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Affective motion textures

Matt Lockyer, Lyn Bartram*

School of Interactive Art Technology, Simon Fraser University, Surrey, BC, Canada

A R T I C L E   I N F O

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A B S T R A C T

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. These effects rely on designer craft; there is to date little empirical evidence of how motion properties contribute to affective impressions. In this paper we report research into affective motion textures that shows how even simple variations in path curvature, speed and texture layout can influence affective impressions. We describe the development of a motion brushing prototype tool and discuss insights from an on-going qualitative study with professional visual effects designers into how such capabilities can enhance their current practice.

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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”. The extension of affect to more traditional visualisation applications is an emerging field of study [32]. The utility of affective representation – the visual encoding of affective dimensions – is now of interest in the traditionally “objective” discipline of data visualisation, as researchers identify its importance in narrative [20,35], audience engagement [25] and contextual framing [16,19,33]. Visual designers and artists explore and manipulate visual elements of a scene to enhance affect, but the knowledge of how to communicate these subtle meanings remains largely rooted in personal experience and design principles that are not computationally operational; that is, there are few algorithmic models that define how to create, amplify or reduce the affect by changing elements such as colour, shadows or animation. (A notable exception, and a motivation for the work reported in this paper, is Seif el-Nasr’s work on adaptive computational lighting for game environments [36].) We term this emerging field affective visualisation: the principled use of visual elements to change the affective nature of a presentation.

Our research focuses on the affective visualisation potential of environmental (i.e., non-character-based) animation, and how this might be computationally encoded into editing tools for affective visualisation and digital visual effects design. In [4], we reported on a study of how simple, abstract motion textures can elicit different affective impressions. This paper extends that work, describing how our results influenced the design of a motion texture editor, and discussing a qualitative evaluation of this tool and of the expressive capacity of motion textures with visual designers from performance, games and artistic domains.

The paper is organised as follows. We begin by defining our scope of affect and the motivation for exploring motion in Section 2. Related work is covered in Section 3. The design and results of a detailed experiment in how motion properties contribute to affective impressions is presented in Section 4. We then describe the design and purpose of a motion texture editing tool in Section 5. This tool serves both as a prototype for a palette of motion “brushes” as well as an elicitation mechanism for exploring how designers might use such motion effects in their domains. We discuss a qualitative exploration with several designers in Section 6. We conclude with a discussion of new questions, future work and challenges in the field.

2. Affect and motion

Affect is traditionally considered to have an emotional context. 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 [15]. Emotions have been traditionally taxonomised by valence (positive/negative) and arousal/activation (intensity) [30]; a newer addition is the aspect of dominance-vulnerability (related to aggression) [22]. These dimensions provide nuanced ways to empirically distinguish emotions: for example, while anger and fear are both negative and intense, they differ in the dominance aspect. We believe that affective visualisation, however, spans both a wider and a shallower scope than such defined emotions. We expand our definition of affect to one of experience: when we are affected by something we experience a feeling as a result, and this might be an emotion, a sense of interest, an atmospheric impression, or other such feelings related to but not exactly one of the basic emotional states. Our previous research suggests these feelings may be highly contextualised: that is, rather than a generalisable distinction of “happy”, “pleasant” or “proud”, the affective impression may be one of positive valence, and the more fine-grained interpretation subject to the particular narrative or experiential context [7].

2.1. Motivation: Why motion?

Motion is a powerful visual cue and has been shown to convey meaning, emotions [27], and intentions [14]. Character animation relies on the exaggeration of movement to deepen our understanding of behaviour and motivation [39]. 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 [7].

Fields of motion – swirling leaves, fog, smoke, or more abstract effects – are often used in interactive environments, video, visualisations and games (Fig. 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 [10]. In the field of games, lighting and camera effects have received attention [36]. 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 visualisations 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 visualisation. 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 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.

2.2. 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 [1,31], amplitude [1], acceleration [31], direction [38], shape [8], effort [26], trajectory [38], and smoothness [6,7]. 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 [7]? 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 [37]. 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 first principles to inform the development of tools harnessing the rich communicative potential of ambient motion based affect.

Fig. 1. Motion textures in: (a) Fable™ and (b) Prince of Persia™ games.
3. Related work

Motion is a powerful visual cue and has been found to be useful in traditional user interfaces and visualisation tasks [8,9]. A number of video and animation researchers have investigated methods for taking techniques from traditional 2D animation and dynamically adding them to video [13] and computer-generated 3D animation [24]. 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 [39]. The arts of drama [43], dance [26], 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 [23].

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 [18,27]. Observers attributed emotions such as aggressiveness and anxiety from the motions alone. Tagiuri investigated single dot animations and found different trajectories eliciting particular complex impressions [38].

3.1. The elements of affective motion

A number of researchers have attempted to categorise movements derived from performing arts (notably the Laban framework [26]) into parameters discernible and distinguishable by humans, suggesting as important speed and tempo; area/space; direction and path (the line the moving object creates) [42,29]. These reflect the well-known techniques used by animators, who rely on speed, extent and amplitude to convey emotional state of their characters [39].

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 visualisation 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 [8]. Direction, flicker, and velocity can efficiently encode multiple data values [21]. In our previous work, we investigated numerous motion attributes for communicating affect [6,7]. We collected or generated motions from three types of sources: captured human gesture, motion stimuli from previous psychological research, and algorithmically defined simple motions. For the motion capture, we instrumented the arm of a variety of participants (including an actor, a conductor and an IT student), and instructed him/her to move the arm freely with one of the following 32 expressions in mind: contentment, discontent, pleasure, pain, pride, shame, joy, sadness, anger, calm, excitement, indifferences, fear, fearlessness, innocence, guilt, amusement, annoyance, interest, boredom, worry, relief, admiration, contempt, attraction, disgust, important, unimportant, relaxed, urgent, welcoming and rejecting. These expressions included basic emotions [ekman] as well as more abstract qualities, such as urgency, importance and interest. While the latter are non-valenced cognitive states that fall outside the traditional classification of emotion [15], we considered them potentially useful for affective communication. We also reproduced motion stimuli from social psychology shown to be affective [18,38] and some simple periodic geometric motions such as spirals, arcs and linear paths. We normalised these motions to a single dot in a common space and had different participants rate them according to the 32 measures described above. We discovered that while the ratings were individually variable they clustered strongly into groups of positive, negative and calm affect: these were significantly influenced by speed, direction and motion “shape” (how curvy or jerky the motion trajectory was).

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 [28]. Another application of motion texture is the animation and enhancement of still images through the application of stochastic motion textures [11]. 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 [12]. Informing such techniques with first principles of motion-based affect would allow for the synthesis of emotional motion textures.

4. Experiment

We carried out an empirical study of textural motion on affective impressions [4]. 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.

Following our previous work, we selected to explore categories of affect rather than attempt to elicit fine-grained emotional interpretations such as “happy” or “pleasant”. We therefore considered more abstract qualities of affect: valence (positive/negative), intensity (calm/exciting), dominance (reassurance/threat), interaction (attraction/rejection) and urgency (relaxed/urgent). We conjecture these general categories subsume and are less contextually sensitive than more detailed ratings [7]. The first two were drawn from our previous experiments [6,7]. Informal interviews with video game and theatrical designers revealed that threat/foreboding, welcome and comfort were affective impressions important to immersive environments, games, and more generally evocative visualisations. Finally, we were curious whether a concept related to a less emotional, more rational rating – urgency – would elicit different ratings. Urgency is a critical condition in many real-time visualisation contexts such as supervisory control, and thus of interest in designing appropriate visualisation techniques. We did not presume that these 5 rating categories would be mutually exclusive: rather, we were interested in how they would overlap, as this can provide insight into exactly how finely one can refine the affective capacity of a visual motion.

4.1. Method

Participants sat in front of a 23” computer monitor with 16 × 9 aspect ratio and 1920 × 1080 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 1280 × 680 pixels centred on a white background, in the middle of which was a 440 × 245 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 Valence (Negative–Positive NP); interaction (Attracting–Rejecting AR); dominance (Reassuring–Threatening RT); intensity (Calming–Exciting CE) and urgency (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 and 5 for the number of layers perceived. The default was set at 1. Fig. 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 1 s and then gradually into the next moving texture over a time of 2 s.

### 4.2. 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. Checkboxes along the bottom allowed the participant to enter a value between 1 and 5 for the number of layers perceived. The default was set at 1. Fig. 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 1 s and then gradually into the next moving texture over a time of 2 s.

### 4.3. Affective measures

Affective ratings were specified using semantic differential scales from $-100$ to $+100$, with 0 in the middle such that a high rating on the scale in either direction would signal a “strong” rating for the affect at that end of the scale (such as calm or exciting as the two ends of the intensity axis), and as the rating approached zero, the affect was considered “weaker”. A neutral rating (i.e., at or very close to the middle) was considered to have no affect; the participant did not make any judgment with respect to that axis. Thus a high positive intensity rating (e.g. $+90$) would be considered close to “exciting” and a high negative intensity rating (e.g. $-90$) would be considered a strong “calming” rating.

Path curvature referred to the type of line the motion traced as it progressed (Fig. 3). Path curvatures for each motion shape were:

<table>
<thead>
<tr>
<th>Texture shape</th>
<th>Speed (S)</th>
<th>Path curvature (PC)</th>
<th>Direction (D)</th>
<th>Layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>Slow</td>
<td>Straight</td>
<td>Upper right</td>
<td></td>
</tr>
<tr>
<td>Radial</td>
<td>Fast</td>
<td>Wavy</td>
<td>Upper left</td>
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<td></td>
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<td>Angular</td>
<td>Down left</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Down right</td>
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<td>inward</td>
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<td></td>
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<td></td>
<td>outward</td>
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</tbody>
</table>

### Table 1

<table>
<thead>
<tr>
<th>Variables Type</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent variables</td>
<td>Texture shape</td>
</tr>
<tr>
<td>Speed (S)</td>
<td>Slow</td>
</tr>
<tr>
<td>Path curvature (PC)</td>
<td>Straight</td>
</tr>
<tr>
<td>Direction (D)</td>
<td>Upper right</td>
</tr>
<tr>
<td>Layers</td>
<td>Valence (PN)</td>
</tr>
<tr>
<td>Intensity (CE)</td>
<td>Dominance (RT)</td>
</tr>
<tr>
<td>Interaction (AR)</td>
<td>Urgency (RU)</td>
</tr>
</tbody>
</table>

Fig. 2. (a) Linear texture and (b) radial texture.
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 1 increase in τ 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 θ. 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.

### 4.4. Design

This combination of $2^{(\text{shape})} \times 2^{(\text{speed})} \times 3^{(\text{path curvature})}$ gave us 12 base conditions. We divided texture shape into 4 direction conditions for linear (total $4 \times 2 \times 3$) and 2 direction conditions for radial (total $2 \times 223$) 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 min per experiment and 24 s per trial.

### 4.5. Hypotheses

We had seven hypotheses drawn from pilot studies and results of previous work [7].

- **H1.** The speed of the texture will affect the ratings reported by users.
- **H2.** Faster motions will increase intensity, dominance and negative valence ratings.
- **H3.** Direction will influence interaction ratings in radial motions with inward motion having a more attracting affect than outward, and outward eliciting a more rejecting affect;
- **H4.** Downward left motion will have a more negative valence than other linear directions;
- **H5.** Path curvature will be highly significant; jerky angular motions will be elicit more negative valence, higher intensity, higher urgency and higher dominance (threat) ratings.
- **H6.** Path curvature will be highly significant; jerky angular motions will be elicit more negative valence, higher intensity, higher urgency and higher dominance (threat) ratings.

These hypotheses cluster by speed (H1,H2); direction (H3,H4,H5) and path curvature (H6) properties. The directional hypotheses can be considered to embody differences in texture shape (linear or radial).

### 4.6. 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 naive to the purpose and hypotheses motivating the study. The participants spanned a variety of ethnic and cultural backgrounds.

### 4.7. Threats to validity

While self-reports of emotional response are the standard way of measuring affect in organisational psychology [15], they are problematic for understanding perceptual phenomena, as they are vulnerable to the context in which the participants may relate that kind of perceptual affect (for example, some people may relate a fast wavy movement to water that for them has a soothing effect, while others may relate it to city lights that are energising or aggravating.) Indeed, this is both a potential threat to validity and at the same time critical to how such motion shapes were chosen, given their approximation to natural phenomena. Similarly, we note that the categories of affective measures we used, while drawn from previous research that suggested such clusters [7], were also vulnerable to individual interpretation that was not in itself previously calibrated: that is, we did not ensure in advance that every participant had the same clear definition of what each of the categories/measures meant. This was at least partially intended, as we were trying to assess whether we would continue to see some agreement around affective impressions without rigorous pre-definitions to the participants. As in many cases, the search for some ecological validity can compromise strict internal validity, and this is a compromise all such researchers must face. We noted weak correlations above 50% (i.e., above pure chance) between the following ratings:

1. Calm positively correlated with Reassuring (.564) and Relaxing (.762);
2. Positive and Attracting were positively correlated (.568);
3. Negative correlated with Threatening (.6145) and Rejecting (.6632);
4. Exciting correlated with Threatening (.582) and Urgent (.651);
5. Relaxing and Reassuring were correlated (.571); and
6. Threatening correlated with Urgent (.587) and Rejecting (.541).

Finally, normalisation is an issue with these types of semantic-differential ratings measures: i.e., not every participant uses the full scale of $-5$ to $+5$, and we did not normalise the relative differences in scale between participants. This more precise measurement will be necessary in future studies.

### 4.8. Results

Table 2 and Figs. 4–6 show the results. A one-way ANOVA of shape (linear, radial) for each of our affective ratings showed that shape was highly significant ($F(1,17)=27.82, P<.001$) in all of our affective ratings with the exception of valence (NP). This led us to separate our two texture shapes and perform a separate analysis on each using a three-way ANOVA. We discuss each in turn.

**Linear** textures had more motion factors contributing to significant effects on ratings compared to radial textures. The most
Overall, direction was significant for valence ratings (Fig. 4). A dominant factor was path curvature (PC) in all 5 dependent variables. Intensity (CE) in addition to urgency (RU) ratings were higher overall. Direction was significant for valence ratings (Fig. 4) and a post-hoc Tukey analysis revealed that upwards-left motions (M = −4) are rated as significantly more negatively than downwards right (M = 5). This was the only significant difference for ratings of direction in linear motions.

Intensity ratings were significantly affected by speed. A post-hoc Tukey analysis revealed that the slower motions (M = 40) rated significantly more calming than fast motions (M = 1.58) that are rated as more exciting. In addition, dominance (RT) ratings have slow motions (M = −33) as being more reassuring than fast motions (M = 58) that are seen as more threatening. Urgency (RU) ratings follow a similar pattern with regard to speed: slow motions (M = −41) are seen as more relaxed, while fast motions (M = 1.53) are more urgent.

Curvature is significant for valence ratings, with straight (M = 82) rated as positive, wavy (M = −0191) rated neutrally, and angular (−78) more negatively rated. In intensity ratings curvature is also significant: straight motions (M = −4980) are rated as less intense, while wavy (M = 6) and angular (M = 1.67) motions are more intense. In dominance ratings straight motions (M = −96) are more reassuring, wavy motions (M = 3) are more or less neutral, and angular motions (M = 1.05) are more threatening. Urgency ratings have straight motions (M = −81) as being relaxed, and wavy (.551) and angular (M = 1.95) as being more urgent. Interaction ratings have straight motions (M = −1.03) rated as attracting, wavy motions (M = 0.6) as neutral, and angular motions (M = .62) as slightly rejecting. However, as we
will discuss later, the differences between the path curvatures were small, and we found the most significant difference was between paths that were either deformed (had a path curvature) as opposed to none (straight path). Fig. 5 shows the effects of speed and path deformation on intensity: fast speeds are most intensely rated than slow, but path deformation contributes more to intensity in slow rather than fast speeds, and this interaction is significant ($F(1,13) = 12.05, p < .001$).

Path curvature was the only contributing factor to the perception of layers. Straight motions ($M = 1.581$) are perceived as having fewer layers than wavy ($M = 2.27$) or angular ($M = 2.36$) motions.

Radial textures had less significant factors. There was a strong effect of direction in interaction (attraction/rejection) judgments, with an inwards radial texture ($M = 2.1$) rated as slightly attracting compared to outwards motions ($M = 4.5$) that are very rejecting. Fig. 6 shows this effect.

Speed ranked highly in 3 of the dependent variables. It has a significant effect in intensity ratings: slow motions ($M = .93$) are moderately intense, while fast motions ($M = 2.74$) are very intense. Speed also significantly effects dominance ratings: slow motions ($M = .46$) have low dominance (threat), fast motions ($M = 1.77$) are more threatening. Urgency ratings differ significantly as well, with slow motions ($M = .47$) 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 path 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 ($3.31$) 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.

4.9. Discussion

One focus of this experiment was to bound the design space of motion-based affect in ambient motion textures. Our results allow us to identify certain factors as important for these simple textures. Our hypotheses of path curvature influence were strongly confirmed (H6): path curvature 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 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 see a general trend 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. Interestingly we saw no influence from wavy paths: they were perceived as predominantly 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.

Not surprisingly, speed was also a significant contributor in three of our dependent ratings, intensity, dominance, and urgency. We can combine intensity and urgency as similar interpretations. This confirmed our hypotheses H1 and H2 and provides environment designers with two key principles about motion in general has a significant negative connotation. Not surprisingly, speed was also a significant contributor in three of our dependent ratings, intensity, dominance, and urgency. We can combine intensity and urgency as similar interpretations. This confirmed our hypotheses H1 and H2 and provides environment designers with two key principles about 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 multicultural participants so perhaps this effect is robust across cultures, but further research is clearly indicated.
Finally, we chose three metrics related to intensity (urgency, intensity and dominance) 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 dominance rating had subtle differences from the other two, warranting investigation into 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.

5. Creating with motion

These results were intriguing and reflected earlier research [7] that simple motion patterns have large potential to communicate affect. However, how might content creators use such effects and textures? An important part of our research is to explore how designers and artists make use of motion to create affect and how our work can both learn from [28] and enhance current practice. An eventual goal of this project is to help professional environment and experience designers to “paint in” affective motions to their scenes by giving them a palette of motion “brushes”, analogous to the effects brushes in tools like Adobe Photoshop™ (Fig. 7 shows one such example: a static frame from a motion texture mapped to a car model.) We therefore turned our attention to more applied questions. First, we seek to discover how (and if) such creators might manipulate motion patterns to create affect, and whether this is of interest to them. Second, if we are to provide such capabilities to their toolsets, what might be the best ways to enhance and support such motion effects—in essence, what might the tool be?

Fig. 7. One frame from a motion texture mapped to a Maya™ model.

To pursue these questions, we have developed a prototype motion texture editor that allows the user to generate motion textures that can be saved, annotated and further edited. We are using this tool in an in-depth, iterative and qualitative study with designers, artists and visualisation specialists. In the following sections we describe the motion editor tool and report on results from several sessions in an ongoing evaluation in which we explore with professional designers and visual artists how they might use such a tool enabling the dynamic creation of motion texture.

5.1. The motion texture editor

We built a 2D abstract motion texture editing tool in the Unity™ game engine that allows the user to create simple motion monochromatic motion textures by manipulating three types of parameters (Table 3). Texture parameters refer to the overall pattern, as in the previous experiment: we added the spiral texture after pilot studies where participants observed these patterns are common in both nature and in games [37]. We also added a “User” texture shape, in which the user can “draw” a motion path that is then followed by each particle. Path patterns remained as before. Object parameters control the appearance of the individual particles, including size, opacity, and a comet-like effect of a trail.

Users control the motion properties with a set of sliders and buttons (Fig. 8). When a shape and path curvature is selected the necessary controls are displayed. Motions can be saved, annotated and loaded via a dialogue screen. Linear motions have a slider for direction in 360° and speed. Straight is the default path curvature for the 3 basic motion types with no extra settings shown. When a wavy path curvature is selected controls for the wave amplitude and speed are presented; the same occurs with angular motion selection. We generalise wavy and angular properties as path deformations and henceforth refer to them as path amplitude and path speed. To control overall frequency of the texture the user must control the speed of the base motion and the path amplitude/speed to achieve desired results. Radial motions function similarly except direction is a binary in/out measure on the slider. Spiral motions are similar to radial, however direction controls which way the spiral bends (clockwise vs. counterclockwise) rather than inward/outward.

Table 3

Properties that can be changed in the Motion Editor.

<table>
<thead>
<tr>
<th>Texture</th>
<th>Shape Direction</th>
<th>Linear, radial, spiral or user-specified</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Speed</td>
<td></td>
</tr>
<tr>
<td>Path</td>
<td>Curvature</td>
<td>Straight, Angular, Wavy</td>
</tr>
<tr>
<td></td>
<td>Speed</td>
<td></td>
</tr>
<tr>
<td>Objects</td>
<td>Size</td>
<td>opacity</td>
</tr>
<tr>
<td></td>
<td>trail</td>
<td></td>
</tr>
</tbody>
</table>

6. Design evaluation

As visualisation researchers know, assessing the effectiveness of a visualisation technique is challenging. Evaluation of visualisation methods is typically either qualitative, via feedback from or observation of expert users, or quantitative, via empirical measurement with relatively naıve users on simple tasks [2,5]. These are typically drawn from three methodologies: scientific-empirical, involving controlled lab studies where only one or two factors are carefully manipulated; ethnographic/qualitative, emphasising the importance of context, observation and subjective human interpretation; and what are loosely termed participant-oriented methods, including design reviews, expert user critiques, participatory design and broad-based user feedback and focus group reviews [41].

A number of eminent researchers stress that controlled studies examining the efficacy of a particular technique have a number of drawbacks that limit their utility [2,17], as they involve non-expert users and constrain the scope of use and what to assess. Thus their results are sometimes difficult to generalise to different, more complex environments and tasks. In fact, Greenberg points out such methods are inimical to developing design
understanding, as they mute creative ideas and do not provide meaningful insights and critiques of how the design would be adopted and useful in everyday practice [17]. Such methods are more suited to summative studies with the goal of refining and improving usability, but poorly suited to formative investigation that seeks to explore and map a design space.

In contrast, these researchers advocate the inclusion of iterative exploration, reviews and critiques with experienced visual designers (an established method in design) both as a rich and effective evaluation method and as a way of increasing knowledge to design new techniques [2,40,17]. We therefore directed our attention to how expert visual effects designers might create and use motion textures in general, and the implications of the tool design in particular. We consider this as both an evocative and an evaluative continuous process, rather than a singular study. We are continually exploring both an understanding of the expressive capacity of motion textures (an evocative investigation) and the utility of motion editing techniques and tools to produce them (a more focused usability and design evaluation). Our goals for this stage of evaluation are twofold: to further our understanding of if and how motion texture can communicate affect and to determine the utility and subsequent requirements for a motion texture painting tool.

6.1. Method

Rather than a managed experiment with set of controlled tasks, we took a dual approach to these questions: a practice-based design review where the participant used the tool and indentified key issues, and a participatory artistic exploration where the participant created motion textures to express affect in keeping with his or her artistic practice. For the latter we were interested in whether the creators would consider the motion properties available (the factors from our previous experiment) as interesting and useful for affect; whether they would consider them expressively limited; and which properties contributed to their impressions. (This was the reason for adding the User texture described above.)

We began each session by introducing the designer to the features of the motion texture editor. To the side of the tool was a series of sliders for 10 affective ratings:

1. positive,
2. negative,
3. calm,
4. exciting,
5. urgent,
6. relaxed,
7. threatening,
8. reassuring,
9. attracting and
10. rejecting.

These reflected our ratings from the previous study. We note that – unlike the first experiment – these base affective measures were not presented as alternatives but rather as simple descriptors (i.e., threatening and reassuring were not defined as mutually exclusive). We introduced these ratings as measures from previous studies, and asked each designer to create motion textures characteristic of these affective measures. This enabled us to link the outcomes to the previous experiment. However, we introduced these only as a starting point: the participants were also encouraged to explore the affordances of the space and to create and describe anything he/she deemed interestingly affective. Thus we did not limit the instructions to simply producing motions that would represent singular affective impressions. While we were interested in seeing whether the designers would generate textures that would reflect each affective impression, we discovered from the start that they were interested in layering and combining affect rather than concentrating on one affective impression uniquely. We also did not limit the amount of textures a participant could generate, as some of our designers wanted to explore multiple options in a single texture, and others wanted to create multiple textures.

When the participant was satisfied with the affective qualities of the motion texture (s)he saved the motion with an open-ended
description and participant name. Textures could be read back in for additional annotation, as a starting point for variants, and to compare to the creation of new textures. During the session, each participant kept a running commentary on the textures, on the affordances of the design space itself, and on the tool. As new points or comments arose, the experimenters engaged the participant as necessary in discussion to clarify and capture information. Each session was between 1 and 2 h in duration.

To date we have explored motion textures with five professional designers from different domains. Participant 1 is a professional game designer and the senior visual effects producer on a large game team, responsible for the complete look and atmosphere of a high-action game. He has a long history in designing virtual environments. Participant 2 is both a practicing visual artist and a scholar of the creation, staging and user experience of ambient video installations. He uses motion in several capacities of his work. Participant 3 is a theatre lighting and staging designer and scholar in the field. He uses various light based motions in a number of works. Participant 4 is a video editor with a large body of work who deals constantly with motion analysis to determine cuts and scene transitions. Participant 5 is a practicing visual artist and scholar. She creates evocative video installations that utilise motion to create new and alternative sensations. For brevity, we refer to the participants as P1...P5.

6.2. Data

Data sources from each session included the experiment notes from participant observations and discussion, the motions created, the associated ratings for each motion, and the participant-supplied annotations and descriptions of each motion. We had a total set of 37 created motions with 10 ratings for each. The descriptions were a mixture of titles, personification, adjective description, and affective labels. The complete data set thus comprised the attributes they manipulated, the complex affect they sought, their description of the effects combined to create it, and finally their comments and suggestions on how such a tool might open the doors of this creative potential to better use. We note that observation was based on listening to and discussing with the participants. As they became deeply engaged with the process, their talk-aloud diminished, so our observation into why they were exploring certain properties in conjunction with others was highly constrained and incomplete. As a result, we used observer notes during the session only for tool use: we relied on post-session interviews reviewing each motion and on the designer annotations in the motion tool itself to analyse the motions rather than observer interpretation.

6.3. Threats to validity

By definition this approach is uncontrolled and highly subjective, in particular as the kinds of artistic expression we are trying to understand in this medium are highly idiosyncratic, difficult to self-report, and thus challenging to generalise. As this approach is not quantitatively based and we have a small sample, statistical analysis is inconclusive. While we do have an objectively collected set of data (the motions and ratings), we noted immediately that all participants did not limit their motion descriptors to a single affective measure. Rather they began to explore what the tool allowed them to create with the different parameter manipulations and then tuned these to evoke the different affects. This meant that rather than resulting in one rating with different motion properties, the creators produced motion textures with numerous, sometimes seemingly contradictory, ratings and descriptions. This makes it difficult to isolate and quantify the individual factors. Nonetheless, within the constraints of the approach, we discovered much useful information to further the development and deployment of these motion-based techniques.

7. Results

We report results for both the motions created by the experts, including a quantitative data as appropriate, and their observations and descriptions of the affective capacity of motion textures. We conclude with their feedback on the motion texture editing tool and subsequent requirements.

7.1. Analysis: motion properties

Fig. 9 shows the kinds of motions created by texture shape, path curvature, speed and participant. A review of the properties manipulated by the designers and their comments indicates some interesting trends. While statistical analysis must be treated with

![Fig. 9. Motion counts by participant and property.](image-url)
7.1.1. Motion texture shape was heavily used and contributed to a sense of animacy

Our designers largely worked with radial and spiral motion shapes. Out of 37 total motions there were 10 linear motions, 7 user generated motions and 20 radial/spiral motions. The designers expressed little interest after initially exploring the user motions, but all felt the radial and spiral motions were “organic, living”, whereas the linear motions were more “rational” (P1), “inevitable” (P2), “departing, leaving” (P4).

7.1.2. Speed affects intensity

Fig. 10 shows that “calm” motions were slower and a linear trend analysis showed this trend is significant, \( p < .01 \), (despite the caveat of the small \( n \) of this study). We see that when the designers created calm motions they manipulated speed; they consistently reported it as a primary visual property for intensity, or more accurately, the lack of intensity.

7.1.3. Path curvature and speed contribute to affect

We noticed that path curvatures do not seem to separate cleanly into our three categories; rather, both from our review of the motion properties and the designer reports, they aggregate into “straight” and “non-straight” path shapes. Fig. 11 shows the influence of path curvature on ratings. The influence on intensity (exciting), dominance (threatening), urgency and interaction (rejecting, attracting) ratings can be seen. While it is difficult to fully isolate the path curvature from other properties such as texture shape, the differences between straight and non-straight paths are notable for the designer descriptions. P1, for example, described angular, large path deformations as “negative, cold, energy, electrical, disconcerting”, where slower, wavy motions were “symphonic, calming, positive”, and faster wavy motions were “dissonant, attracting, exciting, living tissue”. P2 described fast angular deformations as “chaotic, dangerous, compelling, uncertain”, but slow, wavy paths contributed to “inevitability, growth and assimilation”. All had a similar interest in the regularity afforded by path deformation, stating that overlaying path deformations on texture shape created “organic” patterns that were both regular, “hypnotic” and yet “natural”, likening them to patterns such as water caustics (P1, P2, P4, P5); galaxies (P2, P3, P4); explosions (P1, P3); rain and storms (P1, P3, P5), and flowering (P1, P3, P4, P5). These results stand with our previous results that indicate path deformations influence the perception of affect.

Fig. 10. Path amplitude emphasised affect.

Fig. 11. Path curvature and speed. Orange are straight paths, blue non-straight. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
7.1.4. Path amplitude emphasises certain affect
The designers confirmed that path amplitude – the size of the path deformation – is an important property in refining motion textures. Table 4 and Fig. 12 show that as the amplitude of a path deformation is increased, ratings of certain affective ratings increase. These are the same affective ratings we see affected by path curvature in figure with one addition. Interestingly, in the interaction case (welcoming/rejecting) this effect is not related to one of the opposites: it seems that generally to increase the affect of some interaction (either welcoming or rejecting) the designers increased the path deformation. This suggests that, in some cases, path deformation may be useful for emphasis rather than primary meaning.

7.2. Designer observations
The designers were all convinced of the utility and creative potential of abstract motion textures. We discuss each participant in turn. We then summarise their responses with respect to motion textures, the potential applications for such capabilities, and the shortcomings and promise of the motion editing tool.

7.2.1. P1: Visual design for immersive games
Ambient motion is used for visual effect frequently in video games, and is a critical aspect of affective motion, although the formalism of a motion texture was novel for this designer. He explored mainly radial and spiral textures, explaining they had a “natural focal point that drew the viewer in”, where linear textures carried the eye across the scene, communicating more “deterministic, rational, authoritative” impressions. He concentrated on manipulating speed and path deformations to alter affect, creating motions he described as “calming, with a sense of expectation; flower-like; healing” (slow, wavy, large paths); “rational, architectural, determined” (slow, angular, large deformations), or “dissonant, negative, threatening, electrical” (jittery, angular, fast, small deformations). These are all affective impressions that are important in enhancing user experience in games; he indicated he would use these effects for both ambient impressions as well as more focused cues such as navigation suggestions.

7.2.2. P2: Video art
P2 is an ambient video artist who specialises in living landscapes. He focused on spiral and radial motions that reflected “cosmic spin, birth, heartbeat and the attraction to the centre”, where inward direction signified “drawn to the abyss, attraction, assimilation, entropy” and outward directions contributed to a sense of “birth/rebirth, growth, time”. His one linear motion ascended upwards, communicating “inevitability” and “force”. He also expressed that small manipulations in path deformation and speed substantially altered affect: wavy slow trails were “soft” and “relaxed”; angular, fast paths were “dangerous”, “dark” but “energetic”. He also confirmed that inward motions were highly attracting. He expressed a strong desire to be able to embed these effects into actual video streams.

7.2.3. P3: Theatrical lighting
P3 has pioneered the use of video projection for focused theatrical lighting. He was most interested in small, slow, subtle linear textures with path deformations, as he stated the path deformations were the most evocative tool at his disposal for the lighting rather than textural shape, allowing him to create “rainy windshield”, “old windows” and “exploding sunsets” that he then uses to enhance the overall affect in the theatrical set. He found the controls confusing and did not rate his motions, but in post-session interviews and subsequent editing sessions, he has further explored both radial and spiral textures as evocative lighting “washes”.

7.2.4. P4: Videography
P4 is a videographer who curates, edits and adds effects to video for both artistic, professional design and marketing applications. He was most interested in the radial and spiral textures, emphasising the need for inward/outward spirals. He noted that as “shakiness” and “jerkiness” were introduced with fast, non-straight path deformations, impressions of “urgency”, “excitement”, “chaos”, and “mixed feelings” increased. Slow, wavy paths, on the other hand, were used for impressions of “sweet hypnosis” and “calm whiteouts”. He noted that the ability to overlay these effects in video and still images would not only add another affective modality but also provide a rich set of techniques for enhancing transitions between images.

7.2.5. P5: Visual and animated art
P5 is a visual artist who is intrigued by how motion textures can be used to paint organic forms. She noted that linear and radial motions allow very different living forms, using upward, wavy paths to imply “streams”; inward/outward radial directions to convey “propelling and repelling”/rejecting affect; and wavy, radial motions to convey “blooming”, “growth” and “expansiveness”. She expressed she was most interested in the potential of path deformations and how simple changes could affect the regularity, smoothness and intensity of the overall motions.

Table 4
Path amplitude contributes to affect.

<table>
<thead>
<tr>
<th>Rating</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attracting</td>
<td>&lt; .03</td>
</tr>
<tr>
<td>Rejecting</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>Negative</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>Exciting</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Threatening</td>
<td>&lt; .007</td>
</tr>
<tr>
<td>Urgent</td>
<td>&lt; .006</td>
</tr>
</tbody>
</table>

Fig. 12. Path amplitude emphasised affect.
7.3. Discussion

7.3.1. Motion textures have significant expressive capacity

All participants were intrigued and impressed by the expressive scope of the motion textures. The affective measures provided in the instruction phase were used as a springboard by the designers to create more complexity. Rather than focusing on one affective trait, most crafted textures had layers of meaning (for example, one motion was described as “positive, exciting but a little bit threatening”). It may be too simplistic to think of every motion as having a discrete primary and secondary affect; however, all designers referred to a motion texture having a major affect and overtones of other minor affective properties. In some motions affective ratings have complex affective pairings: calming and exciting or threatening and relaxed.

Some groupings of primary effects were found. There were strong groupings of urgent and threatening responses, in addition to a grouping of this pair with an exciting response. Calming and reassuring were also grouped consistently in addition to exciting, attracting, relaxed, and reassuring. Other groupings included positive, exciting, attracting and negative, threatening. These groupings are not dissimilar from the previous study with affective ratings [6,7]. Even though the affective ratings were not mutually exclusive in this study, there was some clustering based on their pairings used in the previous study. Since in the previous study the pairings were intended to be opposites, this is not terribly surprising, but provides some insight for future experiment design of affective ratings and measures.

7.3.2. Motion shape is important

However, there was little interest expressed to the experimenters in the user generated motions and only a slight interest in linear motions. The radial and spiral motions were described by the designers as having the strongest affect in addition to having the capacities for subtle nuances and layering of affect as mentioned previously. Several designers professed themselves to be drawn by the “organic” quality of these motions. However, there was interest expressed by P1 and P5 in the “mechanistic and rational aspect” of linear motions with angular deformation. Attraction ratings by the designers for radial motions confirmed our previous study. Radial motions with inward direction were rated strongly as attracting; outward motions were not symmetrically rejecting. Direction had little effect on spiral motions, but as direction in this case was not inward/outward rather left/right, that is perhaps unsurprising. We will need to examine the spiral in/out direction in further work. Participant E was intrigued by the subtleties that were achieved by only small changes of settings. Most designers stated that changing the properties of the simple, regular algorithmically generated motions was sufficient to create a wide range of affect.

While we saw no quantitative data to indicate affect and texture shape relationships, the designers were emphatic that linear and non-linear textures would be used in very different ways. Designers 1 and 2 discussed that radial and spiral textures are used in games for explosion and navigation (“go this way”) cues that require strongly different affect from threat to attraction. However, our differentiation of radial and spiral textures was seen as artificial, as the designers consider these aspects of the same general shape varying by both direction (inward–outward) and spin (clockwise/ counterclockwise). Our game designer and visual artists pointed out the combination of the two can simulate 3D effects, proposed as a rich addition to the planar 2D textures currently supported.

7.3.3. Path deformations are powerful and differentiating

Our designers had access to three aspects of path deformation: path curvature, path amplitude, and path speed (speed from previous study). These 3 settings in addition to the speed of the motion which would expand and contract path curvature afforded our designers a wide range of deformation shapes and low level controls. Only 6 straight paths were saved: the designers quickly moved to altering path curvature, identifying it as a powerful communicative effect. A common description was that wavy, fluid motions are more “organic” and “engaging”. However, our technique of a simple periodic sine function to implement waviness was insufficient to effectively capture this quality: wavy and angular motions looked quite similar and shared similar affective ratings. Our designers expressed that the controls for the wavy motion were not subtle enough and the path speed (controlling the period of the deformation) for wavy and angular motions was far too sensitive. Another comment was that wavy motions were degenerating visually into being angular when used with higher amplitudes and speeds. We therefore chose to group wavy and angular into “non-straight” motions to better assess trends. However, these comments point out the importance of getting the right “waviness” capability in a motion editor.

The influence of path curvature on motion texture affect mirrors previous research and our previous study. The designers confirmed that path deformations are visually evocative and a powerful communicator of affect. Trends from this study show that path curvature is used to increase affect in areas such as dominance, intensity and urgency in addition to being perceived as more negative and rejecting. Our study clearly does not encapsulate the wide range of path deformations that are possible for the creation of motion texture. The designers were particularly interested in the organic aspect of motion textures with path deformations that were discernibly wavy or angular. Several designers were attempting to emulate natural motions, notably slow spiral emitters (galaxies) and softly swaying grass.

7.3.4. Motion speed has affective potential.

In previous work and in our previous study, speed was discussed as significant to the creation of motion based affect. However, since speed tends to be dominated by the effects of heavy path deformations and motion shape, the affective subtleties of speed were hard to capture. The speeds used by the designers were split into two groups. In this study speed has a large effect on intensity, which was confirmed from previous work. Our designers note the importance and power of even small speed manipulations for intensity and mentioned that even slight changes could make a large affective impact on the overall texture. They also commented that speed enhanced and augmented the strength of other affects: i.e., it can be used a secondary effect.

All designers provided intriguing descriptions of their motions that led to some insights about the affective properties of path. For example, Participant A said wavy motion is very calming, has a great sense of expectation, and is hopeful, positive, attracting, calming, or relaxed, depending on the amplitude and speed of the wave. However, as the wave amplitude became larger and fatter, the motion retained a “smooth organic form”, but became more “dissonant”, “like watching a realistic marionette”. He designed two textures of similar shape – one with a wavy path (M1), and one with an angular path (M2) – both with similar path speed and amplitude. M1 was described as lush, positive and attracting, “like listening to a symphony orchestra”. M2, on the other hand, was described as positive, attracting, but “rational and deterministic, like architecture”. Participant A described angular motions as “alive, dangerous,” and simultaneously attractive and threatening. Participant D tried to, “convey an excited feeling without being negative,” by working subtly with combinations of path curvature and motion speed.
7.4. Feedback on the motion texture editor

The designers were keenly interested in the motion editor—both the potential for new visual effects offered by the concept of dynamic motion textures, and the tool itself was a great deal of interest from all designers. All participants were extremely enthusiastic about the idea of a motion texture editor and stated that such a tool would be useful as a standalone sketching environment or integrated into existing workflows. Our game designer, Participant A, was eager to have a similar tool in his workflow for the creation of atmospheric effects. Participants B and E were interested in further iterations of the tool to inform ambient motion decisions in the compositional process of their video works. Participant C was interested in the tool as a method to create abstract light effects and was further interested in the potential of painting video using motion texture to create affective theatre environments. We had anticipated that the designers would want to capability to generate these motion textures directly as atmospheric effects—for example, to manipulate particle, fog, water or grass movement. We were surprised at the interest in using the simple abstract textures themselves as visual effects.

Our designers had, however, a number of suggestions. Most obvious was the lack of a spiral inwards motion, since the spiral motions were driven by a single slider control offering only a left/right spiral out. A suggestion to collapse the spiral and radial motion shapes into a single shape with a spiral control was a useful insight. Additional motion types identified as interesting were flickers and pulses. A significant shortcoming was the lack of appropriate “waviness” specification for path deformations: rather than simple periodic functions, we clearly need more nuanced wave behaviours to achieve the fluid and curvy effects the designers want. Object properties such as opacity and size were also identified as interesting manipulations for the abstract motions.

It is clear that they would like high level affective motion brushes such as positive motion, threatening motion or calming/soothing motion. However they were also very interested in the low level controls. P1 was instrumental here, detailing that each control should have a secondary control level much as how path curvature effects the motion perpendicular to the path using a linear or sinusoidal movement.

This introduces questions of scope. Future work should not eliminate this control, but perhaps provide some affective presets or guides and allow the user to create custom motion texture brushes.

8. Conclusions and future work

In [4], we reported on an experiment conducted to examine two motion shapes: linear and radial, in three motion factors: speed, direction, and path curvature. This paper extends the previous conference paper [4] with the following contributions: (1) a description of a new tool for creating and editing abstract motion textures for affect, based on [4]; (2) a report on a design evolution how visual effects professionals used the tool to create affective motions; and (3) a discussion of how designers consider the expressive capacity of affective motion textures and the potential and utility of such a tool for these professionals.

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. 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.

We have engaged in an in-depth design evaluation with visual effects designers, visual artists, modelers and environment designers – all practitioners in the creative visual space – to explore the potential of affective motion textures as a design tool. In this paper we have reported on five of these qualitative sessions. These interactions have provided both encouragement and insight into how designers may use abstract motion properties to create textures of powerful and subtle affect. It seems clear that our conjecture – that subtle and rich affect can be achieved with abstract motion effects – is well founded and that there is a rich design space of affective properties, beginning with simple parameters such as shape, path trajectory and speed.

The model of “motion brushes” and a palette of tunable effects fits well with how these practitioners consider integrating this expressive medium into their creative processes and workflow. However, there remain many questions to address around the semantic level of affective motion specification (a “positive” motion brush or a path curvature brush? Or both?) We are actively engaged in extending these designer studies to address these questions.

Future work will address additional motion properties of interest (such as spiral direction). We are also beginning to look at the complex properties of interacting motions in both single and textural forms based on behaviour models such as flocking, herding and chasing, similar to those identified in early psychological research [18], applied perception [27] and computer graphics [34]. Finally, in ongoing work with several visual effects designers, we are implementing motion texture effects into performance and game environments to evaluate the end-to-end process of creating, using and studying affective motion.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.jisomat.2012.02.005.

References