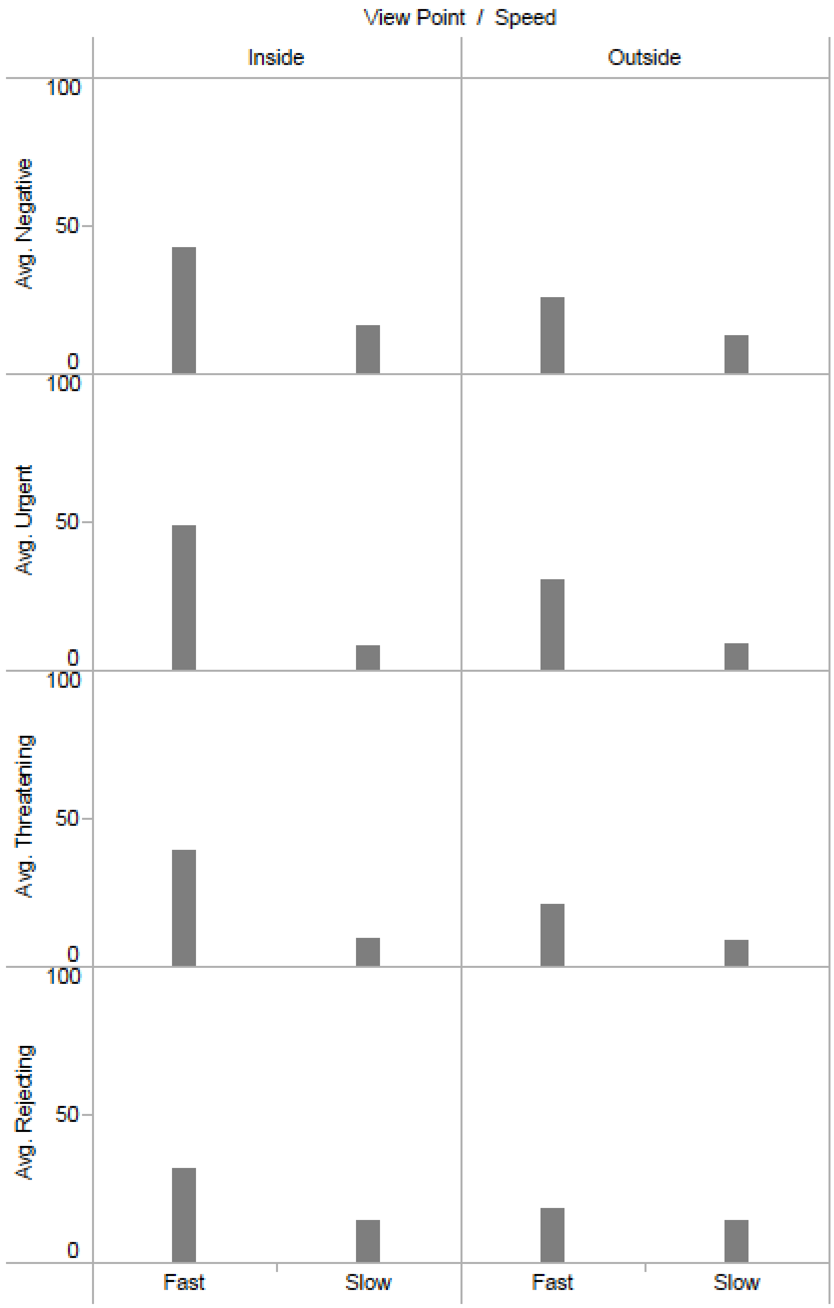


Figure 5.17b Interaction effects of speed and view point, Desktop 3D group

Figure 5.17. Interaction Effects of Speed and View Point

Shape * Direction

Shape and direction have interaction effects on Reassuring, Threatening, Attracting, and Rejecting ratings in VR group; but in Desktop 3D group, they only have interaction effects on Threatening.

Table 5.15. Interaction Effects of Shape and Direction

VR Group		Desktop 3D Group	
Negative $F(1,11)=5.981$, $p=.033$	Positive	Negative	Positive
Calming	Exciting	Calming	Exciting
Urgent	**Relaxed** $F(1,11)=19.362$, $p=.001$	Urgent	Relaxed
Reassuring $F(1,11)=9.263$, p=.011	**Threatening** $F(1,11)=24.779$, $p<.001$	Reassuring	**Threatening** $F(1,11)=6.083$, $p=.031$
Attracting $F(1,11)=8.750$, $p=.013$	**Rejecting** $F(1,11)=14.301$, $p=.003$	Attracting	Rejecting

In VR group: For both Spherical and Spiral motions, inward motions are slightly more reassuring, less threatening, more attracting, less rejecting. In desktop group: among spherical motions, inwards motions were seen as less threatening than outwards motions. No effects were detected among spiral motions.

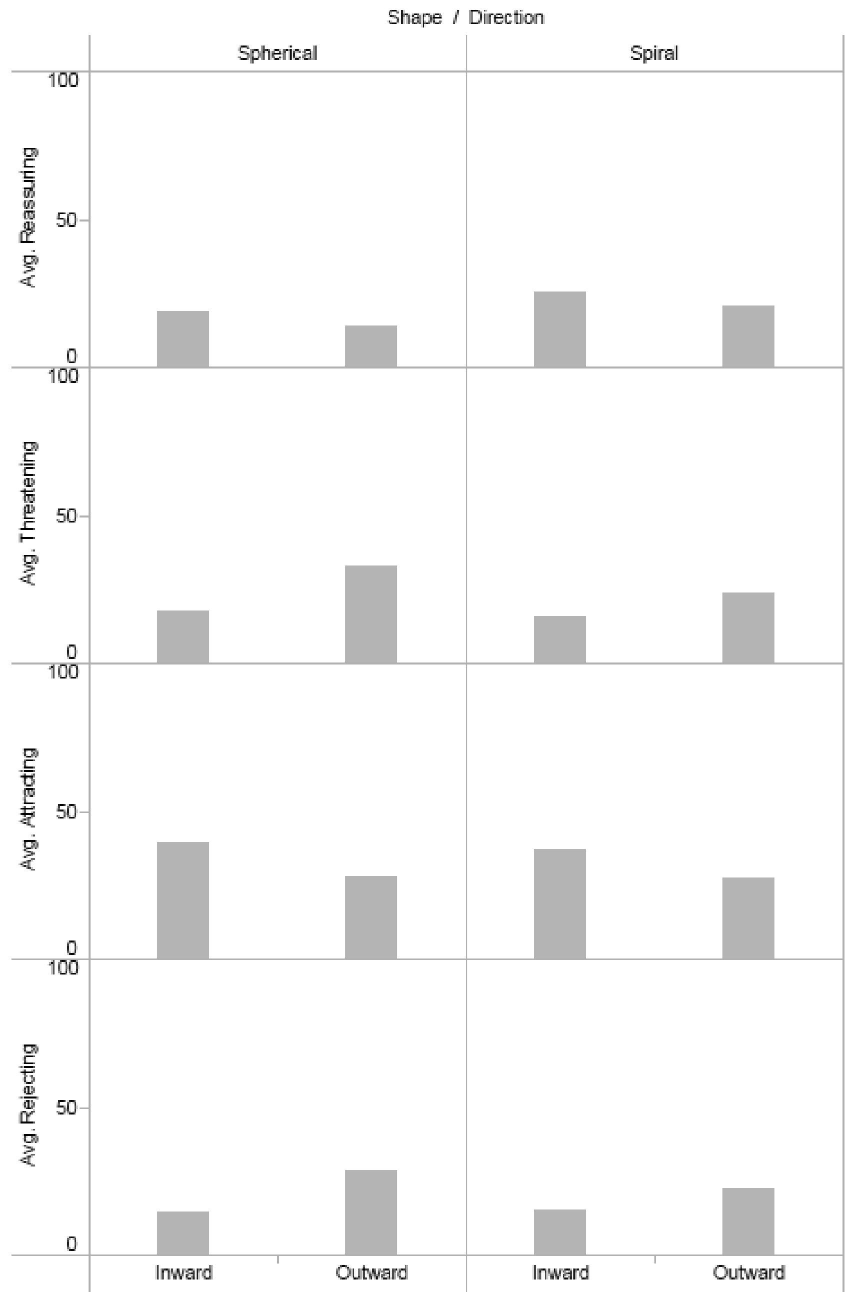


Figure 5.18a. Interaction effects of shape and direction, VR group

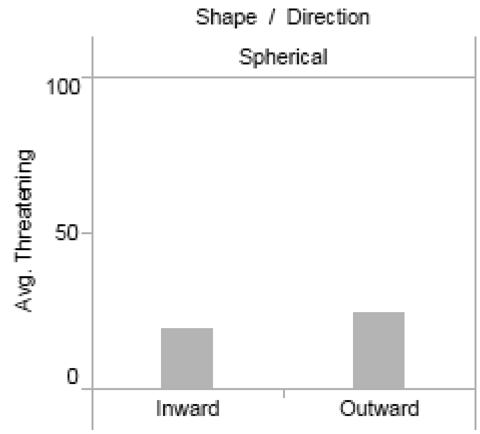


Figure 5.18b. Interaction effects of shape and direction, Desktop 3D group

Figure 5.18. Interaction effects of Shape and Direction

5.5. Discussion

Before continuing on to the discussion, the list below gives a review of the hypotheses that were raised earlier.

- Our first hypothesis **H1** is on the effect of the stereoscopic display conditions: we expected stereo motions would generally have stronger affective rating results than those yielded by non-stereo motions, and VR set up would yield the strongest affective ratings.
- In **H2**, we also expected strong effects from shape: spherical motions will be generally rated as Negative, Exciting, Urgent, Threatening, and Rejecting; while spiral motions will be generally rated as neutral for most affective impressions, except that it will have a strong interaction effect with direction (inward spiral motion will be perceived as more attracting than other combinations of shape and direction).
- In **H3** we foresee path curvature in linear primitives will strongly influence the affective ratings, where primitives with straight curvature will be seen as positive, calming, relaxed, reassuring, attracting, whilst those with non-straight curvature will be seen as opposite.

- **H4 (Speed)**: Speed will significantly affect ratings in intensity (CE), urgency (UR), and dominance (RT), that is, fast motions will be generally perceived as more exciting, urgent, and threatening than slow ones.
- **H5 (Direction)**: Direction will affect ratings for interaction (AR) and valence (NP), with inwards being perceived as attracting and outwards being perceived as more rejecting. And upward motions will be perceived as positive while downward motions will be perceived as negative.
- **H6 (View point)**: Motions displayed in full screen (with participant virtually inside the space of particles) will receive higher ratings for intensity (Exciting), urgency (Urgent), and dominance (Threatening) than those displayed with participant virtually outside the space of particles.

Discussion on the findings and implications regarding each independent variable (the motion properties, scale, and viewing conditions) is provided in the following.

5.5.1. Display

Display's effect is not as significant as we expected: 1) In linear motionscape experiment, VR stereo display (VR set up) is only found to have amplification effect on Exciting, Urgent, and Rejecting. 2) In non-linear motionscape experiment, VR set up contributes to higher threatening and rejecting ratings; while desktop 3D display leads to a greater ratings for positive, exciting, and attracting.

Finding 1) is consistent with our first hypothesis of stereo display (H1), as in VR group the stereo display does amplify (although only slightly) Exciting, Urgent, Rejecting ratings. However, there's no such amplification effect from desktop stereo display.

In finding 2), H1 can be again confirmed by the detected amplification effect from VR set up and desktop display. But the effect of desktop stereo display is surprising as it amplifies the rating for Positive (we did not expect this in H1).

This may lie in that the VR set up contributes to a more immersive viewing experience than that provided by desktop stereo display.

5.5.2. Shape

In non-linear motion study, Shape of motion was a significant factor for Calming, Exciting, Urgent, Relaxed, and Reassuring. Spherical motions were usually less calming, more exciting, more urgent, less relaxed and reassuring than spiral motions. This finding is consistent with what we expected in H2.

One possible explanation for this finding is that spherical motions were visually more complicated, whilst spiral motions were more structured and behaved in more foreseeable manners. This also explains that when wavy path curvature is applied to spherical primitives, primitives were rated as more exciting and urgent but less relaxed and reassuring.

5.5.3. Path Curvatures

In linear motionscape experiment, path curvature has strong effects on most affective ratings, thus this finding confirms H3.

However, path curvature is found to be insignificant for the affective impressions of the non-linear motionscape primitives. In the non-linear motionscape experiment, path curvature is only found to yield a significant main effect on Threatening rating in desktop stereo display group.

That non-linear primitives with non-straight path curvature were seen as more threatening may be due to the fact that the wavy path curvature increased the visual complexity of the motionscape primitives, that is, the patterns of the movements within the primitives were somewhat difficult to distinguish. The resulted threatening effect may thus be possibly due to the complexity in interpreting the motion pattern of the primitives.

Beyond the sole effect to the threatening affect, path curvature made little difference on the other impressions evoked by the non-linear primitives. This finding thus implies that path curvature is not as dominant a motion property in non-linear motionscape primitives as it is in the linear primitives. We distinguish the motionscape effects first by judging and distinguishing the layouts, then by examining path curvatures, speed, direction, and so on.

When particles move in very similar pattern, e.g., in parallel tracks, the difference in path curvature is more likely to be noticed; while in non-linear motions, particles move along different trajectories.

5.5.4. Speed

Speed has been proved a significant factor on motion's affective impressions by a wide range studies in various fields. Thus it is unsurprising to find that speed yielded pronounced influences on most affective ratings in this study (both in the linear and non-linear motionscape experiments). The amplification effects of speed on all 5 affective dimensions (Negative on valence, Exciting on intensity, Urgent on urgency, Threatening on dominance, and Rejecting on interaction) confirmed our H4.

5.5.5. Direction

Direction's effect in linear motion study are consistent with H5.

In non-linear motionscape experiment, only in LS/NS group direction is found to significantly influence the Threatening rating (and thus confirms H5).

When particles fly towards the viewer, the motion effects were seen as threatening. This effect might be very much like some of the visual effects in the current 3D cinema, where visual elements, be it raindrops in storm or pieces from exploding star ships, usually fly out of the screen towards the audience members. With visual elements constantly moving towards the viewer, a sense of personal space being intruded upon may arise. Viewer may thus feel threatened.

5.5.6. View Point

The findings from both linear and non-linear motionscape experiments confirm our hypothesis regarding viewing point's amplification effects (H6).

The difference between the ratings for inside/outside view point is possibly influenced by the difference in perceived speed and the level of experience of immersion.1) the difference of perceived speeds: when viewed from inside, speed of particles is seen as faster when viewed from outside (and if this is the case, view point's effect should be similar with that of speed); 2) immersion vs. Non-immersion (full screen vs. local): when viewed from inside, the motionscape primitive takes up the entire screen and surrounds the viewer (especially under the stereoscopic condition).

5.6. Summary

This study set out to explore how the stereoscopic display conditions may influence the affective affordance of primitives proposed from previous general study on motionscape effects. In addition, the study also attempted to incorporate two variations in the scope (produced by variations in view point of the primitives) of motionscape applications. Hypotheses of this study were therefore reflections of the current trends and general knowledge in the motionscape art and design.

However, to our surprise, display's effect was only detected to have limited effects. In linear motionscape experiment, judging from results, stereo display conditions only had slight amplification effect on Exciting, Urgent and Rejecting. In non-linear motionscape experiment, display had effect on certain ratings, but not consistent between the two groups (VR vs. Desktop stereo display). In the VR group, stereo motionscape primitives were seen as more threatening and rejecting. In the other group, stereo motions were generally seen as more positive (this was surprising), exciting, and attracting.

View Point had quite consistent effects on Exciting, Urgent, Threatening ratings in both linear and non-linear motionscape primitives. When viewed from inside point of view, linear motionscape primitives were seen as more exciting, more urgent, and more threatening. In addition, non-linear primitives viewed from inside were also seen as more negative, which was not the case in linear primitives (and they were generally rated as neutral).

Chapter 6.

Conclusion: Envisioning Motionscape Design

6.1. Research Summary

This thesis research employs a scientific approach as a beginning step to elicit the connection between motionscape's affective expressiveness and its motion aspect. A small set of motionscape primitives were introduced to visualize motion properties and aspects including speed, direction, path curvature, and shape. Based on these primitives, two studies were carried out: the first study was to probe the key motion properties and aspects that contribute to the expressiveness of motionscape; and the second study set out to explore similar motion properties along with other aspects relevant to the motionscape presentation: the stereoscopic spectatorship and the virtual scale of the motionscape applications in virtual environment (VE).

6.1.1. Summary of Results

Shape, the composition layout of the motionscape, was found to be crucial for the affective affordance of the primitives studied in the previous two studies. Primitives of various shapes visited in this research can be grouped as linear and non-linear. While linear motionscape primitives were usually seen as neutral for a range of affective impressions of interest in this research, non-linear motionscape primitives, especially spherical primitives were usually associated with affects with high intensity.

Several other motion properties studied previously in simple abstract motion were examined within motionscape primitives. Among them, the effect of speed was consistent with previous researches in simple motion, for its altering and amplification effects on many affective impressions. Direction's and path curvature's effects were largely dependent on the shape of motionscape primitives, thus the effects were not consistent among the primitives covered by this research.

Beyond the aspect of motion design within motionscape, two other factors (display and view point) regarding presentation and application scale were introduced to this research to make it relevant to the current motionscape design practice. Quite to our surprise, the effect of display was limited in judgement from the results. Stereoscopic display conditions only had slight amplification effects on a limited set of affect ratings, and the findings were not very consistent between the two experiments on linear and non-linear primitives. To the contrary, view point, which contributed to the visible scale of the motionscape in the virtual space, had quite consistent amplification effects on many affects. And these findings were with symmetry in both linear and non-linear motionscape primitives.

6.2. Design Implication

With key findings from the studies summarized above, this part sets out to give an explanation on how such findings should be applied to the more practical application scenarios that involve motionscape design.

In this section, a virtual environment is employed as a virtual stage for the motionscape primitives proposed and studied by this research. While this environment attempts to resemble landscape in nature, the goal of this VE is to provide viewer with reference points to location and scale of the motionscapes within it. We imbued previously studied motionscape primitives in this VE to depict various design scenarios. In so doing, we aim to generalize implications to interactive environments that are visually more realistic or abstract as well.

In the following, we organize our discussion in such a way: first, we start with design implications based on our previous findings on shape, and propose that shape functions as the compositional base of motionscape design; based on the general discussion on shape, we will continue to discuss how the 3 atomic motion properties (speed, direction, and path curvature) enrich the affective expressiveness of motionscapes of various shapes; and in the end, we will discuss about the presentation aspects of the motionscape design, by focusing on the scales of motionscape design both in virtual environment (view point) and the physical (display conditions).

6.2.1. Shape: the Composition Base

In this section, we will start with a general discussion on shape, the dynamic layouts of motionscape composition. While shape was found to be a significant factor for the affective expressiveness of the primitives visited in this research, it is also recognized as a compositional base of the motionscape design and implementation.

Motionscape primitives with linear layouts seemed quite neutral in their affective expressiveness. That is, when compared to the affective impressions produced by primitives of other shapes, linear primitives were usually seen as much less intense on most affect dimensions. However, this doesn't mean that linear motionscape primitives are less expressive than the non-linear ones. From the studies, linear primitives were proved to yield a calming, relaxing, and reassuring effect on the viewer. This means that linear motionscape primitives are suitable for many design scenarios where comforts are to be provided to the viewer. Also, although lacking the intensity on the expressions on other affect dimensions such as interaction, threats, and urgency, these properties have made linear primitives suitable for ambient visualization, where visual elements should be neutral and less intrusive.

To the contrary, non-linear primitives were associated with affective impressions of greater intensity. And among the various non-linear shapes covered by this thesis, spherical layouts were found to yield strong effects on multiple affect dimensions. Spherical motionscape primitives were often seen as more exciting, urgent, threatening, and rejecting. The above affect dimensions are key to the emotional aspects of the interactive systems. As discussed by Norman (2009), users need to be constantly reassured when computational systems work properly, they also need to be warned when things go wrong. In this case, a message to indicate the emergency is needed. Therefore, as spherical motions are seen as urgent and exciting, they can be applied as such visual notations for the warning messages.

While the above generalizations on the possible applications of linear and non-linear primitives are based on their diverse affective expressiveness of various motion properties, another path can be followed to study the application directions of the two categories of primitives.

The linear and non-linear layouts can be categorized under the two categories of basic composition systems summarized by Arnheim (1983). The spherical layout, along with radial, circular layouts visited in the first study, and spiral layout in the second study, represent the system of centricity, where the inner compositional forces (formed by the structured movements of the particles within motionscape) are related to an internal centre (or an internal axis in space). The linear layout, on the other hand, represents a system of eccentricity, where the composition forces react to no such centre or axis. These two different composition systems imply two types of motionscape applications. To ease the following discussion, these two types of applications are categorized according to which effects are intended: the local effects or ambient effects.

Local Effects

As non-linear primitives are always attached to certain positions within the virtual space where they reside in, the primitives can therefore be made relevant to specific positions in the visual space for a range of local effects. For instance, as shown in Figure 6.1, a spherical motionscape primitive is located at a distant point in the virtual space. Here the spherical primitive can be applied as a visual cue to communicate the feeling of excitement, and its composition centre suggests the position where the excitement arises in the space.

The spherical primitive in this case is eligible as visual cue both to evoke an exciting atmosphere for the position it is attached to and to make the evoked affective impression associated with specific positions within a visual space. On the one hand, spherical primitives were usually associated with stronger impressions of excitement and urgency, they are therefore useful in design scenarios where the above two impressions are intended. On the other hand, although spherical primitives aren't always associated with an attracting impression according the findings in previous two studies (to the contrary, spherical primitives were often seen as more rejecting), it should be noted that motion in general is highly efficient in directing viewer's attention. In the field of visual design, the mechanism of visual attention is largely associated with changes in colour, texture, and motion of visual elements (Ware, 2004). The spherical primitive discussed here can therefore serve as a motion cue to address a specific position within space, when the colour, form, and motion pattern of the primitive are designed to differ itself from the background environment.

Figure 6.1 shows how spherical or spiral motionscape primitive can be applied in a virtual space for local effects. According to Murray, it is crucial for any virtual environment to inform the interactors about their position within the whole (Murray 2012, p.167). In the scenarios depicted in figure 6.1, the resulted local effects serve as landmarks that both remind the interactor's relative position in the virtual environment and make certain place of the environment visible. Although the primitives shown in the figure are implemented in large scale (in the scenarios shown in Figure 6.1, both primitives take large space on screen), the primitives' effects are all associated with a specific point in space. Similar to the spherical primitive's effect discussed above, the spiral primitive in this case may indicate the point to which visual force and excitement may be attached or directed.

It should be noted that similar local effects can be achieved by linear motionscape primitives as well. However, as there's no definite central points or axis in linear primitives, the local effects can only be achieved by locating the linear primitive at a specific space within the greater environment.

Motionscape primitives intended for similar local effects are popular in a range of interactive environments. For instance, similar non-linear primitives are often employed as special visual effects for video games, movies, advertisements, and motion title design. But they are not so widely used in more scientifically oriented visualization. In the field of visualization and interface design, the mechanism of user's attention is usually of great interests to the designers. The motionscape primitives may thus serve as an alternative approach for their efficiency in producing affective local effects.

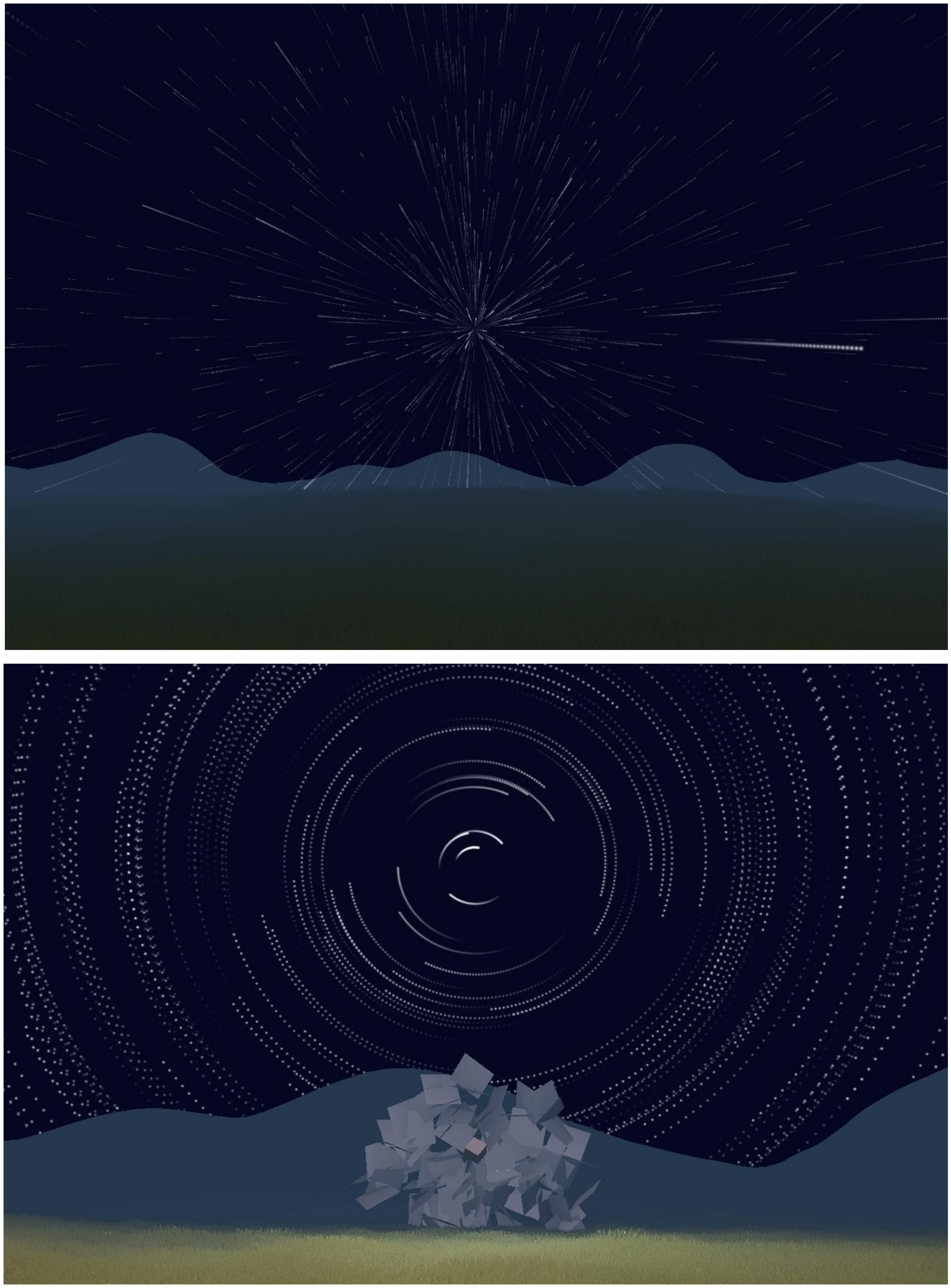


Figure 6.1. Local effects
Note. Non-linear (spherical and circular) motionscape primitives are located in a virtual environment to create local effects

Ambient effects

The composition of linear motionscape primitives requires no specific centre but space within the virtual environment the primitives reside in. Therefore agents within a linear primitive can be equally distributed to a large space to create an environmental effect. It is hard to decide whether the neutral affective impressions of the linear primitives are a result of lacking the composition centre, but when controlling carefully, linear primitives' such neutral impressions are suitable for ambient, natural effects.

In Figure 6.2, the linear primitive applied in this scenario is to simulate a cosmic environment, where particles within the primitive move gently to produce a calming atmosphere. Here, as there's no specific centre or axis within the linear primitive, the arrangement of the particle movements is therefore less “aggressive” than that in spherical or spiral primitives. The viewer should certainly not have to pay attention to any specific point within this environmental motionscape.

Just like linear primitives can be applied for local effects, the previously discussed spherical and spiral (or circular primitives visited in the first motionscape study) are also capable of evoking certain environmental effects. In fact, the two scenarios of local effects can also be seen as environmental as the visual motions within the two non-linear motionscape primitives take up a great ratio of the virtual environment. However, such non-linear motionscape applications are with clear references to specific position or axis within the environment. Thus it should be noted that the environment effects are therefore differ from those evoked by the linear primitives.

Figure 6.2. Ambient effect
Note. Particles in a linear motionscape primitive are distributed throughout the virtual environment to evoke ambient affects

6.2.2. Speed, Direction, & Path Curvature: Controlling Motion on Atomic Level

The variations in shape also leads to variations in several other properties' effects, such as those resulted from direction and path curvature. And it should be noted that through manipulating the other properties under different composition form, the affective affordance of such primitives can be altered. In the following, several motion properties that are applied to the single particle movements within motionscape primitives are discussed respectively, with each section aiming to make itself relevant to the possible design scenarios.

Speed

The influence of speed on the affective impression of motion has been revealed by a range of studies. The findings from this research regarding speed are quite consistent with the general knowledge and understanding.

Speed of the atomic motion agents within the motionscape is a significant factor for almost all affective impressions studied in this research. Motionscape primitives with fast motions were often seen as more negative, exciting, urgent, threatening and rejecting than those with slow motions. This amplification effects were found consistent in both linear primitives and non-linear primitives. This finding suggests that speed is a motion factor strongly associated with the intensity of the above affective impressions. That is, the change in speed will very likely influence the level of certain affects.

To take a glance at the above implication, let's take a look at the two scenarios of non-linear and linear motionscape applications again. In Figure 6.1, as non-linear primitives can be applied for evoking the feeling of excitement, urgency, and threats, manipulating the speed level of the particle movements within such primitives can therefore influence the strength of the intended affective message being communicated. Such adjustment are necessary to a range of applications, as the affective message not only lies in quality, but also in quantity as well (Imagine when multiple urgent situations emerge, a quick decision on which one should be solved first should be made. Being informed with the level of the urgency thus is key to such scenarios).

Another finding regarding speed is critical to the design of motionscape effects: speed influences not only the quantitative level of motionscape effects, but also the qualitative nature of the affects. For example, as increasing the speed may lead to the increase in the impression of excitement, this may also lead to the change in the affect being communicated. In Figure 6.2, the linear primitive with slow moving particles may be seen as calming and relaxing, but when the agents within it start to move enormously fast, the affect evoked by the primitive might be altered: the affective experience of excitement and urgency may arise.

Another instance of such effect from speed can be found on the interaction (Attracting - Rejecting) dimension, where slow motionscape primitives were usually perceived more attracting than fast primitives. Thus, when motions are applied with the purpose of drawing and keeping user's attention, the control of the speed in motionscape primitives is again a crucial aspect that should be considered by the designers.

Path curvature

The role of path curvature in the expressiveness of simple motion has been visited by both scientific studies and theoretical work within the domain of art and design. But generalizations for design from above efforts need to be informed with new perspectives here, as the motion patterns are performed by large amount of visual elements in motionscape. Findings from this research in motionscape primitives have suggested that the role of path curvature should not only be studied by visiting the expressiveness of each single particle but also by examining the dynamic forms achieved by the interplay of all agent movements. Two directions of the path curvature's application in motionscape are visible, each is observed and discussed according to the two main variations in the composition base of motioinscape.

Curve as reference to nature

The affective impression of the path curvature provoked by a single object may be accumulated when the same path are followed by multiple agents. This is especially the case according to the findings in linear motinscape primitives. The linear primitives are significantly influenced by the path curvature applied to the moving agents within them, and the resulted effect is usually consistent with the effect produced by single object. For instance, a wavy motion is usually interpreted as more exciting than the straight motion, a same affective impression can be obtained by motionscape primitive with linear layouts and wavy curvature.

"The straight lines belong to men, the curve lines belong to God." The quote from Antoni Gaudi may be the explanation for another finding regarding the path curvature. The wavy motion was constantly referred as a visual effect resembles those in nature in the studies reported previously. As when applied in linear primitives, the wavy path curvatures formed by the traces of particles may be seen as a visual reference to waves in ocean, forests, or grass land. The design implication here is therefore a direct result from such nature references. Wavy paths, when manipulated carefully, may produce the impressions that are more natural, thus are capable of communicating certain calming, reassuring, and relaxing affects.

Figure 6.3 gives an instance of such calming effect from wavy curvature. In this scene, the linear primitive is comprised of agents moving in wavy paths. Although other visual features (distribution of white dots, moving upwards) are of no references to nature phenomena, the waves of the movements within this motionscape increases its naturalness. Thus, the motionscape primitive may give a feeling of calmness and reassurance to the visual environment.

Visual complexity

The interplay among the moving agents doesn't only lead to an accumulation of the expressiveness of each one of them. For instance, the finding from the non-linear motionscape experiment of the second study suggests that path curvature contributes little to the affective impression of non-linear primitives. This may further imply that the articulated meaning and impression achieved by a movement performed by single object may become blurry when the same movement are performed under the more structured composition effort.

It should be noted that when particles move in parallel tracks in linear primitives, the difference in path curvature is more likely to be noticed; while in non-linear primitives, where particles move along different trajectories, the applied wavy path curvature increased the visual complexity of the motionscape. Therefore, the wavy path curvature may become hard to distinguish and hard to predict. This may sometimes lead to other affective impression that is not often associated with wave curvatures. For instance, spherical primitive with wavy curvature can achieve certain threatening effects. In games, these are thus popular visual effects and are often extensively used. While game designers and researchers pay much attention to manipulate visual load for the gaming experience of visual elements in games (Milam et al, 2011), the wavy curvature will then be another contributing factor to such visual loads. In this case, a compromise between such visual loads and intended affective impressions must be made. Similar implication will also applicable in other affective visualization applications, as such negative effects are useful for various design scenarios. But the application of path curvature must be carefully designed and carried out with a consideration of the composition layout, the shape of the motionscape.

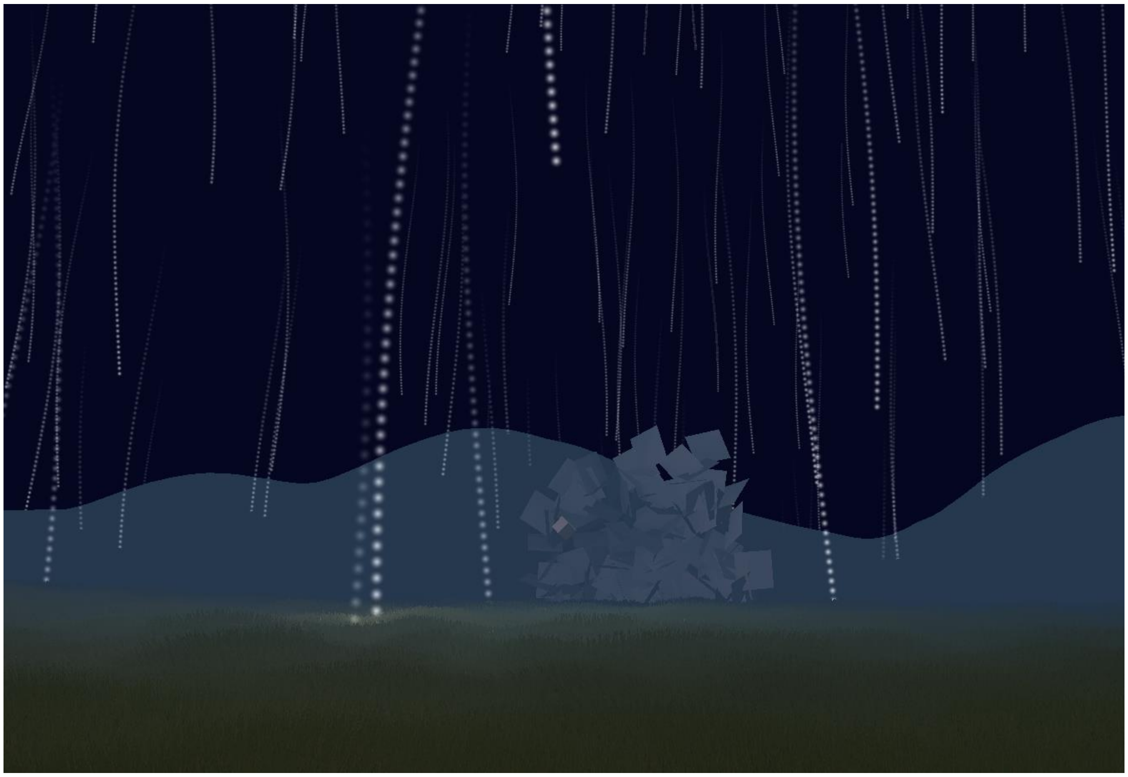


Figure 6.3. Wavy Path Curvatures

Direction

Direction's effects were not consistent for linear motionscape primitives and non-linear ones. In linear primitives, direction was found to be a crucial factor for affect dimensions such as valence, intensity, and interaction. But in non-linear primitives direction was found to be less an expressive motion property.

Up and down

Linear primitives with particles moving upwards were usually seen as more positive and exciting than those with particles moving downwards. That upward motions are seen as positive (and vice versa) implies an applicable guideline in visualizations where articulating positiveness and negativity is necessary. For instance, in Figure 6.3 the upward motions of the linear primitive can serve as ambient cues for positiveness. While the wavy curvatures make the motionscape calming and relaxing, the upward motions can send out a positive message, such as encouragement or cheer.

Another design implication lies in the direction's association with affects on intensity dimension. In previous chapter, such association was attributed to natural references that is similar to the interelationship between wavy path curvature and calmness or reassurance. Indeed, downward motions are more natural due to the universal effect of gravity, therefore upward motions may be seen as more exciting than the more natural and expectable downward motions. This implication is useful when the message of changes should be sent out. Again, take the scene depicted in Figure 6.3 as instance, a change in motions of the particles from static to moving upward may indicate certain situation arises, and such change is very likely a positive and exciting one. Figure 6.4 shows another scenario where direction is manipulated to alter the affective impression of the scene. In the first image in Figure 6.4, the particles within linear primitive are moving to the left, while in the image below the particles are moving to a left upper direction. An atmosphere may be thus altered slightly (the scene may therefore be seen as slightly more positive and exciting) resulting from the change in the motion's direction.

Engaging the viewer

Outward motions within linear motionscape primitives are usually seen as more rejecting and threatening, and vice versa. In the discussion provided in previous chapters, we've learned that when particles fly towards the viewer, the viewer usually felt the rising of threats or being rejected. This effect might be very much similar to some of the visual effects in 3D cinema (knives, baseball, snake... things are thrown out of the screen towards the audience member for surprises). An explanation was given previously: with visual elements constantly moving towards the viewer, a sense of personal space being intruded may arise. This explanation requires further experimental evidence, but it's pertinent as it suggests design strategies regarding viewer involvement. As inward motions were seen as more attracting and outward motions were seen as more rejecting, this implies that viewer's involvement to the visualization can be manipulated by the direction to which the particles are flying to. But the above implication can be only applied to inward or outward motions. When agents within motionscape move to a direction parallel to the plane of the window (or the scene the viewer facing to), the visual elements may become less influential to the viewer.

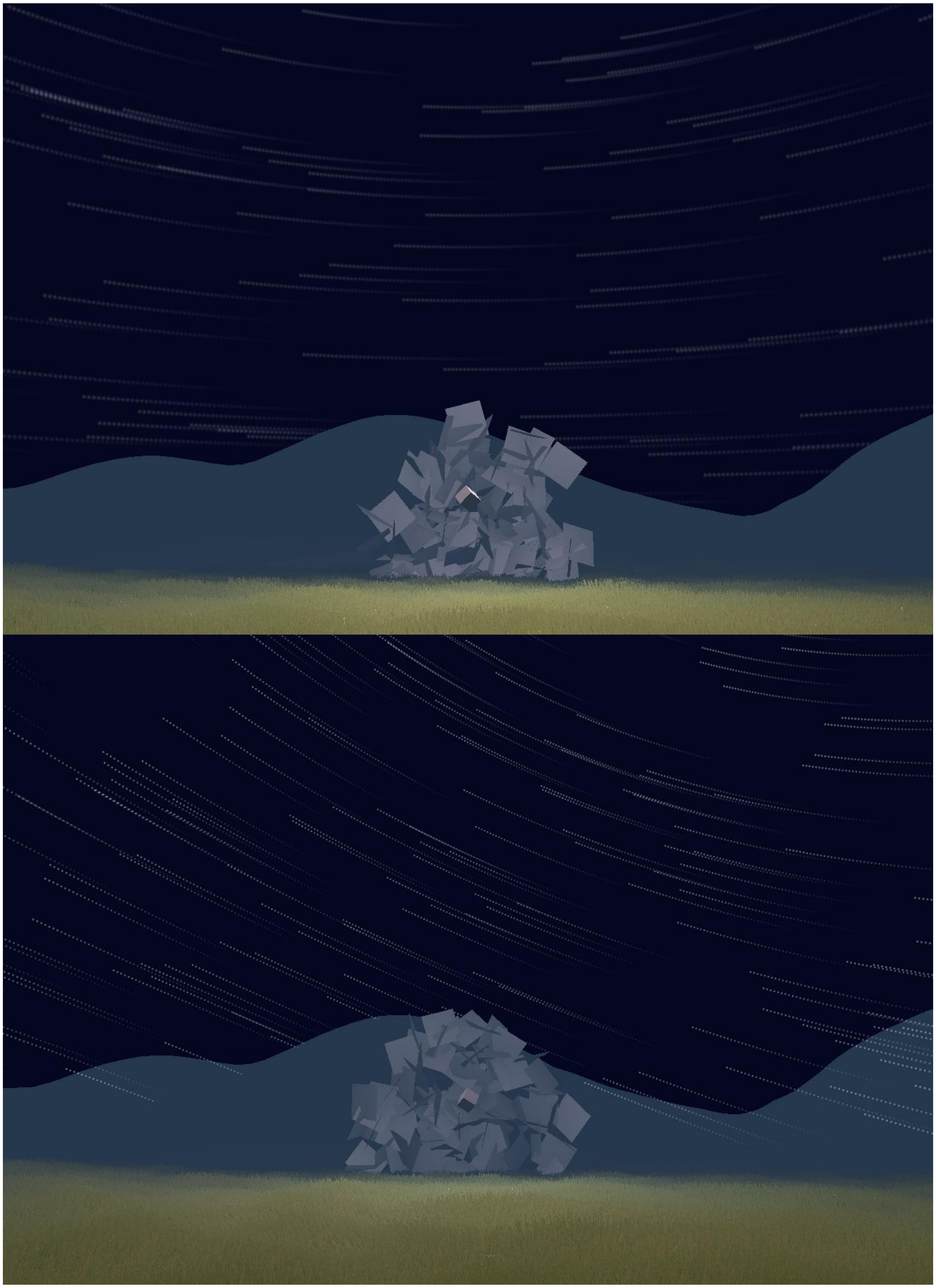


Figure 6.4. Variations in Direction

An instance of the manipulation of inward and outward motion is given in figure 6.5. In this case, the linear motionscape primitive is applied to simulate the mist or fog over a grass land. The mist can be controlled to move either towards or away from the viewer's virtual position in the scene, then a sense of rejection or attraction may arise. Based on the visual feedback in the virtual environment only, the viewer may feel being pushed away by the dense, approaching mist and thus feel the scene (or here in this scenario, the whole virtual environment) rejecting his or virtual existence.

Anonther instance for opposite effects can be observed in Figure 6.2. Here the linear primitive with similar motion pattern is set to move away from the viewer's position. Thus all particles within the motionscape move towards a direction into the distant point of the virtual environment. With the particles surrounding her moving forward, the viewer may feel being attracted to the same direction, which may further encourage the viewer to explore this environment.

The above implication regarding inward and outward motion can be similarly applied to certain non-linear motionscape primitives as well. For instance, in spherical and circular motionscape primitives, inward motions can also applied to engage or reject viewer's activities within the virtual environment. However, the resulted effect may be different from that achieved by linear primitives, as the visual motions within the non-linear primitives will be directed to or away from only certain point or axis within the environment.

Being aware of direction's effect in motion scape is crucial. While direction has strong effect on the impression of attraction or rejection, reassurance or threats, the manipulation of direction thus has significant impact on the user's attention and feeling of atmosphere in scenarios where motionscape primitives are applied.

The contrary of the above implification can be applied vice versa. For instance, downward motions can be applied for achieving calming effects, but such motion pattern should be applied with caution that moving downward may suggest negative affects as well.

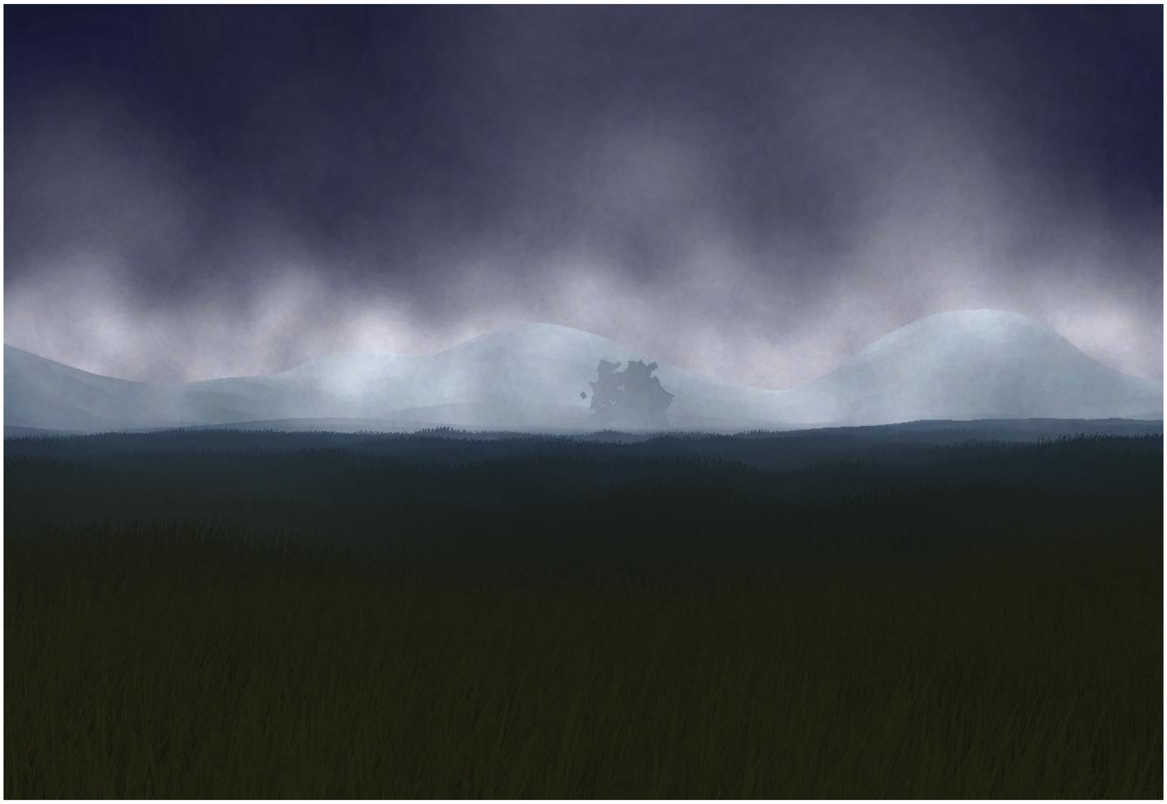


Figure 6.5. Linear Motionscape as Simulation of Mist

6.2.3. View Point: Manipulating Scales

The simulation of the two viewer positions in the stereoscopic motionscape study can also be seen as variations in the scales of the motionscape. The inside view point, from which viewer is virtually positioned among the particles within motionscape primitives, enlarges the motionscape effect to a full-screen (or a full virtual space in the VR scenario) scale. The outside view point, on the other hand, limits the motionscape effect within a small area on screen or a small district within the virtual space.

The above two simulated scales resulted from variations in view point, lead to quite consistent effects in both linear and non-linear primitives. Such difference in the expressions of primitives viewed from inside and outside view point is possibly influenced by the level of experience of immersion (full screen vs. local), which further leads to the two different effects discussed previously: the ambient effects and local effects.

In the above discussion, local and ambient effects have been associated with the composition effort: the shape of motionscape. Here the discussion expands by incorporating the factor of scale. While ambient or local effects can be achieved by the variations in shape, they can also be implemented by manipulating the scale of the motionscape. While the ambient effects discussed previously were intended for calming, relaxing, or reassuring effects (and local effects for exciting, urgency, threatening impression), similar primitives to achieve such ambient and local effects can be manipulated in scale for certain amplified or altered affects.

Amplification and alternation

As discussed above, the linear primitives can be applied to achieve certain ambient effects when applied in full-screen scale. While it has been pointed out such ambient effects can be associated with calming, relaxing, or reassuring impressions, it should also be noted that such affects yielded by linear primitives can be altered or amplified due to the large scale. Compared to the primitives viewed from outside point of view, the full-screen primitives are generally seen as more exciting, urgent, and threatening. This indicates that the scale, or the view point, is an important factor that influence the above affect dimensions.

Similar altering and amplifying effects are visible among non-linear motionscape primitives. In addition to dimensions such as intensity, urgent, and threats, view point also significantly influence the affective impressions on valence dimension: those viewed from inside are seen as more negative than those viewed from outside. As discussed previously, non-linear primitives can be applied for warning message of urgency and threat. Such effects can be amplified by increasing the scale. The visual effects can therefore achieve the above relatively negative affective impressions with greater intensity. Indeed, when viewed from inside, motionscape takes up the entire screen, or even surrounds the viewer under the stereoscopic conditions. The resulted effect is therefore to overwhelm its viewer.

In summary, the two simulation of viewer position represent two categories of design fields based on the scale of the motionscape effects: visual effects designed for certain local space or ambient effects applied to an entire environment. Motionscape effects applied to a local position of a visual field is seen as more subtle and less pronounced than those applied to the entire visual field or virtual environment. The scale of the motionscape can be therefore seen as a slider for the intensity of the intended affective impression, and should be considered by visual designers who face the choice of creating local visual effect or large scale ambient effects.

Two directions (Total immersion vs. Jumping back and forth between application interface and user himself) of interface design for vitual applications/environments are discussed in the book of Virtual Realism (Heim, 1998). The discussion in the book can be appropriated here to study the design choice listed above. In Heim's writing, computer / virtual applications should function not as a total immersion environments (as those envisioned by Sci-Fi works such as Matrix, Strange Days, Tron and so on) but as interface that allow users enter the virtual world and resume the physical reality. Applying motionscape effects in information visualizations or interface design is not so much intended for immersive experience (position the user within the motionscape which function as a total environment constructed by itself) but to invite the user's attention when necessary: to keep the user outside the chaos and allow him jump back and forth between interface or application and himself.

The above appropriated discussion from Virtual Realism (Heim, 1998) and Interface Effect (Galloway, 2012) is on the level of aesthetics or poetics, but can be applied in a more practical context. The fundamental difference between the two categories of motionscape applications (local or environmental) is resulted from that the scale of motionscape takes up the screen or 3D virtual environment. As interactive environments, such as those in video game, art works of VR, or interactive rides in theme parks, are often aimed for both immersion experience and emotional engagement (Murray, 2012), full-screen or environmental motionscape effects can be applied in such fields. And in the following section, we are going to continue to the topic of virtual reality.

6.2.4. From Screen to Virtual Reality

The stereo display conditions incorporated in this study were intended to create a visual illusion for the viewer that the motionscape primitives were positioned in the physical world: either they surrounded the viewer or they were positioned right in front of her. However, whether this objective was achieved was not the goal nor examined in this research. Instead, the stereoscopic motionscape study set out to probe the influence of display conditions on the motionscape expressiveness. To our surprise, the effects yielded by the display conditions were less significant. However, from the limited findings regarding the display, this section attempts to propose two design directions in employing the stereoscopic simulation within interactive environment.

Amplifying affects

Although the effect of display is not as significant as we expected, stereoscopic display was still found to have certain amplification effects, although slight, on most affect dimensions. We've attributed this finding to the more immersive viewing experience. However, we should be keen on the design implication based on such effects, as the findings were usually without symmetry between the two stereoscopic conditions incorporated in the two motionscape experiments.

Depth: the informative third dimension

Stereoscopic display contributes to a greater attracting and rejecting rating in both linear and non-linear motionscape experiments. This may indicate that stereo visual presentations do better in directing user attention than the non-stereo ones do. In addition, the desktop stereoscopic display was also found to amplify viewer's rating for Positive. Such findings can be partly attributed to the visual clarity brought about by incorporating the third dimension: depth. Scott McCloud attributed many terrifying effects in comics to how knowledgeable we are about the situations or objects we are facing, "we tend to fear what we are not familiar with or what we don't understand" (McCloud, 1994). A similar point of view can be appropriated here: since the visual depth achieved by the stereoscopic display grants us a greater level of visual clarity (Irani & Ware, 2003), this may further lead to the more positive affects achieved by the motionscape under stereoscopic viewing condition.

We've already seen that motionscape effects implemented under stereoscopic viewing conditions or even achieved in physical set up, and such effects are only going to be more popularly applied. This expectation is not radical, as more affordable stereo display equipments emerge and techniques in VR and AR (Virtual Reality and Augmented Reality) quickly evolve. This trend is already foreseeable in the recent 3D cinemas: as discussed by Manovich, the stereoscopic display has been widely employed to help cinema achieve a greater level of realism (Manovich, 2002). A similar trend in the field of visualization and interaction design is still less visible, and a possible prospering in the stereoscopic applications may not be only due to the appeal of realism, but also due to the informativeness achieved by the incorporation of depth.

Indeed, as stereo motion cues are possibly better attention directing visual appeal, 3D display applications are likely to contribute to better interface performance and higher efficiency in information retrieving. However, the application of motionscape (especially that rendered under stereoscopic condition or implemented in physical set ups) is still relatively less widely employed. The design for such stereo motionscape primitive affects thus becomes crucial to many efforts within the above fields.

6.3. Limitations and Future Work

This study was designed as a quantitative experiment and set out for probing significant correlations between motion properties and affective impressions of motionscape. Conducting an experiment to elicit both main effects and interaction effects of various independent variables (motion properties) on a set of dependent variables (affective impressions) was challenging, as it involved enormous amount of trials and comparisons between such main effects or interaction effects. This brought problems to both our participants and author. To ensure the reliability of this study, we started piloting early before our formal studies, we carefully adjusted our stimuli, user interface for affective ratings, and split trials into multiple sessions, we also conducted informal after experiment interviews for criticisms and triangulation of the data. Many strategies were employed to avoid possible noises. However, considering the enormous challenges and complexity of studying abstract motion affects (the complexity is resulted partly from the abstract nature of motion texture, partly from the even more mysterious nature of human emotion and perception), we are aware the many limitations and will list a number of criticisms here. All of them suggest the factors or flaws that our readers should keep in mind when understanding, criticizing, and applying our results and findings. They also imply the further steps that should be taken to progress in this research field.

6.3.1. Motion Property & Motionscape

Although we claim our research purpose as to explicate correlation between motion properties and motion texture affects, we cannot ensure that all the responses and results were only influenced by the motion aspect alone. For instance, while motionscape primitives displayed in our experiments inevitably generated various visual forms and patterns that could be evocative as well due to the rendering methods and design choices (such as colour and size of particles, length of trails), to claim that certain affective impressions are only resulted from any one or any combination of the selected motion properties is not appropriated. Through the interviews with our participants, we received feedback that participant affective ratings were sometimes resulted from such visual patterns significantly.

6.3.2. The Myth of Affects: to Qualify and Quantify

To qualify affects is challenging. As it is still arguable whether basic emotion or basic dimensions of emotion are applicable, the validity of the attempts of qualifying affects in this research is still disputable. Also, every participant in our study had different perception and rating patterns or habits. While some participants rated the primitives within the context of study and compared their previous ratings with current ones, some participants regularly referenced their emotional experience in other contexts. This brought about challenges to elicit the trends in affects between participants.

While we chose our affective ratings from various fields of efforts, our 5 dimensions of ratings were not exclusively different from each other. Throughout our experiments, participants usually mentioned that some of the affective impressions were rated similarly, even though clear definition of each was given. Many mentioned that affective ratings such as relaxed and reassuring, positive and attracting, threatening and rejecting, etc. made no difference to them. 2 of the participants from the first motionscape study also stated they experience two affective impressions on the same dimension at the same time. In this case, the affective ratings therefore could not represent or reflect their actual responses with regards to our 5 dependent affects dimensions. Although modifications were made to the stereoscopic motionscape study, the problems of the lack of clarity of various affects still existed.

6.3.3. Set-up

Our study was set up differently from previous studies in visual motion on screen. While we did not perform formal studies to elicit whether the cinematographic set up of the experiment room produced a significant effect, now did we formally test whether participant experienced stereoscopic stimuli, we need to be careful about our claims about the findings that are significantly different from previous studies. Also, as our set up was not to simulate general software interface, visualization, game, cell phone applications, whether same results will be detected in the above scenarios requires further studies.

6.3.4. Population & Triangulation

As perception and rating patterns varied between participants, the small sampling size of this study limited the reliability of our data on quantitative level. Although through performing one-way and multi-way ANOVA and post-hoc test we were able to reveal which motion properties were significant for which affective impressions, we could not claim how they were correlated to each other based on the statistical measures alone. Experiments that cover samples with larger size are yet to be performed.

As have been mentioned, many participants referenced their own experience when rating the motionscape affects. What factors and how these factors triggered the participants to perform so were of interest of this study, as through such information we could retrieve more comprehensive understandings about both the motion properties and affects.

With the above limitations in mind, the implication and application of findings of this study requires further studies to provide. Instead of proposing motionscape affects and principles that can be immediately applied in the current practice, we focus on the detection of possible directions.

The effort of this thesis is aimed for the field of affective visualization within interactive artifacts and environments. That being said, the visible objective of this thesis is to provide insights about the motionscape as an affective visual element in games, visualization, virtual reality and interface. And even given this specific and relatively limited scope, this effort is still extremely brief. But the further objective of this thesis is beyond its provided discussion and envision. It aims to initiate a discussion on how visual motion can be composed to articulate affective contents, in an effort that is similar to the composition in stage art, painting, experimental animation, and even music. We hope the findings of this study will complement the understanding of the motionscape semantics, and the language of motion in general.

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Appendix A.

Additional Tables: Cinematographic Motionscape Study

Significant Main Effects and Interactions of All Factors

Table A.1 Significant Main Effects and Interaction Effects

Valence Negative - Positive	Shape: $F(3,33)=7.377$, $p = .001$ Speed: $F(1,11)=14.643$, $p=.003$ Shape*Curvature: $F(6,66)=3.019$, $p=.011$ Shape*Direction*Speed: $F(3,33)=2.968$, $p=.046$
Intensity Calming - Exciting	Shape: $F(3,33)=19.390$, $p<.001$ Speed: $F(1,11)=28.409$, $p<.001$ Shape*Speed: $F(3,33)=3.238$, $p=.034$ Shape*Curvature: $F(6,66)=2.559$, $p=.027$
Urgency Urgent - Relaxed	Shape: $F(3,33)=20.087$, $p<.001$ Speed: $F(1,11)=58.995$, $p<.001$ Direction*Speed: $F(1,11)=9.636$, $p=.010$ Shape*Curvature: $F(6,66)=6.953$, $p<.001$
Dominance Reassuring - Threatening	Shape: $F(3,33)=16.343$, $p<.001$ Direction: $F(1,11)= 6.275$, $p=.029$ Speed: $F(1,11)=33.075$, $p<.001$ Direction*Speed: F(1,11)=6.461, $p=.027$ Shape*Curvature: $F(6,66)=3.419$, $p=.005$
Interaction Attracting - Rejecting	Shape: $F(3,33)=5.163$, $p=.005$ Direction: $F(1,11)=7.976$, $p=.017$ Speed: $F(1,11)=18.475$, $p=.001$ Shape*Direction: $F(3,33)=5.127$, $p=.005$

Note. Only significant main effects and interactions are listed

Table A.2 Significant Main Effects

Shape	Main Effect	Valence (NP)	Intensity (CE)	Urgency (UR)	Dominance (RT)	Interaction (AR)
Linear	Speed	*F*(1, 11) = 9.203 *p* = .011	*F*(1, 11) = 22.513 *p* = .001	*F*(1, 11) = 59.446 *p* < .001	*F*(1, 11) = 21.883 *p* =. 001	*F*(1, 11) = 11.741 *p* = .006
	Dir					*F*(1, 11) = 8.602 *p* = .014
	PC		*F*(1.584, 17.429) = 5.604 *p* = .018	*F*(1.635, 17.986) =16.001 *p* = .002		*F*(2, 22) = 5.399 *p* = .012
Circular	Speed	*F*(1, 11) = 8.486 *p* = .014	*F*(1, 11) = 31.455 *p* < .001	*F*(1, 11) = 40.856 *p* < .001	*F*(1, 11) = 31.147 *p* < .001	*F*(1, 11) = 21.466 *p* = .001
	PC	*F*(1.539, 16.928) = 4.555 *p* = .034				
Spheric- -al	Speed	*F*(1, 11) = 28.192 *p* < .001	*F*(1, 11) = 24.486 *p* < .001	*F*(1, 11) = 53.207 *p* < .001	*F*(1, 11) = 41.969 *p*<.001	*F*(1, 11) = 19.658 *p* = .001
	Dir				F(1, 11) = 4.883 P = .049	F(1, 11) = 7.854 P = .017
Radial	Speed	*F*(1, 11) = 7.7170 *p* = .021	*F*(1, 11) = 28.037 *p* < .001	*F*(1, 11) = 41.781 *p* < .001	*F*(1, 11) = 10.007 *p* = .009	*F*(1, 11) = 9.910 *p* = .009
	Dir					*F*(1, 11) = 6.718 *p* = .025

Note. Main effects of speed, path curvature (PC), direction (Dir) on all affective ratings by shape. Only significant effects are listed

Means & Standard Errors

The following tables report means, standard errors and confidence intervals; results are grouped by significant main effects and interactions.

Shape

Table A.3 Main Effect of Shape on Valence (NP)

Measure: Negative - Positive

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Linear	9.752	8.135	-8.153	27.657
Radial	-.706	5.006	-11.725	10.312
Circular	-5.915	4.246	-15.260	3.431
Spherical	-22.851	6.990	-38.237	-7.466

Table A.4 Main Effect of Shape on Intensity (CE)

Measure: Calming - Exciting

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Linear	-8.790	2.709	-14.753	-2.827
Radial	8.799	3.045	2.098	15.501
Circular	-.674	2.192	-5.498	4.150
Spherical	14.070	3.877	5.538	22.602

Table A.5 Main Effect of Shape on Urgency (UR)

Measure: Urgent - Relaxed

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Linear	11.844	3.539	4.055	19.634
Radial	-12.966	3.819	-21.371	-4.560
Circular	-10.328	3.345	-17.690	-2.966
Spherical	-23.483	4.466	-33.314	-13.653

Table A.6 Main Effect of Shape on Dominance (RT)

Measure: Reassuring - Threatening

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Linear	-11.725	5.719	-24.313	.862
Radial	5.556	4.224	-3.742	14.853
Circular	3.383	3.999	-5.419	12.185
Spherical	26.169	6.961	10.849	41.489

Table A.7 Main Effect of Shape on Interaction (AR)

Measure: Attracting - Rejecting

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Linear	-9.286	5.274	-20.894	2.322
Radial	-1.665	5.428	-13.611	10.281
Circular	-1.514	6.635	-16.116	13.089
Spherical	13.111	5.165	1.744	24.479

Speed

Table A.8 Main Effect of Speed on Valence (NP)

Measure: Negative - Positive

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Slow	8.808	4.560	-1.229	18.845
Fast	-18.668	6.811	-33.660	-3.677

Table A.9 Main Effect of Speed on Intensity (CE)

Measure: Calming - Exciting

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Slow	-21.468	4.701	-31.815	-11.122
Fast	28.171	5.616	15.810	40.532

Table A.10 Main Effect of Speed on Urgency (UR)

Measure: Urgent - Relaxed

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Slow	21.253	3.637	13.248	29.258
Fast	-38.720	5.469	-50.758	-26.682

Table A.11 Main Effect of Speed on Dominance (RT)

Measure: Reassuring - Threatening

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Slow	-12.844	5.081	-24.028	-1.660
Fast	24.536	5.525	12.375	36.696

Table A.12 Main Effect of Speed on Interaction (AR)

Measure: Attracting - Rejecting

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Slow	-13.380	3.165	-20.347	-6.413
Fast	13.703	6.953	-1.599	29.006

Shape * Speed

Table A.13 Interaction Effect of Shape and Speed on Valence (NP)

Measure: Negative - Positive

Shape	Speed	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Linear	Slow	21.908	8.677	2.810	41.005
	Fast	-2.404	9.443	-23.189	18.381
Radial	Slow	12.672	4.533	2.695	22.649
	Fast	-14.085	8.916	-33.709	5.540
Circular	Slow	6.410	3.151	-.526	13.347
	Fast	-18.240	7.869	-35.560	-.919
Spherical	Slow	-5.757	6.853	-20.842	9.327
	Fast	-39.945	8.455	-58.554	-21.336

Table A.14 Interaction Effect of Shape and Speed on Intensity (CE)

Measure: Calming - Exciting

Shape	Speed	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Linear	Slow	-29.701	5.281	-41.324	-18.078
	Fast	12.120	5.063	.976	23.264
Radial	Slow	-17.931	4.755	-28.396	-7.466
	Fast	35.529	6.849	20.456	50.603
Circular	Slow	-26.709	5.310	-38.397	-15.022
	Fast	25.362	4.951	14.466	36.259
Spherical	Slow	-11.533	5.232	-23.048	-.017
	Fast	39.672	7.498	23.169	56.176

Table A.15 Interaction Effect of Shape and Speed on Urgency (UR)

Measure: Urgent - Relaxed

Shape	Speed	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Linear	Slow	39.328	5.550	27.112	51.544
	Fast	-15.640	4.434	-25.398	-5.881
Radial	Slow	18.993	4.371	9.373	28.614
	Fast	-44.925	7.678	-61.825	-28.025
Circular	Slow	17.088	5.246	5.542	28.635
	Fast	-37.743	5.626	-50.125	-25.361
Spherical	Slow	9.604	6.231	-4.110	23.317
	Fast	-56.571	6.498	-70.872	-42.269

Table A.16 Interaction Effect of Shape and Speed on Dominance (RT)

Measure: Reassuring - Threatening

Shape	Speed	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Linear	Slow	-29.048	7.028	-44.517	-13.579
	Fast	5.597	6.591	-8.910	20.104
Radial	Slow	-10.518	6.015	-23.757	2.721
	Fast	21.629	7.151	5.889	37.368
Circular	Slow	-16.340	3.648	-24.369	-8.311
	Fast	23.107	6.607	8.564	37.649
Spherical	Slow	4.529	7.534	-12.054	21.111
	Fast	47.810	7.903	30.416	65.203

Table A.17 Interaction Effect of Shape and Speed on Interaction (AR)

Measure: Attracting - Rejecting

Shape	Speed	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Linear	Slow	-20.958	4.659	-31.212	-10.704
	Fast	2.386	7.559	-14.251	19.023
Radial	Slow	-15.118	3.783	-23.445	-6.790
	Fast	11.788	9.007	-8.036	31.612
Circular	Slow	-14.233	5.708	-26.797	-1.669
	Fast	11.206	8.398	-7.278	29.690
Spherical	Slow	-3.211	4.807	-13.792	7.370
	Fast	29.434	7.573	12.767	46.101

Shape * Direction

Table A.18 Interaction Effect of Shape and Direction on Valence (NP)

Measure: Negative - Positive

Shape	Direction	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Linear	1	5.953	9.420	-14.781	26.688
	2	13.551	7.297	-2.511	29.612
Radial	1	-2.303	6.829	-17.333	12.728
	2	.890	3.909	-7.714	9.495
Circular	1	-6.737	5.440	-18.711	5.238
	2	-5.093	5.258	-16.664	6.479
Spherical	1	-26.205	8.022	-43.860	-8.549
	2	-19.498	7.632	-36.296	-2.700

Table A.19 Interaction Effect of Shape and Direction on Intensity (CE)

Measure: Calming Exciting

Shape	Direction	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	-5.769	3.700	-13.914	2.375
	2	-11.811	3.231	-18.923	-4.700
2	1	10.488	3.519	2.744	18.232
	2	7.111	3.322	-.201	14.423
3	1	-2.772	3.778	-11.087	5.544
	2	1.425	1.685	-2.285	5.134
4	1	13.307	3.643	5.288	21.326
	2	14.833	5.259	3.257	26.409

Table A.20 Interaction Effect of Shape and Direction on Urgency (UR)

Measure: Urgent - Relaxed

Shape	Direction	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	10.506	4.406	.809	20.202
	2	13.183	3.959	4.469	21.897
2	1	-10.506	5.377	-22.341	1.330
	2	-15.426	3.547	-23.234	-7.619
3	1	-8.410	2.383	-13.655	-3.166
	2	-12.245	4.734	-22.665	-1.824
4	1	-25.754	4.179	-34.953	-16.555
	2	-21.213	5.722	-33.806	-8.620

Table A.21 Interaction Effect of Shape and Direction on Dominance (RT)

Measure: Reassuring - Threatening

Shape	Direction	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Linear	Outward	-8.422	6.857	-23.515	6.670
	Inward	-15.028	5.407	-26.928	-3.129
Radial	Outward	11.259	5.482	-.806	23.325
	Inward	-.148	4.736	-10.573	10.276
Circular	Clockwise	1.442	5.376	-10.389	13.274
	Counter-Clockwise	5.324	3.560	-2.512	13.160
Spherical	Outward	33.221	7.009	17.794	48.647
	Inward	19.118	8.255	.950	37.286

Table A.22 Interaction Effect of Shape and Direction on Interaction (AR)

Measure: Attracting - Rejecting

Shape	Direction	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Linear	Outward	.196	6.379	-13.844	14.235
	Inward	-18.768	5.987	-31.946	-5.590
Radial	Outward	9.788	6.257	-3.984	23.559
	Inward	-13.117	7.669	-29.997	3.762
Circular	Clockwise	-1.419	6.360	-15.418	12.580
	Counter-Clockwise	-1.608	7.733	-18.629	15.412
Spherical	Outward	28.532	6.634	13.930	43.133
	Inward	-2.309	8.360	-20.709	16.091

Shape * Path Curvature

Table A.23 Interaction Effect of Shape and Direction (NP)

Measure: Negative - Positive

Shape	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Linear	Straight	13.800	9.412	-6.916	34.515
	Wavy	6.722	9.123	-13.358	26.802
	Angular	8.734	7.992	-8.857	26.324
Radial	Straight	1.175	9.559	-19.865	22.215
	Wavy	-3.579	4.091	-12.583	5.425
	Angular	.285	6.497	-14.015	14.584
Circular	Straight	-20.798	9.840	-42.454	.859
	Wavy	-3.971	4.487	-13.847	5.906
	Angular	7.025	4.832	-3.610	17.659
Spherical	Straight	-17.824	9.297	-38.287	2.638
	Wavy	-29.550	6.213	-43.225	-15.874
	Angular	-21.181	7.759	-38.259	-4.102

Table A.24 Interaction Effect of Shape and Direction on Intensity (CE)

Measure: Calming - Exciting

Shape	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Linear	Straight	-21.083	4.420	-30.810	-11.355
	Wavy	1.273	5.153	-10.068	12.614
	Angular	-6.562	4.675	-16.852	3.728
Radial	Straight	8.244	5.268	-3.350	19.839
	Wavy	7.559	4.253	-1.801	16.919
	Angular	10.595	3.693	2.466	18.724
Circular	Straight	2.119	4.362	-7.482	11.720
	Wavy	-1.781	4.429	-11.529	7.968
	Angular	-2.359	3.447	-9.947	5.228
Spherical	Straight	9.642	4.179	.445	18.839
	Wavy	15.313	3.949	6.622	24.005
	Angular	17.254	5.645	4.830	29.679

Table A.25 Interaction Effect of Shape and Direction on Urgency (UR)

Measure: Urgent - Relaxed

				95% Confidence Interval	
Shape	Curvature	Mean	Std. Error	Lower Bound	Upper Bound
Linear	Straight	27.911	7.100	12.285	43.538
	Wavy	2.199	2.471	-3.239	7.637
	Angular	5.422	4.325	-4.096	14.940
Radial	Straight	-17.486	5.386	-29.340	-5.632
	Wavy	-6.722	4.185	-15.933	2.489
	Angular	-14.690	4.462	-24.510	-4.870
Circular	Straight	-19.712	8.606	-38.654	-.769
	Wavy	-5.110	5.591	-17.416	7.195
	Angular	-6.161	2.911	-12.569	.247
Spherical	Straight	-21.439	7.085	-37.032	-5.846
	Wavy	-28.419	4.260	-37.795	-19.042
	Angular	-20.593	4.416	-30.312	-10.874

Table A.26 Interaction Effect of Shape and Direction on Dominance (RT)

Measure: Reassuring - Threatening

Shape	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Linear	Straight	-19.302	8.253	-37.466	-1.138
	Wavy	-7.790	6.100	-21.216	5.635
	Angular	-8.084	5.222	-19.577	3.409
Radial	Straight	5.458	7.825	-11.766	22.681
	Wavy	4.986	2.983	-1.579	11.550
	Angular	6.223	4.828	-4.402	16.849
Circular	Straight	15.563	7.732	-1.456	32.581
	Wavy	-1.255	6.167	-14.829	12.318
	Angular	-4.158	3.669	-12.233	3.917
Spherical	Straight	24.822	8.714	5.642	44.002
	Wavy	27.279	6.350	13.303	41.255
	Angular	26.407	7.456	9.996	42.817

Table A.27 Interaction effect of Shape and Direction on Interaction (AR)

Measure: Attracting - Rejecting

Shape	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Linear	Straight	-21.145	7.722	-38.142	-4.148
	Wavy	-5.725	4.880	-16.466	5.016
	Angular	-.988	6.415	-15.107	13.131
Radial	Straight	-4.496	8.892	-24.068	15.076
	Wavy	4.042	4.877	-6.691	14.775
	Angular	-4.541	6.942	-19.820	10.739
Circular	Straight	4.095	11.214	-20.586	28.777
	Wavy	-.062	7.950	-17.560	17.436
	Angular	-8.574	8.934	-28.237	11.089
Spherical	Straight	8.859	7.338	-7.292	25.009
	Wavy	15.910	5.544	3.708	28.112
	Angular	14.566	6.103	1.133	27.998

Appendix B.

Additional Tables:
Stereoscopic Motionscape Study

Table B.1 and B.75 report significant main effects and interaction effects detected in both linear motionscape experiment and non-linear motionscape experiment; the F values and p values are grouped by affective ratings.

The rest tables report means, standard errors and confidence intervals; results are grouped by significant main effects and interactions. In these tables, variations of factors (independent variables) are labeled as numbers. Each variation and its label of all factors is listed as below:

Linear Motionscape Experiment

Display:

VR/Desktop Stereoscopic Display (1)

Standard Non-3D Display (2)

Speed:

Slow (1)

Fast (2)

Direction:

Inward (1)

Outward (2)

Upward (3)

Downward (4)

Path Curvature:

Straight (1)

Non-straight (2)

View Point:

Inside (1)
Outside (2)

Non-linear Motionscape Experiment

Display:

VR/Desktop Stereoscopic Display (1)
Standard Non-3D Display (2)

Shape:

Spherical (1)
Spiral (2)

Speed:

Slow (1)
Fast (2)

Direction:

Spherical motionscapes: Inward (1); Outward (2)
Spiral motionscapes: Outward (1); Inward (2)

Path Curvature:

Straight (1)
Non-straight (2)

View Point:

Inside (1)
Outside (2)

Linear Motionscape Experiment

Table B.1. Significant Main Effects and Interaction Effects

	VR Group	Desktop 3D Group
Negative	S: $F(1,11)=36.284$, $p<.001$ Dir: $F(2.124,23.359)=4.849$, $p=.016$ (Huynh-Feldt) PC: $F(1,11)=5.455$, $p=.039$ S*Dir: $F(3,33)=3.001$, $p=.044$ S*PC: F(1,11)=11.476, $p=.006$ Disp*S*Dir: $F(3,33)=3.236$, $p=.035$	S: $F(1,11)=19.296$, $p=.001$ Dir: $F(1.653,18.186)=3.972$, $p=.044$ (Huynh-Feldt) PC: $F(1,11)=10.738$, $p=.007$ S*PC: $F(1,11)=16.942$, $p=.002$ S*VP: $F(1,11)=5.226$, $p=.043$ Dir*VP: $F(3,33)=3.149$, $p=.038$
Positive	Dir: $F(2.065,22.712)=5.185$, $p=.013$ (Huynh-Feldt) PC: $F(1,11)=14.873$, $p=.003$ S*Dir: $F(3,33)=6.221$, $p=.002$ S*PC: $F(1,11)=5.302$, $p=.042$ Disp*VP: $F(1,11)=6.125$, $p=.031$	S: $F(1,11)=6.922$, $p=.023$ Dir: $F(2.132,23.451)=3.858$, $p=.033$ (Huynh-Feldt) PC: $F(1,11)=6.590$, $p=.026$ Disp*S*Dir: $F(3,33)=7.949$, $p<.001$ Dir*PC: $F(3,33)=4.232$, p=.012 S*Dir*PC*VP: $F(3,33)=3.305$, $p=.032$
Calming	S: $F(1,11)=91.950$, $p<.001$ PC: F(1,11)=11.734, $p=.006$ VP: $F(1,11) = 5.782$, $p=.035$ Dir*PC: $F(1.904,20.945)=6.877$, $p=.006$ (Huynh-Feldt) Dir*VP: $F(3,33)=3.134$, $p=.039$ S*Dir*VP: $F(3,33)=4.608$, $p=.008$ S*PC*VP: $F(1,11)=6.125$, $p=.031$ S*Dir*PC*VP: $F(3,33)=3.134$, $p=.039$	S: $F(1,11)=42.780$, $p<.001$ Dir: $F(3,33)=4.789$, $p=.007$ PC: $F(1,11)=19.694$, $p=.001$ Dir*PC: $F(3,33)=4.123$, $p=.014$ S*Dir*VP: $F(3,33)=4.466$, $p=.010$ Disp*PC*VP: $F(1,11)=13.909$, $p=.003$ S*PC*VP: $F(1,11)=15.742$, $p=.002$

Exciting	Disp: $F(1,11)=7.196$, $p=.021$ S: $F(1,11)=28.803$, $p<.001$ Dir: $F(3,33)=5,423$, $p=.004$ VP: $F(1,11)=28.840$, $p<.001$ S*VP: $F(1,11)=16.003$, $p=.002$	S: $F(1,11)=33.137$, $p<.001$ Dir: $F(3,33)=9.045$, $p<.001$ PC: $F(1,11)=15.017$, $p=.003$ VP: $F(1,11)=24.069$, $p<.001$ S*PC: $F(1,11)=5.553$, $p=.038$ Disp*S*VP: $F(1,11)=6.067$, $p=.032$
Urgent	Disp: $F(1,11)=8.829$, $p=.013$ S: $F(1,11)=95.018$, $p<.001$ Dir: $F(1.778,19.559)=8.246$, $p=.003$ (Huynh-Feldt) PC: $F(1,11)=39.474$, $p<.001$ VP: $F(1,11)=16.221$, $p<.002$	S: $F(1,11)=58.137$, $p<.001$ Dir: $F(3,33)=5.533$, $p=.003$ PC: $F(1,11)=37.551$, $p<.001$ VP: $F(1,11)=16.427$, $p=.002$ S*Dir: $F(3,33)=5.999$, $p=.002$

VR Group

Display

Table B.2. Main Effect of Display on Exciting

Measure: Exciting

Display	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
VR	23.942	3.080	17.162	30.722
Non-3D	20.556	2.762	14.477	26.634

Table B.3 Main Effect of Display on Urgent

Measure: Urgent

Display	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
VR	32.066	3.243	24.929	39.203
Non-3D	27.220	2.839	20.971	33.468

Table B.4 Main Effect of Display on Rejecting

Measure: Rejecting

Display	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
VR	28.452	3.320	21.144	35.759
Non-3D	24.244	2.594	18.535	29.954

Speed

Table B.5. Main Effect of Speed on Negative

Measure: Negative

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	18.005	2.453	12.606	23.403
2	33.890	3.413	26.377	41.403

Table B.6. Main Effect of Speed on Positive

Measure: Positive

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	29.326	2.813	23.135	35.517
2	23.051	3.400	15.568	30.534

Table B.7. Main Effect of Speed on Calming

Measure: Calming

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	42.494	3.324	35.177	49.811
2	6.141	1.436	2.981	9.301

Table B.8. Main Effect of Speed on Exciting

Measure: Exciting

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	6.995	1.466	3.769	10.222
2	37.502	5.507	25.381	49.623

Table B.9. Main Effect of Speed on Urgent

Measure: Urgent

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	6.268	1.268	3.477	9.058
2	53.018	5.209	41.552	64.483

Table B.10. Main Effect of Speed on Relaxed

Measure: Relaxed

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	38.354	3.615	30.396	46.311
2	4.934	1.423	1.802	8.065

Table B.11. Main Effect of Speed on Reassuring

Measure: Reassuring

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	34.143	3.652	26.106	42.180
2	8.802	1.781	4.883	12.721

Table B.12. Main Effect of Speed on Threatening

Measure: Threatening

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	6.781	.971	4.643	8.920
2	32.467	3.638	24.460	40.474

Table B.13. Main Effect of Speed on Attracting

Measure: Attracting

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	29.362	3.657	21.314	37.410
2	21.297	2.497	15.802	26.792

Table B.14. Main Effect of Speed on Rejecting

Measure: Rejecting

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	17.686	2.230	12.777	22.594
2	35.011	3.804	26.638	43.384

Direction

Table B.15. Main Effect of Direction on Positive

Measure:Positive

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	24.795	3.256	17.628	31.962
2	26.114	5.086	14.920	37.307
3	39.314	6.559	24.878	53.750
4	14.533	2.851	8.258	20.807

Table B.16. Main Effect of Direction on Exciting

Measure: Exciting

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	21.869	2.776	15.758	27.979
2	21.366	3.285	14.136	28.597
3	26.242	3.240	19.111	33.373
4	19.518	2.851	13.243	25.793

Table B.17. Main Effect of Direction on Urgent

Measure: Urgent

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	26.661	2.989	20.083	33.239
2	27.611	3.065	20.866	34.357
3	33.634	3.109	26.791	40.478
4	30.664	3.183	23.658	37.670

Table B.18. Main Effect of Direction on Threatening

Measure: Threatening

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	14.598	2.262	9.619	19.576
2	26.323	3.786	17.991	34.656
3	17.744	2.158	12.995	22.493
4	19.831	3.291	12.588	27.074

Path Curvature

Table B.19. Main Effect of Path Curvature on Negative

Measure: Negative

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	21.340	3.085	14.550	28.130
2	30.556	3.529	22.787	38.324

Table B.20. Main Effect of Path Curvature on Positive

Measure: Positive

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	31.321	2.491	25.839	36.804
2	21.056	3.353	13.676	28.436

Table B.21. Main Effect of Path Curvature on Calming

Measure: Calming

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	27.699	2.025	23.242	32.157
2	20.936	1.943	16.660	25.212

Table B.22. Main Effect of Path Curvature on Urgent

Measure: Urgent

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	24.846	3.129	17.960	31.733
2	34.439	2.936	27.977	40.901

Table B.23. Main Effect of Path Curvature on Relaxed

Measure: Relaxed

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	24.910	2.764	18.826	30.994
2	18.035	1.992	13.651	22.420

Table B.24. Main Effect of Path Curvature on Threatening

Measure: Threatening

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	15.129	2.164	10.367	19.891
2	24.119	2.260	19.144	29.093

Table B.25. Main Effect of Path Curvature on Attracting

Measure: Attracting

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	29.917	2.683	24.011	35.823
2	20.742	2.962	14.222	27.261

Table B.26. Main Effect of Path Curvature on Rejecting

Measure: Rejecting

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	21.431	2.793	15.283	27.579
2	31.265	3.563	23.422	39.108

View Point

Table B.27. Main Effect of View Point on Negative

Measure: Negative

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	28.146	3.143	21.229	35.064
2	23.749	2.700	17.807	29.691

Table B.28. Main Effect of View Point on Calming

Measure: Calming

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	22.995	1.724	19.201	26.789
2	25.640	1.887	21.487	29.793

Table B.29. Main Effect of View Point on Exciting

Measure: Exciting

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	25.979	3.187	18.965	32.992
2	18.519	2.670	12.641	24.396

Table B.30. Main Effect of View Point on Urgent

Measure: Urgent

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	33.265	3.407	25.766	40.764
2	26.020	2.693	20.093	31.948

Table B.31. Main Effect of View Point on Threatening

Measure: Threatening

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	23.809	2.302	18.742	28.877
2	15.439	2.006	11.023	19.854

*Speed * Path Curvature*

Table B.32. Interaction Effect of Speed and Path Curvature on Negative

Measure: Negative

Speed	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	17.298	2.800	11.134	23.462
	2	18.712	2.628	12.928	24.495
2	1	25.382	4.036	16.498	34.265
	2	42.399	5.017	31.357	53.442

Table B.33. Interaction Effect of Speed and Path Curvature on Positive

Measure: Positive

Speed	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	32.619	2.733	26.604	38.634
	2	26.033	3.313	18.742	33.325
2	1	30.024	3.648	21.995	38.052
	2	16.079	4.103	7.049	25.108

Table B.34. Interaction Effect of Speed and Path Curvature on Urgent

Measure: Urgent

Speed	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	4.724	1.013	2.495	6.953
	2	7.812	1.718	4.031	11.592
2	1	44.968	5.633	32.571	57.366
	2	61.067	5.087	49.870	72.263

Table B.35. Interaction Effect of Speed and Path Curvature on Reassuring

Measure: Reassuring

Speed	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	35.530	3.858	27.039	44.020
	2	32.756	3.849	24.284	41.229
2	1	14.291	2.692	8.366	20.215
	2	3.314	.995	1.124	5.504

Table B.36. Interaction Effect of Speed and Path Curvature on Threatening

Measure: Threatening

Speed	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	6.927	1.391	3.864	9.989
	2	6.636	1.061	4.300	8.972
2	1	23.332	3.673	15.249	31.415
	2	41.601	4.364	31.995	51.207

Table B.37. Interaction Effect of Speed and Path Curvature on Attracting

Measure: Attracting

Speed	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	31.624	3.980	22.866	40.383
	2	27.099	3.731	18.888	35.310
2	1	28.210	2.737	22.185	34.235
	2	14.384	3.124	7.508	21.261

Table B.38. Interaction Effect of Speed and Path Curvature on Rejecting

Measure: Rejecting

Speed	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	16.173	2.274	11.167	21.179
	2	19.198	2.698	13.260	25.135
2	1	26.689	3.678	18.593	34.784
	2	43.333	5.012	32.302	54.364

Desktop 3D Group

Speed

Table B.39. Main Effect of Speed on Negative

Measure: Negative

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	11.085	2.658	5.234	16.935
2	25.600	5.074	14.431	36.768

Table B.40. Main Effect of Speed on Positive

Measure: Positive

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	25.988	4.232	16.673	35.302
2	17.037	3.633	9.041	25.032

Table B.41. Main Effect of Speed on Calming

Measure: Calming

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	38.549	5.344	26.787	50.312
2	4.137	.766	2.452	5.822

Table B.42. Main Effect of Speed on Exciting

Measure: Exciting

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	7.339	1.634	3.743	10.935
2	38.170	6.584	23.679	52.661

Table B.43. Main Effect of Speed on Urgent

Measure: Urgent

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	4.692	1.311	1.807	7.576
2	47.661	6.142	34.143	61.179

Table B.44. Main Effect of Speed on Relaxed

Measure: Relaxed

			95% Confidence Interval	
Speed	Mean	Std. Error	Lower Bound	Upper Bound
1	39.052	6.418	24.926	53.179
2	6.484	1.274	3.679	9.289

Table B.45. Main Effect of Speed on Reassuring

Measure: Reassuring

			95% Confidence Interval	
Speed	Mean	Std. Error	Lower Bound	Upper Bound
1	32.620	4.633	22.423	42.818
2	12.997	2.205	8.144	17.849

Table B.46. Main Effect of Speed on Threatening

Measure: Threatening

			95% Confidence Interval	
Speed	Mean	Std. Error	Lower Bound	Upper Bound
1	5.865	1.623	2.294	9.437
2	26.312	4.847	15.643	36.981

Table B.47. Main Effect of Speed on Rejecting

Measure: Rejecting

			95% Confidence Interval	
Speed	Mean	Std. Error	Lower Bound	Upper Bound
1	8.371	1.935	4.112	12.629
2	23.646	4.947	12.758	34.534

Direction

Table B.48. Main Effect of Direction on Negative

Measure: Negative

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	14.594	2.991	8.012	21.177
2	18.739	3.981	9.977	27.500
3	14.246	3.895	5.673	22.820
4	25.789	6.042	12.490	39.088

Table B.49. Main Effect of Direction on Positive

Measure: Positive

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	23.038	4.039	14.149	31.926
2	20.995	3.282	13.771	28.218
3	27.416	5.913	14.402	40.430
4	14.601	3.268	7.409	21.794

Table B.50. Main Effect of Direction on Calming

Measure: Calming

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	22.725	2.639	16.916	28.534
2	20.666	2.879	14.331	27.002
3	18.981	2.896	12.608	25.354
4	23.001	3.035	16.321	29.681

Table B.51. Main Effect of Direction on Exciting

Measure: Exciting

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	20.328	3.716	12.148	28.507
2	23.216	4.110	14.170	32.262
3	26.788	4.589	16.689	36.888
4	20.687	3.812	12.296	29.078

Table B.52. Main Effect of Direction on Urgent

Measure: Urgent

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	23.005	3.498	15.306	30.704
2	24.971	3.819	16.564	33.377
3	29.030	3.642	21.014	37.046
4	27.699	3.318	20.398	35.001

Table B.53. Main Effect of Direction on Reassuring

Measure: Reassuring

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	27.089	3.919	18.463	35.714
2	20.958	2.401	15.675	26.242
3	22.236	3.626	14.256	30.216
4	20.951	2.796	14.797	27.105

Table B.54. Main Effect of Direction on Threatening

Measure: Threatening

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	10.477	2.134	5.780	15.174
2	20.898	3.415	13.382	28.414
3	16.028	3.379	8.590	23.466
4	16.951	3.489	9.273	24.630

Table B.55. Main Effect of Direction on Attracting

Measure: Attracting

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	28.368	3.989	19.588	37.149
2	19.955	3.874	11.429	28.482
3	25.061	5.081	13.877	36.245
4	19.546	4.229	10.238	28.853

Table B.56. Main Effect of Direction on Rejecting

Measure: Rejecting

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	10.310	2.589	4.612	16.008
2	20.673	3.796	12.318	29.027
3	14.613	3.339	7.264	21.963
4	18.437	3.829	10.010	26.863

Path Curvature

Table B.57. Main Effect of Path Curvature on Negative

Measure: Negative

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	14.501	2.876	8.171	20.831
2	22.183	4.672	11.900	32.467

Table B.58. Main Effect of Path Curvature on Positive

Measure: Positive

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	24.858	3.848	16.389	33.327
2	18.166	3.730	9.957	26.376

Table B.59. Main Effect of Path Curvature on Calming

Measure: Calming

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	25.037	3.219	17.951	32.122
2	17.650	2.516	12.113	23.187

Table B.60. Main Effect of Path Curvature on Exciting

Measure: Exciting

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	19.289	3.504	11.577	27.002
2	26.220	4.582	16.136	36.305

Table B.61. Main Effect of Path Curvature on Urgent

Measure: Urgent

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	20.854	3.171	13.876	27.833
2	31.498	3.875	22.969	40.027

Table B.62. Main Effect of Path Curvature on Relaxed

Measure: Relaxed

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	26.145	3.956	17.439	34.851
2	19.392	3.213	12.321	26.463

Table B.63. Main Effect of Path Curvature on Reassuring

Measure: Reassuring

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	28.270	3.998	19.469	37.070
2	17.348	2.505	11.834	22.861

Table B.64. Main Effect of Path Curvature on Threatening

Measure: Threatening

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	11.091	2.350	5.919	16.263
2	21.086	3.641	13.072	29.099

Table B.65. Main Effect of Path Curvature on Rejecting

Measure: Rejecting

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	13.064	2.570	7.407	18.720
2	18.953	3.689	10.833	27.073

View Point

Table B.66. Main Effect of View Point on Exciting

Measure: Exciting

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	26.687	4.614	16.532	36.842
2	18.822	3.416	11.303	26.341

Table B.67. Main Effect of View Point on Urgent

Measure: Urgent

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	29.589	4.087	20.593	38.585
2	22.764	2.877	16.432	29.095

Table B.68. Main Effect of View Point on Threatening

Measure: Threatening

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	19.000	3.355	11.617	26.384
2	13.177	2.592	7.473	18.881

Table B.69. Main Effect of View Point on Attracting

Measure: Attracting

ViewPoint	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	25.452	4.301	15.986	34.918
2	21.013	3.675	12.924	29.102

*Speed * Path Curvature*

Table B.70. Interaction Effect of Speed and Path Curvature on Negative

Measure: Negative

Speed	Curvature	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	1	9.955	2.511	4.428	15.481
	2	12.214	3.142	5.299	19.130
2	1	19.047	3.783	10.721	27.374
	2	32.152	6.509	17.825	46.479

Table B.71. Interaction Effect of Speed and Path Curvature on Exciting

Measure: Exciting

Speed	Curvature	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	1	5.076	1.163	2.515	7.636
	2	9.603	2.372	4.381	14.824
2	1	33.503	6.194	19.870	47.136
	2	42.838	7.136	27.131	58.544

Table B.72. Interaction Effect of Speed and Path Curvature on Urgent

Measure: Urgent

Speed	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	3.166	.861	1.271	5.060
	2	6.218	2.008	1.798	10.637
2	1	38.543	5.876	25.611	51.475
	2	56.778	6.730	41.966	71.591

Table B.73. Interaction Effect of Speed and Path Curvature on Threatening

Measure: Threatening

Speed	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	4.535	1.490	1.255	7.814
	2	7.196	2.123	2.524	11.868
2	1	17.648	3.905	9.054	26.242
	2	34.975	6.099	21.551	48.400

Table B.74. Interaction Effect of Speed and Path Curvature on Rejecting

Measure: Rejecting

Speed	Curvature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	8.282	1.947	3.996	12.567
	2	8.460	2.264	3.477	13.443
2	1	17.845	4.059	8.912	26.779
	2	29.446	6.058	16.113	42.780

Non-linear Motionscapes

Table B.75. Significant Main Effects and Interaction Effects

	LS vs. NS	SS vs. NS
Negative	S: *F*(1,11)=33.420, *p*<.001 VP: *F*(1,11)=49.958, *p*<.001 Disp*Dir: *F*(1,11)=5.407, *p*=.040 Shape*Dir: *F*(1,11)=5.981, *p*=.033 Shape*S: *F*(1,11)=7.501, *p*=.019 S*VP: *F*(1,11)=30.419, *p*<.001 PC*VP: *F*(1,11)=8.089, *p*=.016 Disp*Shape*Dir*PC: *F*(1,11)=5.475, *p*=.039 Disp*Shape*S*PC: *F*(1,11)=4.964, *p*=.048	S: *F*(1,11)=14.156, *p*=.003 VP: *F*(1,11)=8.981, *p*=.012 S*PC: *F*(1,11)=6.771, *p*=.025 S*VP: *F*(1,11)=7.008, *p*=.023 Disp*Shape*Dir*S*VP: *F*(1,11)=5.036, *p*=.046 Shape*S*PC*VP: *F*(1,11)=10.392, *p*=.008
Positive	S: *F*(1,11)=22.178, *p*=.001 VP: *F*(1,11)=19.043, *p*=.001 S*VP: *F*(1,11)=11.026, *p*=.007 Disp*Shape: *F*(1,11)=6.155, *p*=.031 Disp*Dir*S: *F*(1,11)=5.018, *p*=.047 Disp*Shape*S*VP: *F*(1,11)=21.851, *p*=.001 Disp*Shape*S*PC: *F*(1,11)=6.906, *p*=.023	Disp: *F*(1,11)=5.014, *p*=.047 Disp*PC: *F*(1,11)=17.859, *p*=.001 S*PC: *F*(1,11)=10.134, *p*=.009 Disp*Shape*S*PC: *F*(1,11)=12.001, *p*=.005 Disp*Dir*S*VP: *F*(1,11)=4.890, *p*=.049 Shape*S*PC*VP: *F*(1,11)=25.886, *p*<.001

Calming	Shape: *F*(1,11)=23.411, *p*=.001 S: *F*(1,11)=65.279, *p*<.001 VP: *F*(1,11)=15.708, *p*=.002 Disp*PC: *F*(1,11)=5.843, *p*=.034 Shape*VP: *F*(1,11)=11.615, *p*=.006 Disp*Shape*Dir*PC: *F*(1,11)=5.839, *p*=.034 Disp*Shape*S*PC: *F*(1,11)=6.222, *p*=.030 Shape*Dir*VP: *F*(1,11)=6.945, *p*=.023 Shape*Dir*S*VP: *F*(1,11)=6.365, *p*=.028	Shape: *F*(1,11)=11.093, *p*=.007 S: *F*(1,11)=25.200, *p*<.001 Disp*Shape: *F*(1,11)=5.685, *p*=.036 Disp*S: *F*(1,11)=10.941, *p*=.007 Shape*S: *F*(1,11)=5.016, *p*=.047 Disp*PC: *F*(1,11)=22.787, *p*=.001 S*PC: *F*(1,11)=5.880, *p*=.034 Disp*Dir*PC: *F*(1,11)=5.061, *p*=.046 Disp*S*PC: *F*(1,11)=6.823, *p*=.024 Disp*Shape*Dir*S*VP: F(1,11)=5.965, p=.033 Dir*PC*VP: F(1,11)=5.291, p=.042 Dir*S*PC*VP: F(1,11)=5.348, p=.041
Exciting	Shape: *F*(1,11)=21.471, *p*=.001 S: *F*(1,11)=61.050, *p*<.001 VP: *F*(1,11)=15.648, *p*=.002 Shape*Dir*PC: *F*(1,11)=7.468, *p*=.019 Disp*Shape*Dir*S*PC: F(1,11)=8.713, *p*=.013	Disp: *F*(1,11)=4.823, *p*=.050 Shape: *F*(1,11)=14.576, *p*=.003 S: *F*(1,11)=28.018, *p*<.001 VP: *F*(1,11)=11.226, *p*=.006 Dir*S: *F*(1,11)=4.868, *p*=.050

VR Group

Display

Table B.76. Main Effect of Display on Threatening

Measure: Threatening

Display	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	24.954	3.084	18.167	31.741
2	19.619	2.367	14.409	24.828

Table B.77. Main Effect of Display on Rejecting

Measure: Rejecting

Display	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	23.426	3.681	15.323	31.528
2	17.031	2.941	10.557	23.505

Shape

Table B.78. Main Effect of Shape on Calming

Measure: Calming

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	25.748	2.313	20.656	30.840
2	17.904	3.118	11.041	24.767

Table B.79. Main Effect of Shape on Exciting

Measure: Exciting

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	20.794	2.639	14.985	26.602
2	28.522	3.285	21.291	35.753

Table B.80. Main Effect of Shape on Urgent

Measure: Urgent

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	23.310	1.550	19.898	26.722
2	32.117	2.919	25.692	38.542

Table B.81. Main Effect of Shape on Relaxed

Measure: Relaxed

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	22.734	3.107	15.896	29.572
2	16.812	3.232	9.699	23.926

Table B.82. Main Effect of Shape on Reassuring

Measure: Reassuring

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	23.069	2.071	18.511	27.627
2	16.399	2.827	10.177	22.622

Speed

Table B.83. Main Effect of Speed on Negative

Measure: Negative

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	14.437	1.915	10.222	18.652
2	34.421	4.045	25.519	43.323

Table B.84. Main Effect of Speed on Positive

Measure: Positive

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	30.568	4.019	21.721	39.414
2	18.668	2.133	13.972	23.364

Table B.85. Main Effect of Speed on Calming

Measure: Calming

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	34.519	3.974	25.772	43.266
2	9.133	1.704	5.383	12.883

Table B.86. Main Effect of Speed on Exciting

Measure: Exciting

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	10.184	1.981	5.824	14.544
2	39.131	4.394	29.461	48.802

Table B.87. Main Effect of Speed on Urgent

Measure: Urgent

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	8.220	1.338	5.275	11.165
2	47.207	3.699	39.065	55.348

Table B.88. Main Effect of Speed on Relaxed

Measure: Relaxed

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	31.891	4.699	21.549	42.234
2	7.655	1.816	3.659	11.651

Table B.89. Main Effect of Speed on Reassuring

Measure: Reassuring

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	28.792	3.421	21.261	36.322
2	10.677	1.390	7.617	13.737

Table B.90. Main Effect of Speed on Threatening

Measure: Threatening

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	10.655	1.923	6.423	14.887
2	33.918	3.807	25.538	42.297

Table B.91. Main Effect of Speed on Rejecting

Measure: Rejecting

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	14.472	3.078	7.697	21.248
2	25.984	4.453	16.182	35.786

Direction

Table B.92. Main Effect of Direction on Threatening

Measure: Threatening

Direction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	24.128	2.468	18.695	29.561
2	20.444	2.887	14.090	26.799

View point

Table B.93. Main Effect of View Point on Negative

Measure: Negative

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	34.457	3.645	26.433	42.480
2	14.401	2.188	9.584	19.217

Table B.94. Main Effect of View Point on Positive

Measure: Positive

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	19.160	2.666	13.293	25.027
2	30.076	3.679	21.978	38.173

Table B.95. Main Effect of View Point on Calming

Measure: Calming

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	17.958	2.693	12.031	23.884
2	25.694	2.901	19.309	32.079

Table B.96. Main Effect of View Point on Exciting

Measure: Exciting

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	30.475	3.268	23.283	37.667
2	18.841	3.165	11.876	25.806

Table B.97. Main Effect of View Point on Urgent

Measure: Urgent

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	36.354	2.413	31.043	41.664
2	19.073	2.056	14.548	23.598

Table B.98. Main Effect of View Point on Relaxed

Measure: Relaxed

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	15.827	2.669	9.952	21.702
2	23.719	3.529	15.951	31.488

Table B.99. Main Effect of View Point on Reassuring

Measure: Reassuring

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	15.273	1.771	11.374	19.172
2	24.196	3.041	17.503	30.888

Table B.100. Main Effect of View Point on Threatening

Measure: Threatening

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	33.679	4.122	24.608	42.751
2	10.893	1.520	7.548	14.238

Table B.101. Main Effect of View Point on Rejecting

Measure: Rejecting

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	25.994	3.971	17.254	34.734
2	14.462	3.016	7.824	21.100

*Shape * Direction*

Table B.102. Interaction Effect of Shape and Direction on Negative

Measure: Negative

Shape	Direction	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	19.480	2.377	14.249	24.711
	2	23.678	2.399	18.399	28.957
2	1	32.213	5.059	21.078	43.347
	2	22.344	3.781	14.022	30.666

Table B.103. Interaction Effect of Shape and Direction on Reassuring

Measure: Reassuring

Shape	Direction	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	25.445	2.643	19.627	31.264
	2	20.693	1.996	16.300	25.087
2	1	14.084	2.821	7.875	20.294
	2	18.715	3.068	11.962	25.467

Table B.104. Interaction Effect of Shape and Direction on Threatening

Measure: Threatening

Shape	Direction	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	15.664	2.158	10.913	20.414
	2	23.615	3.071	16.856	30.374
2	1	32.593	4.015	23.757	41.429
	2	17.274	3.157	10.325	24.223

Table B.105. Interaction Effect of Shape and Direction on Attracting

Measure: Attracting

Shape	Direction	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	36.821	3.346	29.457	44.185
	2	27.313	4.330	17.784	36.842
2	1	27.985	5.770	15.285	40.685
	2	39.371	3.857	30.883	47.859

Table B.106. Interaction Effect of Shape and Direction on Rejecting

Measure: Rejecting

Shape	Direction	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	15.450	3.366	8.042	22.859
	2	22.388	3.623	14.414	30.362
2	1	28.353	5.169	16.978	39.729
	2	14.721	3.322	7.410	22.032

*Speed * View Point*

Table B.107. Interaction Effect of Speed and View Point on Negative

Measure: Negative

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	19.327	2.741	13.295	25.360
	2	9.547	2.110	4.902	14.191
2	1	49.586	5.401	37.699	61.474
	2	19.255	3.231	12.144	26.366

Table B.108. Interaction Effect of Speed and View Point on Positive

Measure: Positive

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	27.928	4.186	18.715	37.142
	2	33.207	4.517	23.265	43.149
2	1	10.392	1.738	6.567	14.216
	2	26.944	3.099	20.124	33.764

Table B.109. Interaction Effect of Speed and View Point on Exciting

Measure: Exciting

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	12.252	1.581	8.772	15.732
	2	8.117	2.740	2.085	14.149
2	1	48.698	5.971	35.557	61.840
	2	29.565	4.123	20.490	38.639

Table B.110. Interaction Effect of Speed and View Point on Urgent

Measure: Urgent

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	11.018	2.169	6.243	15.792
	2	5.423	.709	3.861	6.984
2	1	61.689	4.426	51.947	71.432
	2	32.724	4.067	23.773	41.675

Table B.111. Interaction Effect of Speed and View Point on Relaxed

Measure: Relaxed

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	29.715	5.029	18.646	40.785
	2	34.067	4.556	24.040	44.094
2	1	1.938	.635	.540	3.337
	2	13.372	3.306	6.096	20.647

Table B.112. Interaction Effect of Speed and View Point on Threatening

Measure: Threatening

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	16.088	3.636	8.085	24.092
	2	5.222	.680	3.725	6.718
2	1	51.270	5.861	38.370	64.171
	2	16.565	2.867	10.255	22.875

Table B.113. Interaction Effect of Speed and View Point on Attracting

Measure: Attracting

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	35.611	3.768	27.318	43.903
	2	32.047	3.988	23.269	40.824
2	1	28.068	6.304	14.193	41.943
	2	35.764	3.573	27.900	43.629

Table B.114. Interaction Effect of Speed and View Point on Rejecting

Measure: Rejecting

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	15.852	2.957	9.344	22.361
	2	13.092	3.763	4.810	21.375
2	1	36.136	5.796	23.380	48.892
	2	15.832	4.038	6.945	24.718

Desktop 3D Group

Display

Table B.115. Main Effect of Display on Positive

Measure: Positive

Display	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	21.139	3.196	14.104	28.174
2	26.155	3.203	19.105	33.206

Table B.116. Main Effect of Display on Exciting

Measure: Exciting

Display	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	22.076	5.120	10.807	33.346
2	26.752	4.991	15.768	37.737

Table B.117. Main Effect of Display on Attracting

Measure: Attracting

Display	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	25.782	4.329	16.254	35.311
2	33.391	4.565	23.345	43.438

Shape

Table B.118. Main Effect of Shape on Calming

Measure: Calming

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	22.125	3.994	13.334	30.915
2	16.158	2.816	9.960	22.356

Table B.119. Main Effect of Shape on Exciting

Measure: Exciting

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	22.381	4.492	12.495	32.268
2	26.447	5.408	14.544	38.350

Table B.120. Main Effect of Shape on Urgent

Measure: Urgent

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	21.468	4.522	11.514	31.421
2	26.445	5.129	15.156	37.735

Table B.121. Main Effect of Shape on Relaxed

Measure: Relaxed

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	20.613	3.937	11.947	29.279
2	15.209	2.711	9.241	21.177

Table B.122. Main Effect of Shape on Reassuring

Measure: Reassuring

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	21.808	4.232	12.494	31.123
2	17.949	3.626	9.968	25.931

Table B.123. Main Effect of Shape on Threatening

Measure: Threatening

Shape	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	17.470	4.697	7.132	27.808
2	21.897	5.857	9.006	34.787

Speed

Table B.124. Main Effect of Speed on Negative

Measure: Negative

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	14.495	3.258	7.324	21.666
2	34.223	7.356	18.032	50.415

Table B.125. Main Effect of Speed on Calming

Measure: Calming

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	33.351	6.008	20.128	46.575
2	4.931	1.485	1.663	8.199

Table B.126. Main Effect of Speed on Exciting

Measure: Exciting

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	10.934	3.241	3.800	18.067
2	37.895	7.164	22.126	53.663

Table B.127. Main Effect of Speed on Urgent

Measure: Urgent

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	8.401	3.105	1.566	15.237
2	39.512	7.045	24.006	55.017

Table B.128. Main Effect of Speed on Relaxed

Measure: Relaxed

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	30.696	5.956	17.586	43.806
2	5.127	1.580	1.649	8.604

Table B.129. Main Effect of Speed on Reassuring

Measure: Reassuring

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	28.845	5.985	15.672	42.017
2	10.912	3.149	3.983	17.842

Table B.130. Main Effect of Speed on Threatening

Measure: Threatening

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	9.284	3.216	2.204	16.363
2	30.083	7.661	13.221	46.945

Table B.131. Main Effect of Speed on Rejecting

Measure: Rejecting

Speed	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	13.999	3.254	6.837	21.160
2	25.139	5.766	12.449	37.829

Path Curvature

Table B.132. Main Effect of Path Curvature on Threatening

Measure: Threatening

Curvature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	17.826	4.852	7.148	28.504
2	21.541	5.733	8.923	34.158

View point

Table B.133. Main Effect of View Point on Negative

Measure: Negative

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	29.303	5.457	17.293	41.314
2	19.415	5.162	8.053	30.777

Table B.134. Main Effect of View Point on Exciting

Measure: Exciting

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	27.058	5.174	15.669	38.447
2	21.770	4.830	11.140	32.401

Table B.135. Main Effect of View Point on Urgent

Measure: Urgent

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	28.300	4.763	17.816	38.784
2	19.613	4.835	8.972	30.255

Table B.136. Main Effect of View Point on Threatening

Measure: Threatening

ViewPoint	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	24.192	5.190	12.768	35.616
2	15.175	5.512	3.043	27.306

*Shape * Direction*

Table B.137. Interaction Effect of Shape and Direction on Threatening

Measure: Threatening

Shape	Direction	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	16.170	4.601	6.042	26.297
	2	18.770	4.921	7.938	29.602
2	1	24.342	6.103	10.908	37.775
	2	19.451	5.757	6.781	32.122

*Speed * View Point*

Table B.138. Interaction Effect of Speed and View Point on Negative

Measure: Negative

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	15.925	3.623	7.950	23.899
	2	13.065	3.832	4.631	21.499
2	1	42.682	8.523	23.923	61.441
	2	25.765	6.852	10.684	40.845

Table B.139. Interaction Effect of Speed and View Point on Exciting

Measure: Exciting

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	11.000	3.091	4.197	17.802
	2	10.868	3.467	3.236	18.500
2	1	43.117	7.824	25.896	60.338
	2	32.673	6.777	17.757	47.588

Table B.140. Interaction Effect of Speed and View Point on Urgent

Measure: Urgent

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	8.266	3.106	1.430	15.103
	2	8.536	3.283	1.309	15.763
2	1	48.334	7.486	31.858	64.809
	2	30.690	6.926	15.445	45.935

Table B.141. Interaction Effect of Speed and View Point on Threatening

Measure: Threatening

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	9.454	3.010	2.828	16.080
	2	9.113	3.876	.582	17.644
2	1	38.930	8.204	20.872	56.987
	2	21.236	7.503	4.723	37.749

Table B.142. Interaction Effect of Speed and View Point on Rejecting

Measure: Rejecting

Speed	ViewPoint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	14.140	3.219	7.055	21.226
	2	13.857	4.188	4.639	23.075
2	1	31.919	7.251	15.959	47.879
	2	18.359	4.961	7.440	29.278