Motion, Emotion, and Form: Exploring Affective Dimensions of Shape

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Abstract
In this paper, we present a study examining how individuals embody emotion within form. Our findings provide a general taxonomy of affective dimensions of shape consistent with and extending previous literature. We also show that ordinary people can reasonably construct embodied shapes using affective dimensions, and illustrate that emotion is conveyed through *both* visual dimensions and tactile manipulations of shape. Participants used three distinct strategies for embodiment of emotion through shape: the look of a shape (*visual representation*), creation of a shape symbolizing the experience of an intended emotion (*metaphor*), and by evoking the intended emotion in the creator through affective movements and manipulations during construction (*motion*). This work ties together and extends understanding around emotion and form in HCI subdomains such as tangible embodied interaction, emotional assessment, and user experience evaluation.

Author Keywords
Form; Affect; Emotion; Embodiment

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

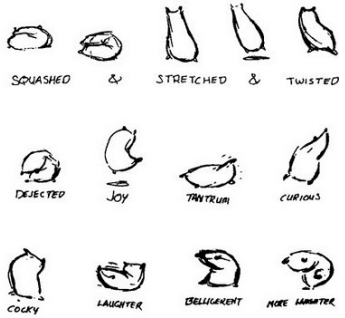

Figure 1: The Disney flour sack expressing emotions [28].

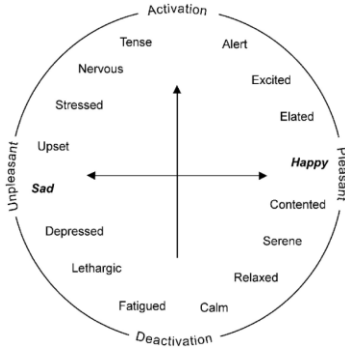

Figure 2: Russell's circumplex model of affect [26].

Introduction

In HCI, research linking dimensions of shape to phenomena such as emotion is fairly limited. Certain visual dimensions of form have been shown to express a wide range of emotions [9, 15, 21, 22, 25, 28], but there is no unified understanding of which dimensions relate to which emotions [20]. To address this gap, we explore the relationship between shape and emotion, providing a taxonomy of affective shape dimensions and insight to how individuals embody emotion in form.

Related Work

In this section we present an overview of related work on emotion and form, tangible interaction, models of emotion, and emotional assessment tools. We note that studies tend to focus on perception and modulation of emotion rather than embodying it, indicating a novel space for exploration through our study.

Emotion and Form

There has been a variety of work examining the relationship between emotion and form. Poffenberger studied stimulus-response mapping of adjectives to small, medium, and large angular or sinusoidal waves going in flat, ascending, or descending directions [25]. These results were replicated by Collier and mapped onto valence-arousal dimensions showing downward facing lines represent low arousal emotions, upward facing lines represent high arousal, angular lines represent negative valence, and smooth curves represent positive valence [9]. Interestingly, the expression of emotion through curvature and orientation of form appears to apply more broadly to complex two-dimensional figures such as the Disney flour sack [28] which can convey a range of emotions without clearly defined human form (see Figure 1).

Also of importance is the somewhat generalizable affective dimensions of three-dimensional shapes found by Isbister et al through development of their Sensual Evaluation Instrument. They identified that rounded shapes correspond to positive valence, spiky shapes to negative valence, smooth shapes to low arousal, and protruding surfaces to high arousal [14, 15].

Recent work has also been done in the mapping of words to form through a CAD tool (EmotiveModeler) for emotive design [22, 23]. By typing an emotion-based word into the tool, a three-dimensional shape will be generated based on many of the affective dimensions described above. Conversely, fuzzy logic models have been used to perceive emotion from characteristics of shape and validated through an empirical study with design students and professionals [1].

Tangible Interaction

Tangible interaction can be thought of as encompassing a range of systems and interfaces relying on embodied interaction, physical representation and tangible manipulation of data, and embeddedness in real space [4, 13, 16]. The related work that deals with emotion tends to focus on the use of tangible and embodied interactions to evoke emotion (e.g., through physical gestures [12]) or modulate it [2, 10, 17].

A Circumplex Model of Emotion

For understanding emotion, our work utilizes Russell's circumplex model of affect (see Figure 2) which proposes that all affective states can be described with two dimensions, valence—the positive and negative spectrum of emotional states—and arousal—the energetic level of an emotion [26]. In this model, emotion can be understood as linear combinations of

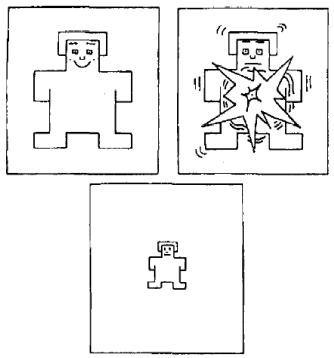

Figure 3: Three points from the Self-Assessment Manikin [6]. Top left, from the pleasure/valence dimension; top right, from the arousal dimension; bottom, from the dominance dimension.

Figure 4: The Sensual Evaluation Instrument [15].

valence and arousal at varying degrees. Additionally, this allows a more continuous representation of emotion than earlier theories of basic emotions which contained a discrete and limited set of emotions [26]. Recent work in emotion supports this notion of 'core affect' comprised of valence and arousal [3].

Visual and Tangible Emotional Assessment Tools

Most emotional assessment tools rely entirely on words or Likert scales. However, there are some pictorial tools that utilize the relationship between form and emotion for assessment. A prominent example is the Self-Assessment Manikin (SAM) [6] which uses the pleasure, arousal, dominance (PAD) model of emotion. SAM depicts a graphic character arrayed along a nine-point scale (see Figure 3). For the pleasure dimension, the character is portrayed with a smiling face on one end, a neutral face in the middle, and a frowning face on the other end. The arousal dimension modulates size and intensity of an explosion and the manikin's apparent alertness through facial features. In the dominance dimension, manikin size is modulated.

There is also one example of an emotional assessment measure that uses 3D form. The Sensual Evaluation Instrument (mentioned above) [15] provides users with a set of hand-sized, ambiguous physical objects meant to afford a channel of emotionally evaluative communication through dialog between user and designer (see Figure 4) [15, 18]. The creators of the instrument documented consistencies in response of users to shape characteristics across cultural contexts [14]. However, it has been noted that the taxonomy of the shapes is limited and participants have expressed a need for additional affective dimensions and more forms to better capture emotional nuances [15, 24].

Clay Shape Construction Study

The SEI tool provided us with inspiration for an approach to conducting exploratory research about the relationship of emotion and form. The SEI researchers had an artist create their objects. Would non-experts make use of similar form factors to convey emotions? Considering the significance of tangibility and collaboration in many affective domains [13, 15, 29], we felt it was of interest to examine how individuals and groups construct objects intended to convey specific emotions through form, when given the tools to do so. However, creating digital models with Computer Aided Design (CAD) tools is a difficult task for most users [7]. We decided to experiment with a modality that was tangible and accessible to everyday creators while remaining flexible in manipulations of form. Plasticine clay—commonly used in clay animation—was a natural choice since the material can maintain fine grain details of shape, but has a low barrier to entry for moderately skilled manipulation and use. Additionally, mixed emotions (i.e., multiple emotions experienced simultaneously [5]) are important to emotion research [19, 20, 24], so we were curious if the complexity of multiple emotions could be expressed through a single shape. We hypothesized participants would accurately construct shapes representative of emotion, but anticipated difficulty during collaborative construction due to the implicit, individual subjectivity of emotion. We anticipated that many affective dimensions of shape from related work [9, 15, 25] would be utilized in the embodiment of emotion in clay shapes.

Methodology

PARTICIPANTS, EXPERIMENTAL SETUP, AND PROCEDURE

A total of 6 male and 8 female subjects (ages 22-51, M=36.5) participated in the clay shape construction

	Single Emotion	Mixed Emotion
1	Contentment	Disinterest & Surprise
2	Boredom	Excitement & Frustration
3	Excitement	Boredom & Frustration
4	Frustration	Contentment & Boredom

Table 1: Emotional sets used for testing.

	Study Phases
1	Practice replication of two Sensual Evaluation Instrument objects individually
2	Individual construction of a single emotion
3	Collaborative construction of a single emotion
4	Individual construction of a mixed emotion
5	Collaborative construction of a mixed emotion
6	Posttest semi-structured interview

Table 2: Experimental phases of the study.

study. Of the 14 participants, 11 reported prior experience with clay based activities, and no participants were professional designers. For the experiment, we placed two desks in separate rooms with a 5 pound block of plasticine clay. A webcam was also placed several feet above each desk to capture top-down video and audio from the construction and interview portions of the test.

Each test was conducted with two participants. Before beginning, we randomly chose 1 of 4 emotional sets for the procedure (see Table 1). Each set was designed to encompass a broad spectrum of high and low arousal/valence emotions that would fall in different quadrants of Russell's circumplex model. During phases with clay construction, participants were instructed to think-aloud by describing their thoughts, actions, and feelings as they worked. When working individually, participants were placed in separate rooms and when working collaboratively, participants were placed at a shared desk in the same room. The study consisted of 6 experimental phases (see Table 2) over about one hour. After testing, audio recordings were transcribed and analyzed. Basic text analysis was used to identify shape descriptions with respect to an emotion and count the frequency of shape description occurrence. Descriptions were later clustered by theme and emotion to create a taxonomy of affective dimensions.

Results and Discussion

The clay shape construction study generated a total of 42 clay shapes among the 14 participants (see Figure 5 for a broad sampling). Of that, 35 shapes were thought to accurately represent their intended emotion by at least one creator. During creation of shapes, several themes emerged around the embodiment of emotion.

Affective Shape Descriptions: Arousal as Overall Structure and Valence as Fine-Grained Detail

Audio recordings were taken during the shape creation process and later analyzed to identify themes in the descriptions of shape and its relationship to certain emotions. The themes around common affective dimensions of shape described by participants were then synthesized into a general taxonomy (see Figure 6). Shape descriptions that often appeared in usage for emotions of similar arousal levels (i.e., frustration and excitement, boredom and contentment) were put in separate high/low arousal categories.

Our taxonomy identifies many known affective dimensions of shape, such as spiky shapes conveying frustration and round shapes conveying contentment. It also identifies many new dimensions, such as flatness conveying boredom or symmetry conveying contentedness. Importantly, we found that the expression of emotion through form is not as simple as just combining different affective dimensions into one shape. Instead, both visually and in the usage of descriptions, the arousal of a shape tended to be expressed through its overall structure (e.g., the *entire* shape is big, has visual variation, etc.) while valence tended to be expressed through fine-grained detail of elements within the shape (e.g., the shape *contains* some arches and spikes that extend upwards).

Visual Representation, Metaphor, and Motion

When constructing shapes, we found that participants embodied emotion in three distinctly different ways: (1) through the look of a shape (*visual representation*), (2) through creation of a shape symbolizing the experience of an intended emotion (*metaphor*), and (3) by evoking the intended emotion in the creator through affective

Figure 6: A broad sampling of affective shapes created during the clay shape study.

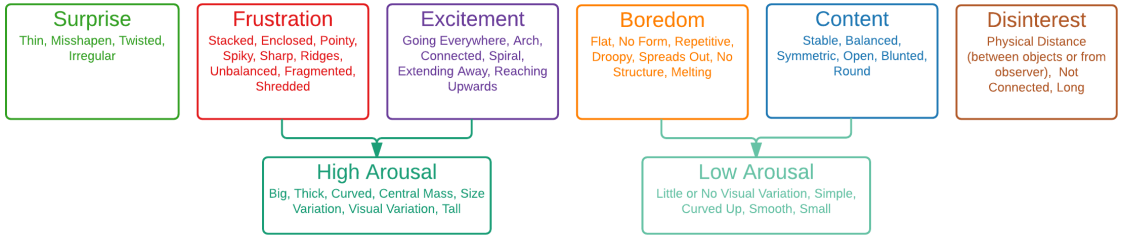

Figure 5: A taxonomy of affective dimensions of shape identified from the clay shape study.

movements and manipulations during construction of a shape (*motion*). Of the 42 shapes constructed, 15 shapes were created by 12 participants using visual representation for embodiment; 21 shapes were created by 13 participants using metaphor; and 6 shapes were created by 6 participants using motion.

During embodiment through visual representation, focus is placed on visual features of the shape itself that represent and evoke an emotion in the viewer (e.g., a flat shape for boredom or a spiky shape for frustration). For one such occurrence, P11 notes their use of visual representation to embody boredom in their object (Figure 7 left): *"...I don't think it should have any curves or even things protruding out of it. But just sort of flat and consistently the same size so that nothing really catches your eyes"* (P11, Boredom).

During embodiment through metaphor, focus is narrative driven and relies on the shape symbolically representing a person or object experiencing the intended emotion (e.g., curving a shape inwards to represent a person curled up from boredom or trapping an object in an enclosed space to show frustration). For instance, P10 describes how they embodied contentment in their object through metaphor (Figure 7 middle): *"Now I'm gonna make a ball that lives in a bowl. He's totally happy... It's very comfortable. I bet it's really soft. So he can get out if he wants to. He's not confined"* (P10, Contentment).

For embodiment through motion, focus is on utilizing the construction process to evoke an intended emotion in the creators themselves. Motions and manipulations that modulate the builder's internal emotion (e.g., repeated rolling to feel boredom, or tearing and smashing the clay to feel anger) are key to this form of embodiment. When constructing a shape representative of boredom, P4 embodied boredom through the act of repeatedly rolling and folding clay until they felt bored (Figure 7 right): *"I rolled it out into a flat line because I couldn't think of anything more monotonous than rolling clay. And then when it got long and narrow, I'm bored. Maybe I'll just fold it. And I just kept folding and folding and folding"* (P4, Boredom).

Figure 7: Shapes constructed with three different forms of embodiment. Left is boredom embodied through visual representation. Middle is contentment embodied through metaphor. Right is boredom embodied through motion.

Individual vs. Collaborative Construction
Preference for individual or collaborative construction was split among participants: 6 individual, 6 collaborative, and 2 liked both equally. However, all participants noted contrasting benefits to each approach. The individual benefits described were a more emotionally pure experience, greater creativity, higher accuracy representing emotions, and ease of constructing the intended shape. Conversely, the collaborative benefits described were increased emotional perspective and context, modularity of the construction process, and greater enjoyment overall. Far more dialog on emotion was also generated during collaborative conditions as participants had to navigate social dynamics, explain their thoughts, and justify every potential manipulation to the shared shape.

One notable problem participants had was difficulty in successfully creating mixed emotion shapes and shapes through metaphor. Although the overall success rate for construction of shapes (i.e., at least one creator felt a shape accurately represents the intended emotion) was reasonable at 83%, the success rates for collaborative construction of mixed emotion and metaphor shapes was much lower at 58% and 64% respectively. This poor result reflects the common disagreement between participants on how shapes should be manipulated based on narrative or a complex mixed emotion representation; often leading to shapes that neither participant was happy with.

Discussion
Based on participant discussions of emotion and success rates from the results, it appears that ordinary individuals can embody emotion within form to some extent. While many of our hypotheses about these results were intuitive, we found one unexpected aspect of embodiment: the importance of motion and tactile manipulation for the expression of emotion in form. When creating affective shapes, embodiment of emotion occurred through *visual representation*, *metaphor*, and *motion*. The use of motion-oriented forms of embodiment with visual forms helps tie together understanding of the relationship between motion, emotion, and form in domains such as tangible embodied interaction [4, 11–13, 27], user experience evaluation [29], and emotional assessment [8, 15, 18, 20]. There are also parallels between current research on emotion in form and our results. Many affective dimensions of shape identified in our study (see Figure 6) match, closely parallel, or extend affective dimensions found in other studies. Specifically, what is legible to individuals are dimensions manipulating core affect [3]; such as sharp angled edges represent negative valence while rounded edges represent positive valence [9, 15, 25], and smooth surfaces represent low arousal while visual variation/various extrusions represent high arousal [15].

Future Work
Moving forward, we hope this work will provide theoretical underpinnings for future projects and affective design endeavors in more hedonically oriented HCI domains such as TEI, mood modulation, user experience evaluation, and emotional assessment. We believe our taxonomy describing affective dimensions of shape will aid in the creation of CAD tools that afford users quick and simple affective manipulations during the modeling process. We also feel this work naturally translates to the design and evaluation of tangible tools meant to evoke emotions or allow users to express their internal state.

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