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Simple Motion Textures for Ambient Affect

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Abstract

The communication of emotion and the creation of affect are core to creating immersive and engaging experiences, such as those in performance, games and simulation. They often rely on atmospheric cues that influence how an environment feels. The design of such ambient visual cues for affect is an elusive topic that has been studied by painters, theatre directors, scenic designers, lighting designers, filmmakers, producers, and artists for years. Research shows that simple motions have the capacity to be both perceptually efficient and powerfully evocative, and motion textures – patterns of ambient motion throughout the scene – are frequently used to imbue the atmosphere with affect. To date there is little empirical evidence of what properties of motion texture are most influential in this affect. In this paper we report the results of a study of simple, abstract motion textures that show path curvature, speed and texture layout can influence affective impressions such as valence, comfort, urgency and intensity.

Categories and Subject Descriptors I.3.3 [Computer Graphics]: Animation, perception, affective user interfaces, information visualization

1. Introduction

The communication of *affect*, an experienced feeling, impression or emotion, has a central role in creating immersive and engaging experiences in performance, interactive art, and gaming. Affect is also important in an ambient context, the result of how an experience or environment "feels". Motion is a powerful visual cue and has been shown to convey meaning, emotions [LW89], and intentions [DL94]. Character animation relies on the exaggeration of movement to deepen our understanding of behaviour and motivation [TJ81]. The arts of drama, dance and music map very complex emotions and motivations on to gestures and movement. Even direct single point motions with simple paths can offer the affective cues necessary to create a sense of mood and feeling [BN10].

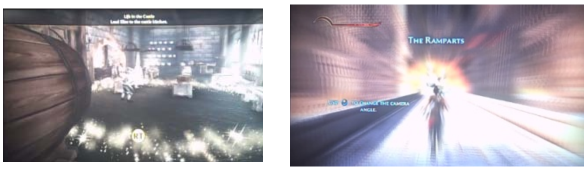

Figure 1. Motion textures in (a) Fable™ and (b) Prince of Persia™ games

Fields of motion – swirling leaves, fog, smoke, or more abstract effects – are often used in interactive environments, video, visualizations and games (Figure 1) to imbue atmosphere and evoke feeling. We term these *motion textures*. Visual design for affect is an elusive topic that has been studied by painters, theatre directors, scenic designers, lighting designers, filmmakers, producers, and artists for years [Bl01]. In the field of games, lighting and camera effects have received attention [Se05]. However, to date motion textures have received little empirical attention within the literature. Since motion is so interpretively rich, we are intrigued by how we might use algorithmically generated motion effects to create the perception of emotion and affect in visualizations and environments.

A rich history of performance, animation and the construction of engaging experiences suggest that motion can be highly evocative in both *focused* and *diffuse* applications. Focused communication involves directly applying motion to a particular object to convey properties associated with that object: a common interface example might be an icon. Diffuse applications are more experiential, in that motion may be applied as a sort of environmental "texture" or brush to create an aesthetic effect or evoke an impression. The analogy to lighting and sound effects and design is obvious. Particularly with respect to the latter, we are interested in the expressive scope of relatively small motions combined into textures for both emphasis and more subtle ambient visualization. We formally define *motion texture* as an area or volume of movement following some shared pattern, with possible random variation. We extend previous work that explored the expressive motion of a single point to textures of ambient motions created by a field of distributed points. In this paper we report on an initial investigation into the quality of textural motion and its potential role in affect. Much of the previous work in examining qualities of motion has concentrated on animation and the production of movement

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for articulated figures. In order to communicate affect from pure motion, we must isolate motion from the object, making the distinction between motion and movement. Movement involves two semantic elements: what the moving object affords (the falling of rain is visually and interpretively different than the falling of missiles), and what the motion suggests (drifting as opposed to exploding). Thus we began by examining purely abstract motion effects.

1.1. What's in a motion? The research question

While there are a number of parameters by which a motion can be described, little is known about which dimensions are most responsible for conveying meaningful information through motion. Previous studies have suggested the following as candidates: velocity [ABC96,PPB*01], amplitude [ABC96], acceleration [PPB*01], direction [Tag60], shape [BW02], effort [LL74,],] trajectory [Tag60], and smoothness [BN09,BN10]. We are interested in the affective scope of abstract, ambient, algorithmically generated motion. We have several questions regarding abstract motion textures. Are there properties of textured motion that influence affect? If so, are they the same properties found to be important in single point abstract motion from previous studies – namely, path curvature, shape and direction? Are there different or additional properties of motion in motion textures that contribute to affect? And finally, to what extent do the factors of motion from simple algorithmically generated motions contribute to the perception of layers in a texture? We know that artists and game designers composite and interweave effects in layers [SB*11]. This last question arises from the importance of visually compositing – and distinguishing - layers of effects in such environments. Our findings are intended to bound the design space and provide initial first principles to inform the development of tools harnessing the rich communicative potential of ambient motion based affect.

2. Background

Motion is a powerful visual cue and has been found to be useful in traditional user interfaces and visualization tasks {BW02,BWC03]. A number of video and animation researchers have investigated methods for taking techniques from traditional 2D animation and dynamically adding them to video [Co05] and computer-generated 3D animation [JB04]. These stylizations allow artists and animators to create new effects and enhancements in the sequences, exposing new behaviours and adding nuances of meaning, but depend on the analysis (both manual and machine-generated) of existing styles and sequences of articulated figures.

Character animation relies on the exaggeration of movement to deepen our understanding of behaviour and motivation [TJ81]. The arts of drama [Zo68], dance [LL74], animation, cinematography and music map very complex emotions and motivations on to gestures and movement. Researchers have studied a variety of emotions elicited by animations of both veridical figures (depiction of a body) and more abstract point-light displays that convey an articulated figure [Joh74]. The basic emotions (universal and distinguishable) indentified by emotion theorists include anger, disgust, fear, sadness, sensory pleasure, surprise, courage, joy, worry, pride, shame, and guilt [Ekm99]. Body movements communicate these emotions effectively [Wal98]. Emotions are taxonomised by valence (positive/negative), arousal/activation (intensity) and dominance-vulnerability (related to aggression). These dimensions provide nuanced ways to empirically distinguish them [OT90].

While many studies rely on the depiction of an articulated figure, several researchers have investigated the affects of more abstract motions. In several studies participants attributed very complex motivations and emotions to a set of animated geometric primitives [HS44,LW89]. Observers attributed emotions such as aggressiveness and anxiety from the motions alone. Tagiuri investigated single dot animations and found different trajectories elicit particular complex impressions [Tag60].

2.1. The elements of affective motion

A number of researchers have attempted to categorize movements derived from performing arts (notably the Laban framework [LL74]) into parameters discernible and distinguishable by humans, suggesting as important speed and tempo; area/space; direction and path (the line the moving object creates) [Vau97, Bac98,MCG*06]. These reflect the well-known techniques used by animators, who rely on speed, extent and amplitude to convey emotional state of their characters [TJ81].

These studies all concentrated on the representation or re-mapping of embodied motion attributes. Researchers have also investigated what attributes of simple, periodic motions applied to abstract elements are effective for information visualization tasks. Strong perceptual factors of simple motion include velocity, shape (path), phase, direction, flicker and amplitude. Shape, phase and direction are important attributes for notification, filtering and grouping [BW02]. Direction, flicker, and velocity can efficiently encode multiple data values [HH05]. Bartram and Nakatani discovered that speed, direction and motion "shape" (how curvy or jerky the motion trajectory was) influenced judgements of positive, negative and calm affect [BN09,BN10].

Little research has investigated the application of this knowledge to motion textures. Recent studies into visual composition in video games are providing insight into specific factors of ambient motion textures attributing to affect: speed, shape, direction [SBM11]. Another application of motion texture is the animation and enhancement of still images through the application of stochastic motion textures [CG*05]. Here motion texture is used to bring life to still images by applying generated textures to user-selected masks of the original scene. More recent work combines a static texture to an existing motion field in order to create non-physics based motion textures that behave characteristically of the exemplar input texture [MW*09]. Informing such techniques with first principles of motion-based affect would allow for the synthesis of emotional motion textures.

3. Motivation and Approach

The study reported in this paper is an initial empirical classification of textural motion on affective impressions.

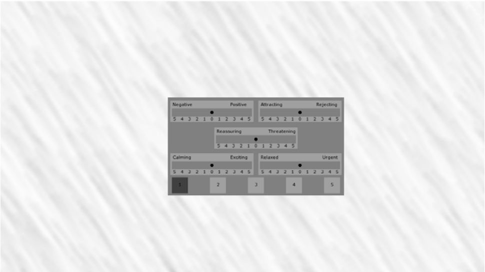

Figure 2 (a) Linear texture

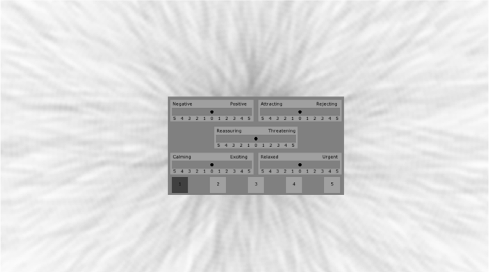

Figure 2 (b) Radial texture

Rather than attempt to define fine-grained emotional interpretations such as “happy” or “pleasant”, we looked at more abstract qualities of affect: *valence* (positive/negative), *intensity* (calm/exciting), *dominance* (reassurance/threat), i*nteraction* (attraction/rejection) and *urgency* (relaxed/urgent). Previous experience suggests these general categories subsume and are less contextually sensitive than more detailed ratings [BN10]. They are also representative of affective impressions that designers of immersive environments, games, and more generally evocative visualizations are interested in creating. We examined monochromatic abstract motion textures to isolate the properties of motion from object and context. Our textures were comprised of simple, geometrically defined motions in contrast to the more nuanced, human-generated singular motions from previous studies.

4. Experiment

Participants sat in front of a 23” computer monitor with 16x9 aspect ratio and1920x1080 resolution. The environment was well lit, silent, and seating was adjusted to correct glare/contrast. The experiment screen showed a rectangular, monochromatic motion texture of size 1280x680 pixels centred on a white background, in the middle of which was a 440x245 pixel rectangle containing 5 sliders used to enter the affective ratings and a checkbox field to enter the number of layers perceived (the dependent measures). Affective ratings, in order from left-right, top-bottom, were Negative-Positive (`NP`); Attracting-Rejecting (`AR`); Reassuring-Threatening (`RT`); Calming-Exciting (`CE`) and Relaxed-Urgent (`RU`). People were instructed to rate the motions and response to the layering question based on their interpretation. Each screen represented one trial. The participant had unlimited time to enter the 6 dependent measures. The 5 affective ratings were presented as semantic differential scales from -100 to +100 with the default at 0 (neutral). Checkboxes along the bottom allowed the participant to enter a value between 1-5 for the number of layers perceived. The default was set at 1. Figure 2 shows one example experiment screen. When a trial started the texture was not active but faded in slowly and remained until the participant hit “t” to advance to the next trial. There was no timing constraint on the trial, and participants could watch and adjust their ratings as long as desired. Ratings did not have to be entered: the participant could simply leave the default setting. Once “t” was pressed, the screen faded to a static texture for one second and then gradually into the next moving texture over a time of 2 seconds.

4.1. Textures, Motions and Factors

Each motion texture comprised a randomly distributed field of points on a 2D Cartesian plane. The density of the field and number of points were piloted to create an even distribution of motion over the plane. Each point was small and semi-transparent. The overall display of all points was blurred using an OpenGL accumulation buffer to soften the effects of any one single point.

Our previous studies showed that smoothness (path curvature), direction and speed were significant in certain emotional ratings, so we selected these as factors of interest. When motions are combined into a texture additional properties of shape (layout), distribution, density and phase are added to visual effect. Because single motion shape had also proven affective, we used two textural “shapes” defined by the common motion trajectories: linear (Figure 2a) and radial (Figure 2b). The remaining texture parameters were held constant. The remaining texture parameters were held constant. Thus our factors (independent variables) were:

- Texture `shape`: Linear, radial;
- Speed (`S`): Slow, Fast
- Curvature (`PC`): Straight, Wavy, Angular
- Direction (`D`): upper right, upper left, down left, down right (Linear); inward, outward (Radial)

All motion factors were computed, updated, and displayed at a constant frequency of 60hz. Each motion could be fast or slow. Fast motions travelled at 12 pixels per second, while slow motions travelled at only 4 pixels per second. These speeds were piloted with test subjects in order to determine a just noticeable difference in the speed for the purpose of yielding accurate judgments.

Direction was defined differently for each motion shape. In the linear motions direction was defined in 4 parts: upwards-right, upwards-left, downwards-left, downwards-right. Previous research suggests that downwards-left movements have significant negative affect judgments [BN10]. 2 distinct radial motion directions were defined: sucking inwards (black hole), and radiating outwards (star burst). These directions were informed by prior research into visual cues and elements in video games. Examples can be seen in the accompanying videos.

(a) Straight path *(b) Angular path*

(c) Wavy path

Figure 3. Path curvature

Path curvature referred to the type of line the motion traced as it progressed (Figure 3). Path curvatures for each motion shape were straight, wavy (sinusoidal), or angular (jerky). The wavy motions had a sinusoidal amplitude of 72 pixels calculated perpendicular to the motion trajectory with a period defined by a 0.1 increase in theta per frame. Angular paths followed a similar design with amplitude of 64 pixels. While angular paths were still calculated perpendicular to the motion trajectory, they were not based on any theta. In slow motions the angular curvature speed was 4 pixels per frame whereas in fast motions this curvature speed was raised to 6 pixels per frame. Curvatures were piloted extensively and the discrepancies in calculation were intentional to achieve a just noticeable difference for user perception.

4.2. Design

This combination of 2(shape) x 2(speed) x 3(path curvature) gave us 12 base conditions. We divided texture shape into 4 direction conditions for linear (total 4 x 2 x 3) and 2 direction conditions for radial (total 2 x2 x 3) for a total of 36 unique conditions. Each participant saw 2 replications of each motion texture for a total of 72 trials. Trials were randomised to avoid first and second order effects. The experiment began with two training motions not present in any of the trials. During this time participants were free to ask questions, and it was established that they understood the ratings and the task ahead. Once a user was prepared for the experiment they were instructed that pressing 't' on the keyboard would begin the experiment. Users' time averaged 40-45 minutes per experiment and 24 seconds per trial.

4.2.1. Hypotheses

We had seven hypotheses. These were based on our piloting tests and on the results of previous work [BN10].

- H1 Speed will be significant
- H2 Faster motions will have stronger ratings than slow motions.
- H3 Direction will be significant in radial motions
- H4 Downward left will be more negative than other linear directions
- H5 Inward radial motions will be highly attracting
- H6 Path curvature will be highly significant
- H7 Jerky angular motions will be rated more negatively, urgently and threatening.

4.3. Participants

Sixteen university students were paid to participate in the experiment. All had normal or corrected-to-normal acuity and normal colour vision. All were naïve to the purpose and hypotheses motivating the study. The participants spanned a variety of ethnic and cultural backgrounds.

5. Results

Table 1 and Figure 4 show the results. Our first analysis of our results was a simple ANOVA of shape (linear, radial) for each of our dependent ratings showing that shape was significant (F (1,17) = 27.82, P < 0.001) in all of our affective ratings with the exception of Negative-Positive (NP). This led us to separate our two texture shapes and perform a separate analysis on each using a 3-way ANOVA.

Linear motions had more motion factors contributing to significant effects on ratings compared to radial motions. The most dominant factor was path curvature (PC) in all 5 dependent variables. CE in addition to RU ratings were stronger overall. Direction was significant for NP ratings and a post-hoc Tukey analysis revealed that upwards-left motions (M = -0.4) are rated as significantly more negatively than downwards right (M = 0.5). This was the only significant difference for ratings of direction in linear motions.

CE ratings were significantly affected by speed. A post-hoc Tukey analysis revealed that the slower motions (M = 0.40) are significantly more calming than fast motions (M=1.58) that are rated as more exciting. In addition, RT ratings have slow motions (M = -0.33) as being more reassuring than fast motions (M = 0.58) that are seen as more threatening. RU ratings follow a similar pattern with regard to speed: slow motions (M = -0.41) are seen as more relaxed, while fast motions (M = 1.53) are more urgent.

Curvature is highly significant for NP ratings, with straight (M = 0.82) rated as positive, wavy (M = -0.0191) rated neutrally, and angular (-0.78) more negatively rated. In CE ratings curvature is also significant: straight motions (M = -0.4980) are rated as calming, while wavy (M = 0.6) and angular (M = 1.67) motions are more excited. In RT ratings straight motions (M = -0.96) are more reassuring, wavy motions (M = 0.3) are more or less neutral, and angular motions (M = 1.05) are more threatening. RU ratings have straight motions (M = -0.81) as being relaxed, and wavy (0.551) and angular (M = 1.95) as being more urgent. AR measures have straight motions (M = -1.03) rated as attracting, wavy motions (M = -0.06) as neutral, and angular motions (M = 0.62) as slightly rejecting. Curvature was the only contributing factor to the perception of layers. Straight motions (M = 1.581) are seen as having fewer layers than wavy (M = 2.27) or angular (M = 2.36) motions.

Radial motions had far less significant factors. Speed ranked highly in 3 of the dependent variables and direction was significant in attracting and rejecting judgments. Direction was significant in AR ratings with an inwards radial (M = 2.1) rated as slightly attracting compared to outwards motions (M = .45) that are rejecting.

Speed has a significant effect in CE ratings: slow motions (M = 0.93) are moderately exciting, while fast motions (M = 2.74) are very exciting. Speed also significantly effects RT motions: slow motions (M = 0.46) are only a little threatening, fast motions (M = 1.77) are more threatening. RU ratings differ significantly as well, with slow motions (M = 0.47) being rated as slightly urgent, and fast motions (M = 2.561) as being very urgent. Path curvature PC, contrary to linear motions, had no significant effects in the radial motions. The perception of layers was similar to linear motions with curvature being the only significant contributing factor. It follows the same pattern, with straight motions (M = 2.4) having slightly less layers reported than wavy (3.11) and angular (3.37) motions. While the ratings follow a similar distribution, the means are shifted forward by a single layer from the linear motions.

6. Discussion

One focus of this experiment was to bound the design space of motion based affect in ambient motion textures. The initial results for both shapes have allowed us to dismiss some factors as not contributing significantly to affect at all.

Overall, the path curvature of motion was shown to significantly influence affective ratings. This fits with previous research stating that jerkiness of motion is a significant factor in any motion-based affect. From the significance of PC in each independent affective rating we can accept H6 and H7 that path curvature is the most significant contributing factor to ambient motion affect and jerky angular motions are viewed as more negative, urgent, and threatening. We have established that angular ambient motions are perceived as more negative, exciting, threatening, urgent, and rejecting, while straight motions are more positive, calming, reassuring, relaxed, and attracting. Our wavy motions were perceived as predominantly

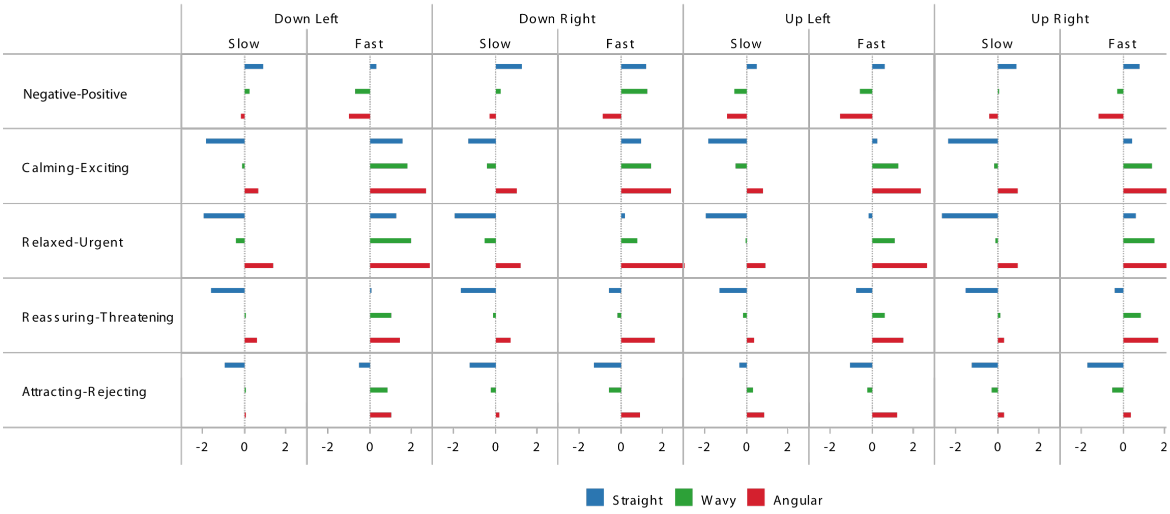

Figure 4a. Linear rankings by direction, speed and curvature

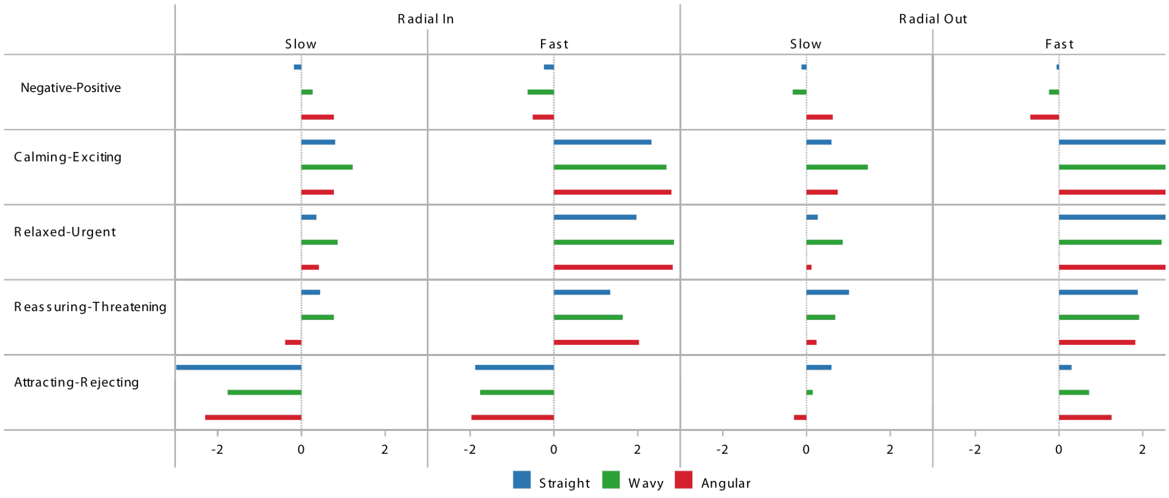

Figure 4b. Radial affective ratings by direction, speed and curvature

	Both Shapes	Linear	Radial
Negative - Positive NP	PC: F(2,17) = 28, p<.001 S: F(1,17)= 6.02, p<.014 D: F(5,17)= 4.4, p<0.036	**PC**: F(2,17) = 58.1, p<.001 **D**: F(5,17)= 6.08, p<0.014	
Calming - Exciting CE	PC: F(2,17) = 77.2, p<.001 S: F(1,17)= 205, p<.001 D: F(5,17)= 5.92, p<0.015	**PC**: F(2,17) = 144, p<.001 **S**: F(1,17)= 183, p<.001	**S**: F(1,7)= 70.8, p<.001
Reassuring - Threatening RT	PC: F(2,17) = 55, p<.001 S: F(1,17)= 57, p<.001 D: F(5,17)= 13.7, p<0.001	**PC**: F(2,17) = 117, p<.001 **S**: F(1,17)= 35.8, p<.001	**S**: F(1,7)= 28.3, p<.001
Relaxed - Urgent RU	PC: F(2,17) = 116, p<.001 S: F(1,17)= 191, p<.001 D: F(5,17)= 4.01, p<0.046	**PC**: F(2,17) = 201, p<.001 **S**: F(1,17)= 149, p<.001	**S**: F(1,7)= 69.9, p<.001
Attracting - Rejecting AR	PC: F(2,17) = 28.1, p<.001 D: F(5,17)= 5.53, p<0.036	**PC**: F(2,17) = 50, p<.001	**PC**: F(1,7) = 66, p<.001
Layers	PC: F(4,17) = 25.3, p<.001 D: F(5,17)= 47.4, p<0.001	**PC**: F(4,17) = 42.3, p<.001	**PC**: F(4,7) = 11.8, p<.001

Table 1. Main Effects, All Factors

neutral in all 5 affective ratings. These principles of affect for ambient motion with regard to path curvature can inform environment design of high, neutral, or low intensity environments.

Speed was also a significant contributor in 3 of our dependent ratings, CE, RT, and RU, two of which deal with intensity, CE and RU, and the third with dominance. This provides environment designers with two key principles about the speed of ambient motion: if you want to increase intensity, increase the speed of ambient motion, and as you increase speed the same ambient motions may start to be perceived as more threatening. This significance for our affective ratings CE and RU is true regardless of direction or path curvatures, confirming H1. We know from past research that radial motions (sucking in, radiating out) are powerful directive visual cues. An artist or designer could couple this knowledge with variations of speed in order to increase or decrease the perceptual intensity of these cues.

Direction for linear motions was only significant in a NP rating and between downwards-right motions seen as predominantly positive and upwards-left motions seen as predominantly negative. Path curvature (PC) was a significant influence in this area and as such this result is neither significant nor reliable: we cannot, therefore, confirm either of our direction-related hypotheses. Nonetheless, we believe there are still interesting implications given the valence influence and will continue to investigate. However, direction strongly affected the “attracting” judgement in the inward radial motions. This holds promise for both encouragement and navigation cues in interactive environments.

One interesting feature of the affective rating results is the lack of symmetry. With regards to direction there is no indication if a specific direction is rated as negative that the opposite will be rated as positive. For example, radial motions were rated the same in CE, RT, and RU regardless of direction, and while the AR rating was heavily attracting for radial inward motions, radial out registered as predominantly neutral. Additionally, it was simply not the case that changes in speed had symmetrical results. For example, linear motions displayed several different characteristics with varying speeds, some motion ratings were symmetrical, while the same direction with a different path curvature displayed no symmetry at all. The closest symmetries in our ratings were achieved in linear motions with respect to path curvature. In all 5 affective ratings, straight paths tended towards to positive side of our ratings, while angular tended towards the negative, leaving wavy motions relatively neutral. Path curvature in linear motions is the most significant contributing factor to affect. This fits with previous research stating that direction distribution (jerkiness of motion) is a significant factor in any motion-based affect. In simple algorithmically generated curvatures we consistently had jerky motion rated as more negative, exciting, threatening, urgent, and rejecting. We regard jerky angular motion as being generally more negative. Wavy motions on the other hand were generally rated neutral. Straight motions tended to stay on the positive side of the ratings, judged relatively symmetrically to the angular motions. We gained insight into the effects of path curvature on motion textures: generally the more jerky the path, the more negative, threatening, and intense the motion affect.

When the speed was increased our path curvatures degenerated visually. Heavy blurring also effected this degeneration and some of the curvature was perhaps not as pronounced as it should have been. Since this degeneration had the most effect on the wavy motion textures as opposed to causing little degeneration in the straight and angular motions, we believe that wavy motions may perhaps have more of an influence on affect in linear motion textures than we have found. Wavy motions by common sense should have contributed to more calming rather than exciting ratings.

Since upwards-left motions were significantly more negative than downwards-right motions, we conjecture that leftward motion in general has a significant negative connotation. One limitation of our experiment design was that path curvature dominated our affect ratings. This fits with previous research concluding similar results with regards to downwards-left motions. Our participant population was multicultural, so perhaps this effect is robust across cultures, but further research is clearly indicated.

Finally, we chose three metrics related to intensity (`RU`, `CE` and `RT`) rather than one to explore whether there were small semantic differences. We anticipated that they would group together quite strongly, and this largely proved to be the case. We note however that the `Reassuring-Threatening` rating had subtle differences from the other two. Because this was the one rating that could partly represent the emotional dimension of dominance we wanted to tease out what might affect it. While our results are not at all conclusive, we remain curious as to whether there are elements of motion that can elicit this impression, as it is an evocative and important one in the areas of gaming, performance and immersive experiences.

7. Conclusions and Future Work

Motion based affect is a rich design space with several studies showing specific motion factors as particular salient in the communication of emotion. While single point motions from bodily movement and abstract motion have been studied extensively, there has been little accomplished in defining the dominant motion factors contributing to perceptions of emotion in ambient motion textures. It is precisely these motion textures that we have evaluated for dominant motion based affect factors. An experiment was conducted to examine two motion shapes: linear and radial, in 3 motion factors: speed, direction, and path curvature. Factors chosen were informed from past research and results were similar or slightly varied in some instances. The orientation of the texture (linear or radial), the speed of motion, and most notably the curvature of the individual motion paths have all proven to be distinctive in eliciting different affective ratings.

8. Acknowledgements

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