GUIDELINES FOR DEPICTING EMOTIONS IN STORYBOARD SCENARIOS

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ABSTRACT

Designers use storyboards to present scenarios of future product use. Despite the benefits of conveying emotional experiences in storyboard scenarios, the design community lacks guidance on how emotion should be depicted in storyboards. We conducted interviews with cartoon artists and used crowdsourcing to classify a large set of emotion examples from comics and manga. Results show that people can recognize instances of happy, angry, and sad emotions rather reliably, but they often misinterpret emotional expressions for fearful, surprised, and disgusted. We extract the most salient features for expressing basic emotions, and create design recommendations for how to depict emotion successfully in storyboards.

Keywords: Storyboards, emotional expression, emotion recognition, cartoon, salient features

INTRODUCTION

Storyboards are used to depict scenarios in the design process, to tell a story about how people will interact with a yet-to-be-designed product (Rosson and Carroll, 2003; Erickson, 1995). Designers use storyboards to investigate possible human behaviors and reactions towards a future product, to reflect on the context of interaction, to evoke feedback from potential stakeholders, and to elicit design rationales (Carroll, 1999; Rosson and Carroll, 2003; Erickson, 1995; Davidoff et al., 2007).

Instead of merely sketching out the functional and operational specifications of the proposed design, a storyboard scenario simulates why and how potential user(s) may interact with a design in real life. The story often consists of a setting, one or more actors with personal motivations, knowledge, and capabilities, various objects that the actors encounter, a sequence of actions and events that leads to an outcome, and a usage context that includes the goals, plans, and reactions of the people taking part in the episode (Rosson and Carroll, 2003).

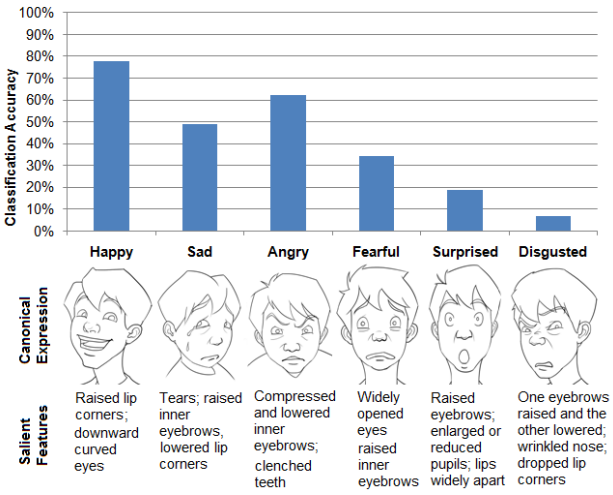

Figure 1. Results of our emotion classification study indicate that people most accurately recognize happy and angry, and uncover canonical expressions and salient features for the six basic emotions.

Designers often depict emotions in storyboard scenarios as they play a critical role in the envisioned user experience. By depicting emotion in storyboards, designers can highlight the potential benefits and competitive differentiators of the new design (Truong, et al., 2006). Emotion makes the design scenario less ambiguous and more convincing, and increases the likelihood that the readers will adopt and support the designer's point of view (Clark and Mills, 1979).

Despite the value of communicating emotion in storyboarding, the design community lacks resources about the canonical depiction of emotion. To this end, we recruited about 300 people over the Internet to classify examples of how emotion is depicted in Western and Japanese comics. From this dataset, we present design guidelines for communicating emotion in storyboard scenarios (Figure 1).

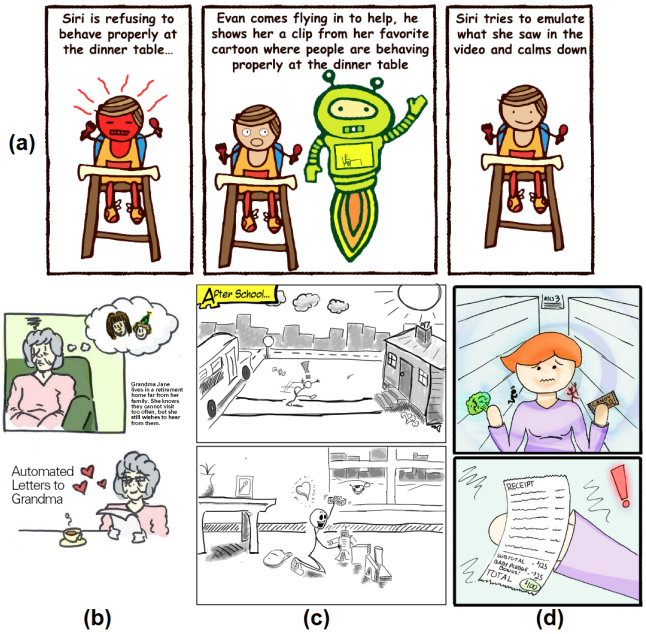

Figure 2. Examples of how emotion is depicted in storyboards.

Designers commonly convey characters' emotions in their storyboards. To develop intuition about how this is done, we compiled and analyzed 158 storyboards created by 63 students from two design courses at our university (Figure 2). In total, 46% of the storyboards depicted emotion related to the intention to use the product, 54% depicted emotional responses when interacting with the product, and 44% depicted emotion about the outcome. The affective experience of users illustrated in the storyboards paints a clear picture of what triggers the need for the new product, how the product influences the user's activity, and what difference the product could make in daily life.

While designers may have some intuitive sense and/or training about how to draw a happy or a sad face, communicating emotion effectively in storyboards can be difficult. First of all, not all emotions can be recognized consistently. Prior research in psychology has shown that certain primary emotions such as happiness are easy to identify, but people's ability to recognize surprise, disgust, and other emotions varied greatly from study to study (Bassili, 1979, Ekman, 1971b). People found these facial expressions ambiguous when looking at photos. Hand-sketched storyboards often provide fewer, abstracted details and thus may introduce even more confusion than photorealistic representations.

Second, designers must choose from a wide variety of emotional features, such as different levels of facial details and assorted gestures and body languages. Designers can also convey emotion through various additional visual cues, such as color, background texture, motion lines, and symbols (see Figure 2). Facial expression, gestures and body language, and additional visual cues can be used in combination or separately. Designers need to choose features based on the style of drawing and the composition of the scene. For example in Figure 2(d), a red exclamation mark and wavy motion lines are used to convey excitement.

Third, several factors may influence an individual's ability to recognize emotion in storyboards. People from different cultures may rely on different features to interpret an emotion. For example, a face with frowning eyebrows and raised mouth corners is likely to be interpreted as "happy" by a Westerner, but "sad" by an Easterner (Yuki et al., 2007; Koda and Ruttkay, 2009). In addition, Masuda et al. (2008) showed that Westerners who are considered more "self-centered" concentrated on facial and body features to interpret an emotion, while Eastern Asians were more sensitive to the context. An individual's familiarity with the visual vocabulary has an effect on their interpretation of the illustration as well. For example, in one of our pilot studies, participants who had never read Japanese comic books (manga) often failed to interpret symbols that indicate anger. They also mistook sweat drops on the face due to fear as tears of sadness. As with any medium, designers should consider the characteristics of the audience when selecting features that depict emotion.

The current design literature offers little discussion on the salience of different emotional features for communicating emotion in storyboards. In this paper, we aim to address this problem by extracting canonical representations of basic emotions from cartoons (i.e. Western comics and Japanese manga), studying how different features affect recognition of emotion, and creating design guidelines for their use.

Storyboard scenarios (hereafter referred to as *scenarios*) are similar to cartoons and animations in the sense that they are sequential graphic

presentations. They ask the readers to imagine what *is* and what *might be*. Therefore, it is reasonable to borrow techniques to depict emotion from cartoon and animation creation. For example, McCloud (2006) explained how to render affective expressions in comics based on the movements of facial muscles. Thomas and Johnston (1981) listed nine ways (e.g. as angle of views, background rendering, shadows, layout, etc.) to depict emotion in Disney animation.

However, most artists develop these techniques through experience and knowledge accumulated over time. There is little comprehensive analysis in related literature on the salience of various emotional features and how they affect readers' interpretation of emotion when presented with different graphic strategies, such as realism, simplification, exaggeration, and symbolism (McCloud, 2006). Our work aims to gain a systematic understanding of when and how to communicate emotion in scenarios.

To this end, our first step was investigating canonical representations of emotion by interviewing cartoon artists. We used the experts' knowledge to guide our example collection, codebook generation, and feature-labeling of a large cartoon emotion corpus. With this corpus, we then examined if cartoon style emotion could be communicated universally through a classification study conducted on Amazon's Mechanical Turk. The results show that happy, sad and angry were recognized more consistently and reliably than surprised, fearful, and disgusted, regardless of the graphic strategy. We also identified the most salient features that differentiate each emotion category — such as eyebrow corners, mouth corners, tears, etc. — and found that overlapping salient features can cause confusion in emotion identification. The assessments of the salience and effectiveness of a wide range of design features were later added to the corpus. Based on the results, we provide actionable design guidelines for how to depict emotion in design scenarios, and propose the potential use of our dataset to support design communication as well as future research directions.

RELATED WORK

Researchers in the human sciences have investigated different aspects of emotion, including the types and roles of emotion and how people express and recognize emotion. In this section, we review each aspect and its implications for communicating emotions in design.

TYPES OF EMOTION

Izard and colleagues divided emotion into two types: basic emotions and emotion schemas (Izard, 2009). Basic emotions include positive emotions such as joy and interest as well as negative emotions such as sadness, anger, disgust, and fear (ibid). In contrast, an emotion schema is an affect state that influences mind and behavior, such as anxiety and guilt (ibid). Basic emotions involve a lower order of cognitive process than emotion schemas (Izard, 2009; Ortony et al., 1988; Tangney et al., 2007). Ekman further argued that basic emotions can be differentiated from other affects by distinctive universal signals (Ekman, 1999). In particular, he identified a set of common facial expressions across different cultures for six primary emotions (i.e. angry, disgusted, fearful, happy, sad, and surprised) (Ekman, 1993). Designers can utilize these universal and basic emotions in design communication, including storyboards.

ROLES OF EMOTION

Research has shown that emotions can activate or inhibit perceptual and cognitive processes of specific stimuli (Mineka and Sutton, 1992). Emotions draw attention, assist in remembering, and shape decision-making (ibid). Designers could leverage these near autonomous processes to help communicate designs and to create empathy with characters in a scenario.

Emotion can manipulate different aspects of attention to narrow the focus among competing visual stimuli (Hudlicka, 2003; Clore and Gasper, 2000). For example, in critical scenes in a scenario, designers can give characters intense emotion expressions to attract the reader's attention.

In addition, emotional experiences are better memorized than unemotional ones in general (Thorson and Friestad, 1985). For example, it is shown people have stronger memory of compelling positive and negative scenes and messages on TV (even more so for negative events than positive ones) (Reeves et al., 1991). If designers amplify the

character's emotional expression during product interaction, readers may have better recall of the competitive features of the new design.

Emotion and mood can affect one's judgment and decision-making (Thagard and Barnes, 1996). Individuals with positive emotion have the tendency to assess stimuli more positively (Brave and Nass, 2003), while anxious individuals are likely to interpret ambiguous information as threatening (Mineka and Sutton, 1992). It suggests that readers may project the character's positive affective response on the product and form more positive evaluation of the design.

EXPRESSIONS OF EMOTION

The myriad of ways people express emotion — including facial movements, gestures, postures, and body movements — can all be used to suggest a set of design features. Facial muscle movements are universally used to signal different emotions (Bassili, 1979; Ekman, 1978). Gestures, postures, and body movements are also embedded with emotional cues. For example, emotion analysis research suggests that people are likely to turn inward when they are sad, and to hunch the shoulders when they are experiencing fear (Frijda, 1986). However, when and to what extent emotions could be expressed may vary from culture to culture (Darwin, 1872; Ekman, 1971a; Ekman, 1971b).

EMOTION RECOGNITION

Not only is the expression of primary emotions universal, so is people's ability to recognize the basic emotions (Ekman, 1971b). Both photographs of human faces and simple drawings can provide sufficient details for one to perceive basic emotions accurately (Etcoff and Magee, 1992).

However, research findings contradict regarding what emotions are easy or hard to perceive. For example, Bassili (1979) found that happiness is easy to recognize, but participants achieved higher accuracy on identifying surprise; whereas the recognition for disgust, an emotion said to be easy to pick out in previous research, was fairly poor.

Culture may differently emphasize different emotions. For example, it is shown that individuals from an emotional expression culture pay more attention to the position of the mouth when trying to understand an emotion, while those from an emotional suppression culture tend to interpret emotions based on the region around the eyes (Yuki et al., 2007; Koda and Ruttkay, 2009). Therefore, designers need to take the cultural background of the potential user population into consideration when choosing emotional signals. Ideally, designers should choose cues and features that are independent of culture.

COMMUNICATING EMOTION IN SCENARIOS

Storyboards should depict not only the activities taking place in the scenario, but also the changes in situation, atmosphere, and feelings, allowing both the designer and the audience of the storyboard to gain a better knowledge of technical, social, economic, psychological, and even cultural functions of the design (van der Lelie, 2006). Given that more and more products are comparable in terms of quality, price and the technology applied, capturing a vivid emotional experience in a product interaction scenario allows readers to perceive richer characteristics of the design in addition to usability (Desmet, 2005; Truong et al., 2006). In addition, the depiction of emotion in scenarios helps evoke empathy for the characters, enabling readers to situate themselves in the scenario (Haesen et al., 2010; Truong et al., 2006). Therefore, it can be beneficial to transfer techniques from other popular sequential arts to storyboarding. Designers can more effectively communicate emotion and help the storyboard audience envision potential users' motivation, expectation and attitudes towards the future product (Spillers, 2003).

EMOTION EXPRESSION IN CARTOONS

Emotion expression is one key to the believability of characters and the appeal of the story in cartoons (McCloud, 2006; McCloud, 1993). Research has shown that individuals can recognize emotion from simple line drawings (Etcoff and Magee, 1992). Cartoons also augment basic lines and shapes with more visual cues, such as textures, lighting and shading, symbols and letters, colors, and special effects, such as exaggeration (McCloud, 2006). These cues may further facilitate people's interpretation of

emotion representations. In this paper, we studied two kinds of representations: Western cartoons, which we refer to as comics and Eastern cartoons, called manga.

We chose cartoons as the stimuli to study instead of animations, which may be too complex or too rapid to be understood (Tversky et al., 2002). In contrast, static cartoons mainly concentrate on the key frame of an emotion, which makes it easier to identify the salient features. In addition, most of the emotion recognition studies were conducted on photos. Cartoons will provide an interesting comparison to photos.

The design research community lacks a systematic investigation of how cartoons communicate emotion. An opportunity exists for contributing this knowledge so that designers can apply it to emotional communication in design scenarios.

INTERVIEWS WITH CARTOON ARTISTS

In order to gain an idea of how professional cartoon artists approach the depiction of emotion in their work, and what the conventions and trends are in the cartoon industry, we conducted expert interviews with four cartoon artists. Each had over ten years of experience in the Western comic industry. They participated in a one-hour phone interview and talked about their experience with comics and manga. They also discussed topics including to emotion depiction strategies, cultural differences, and the common visual vocabularies in comics and manga. The interviews were recorded and coded thematically. Some common themes include:

- Emotion plays a critical role in the communication of a cartoon story, and there are conventions for how emotion is conveyed.
- Exaggeration of facial features is widely used when trying to express a strong emotion. In manga, a character may turn into a more cartoony face to emphasize such exaggerations, and switch back to the normal face when the emotion explosion is completed.
- Contextual cues (e.g. motion lines, symbols, lighting, and background texture) are used, but are more common in manga. Comics are adapting some of the features under the influence of manga.
- Artists employ angles, perspectives and distance to further project the emotion.
- There are culturally-specific visual vocabularies, and these vocabularies may not translate from one culture to another.
- Artists usually learn to illustrate emotions by mimicking other artists, observing themselves or people around, and getting inspiration from acting (e.g. in movies or theatre).
- Great attention has been paid to how people perceive visual information in domains like advertising and film, in which it is of great importance for the professions to make sense of what catches people's attention and assists them in absorbing information. However, there is a lack of understanding of how people read comics.

The interviews with cartoon artists led to specific research questions: first, are people able to recognize cartoon emotions consistently? Second, what are the salient features that can effectively convey an emotion independent of the style of drawing? Third, where do people become confused in reading emotion from cartoons? To be able to answer these questions, we conducted a classification study with online participants.

EMOTION CLASSIFATION STUDY

To understand how people interpret depictions of emotion, we conducted a classification study using participants from the crowdsourcing platform, Amazon's Mechanical Turk[1]. We collected a large set of cartoon stimuli from 30 popular manga and nine comic books[2]. For each book, we extracted examples from five volumes. For books that have been

[1] Amazon's Mechanical Turk (https://www.mturk.com/) is a crowdsourcing Internet marketplace that allows users to post or participant in small paid computing tasks.

[2] Japanese manga: Akira, Berserk, Black Jack, Bleach, Death Note, Detective Conan, Doraemon, Dragon Ball, Fruit Basket, Full Metal Alchemist, GTO, Hellsing, Hunter X Hunter, Love Hina, JoJo's Blizzard Adventure, Lupin the Third, Master Keaton, Mushishi, Naruto, One Piece, Ookiku Furikabutte, Ranma ½, Rose of Versailles, Rurouni Kenshin, Slam Dunk, Touch, Tsubasa, Valley of the Wind, Vinland Saga, Yotsubato.

Western comics: Amazing Spiderman, Astonishing X-men, Batman, Fantastic Four, Incredible Hulk, Preacher, Teen Titans, Sandman, Swamp Thing.

published for many years, we sampled volumes n category. different years to reflect the changes in the artist th comics style over time. This collection covers a wide ra ed mouth genres, artist styles, years of production, and ty rming our characters. Our goal was to generate a comprehensive view of how people perceive and interpret cartoon emotions.

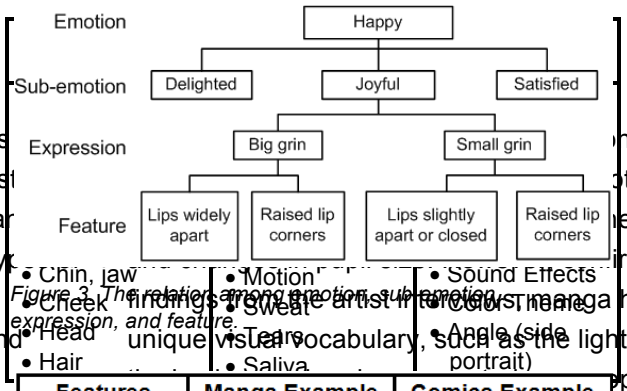

Figure 3. The relations among emotion, sub-emotion, expression, and feature.

SELECTION OF EMOTIONS OF INTEREST

Our study focused on the six basic emotions ide in Ekman's research — happy, sad, angry, fearf surprised, and disgusted (Ekman, 1993) — and sub-emotions based on Watson's PANAS-X sca (Watson et al., 1988). For example, the angry er includes hostile, irate, and loathing (Table 1, ne page).

findings from the artist interviews, manga has some unique visual vocabulary, such as the lightning bolts in pping out

COLLECTING AND CODING EMOTION ILLUSTRATI

Using our findings from the cartoonist interviews guideline, we captured examples that 1) are consistent with a long-standing convention, 2) ha potentially culturally-specific element, or 3) demonstrate a clear use of distinctive symbol, color, motion lines, background, lighting, or sound effects to convey an emotion. We manually coded the basic emotions and sub-emotions implied by each example based on the context and story of the frame where it appeared. Examples that express a combination of multiple emotions were excluded. Examples were coded according to the differentiating features specified in the interviews (Table 1). Overall, 116 examples were gathered from comic books, and 716 examples from manga.

Features	Manga Example	Comics Example
Raised upper lids, lips widely apart		
Raised upper lids and eyebrows, pupils enlarged or reduced		
Lightning bolts in the background		Not common in Western comics
Eyes popping out from sockets, raised eyebrows		Not common in Western comics

Figure 4. Examples of four expressions of "astonished" identified by differentiating features.

We coded the examples for the presence and absence of features. We employed most of the facial movement codes and some of the head movement, eye movement and gross behavior codes from the Facial Action Coding System (FACS) (Ekman, 1978)), and added additional visual cues suggested by the artists in the interviews (Table 2). Figure 3 demonstrates the relation between emotion, sub-emotion, expression, and feature.

Figure 4 shows some examples of manga and comics expressions that indicate the sub-emotion

emotion	Common Features that Comprise Expressions	Rate		Interpretation
Delighted	Happy tears; raised lip corners	100%	 78%	Sad: 4% Angry: 1% Fearful: 1% Surprised: 1% Others: 1% Not sure: 14%
Joyful	lips widely apart; raised lip corners (big grin)	85%		
	lips closed or slightly apart; raised lip corners (small grin)	78%		
Satisfied	Raised inner eyebrows; raised lip corners	46%		
Blue	Looking down; lowered head; lowered upper lids; compressed lips	74%	 49%	Fearful: 17% Surprised: 6% Happy: 4% Angry: 3% Others: 2% Not sure: 19%
Sorrow	Compressed and raised inner eyebrows; tears	68%		
Worried	Raised inner eyebrows; lips slightly apart; dropped lip corners	56%		
	Raised upper lids; lips widely apart; raised inner eyebrows	9%		
Loathing	Teeth tightly clenched; grinding sound; sweat drops on the face	100%	 62%	Sad: 7% Happy: 3% Disgusted: 2% Fearful: 2% Surprised: 1% Others: 3% Not sure: 20%
	Compressed and lowered inner eyebrows; teeth tightly clenched	81%		
Irate	Lips widely apart; teeth shown; compressed inner eyebrows; raised outer eyebrows	78%		
	Compressed inner eyebrows; steam/smoke cloud	60%		
	Compressed inner eyebrows; raised outer eyebrows; teeth tightly clenched; dropped lip corners	54%		
	Compressed inner eyebrows; fire flame in the eyes, above the head, or around the body	45%		
	Compressed inner eyebrows; raised outer eyebrows; teeth tightly clenched; angry mark; wavy motion line	45%		
	Compress inner eyebrows; shadow over (upper) face	43%		
Hostile	Lowered head; looking straight ahead; compressed inner eyebrows; compressed lips	61%		
	Tongue sticking out; raised outer eyebrows	22%		
Scared	Raised shoulders; chest backward; hands covering mouth	61%	 34%	Angry: 11% Sad: 10% Surprised: 7% Happy: 1% Disgusted: 1% Others: 1% Not sure: 34%
	Raised upper lids; pulled mouth corners; teeth tightly clenched	43%		
	Raised upper lids; lips widely apart; teeth shown	43%		
	Raised upper lids; pupils reduced; frozen emotions	13%		
	Closed eyes; lowered head; hands covering the head or face	9%		
	Eyes popping out from sockets; bloodshot in eyes	0%		
Afraid	Compressed inner eyebrows; pulled lip corners	29%		
	Raised upper lids; lips slightly apart	22%		
Nervous	Spraying sweat drops; wavy /dashed shivering motion lines	27%		
	Sweat drops on the face	13%		
Amazed	Raised eyebrows; lips apart	38%	 19%	Fearful: 17% Angry: 15% Happy: 4% Sad: 3% Others: 4% Not sure: 38%
	Slightly raised upper lids; lips slightly apart; exclamation mark	17%		
Astonished	Raised upper lids; lips widely apart	26%		
	Raised upper lids; raised eyebrows; lightning in the background or cracks on the face	23%		
	Eyes popping out from sockets; raised eyebrows	14%		
	Raised upper lids; raised eyebrows; pupils enlarged or reduced	10%		
Startled	Spiky motion lines; raised upper lids	10%		
	Raised shoulders; raised upper lids	9%		
	Frozen face with sparks in the background	0%		
Repulsed	Compressed inner eyebrows; lowered upper lids; dropped lip corners	13%	 7%	Sad: 36% Angry: 13% Happy: 4% Fearful: 1% Not sure: 39%
	Lowered upper lids; looking to the side; compressed lips; dropped mouth corners	5%		
Suspicious	Lowered upper lids; looking to the side	0%		
(b)	(c)	(d)	(e)	(f)

e 1. Complete list of the six basic emotions (a), sub-emotions (b), frequently used features for expressing those sub-emotions (c), gnition accuracy for each expression (d) and for each basic emotion (e), and the mistaken interpretation of each basic emotion (f).

STUDY PROCEDURE AND PARTICIPANTS

The study was conducted on Amazon's Mechanical Turk (mTurk). Sixty tasks of 20 examples from each emotion category were posted. Participants viewed examples one at a time, and selected their answer from six basic emotions: happy, sad, angry, fearful, surprised, and disgusted, or none of the above (Figure 5). After the classification task, participants filled out a short demographic questionnaire on their gender, age range, and country of birth. Each task was assigned to five different participants. Each task had several unambiguous examples identified in a pilot study for quality control. We filtered out submissions that failed to recognize the embedded checks before data analysis.

A total of 296 participants successfully completed the study. Overall, participants were mainly from India (180) and United States (58), and 57% of the workers were male. The age distribution was wide (80 in their 18-24, 99 in 25-30, 65 in 31-40, 43 in 41-50, and 3 people were 51 and above).

RESULTS AND ANALYSIS

We computed the consistency of human judgment on the emotion categories for each example. Seventy percent of the examples had at least three out of five workers in agreement. There were no significant differences in people's responses in terms of gender, age, and cultural background (i.e., whether they were from India or U.S. or elsewhere).

ANALYSIS OF EMOTION RECOGNITION

Participants recognized happy, angry and sad examples, while the other emotions remained more ambiguous. Over 50% of happy, angry, and sad examples were correctly identified by at least three out of the five participants (Column (e) in Table 1). When participants classified examples incorrectly, they were most commonly mistaken as sadness. Over 50% of sadness judgments were actually examples of other emotions.

Column (f) of Table 1 shows the confusion errors of every emotion category. It shows that 17% of the sad examples were mistaken as being fearful. About 34% of the fearful faces could not be identified and 11% were misinterpreted as angry. Only about 19% of the surprised expressions were accurately identified and the rest were often interpreted as angry or fearful. Over a third (36%) of the examples for disgusted were classified as sad. Overlapping features among emotions caused many of the misinterpretations.

Overall, people could consistently and correctly recognize happy, angry and sad regardless of how the emotion was expressed in the example. To gain a more comprehensive understanding of the influences of variety in emotion depiction, we further calculated the workers' agreement based on individual expressions.

ANALYSIS OF SALIENT FEATURES

Each basic emotion category (Table 1a) consists of several sub-emotions (Table 1b), each of which could be expressed in different ways (Table 1c). We grouped the examples into common expressions based on the set of low-level facial, body, and/or additional visual features shared by these examples. For example, one form of astonishment (Figure 4) contains the features *raised upper lids* and *lips widely apart*, while another form of astonishment was coded as *eyes popping out from sockets and raised*. Although some of the expressions were only found in manga, participants, regardless of their demographic and cultural background, had similar recognition performance.

To identify the most popular and salient features, we aggregated counts of each face, body and additional visual cues over all the examples that were correctly classified by at least three out of five participants for each emotion. We present examples of the most reliably recognized expressions of the six basic emotions together with the salient features extracted in Table 3 (next page).

	Happy (joyful) • Big grin • Looking straight ahead • Opening eyes widely and raising eyebrows
	Sad (sorrow) • Tears • Frowning mouth • Frowning eyebrows
	Angry (loathing) • Clenching teeth with grinding sound • Frowning eyebrows • Lightning bolt symbol in the background • Opening eyes widely
	Fearful (scared) • Opening eyes widely • Raising shoulders • Holding back chest • Covering mouth with hands • Looking straight ahead
	Surprised (amazed) • Opening eyes widely • Raising eyebrows • Opening mouth widely • Looking straight ahead
	Disgusted (repulsed) • Lowering upper lids • Frowning eyebrows • Frowning mouth • Looking down or to the side

Table 3. Most reliably recognized expressions of the six basic emotions.

DESIGN RECOMMENDATIONS

By comparing the feature set of the effective expressions in each emotion category, we realized that there are some features that are more informative than others for communicating emotion. If the differentiating feature of emotion A appears in the illustration of emotion B, it is likely that people will make a wrong interpretation. For instance, the hostile expression (Figure 6 left) and startled expression (Figure 6 middle) were mistaken as happy because the characters have their lip corners raised – looking as if they were laughing. Another example, widely opened eyes is the feature that commonly appears in examples for angry, surprised, fearful, and sometimes sad and gets people confused about these emotions, e.g. the worried expression in Figure 6.

Therefore, it is important to generate a set of design recommendations to guide designers in successfully depicting emotion in scenarios. Table 3 only presents the easiest-to-recognize emotional expressions. We summarize the general “good-to-have” and “must-not-have” features for the six basic emotions below:

- Happy. Designers should feature characters that are grinning, and employ downward curves in the eyes. Avoid showing characters that are frowning, have a compressed mouth, lowered head, and averted gaze.
- Sad. Tears are the most powerful feature for expressing sorrow. Designers can also feature characters that are frowning, with heads lowered and averted gaze. Characters should not feature a widely opened mouth or any features that suggest grinning or smiling.
- Angry. Designers should feature characters with compressed and lowered inner eyebrows, raised outer eyebrows, and clenched teeth. A sneer is often confused with a grin, so it should be avoided. In addition, it is important to note that an angry frown should be depicted differently than a sad frown.
- Fearful. Designers should feature characters with eyes widely opened, pupils enlarged or reduced, and a frown. Nervous smiles or compressed lips should be avoided.
- Surprised. Designers should feature characters with eyes widely opened, pupils enlarged or reduced, and a wide open mouth. To distinguish from fear, designers should draw raised eyebrows without a frown. Designers should avoid features that imply low emotional valence, such as lowered eyebrows, half-opened eyes, and compressed lips.
- Disgusted. Characters can communicate disgust by featuring one upper eyelid or eyebrows raised and the other lowered, a wrinkled nose and a frowning mouth. Do not depict eyes that are widely opened.

Figure 1 shows a canonical face, employing these design recommendations, for each of the six basic emotions.

Figure 7. Our preliminary auto-classification tool correctly identified the left image as angry, while incorrectly tagging the right image as fearful (the artist intended an angry emotion).

CONCLUSION AND FUTURE WORK

This paper presents research that contributes to a systematic treatment of emotional communication in design storyboarding. We interviewed cartoon artists and evaluated a large set of examples extracted from popular Western comics and Japanese manga in a classification study. The classification results produced a large dataset of examples and the most salient features for depicting particular emotions. This research provides interaction designers a set of recommendations for how to communicate emotion consistently and reliably in storyboard scenarios.

One direction for future work is to better understand the function and value of emotional representation for various design activities. We plan to investigate how storyboard emotions affect users' ability to empathize and provide feedback for future scenarios.

Although the literature says cultural background can influence an individual's recognition and interpretation of emotion, our data did not find any significant differences between cultures. In future work, we plan to investigate this in more detail.

Further, we can extend this work to develop tools to support communication of emotion in storyboards for designers. For example, we will compile our collection of examples into a searchable database. Based on our design guidelines, we might develop an avatar-creation tool that can guide designers in selecting appropriate emotional feature sets based on a number of factors such as drawing style and audience. Such a tool could support manipulation of facial features, similar to existing systems like the Grimace Project (2012) and allow designers to explore features such as the angle of the face, gestures and body languages, additional visual cues, and special effects.

Furthermore, we are currently exploring methods for automatically classifying sketches of emotion using machine learning algorithms and our cartoon emotion database as the training data. With an auto-classification tool, designers can assess how likely readers are to misinterpret emotional expressions. Designers can use the tool to improve their scenarios recursively throughout an iterative design process. For example, one of the artists we interviewed created two expressions of angry (Figure 7), and our automatic classification algorithm suggested that the right image is likely to be mistaken as fearful because of the widely opened eyes and mouth. Designers will be able to explore transition between emotions and new combinations of features with this tool as well.

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