Behavioral Measures of Emotion

5

Rubén Jacob-Dazarola[1], Juan Carlos Ortíz Nicolás[2] and Lina Cárdenas Bayona[3]

[1]School of Design, Universidad de Chile, Santiago, Chile [2]Institute of Architecture, Design and Art, Autonomous University of Ciudad Juarez, Ciudad Juarez, CH, México [3]Department of Design, Universidad de Chile, Santiago, Chile

1 Behaving emotionally

> *In a toy store, Peter laughs and runs from one side to another continuously. Every now and then, he goes back with his mother to show her a different toy and with a broken voice and full of excitement, he explains to her how it works and to which of his favorite TV shows it belongs. Then, he runs again and disappears in the aisles.*
>
> *When mom says it is time to leave the store, Peter takes a step back and with eyes wide open, he starts whining that he does not want to leave yet and in a matter of seconds, he starts throwing a tantrum. At this point Peter has his face on the floor, and his mother tries to convince him to leave the store. After a while, Peter stands up with his slumped shoulder and eyes still full of tears looking at the floor. Slowly, he accepts his mother's hand to walk to the exit.*

Almost all of us have witnessed (or have started) a similar situation as the described above. Peter's mom and certainly every person who observed the scene can recognize many of the behavioral reactions and triggered emotions that Peter experienced. When Peter laughs, screams and runs out of control, we are able to distinguish that he is full of joy. When he steps back with eyes wide open, we are able to recognize clear signs of surprise. On the other hand, the explosive crying and the tantrum show high levels of anger and frustration. Peter experienced emotions of joy, surprise, anger, and frustration.

Emotions have been described as episodes of interrelated and synchronized changes in human beings that occur in response to the evaluation of external or internal stimuli and have some personal relevance (Scherer, 2005). They are typically event-focused, adaptable, short-lasting, of variable intensity, and have an impact on human behavior (see Frijda, Kuipers, & ter Schure, 1989). In addition, current emotional theories tend to agree that they are a multidimensional phenomenon. Therefore, in order to study and understand them, it is important to consider the emotion's characteristics.

In relation to behavior, it has been suggested that it is self-propelled movement producing a functional interaction between an animal and its environment, such as finding a mate or fleeing from a predator (Aunger & Curtis, 2013, 2015). Three propellers have also been suggested: *pre-mammalian*, that is, a bad taste will cause a gagging reflex; *motivated behavior*, these are goal-oriented and are related to undertaking day-to-day tasks, for example waking up at 7:00 a.m. on weekdays; *complex behavior* is also goal-oriented, and is related to long-term objectives, for example losing weight

or saving for retirement (Aunger & Curtis, 2013). Therefore, this view of behavior is a multisensory expression and it can be linked to motives, as in the case of motivated and complex behavior.

The aim of this chapter is first to briefly establish what an emotion is and what its different dimensions are, and second, to identify and review the behavioral reactions that are involved in emotions, with a focus on three modalities: vocal, facial, and body expressions. We also review the interactions between these modalities. The third aim is to explain the impact of behavioral reactions on product design.

This chapter is divided into six main sections. The first describes the different dimensions of emotions. The second section introduces behavioral characteristics of emotions. The third discusses the role of behavior in emotions. The fourth, introduces measuring methods to identify emotions based on behavior. The fifth, discusses the role of behavior triggered by emotions in product design. Finally, the sixth section draws the conclusions of the chapter.

2   Hulk… Emotional! The different dimensions of emotions

One of the first attempts to define emotion was introduced in the article *What is an emotion?* William James (1884) establishes the body as the center of the emotional experience. He stated that emotions are "sensations from bodily changes produced by the perception of external stimuli." Therefore, when an emotion is experienced, especially when it is intense, the body undergoes certain reactions, and these reactions arise directly and subsequently from the perception of stimuli.

Most recent views on emotions tend to agree that they are a multidimensional phenomenon. It has also been suggested that they follow a process at which the different dimensions emerge gradually and not at once. Thus, emotions can be analyzed based on the experience of each dimension. For example, some scholars (Scherer, 1993, 2000, 2005; Smith & Kirby, 2001) have suggested *component processes* that include five subsystems. The recent views align, in some degree, with James' ideas, particularly when he mentions that the body undergoes certain reactions, for example, physiological and behavioral.

To explain the multidimensional characteristics of emotions we rely upon Hulk, the well-known character of Marvel comics. Bruce Banner, the peaceful Hulk's alter ego is constantly striving to control his emotions. Bruce knows that when something disrupts his peace of mind or a situation overwhelms him, Hulk emerges full of anger (Fig. 5.1). The following dimensions gradually emerge during the emotional process and some are more likely to be conditioned and modified by immediate dimensions than others:

- *Cognitive process*: It has been suggested that emotions help a person evaluate whether a stimulus enhances positive or negative emotions. For example, Bruce Banner appraises a stimuli based on its hedonic tone response, that is, whether the stimulus is positive or negative. Thus, Bruce

Figure 5.1 The changes experienced by Bruce Banner / Hulk illustrate the different dimensions that emerge during the emotional process. Image created by Andre Koekemoer and reproduced with permission of the author ("Lou Ferrigno - Hulk" 2011(c), http://www.andrekoeks.com).

Banner can appraise whether an enemy represents a real danger for him or not. It is important to remember that this is Bruce Banner's appraisal and others can appraise it differently.

- *Physiological processes*: The assessment of a given situation, whether positive or negative, triggers physiological change in an individual, for example, it affects the nervous and circulatory systems. It also modifies hormonal levels and the heart rate. The changes occur to prepare the individual's body to adapt to the current situation properly. In the case of Bruce Banner, his transformation is one of the most recognizable comic moments. He starts to hyperventilate, his heart rate increases, his eyes turn green and he starts sweating. Hulk's transformation is starting.
- *Facial and vocal expressions*: Some expressions and gestures are associated with particular emotions, and they act as a communication channel about individual intentions and actions. Hulk's roar and its characteristic phrase "Hulk smash!" are a clear example of this dimension.
- *Thought–action tendencies*: Cognitive processes and physiological changes stimulate behavior. For example, Bruce Banner aims to consciously be relaxed and he may think in positive scenarios. Nevertheless, when Bruce Banner is gone and Hulk emerges, he is full of anger. This enhances a behavior tendency to attack and crush any possible threat. Hulk waves his hands, in synthesis showing an aggressive behavior.
- *Subjective emotional experience*: The changes and modifications that have occurred in Bruce Banner act as a basis of the emotional experience, which is subjective in nature and the individual may be aware of. Based on this awareness a person sometimes can reflect on the emotional experience. When the danger has passed, Hulk rests, calms down, the physical symptoms are lessened and Banner takes control again. At this moment, Bruce is aware of the destruction caused by Hulk. He may regret the consequences and consider options to avoid Hulk's reemergence.

3   The historical role of behavior to identify emotions

In the study of emotions, one of the fundamental proposals related to behavior corresponds to the evolutionary ideas of Paul Ekman (Ekman, 1999; Ekman & Oster, 1981; Ekman, Sorenson, & Friesen, 1969). He proposed the existence of a group of basic emotions (anger, joy, fear, disgust, sadness, and surprise) that are innate, universal, and transcultural. Basic emotions can also be expressed and recognized, among other things, by the behavior of those who experience them, for example, through facial gestures.

Other perspectives on emotions challenge the universal perspective. LeDoux (1999) argues that social factors determine the capabilities to externalize manifestations of complex emotions, that are acquired mostly based on the context in which the individual exists. In other words, some emotions are not innate. These ideas are in line with social constructionism theory (Averill, 1980; Plutchik, 2003). In this theory, complex or secondary emotions are constructed from the primary emotions and they can be developed even in adulthood. For example, Averill (1979, 1980) argues that emotions are an appraisal of environmental stimuli and they can define stereotypical patterns of acceptable responses, which fit the environment based on patterns and valuations that are particular to each individual's culture. Each person then behaves in a certain emotional pattern, a stereotype validated by his/her culture that corresponds to voluntary actions that "appear" to be involuntary. Prinz (2004) claims that although it is frequently assumed that emotions, such as anger, are involuntary, it is often used voluntarily and in a "strategic" way, for example, to make clear that an individual is annoyed and/or is preparing to attack. In social constructionism terms, anger does not correspond to an animal reflex. It is rather a sophisticated behavioral configuration to define what is acceptable or relevant in a particular context and to achieve certain objectives, for example, establishing or defending a territory.

Other scholars have also challenged the limited consensus among the different perspectives on emotion beyond their vast differences (Barrett, 2006). This scholar questions the limited consensus among the different perspectives on emotion beyond their vast differences. People think they can recognize an emotion when they see it, and therefore, assume that emotions are events with defined limits that can be recognized with some precision based on a "set" of reactions linked to a particular emotion. However, the author presents evidence of the emotional construction that is particular to each individual and influences the emotional experience, for example, knowledge, culture, context, reactions to the environment in which the person lives, to name a few. From this perspective, emotions are not simple reflections or a predetermined set of reactions, they correspond to concrete actions of perception based on information gathered from the outside world at a specific time. According to Barrett, emotions vary from culture to culture, from moment to moment, and from person to person. This implies that the behavioral signs of apparent sadness in someone could be reinterpreted as another emotion in a different person (see chapter: "Navigating the Science of Emotion" for the most recent contributions).

This brief review allows us to establish that the different emotional theories that have been defined throughout history agree, at least, on the existence of behavioral components, consisting of actions, attitudes, and perceptible physical manifestations, both voluntary and involuntary. It has also been established that behavior is fairly recognizable to others, at least in certain contexts (see chapters: Theoretical Approaches to Emotion and Its Measurement, Navigating the Science of Emotion, for a discussion about different theories).

The analysis of emotions based on a person's behavior has enabled humans to modify and moderate their own behavior to the situation in which the person is immersed. This shows the potential of measuring emotions based on behavior. In addition, we can recognize an emotion relying upon our senses with a high degree of success.

4 The role of behavior in emotions

4.1 To recognize emotions

Scherer and colleagues (Bänziger, Tran, & Scherer, 2005; Scherer, 2005) suggest some strategies to identify emotions; interestingly, behavior is an important element to do so. The following elements are involved when recognizing emotions:

- *Event focus*: Emotions are elicited by stimulus events (internal and external). In the short story at the beginning of this chapter the event that triggers positive emotions is Peter's visit to the toy store. On the other hand, he starts to experience negative emotions when he leaves the store.
- *Appraisal-driven*: The eliciting event and its consequences are relevant to major concerns of the person. In other words, if the event is irrelevant for Peter, he may not experience positive or negative emotions.
- *Response synchronization*: There is synchronization between the relevance of the event for the person and the context where it occurs. Emotions are means to prepare a person to appropriate response to events. Peter reacts with wonder when he sees all the toys at the store and with disappointment when he has to leave.
- *Rapidity of change*: Events, and their appraisal, change rapidly. This often occurs due to the introduction of new information or reevaluations of the situation. Peter experiences happiness and a few seconds later anger. This is the result of Peter's evaluation of the new context of the information.
- *Behavioral impact*: Emotions prepare adaptive action tendencies and their motivational underpinnings. Peter reacts with clear differences in his behavior that are the result of the emotions that he is experiencing. When he experiences joys he laughs and smiles. When he experiences anger he reacts with temper tantrums.
- *Intensity*: Intensity may be linked to the relevance of the events that provide the context that triggers the emotion, and it is influenced by personality traits, moods, and the subjective reality in general. Furthermore, there is a correlation between intensity and consequent behavior. For example, Peter experienced high levels of joy and anger. This can be inferred based on his behavioral reactions.

- *Duration*: Emotions imply massive response mobilization and synchronization as part of specific action tendencies. This explains why they are short in their duration. Otherwise, emotions could deplete energy resources of the person quickly. When Peter reacts with temper tantrums he invests lots of energy, because he is crying, kicking, and resisting leaving the store. If he maintains his tantrum for a couple of hours his hydration will go down, his muscles get tired and his energy reserves will deplete rapidly.

Emotions involved the activation of many elements, one of which is behavior. It is clear that there are particular reactions, gestures, or body movements that help identify the emotions that another human is experiencing.

4.2   To classify emotions

The classification of emotions has been researched from two fundamental viewpoints: one, emotions are discrete and fundamentally different constructs; or two, emotions are characterized on a dimensional basis in groupings (see chapter: Theoretical Approaches to Emotion and Its Measurement).

- *The discrete approach* suggests that emotions are distinguishable among others and the differences are based on facial expressions and biological processes. The idea of discrete emotions is synthesized in universal emotions, these are the ones that any human can experience and recognize.
- *The dimensional approach* suggests that subjective feelings can be described by their position in a three-dimensional (3D) space formed by the dimensions of valence (positive–negative), arousal (calm–excited), and tension (tense–relaxed) (Wundt, in Scherer, 2005).

Emotions have also been classified as utilitarian and aesthetic (Scherer, 2005). It has been suggested that *utilitarian emotions* facilitate our adaptation to events that have important consequences for our well-being. Such adaptive functions are the preparation of action tendencies (fight, flight), recovery and reorientation (grief, work), motivational enhancement (joy, pride), or the creation of social obligations (reparation) (Scherer, 2005). On the other hand, *aesthetic emotions* are related to appreciating qualities of beauty in art or art performance. It is well established that music, pictorial art, and sculptures trigger emotions in people that may not have a utilitarian reason (Bartlett, 1999; Dillman-Carpentier & Potter, 2007; Scherer & Zentner, 2001). Other scholars (Bradley, Codispoti, Sabatinelli, & Lang, 2001) suggest that emotions and emotional responses in general are useful for a variety of functions, not only practical or aesthetic. For example, in relation to disgust, Reeve (1994) argues that it serves to promote healthy habits and hygiene and Averill (1979) notes that sadness has the function of social cohesion, especially with those who are in similar situations. Attention may also be useful in works of art or product design (see Desmet, 2002; Lazarus, 1982, 1991).

It is clear that classification takes into account the behavioral aspect of emotions, for example, universal emotions. It is also considered in the potential reactions that the person performs in a particular situation.

4.3   To measure emotions

Emotions can be recognized and classified. However, when they have to be measured there are some challenges because they are multidimensional in nature. Therefore, it is relevant to measure all the components instead of parts. For example, arousal is a component and it can be measured, however, this dimension does not offer a full picture of the experienced emotion. It can also measure the valence of the emotion and then we can assume that the experienced emotion is positive and high in arousal. Nevertheless, this approach ignores other elements such as behavior. Scholars have also suggested detailed approaches to measure emotions. For example, Scherer (2005) report five aspects:

- The continuous changes in appraisal processes at all levels of central nervous system processing.
- The response patterns generated in the neuroendocrine, autonomic, and somatic nervous systems.
- The motivational changes produced by the appraisal results, in particular action tendencies.
- The patterns of facial and vocal expression as well as body movements.
- The nature of the subjectively experienced feeling state that reflects all of these component changes.

Based on Scherer's ideas, it can be inferred that current methods tend to focus on particular emotion components, which are effective and incomplete at the same time. Scherer (2005), however, also acknowledges the complexity of measuring the five aspects that he suggests.

Meanwhile, Mauss and Robinson (2009) conducted an extensive review on the state of art about emotion measurement, and refer to methods based on:

Self-reports: These are undertaken with questionnaires that are answered by individuals who experience different emotional states; with interviews when they report their experience and reports that detail moment-to-moment experiences. Self-reports can also be verbal and nonverbal, for example, when using characters or faces that represent particular emotions.

Physiological aspects

Autonomic measures. These methods rely on the autonomic nervous system (ANS). Indices of ANS activation can be assessed based on electrodermal (ie, sweat gland) or cardiovascular (ie, blood circulatory system) responses (see chapter: "The Psychophysiology of Emotions" for a complete review).

Startle response magnitude. This method is based on the startle response, a reflex to a sudden, intense stimulus, which is a universal reflex that involves multiple motor actions, including tensing of the neck, back muscles, and eye blink (Vrana, Spence, & Lang, 1988, in Mauss & Robinson, 2009).

Brain states. There is evidence that there is a physiological correlation of emotions with the brain rather than in peripheral physiological responses. Therefore, there are methods to measure emotions based on electroencephalography, neuroimaging, and magnetic resonance imaging.

Behavior: Most of the research that focuses on the emotional phenomena acknowledges that it is possible to infer the emotional state based on actions, behavioral tendencies, gestures, and body expressions (Frijda, 1986; Lang, Bradley, & Cuthbert, 2013). It is therefore possible to measure emotions based on behavior. This issue, which is the main topic of this chapter is detailed in the next section.

5 Behave yourself! Measuring emotions based on behavior

Behavioral theories (Skinner, 1938; Watson, 1913, 1925) consider emotions as conditioned responses that are triggered by a neutral stimulus and associated with an internal stimulus, which evokes responses in the individual that are perceptible to others. Interestingly, there is a general consensus in the field of emotional research that admits the perceptual reactions or obvious manifestations that emerge when experiencing emotions, what other scholars call body expressions. It has also been argued that the manifestations tend to be the most visible and familiar signs of emotion (Van den Stock, Righart, & De Gelder, 2007).

There are various approaches to model behavior. Lang (1968) defined the existence of behavior dimensions, that is, verbal, somatic, and overt-motor. Other scholars (Mauss & Robinson, 2009) also mention vocal, facial, and body components of behavior that can be measured. A recent view of behavior argues that it is derived from an individual's attitude to a particular stimulus, and it consists of three elements: cognition, emotion, and intention (Tsaur, Luoh, & Syue, 2015 based on the ideas of Assael, 1999, and DeBruicker, 1979).

Remembering Peter's tantrum, he shouts and protests and these are part of the vocal/verbal dimension. He also shows his disappointment, based on his facial gestures, for example, sad eyes and a slightly downturned curved mouth, and body expressions, for example, his posture is downwards. Therefore, facial gestures and somatic or body expression are also involved.

It is also important to report that when experiencing particular emotions certain reactions are automatically activated, for example, the secretion of certain body fluids. Tears are a noticeable characteristic that contributes to the assessment of a person's emotion. Other examples of these involuntary responses are sweat or rapid breath, a change in skin color, such as when the face turns red. The automatic reactions and body expressions allow the viewer to identify, with a certain level of precision, the emotions that other individuals are experiencing. Nevertheless, these reactions emerge when the intensity of the emotion is high. Therefore, they are not always visible when experiencing a particular emotion. This explains why these reactions are not considered behavior.

It should also be noted that simple observation of others' behaviors and reactions helps identify emotions. Therefore, it is a potential method to measure emotions, however, there are limitations, for example, it does not rely upon solid parameters. It could be said that behavioral observation is a natural and intuitive human approach to identify other's subjective experiences. Regarding the specific use of behavioral

manifestations of emotions it has to be considered that for each of its components (vocal, facial, body) academic research has proposed a variety of methods and techniques to record, measure, and evaluate them. Furthermore, they can be evaluated separately or together.

5.1   Vocal and verbal characteristics

Many studies have shown that vocal and verbal characteristics deliver excellent parameters to measure whether an individual is experiencing a particular emotion (Bachorowski, 1999; Gobl & Chasaide, 2003; Johnstone, 2001; Johnstone, van Reekum, Oakes, & Davidson, 2006; Laukka, Neiberg, Forsell, Karlsson, & Elenius, 2011; Mordkovich, Veit, & Zilber, 2011). The involved vocal and verbal characteristics are voice tone and volume, fluency of speech, vibration, and the verbal content itself. These vocal and verbal signals may vary from person to person, and they may present alone or mixed (or not occur). Thus, a person's evaluation based on vocal and verbal expressions is fallible, according to Juslin and Scherer (2008). However, research has also identified that vocal and verbal expressions are an accurate way to identify other's emotions based on behavior (Johnstone et al., 2006; Planalp, 1999). Furthermore, in everyday social life, vocal and verbal characteristics are usually sufficient to recognize other's emotions, with a high rate of success (Bachorowski, 1999).

Many scholars have also associated changes in voice tone and pitch to specific emotions, for example, a whispering voice could be associated with confidentiality, a strong and rough voice with anger, and a squeaky voice with boredom (Gobl & Chasaide, 2003; Laver, 1980). Research has also identified mutual relationships between vocal tone and arousal, for example, high-pitch vocal tones have been linked to high levels of arousal that fear, joy, or anger involve. The mutual relationships, however, ignore the valence of emotions. For example, anger and joy involve high levels of arousal, but they are very different in their valence, one is positive and the other is negative. They are also often considered opposite ends of the positive and the negative valence. This is a clear limitation of linking vocal tones to arousal (Mauss & Robinson, 2009). Nevertheless, studies that link pitch with the emotions indicate that the relationship is less automatic and direct. On the other hand, there are many studies that link facial gestures with emotions in very specific ways.

Simple observation and listening, that include vocal characteristics, do not constitute a formal behavioral method, however, there are established methods based on academic parameters to analyze vocal (Vogt, André, & Bee, 2008) and verbal (Yildirim, Narayanan, & Potamianos, 2011) characteristics to identify emotions. For example, Augsburg University developed a framework and tool to recognize emotions based on vocal inputs. The data are gathered online and in real time. Another tool is *EMOVoice* (Vogt et al., 2008; Wagner, Lingenfelser, & André, 2011). This tool analyzes the speech of the speaker and identifies his emotions based on the following aspects of the acoustic voice analysis (see also Kent, 1997; Kent & Kim, 2008; Weatherley-White, Stark, & DeHaan, 1966):

- Logarithmized pitch.
- Energy or intensity.

- *MFCC or Mel Frequency Cepstral Coefficients*, these are representations of speech based on human auditory perception (see also Hasan, Jamil, Rabbani, & Rahman, 2004; Muda, Begam, & Elamvazuthi, 2010).
- Frequency spectrum.
- *HNR*, *harmonics-to-noise ratio*, acoustic phonetic index voice (see also Ferrand, 2002; Severin, Bozkurt, & Dutoit, 2005).

It is also possible to find commercial tools that aim to support behavioral emotion recognition based on voice analysis. *Memotion* is an application created for smartphones that performs voice cadence and speech analysis and compares 20 seconds of recorded speech with predefined parameters to establish the speaker's emotional tone. The tool is based on 18 years of research on emotion analysis performed by Beyond Verbal Company (see webpages links in references under *Memotion (Emotion Analysis)* (2015) and Beyond Verbal (2016)). Another tool called *EMOSpeech* (link under *EMOSpeech. Speech emotion recognition* (2015) uses a tridimensional model based on Valence, Dominance, and Activation parameters. Another similar tool is *EMOVoice*, which generates information in real time about the emotions that an interlocutor, in a phone call, manifests in his voice (Vogt et al., 2008). The applications that arise from these technologies include call identifiers with very practical functions. For example, an unsatisfied client can be directed to the correct agent or supervisor in a call center.

Vocal characteristics, including speech, have proven to be an effective signal to recognize and measure emotions. This has been identified based on methods that include magnetic resonance imaging or instrumental sound measurement. Particular emotions present clear differences in brain activation levels (Johnstone et al., 2006). Volume and acoustic characteristics also activate particular brain levels (Johnstone, 2001), which are useful when studying opposite emotions, such as anger and joy. Although this does not correspond to behavioral measurement it seems to confirm the relevance of expressing emotion through the voice and speech and the ability to recognize it from vocal and verbal manifestations.

5.2 *Facial characteristics*

Facial behavior is one of the most frequently used methods when measuring emotions. In the last two centuries, a great deal of literature has evidenced the use of this method as a valid resource (Adolphs, 2002; Ekman, 2003; Lang, Greenwald, Bradley, & Hamm, 1993; Secord, 1958). However, there are some challenges, for example, in defining primary and secondary emotions. Facial behavior associated with primary emotions is easily recognized, conversely, secondary emotions may be more complex and difficult to read (Matsumoto, Keltner, Shiota, Frank, & O'Sullivan, 2008). Adolphs (2002) established that facial behavior can be used to express emotional responses and social communication. Both expressions can emerge simultaneously when experiencing an emotion (see chapter: "Measuring Emotions in the Face" for further research in this area).

Facial movements, eyebrow muscles, frowns, etc., are a few examples of the wide human capability to gesticulate the human face. Recent studies have shown that all 42

face muscles can originate 21 different macro-expressions linked to particular emotions (Du, Tao, & Martinez, 2014). In addition, a significant group of researchers also support the existence of micro-expressions. These last approximately 0.03 seconds and occur simultaneously with macro-expressions, which tend to last between 0.5 and 4 seconds (Matsumoto & Hwang, 2011). Porter and Ten Brinke (2008) proposed that micro-emotions appear when people are trying to hide their emotional states. Micro-expressions have also been associated with abrupt processes that are not physically evident to others.

There is a long tradition of research to understand relationships between facial expressions and specific emotions (Ekman et al., 1969; Izard, 1972; Tomkins & Mc Carter, 1964). A number of models and systems have been developed to establish a rigorous measurement of emotions based on gestures. For example, the *Facial Action Coding System* or FACS (Ekman & Friesen, 1978) identifies discrete emotions based on specific movements of the facial muscles. Other measurement methods have focused on specific aspects of the gesticulations of the human face (Izard, 1972); generic expressions (Notarius & Levenson, 1979); and the use of electromyography to measure the electrical activity of facial muscles (Benedek & Hazlett, 2005). In 2007 the *Facial Coding Expression System* (FACES) was introduced by Kring and Sloan. This method measures emotions in three forms: 1) video analysis (in training stages), 2) direct observation of facial gestures (with the basic training completed), 3) and using a database of predefined expressions. Furthermore, it considers four aspects in facial expressions simultaneously: *frequency*, *intensity*, *valence*, and *duration*.

It is easier to have access to software that measures emotions based on facial gestures in comparison to vocal characteristics of behavior, both in academia and industry. One of the challenges of the FACS systems is that they rely on bidimensional data. Therefore, the most recent tools have been improved and expanded with 3D data. The 3D data rely upon video, facial recognition algorithms, and comparison of expressions that have been previously recorded in an extensive database (Cohn, Ambadar, & Ekman, 2007). Examples of tools that were developed based on the FACS model and include 3D data are: *FaceReader* (Den Uyl & Van Kuilenburg, 2005; Lewinski, den Uyl, & Butler, 2014) (see in references under *Noldus. Facial action coding system (2015)* and *BP4D-Spontaneous* (Zhang et al., 2014)).

Facial and vocal information allow behavioral recognition of emotions based on bimodal criteria. The scarce evidence that exists in relation to identifying emotions based on bimodal information indicates that the sum of both aspects delivers better results in comparison to measuring them separately (Busso et al., 2004).

5.3   *Body expressions and postures*

Bodies, as well as faces, communicate emotions. Research has identified that it is possible to identify the emotions that a person experiences based on what their body communicates, even when the observer cannot see the facial gestures of the experiencer (Oberst, 2014). According to research the development of capacities of expression and recognition of body manifestations seem to be related to facial gestures (Slaughter & Heron, 2004; Slaughter et al., 2004). Research has also identified that there is little

work developed to study body language as a nonverbal means to express emotions. This may be explained because scholars have strongly focused on facial gestures. For example, Van den Stock et al. (2007) and Bernhardt (2010) argue that the undertaken studies that aim to understand body expressions in comparison with those that focus on facial gestures or vocal characteristics are significantly less and they documented only three (Argyle, 1988; Ekman, 1965; Sprengelmeyer et al., 1999). Nevertheless, body manifestations have a high value in understanding the emotions experienced by others, for example, we can infer the emotion that another person is experiencing and the intentions that accompany that emotion.

Another research issue that has been little explored is *emotional body postures* (Mauss & Robinson, 2009; Sprengelmeyer et al., 1999). The existing framework of literature supports the idea that certain postures may interact significantly with specific emotions. Mauss and Robinson (2009) identified two studies that report postures as part of emotional behavior (Stepper & Strack, 1993; Tracy & Robins, 2004). Shame and pride have been associated with contraction and expansion postures, respectively. These examples indicate that body postures also have an impact on expressing and recognizing emotions.

The analysis of the manifestations of particular emotions, including gestures, vocal expressions, and body postures to communicate and recognize emotions, are recurrent in research on emotions. For example, App, McIntosh, Reed, and Hertenstein (2011) argue that basic emotions are related to facial gestures because an individual uses them to communicate with other people and they are also important to survive. Other emotions, such as shame or pride, are associated with the social status of a person in a given context. These emotions involve manifestations that are interpreted by groups of people. Other emotions, such as love, favor touch, which is a clear behavioral expression. Van Gorp and Adams (2012) discuss behavioral reactions, such as approach or avoid, based on the evaluation of the stimuli, if it is pleasant individuals will approach the stimulus and they will reject it if the stimulus is unpleasant.

There are current systems that take advantage of body movements, for example the *VICON Motion System* (see VICON, 2015) is software that captures body movements using six cameras in a tridimensional space. The gained data help identify four emotions with a high level of effectiveness: sadness, anger, joy, and fear (Kapur, Kapur, Virji-Babul, Tzanetakis, & Driessen, 2005). Another alternative was developed by Coulson (2004). This scholar generates 3D computer figures with static postures. Observers identify six basic emotions with a high degree of success from the figures. There is also software that captures movements and compares the information with a large database to identify the experienced emotion (Bernhardt, 2010). The database relies upon previous research on body postures (*corpus of Glasgow, FABO*, and *GEMEP*; see Bänziger & Scherer, 2007; Gunes & Piccardi, 2005; Ma, Paterson, & Pollick, 2006, respectively for more details).

This area of research is promising and some scholars are suggesting that it a new area of study in the field of emotions (De Gelder, de Borst, & Watson, 2015). This indicates that body expressions and postures deliver important information in emotions.

A limited number of emotional measurement systems are based on the body's behavior (or even considered). Measurements based on the body are defined with technologies imported from neuroscience and medicine and with systems that are based on computer media. A limitation of this method is that they are performed in a controlled environment, for example, with a person sitting in front of a camera and a microphone, which limits the body gestures and may increase artificial ones. This also occurs in neurophysiological measurements that place the individual in a seated position (De Gelder & Hadjikhani, 2006). Based on these limitations, Bernhardt (2010) and previously Pantic and Rothkrantz (2003) mention that methods undertaken in controlled environments, tend to deliver "performances" of stereotypical expressions of emotions instead of spontaneous behavioral manifestations that occur in ecological contexts.

5.4   Multimodal methods and systems

The methods and systems that integrate information from more than one of the three behavioral manifestations, that is, gestures, vocal, and body manifestations, are called multimodal. These methods acknowledge that humans recognize and express emotions in an integrated way. Recent studies (De Gelder et al., 2015) suggest that the three manifestations interact together and body postures intensify gestures and vocal manifestations of the experienced emotion. Previous studies (Stekelenburg & De Gelder, 2004) had already reported significant similarities in the way in which gestures and body manifestations are processed. Thus, behavioral methods and systems to measure emotions could aim to integration the various modalities and the context where the emotion occurs (Bänziger & Scherer, 2007). This is in line with Pantic and Rothkrantz (2003), who suggest that automated systems generated to recognize emotions must include visual, auditory, and tactile aspects. They also suggest that behavioral signs should be included to acknowledge the importance of context. However, current studies in emotions tend to focus on one modality. This may occur because multimodal methods are complex. In addition, it has to be defined as the most appropriate way to integrate the different modalities in the evaluation of emotions (Busso et al., 2004).

5.4.1   Vocal and facial manifestations

Research has indicated that it is easier to recognize emotions based on multimodal manifestations (De Silva, Miyasato, & Nakatsu, 1997). For example, in Peter's story, the combination of gestures and vocal expressions helps us to understand the emotion that the kid is experiencing.

De Silva et al. (1997) study the impact that gestures, vocal expressions, and the combination of both manifestations have to identify the six basic emotions defined by Ekman. The scholars edited the vocal expressions and changed them with noncorrespondent expressions. They presented the modified stimuli to a group of participants to identify the levels of recognition of the six basic emotions. Based on the levels of recognition that they obtained, the following conclusions were established: sadness

and fear are emotions in which audio recognition dominates. Joy, surprise, and anger are emotions that are mostly recognized based on gestures. Disgust showed no predominance of any of the two manifestations. These results indicate that the integration of modalities positively influences the recognition of emotions, and that some of the modalities have a particular weight to recognize specific emotions.

In other studies on the subject (De Gelder & Vroomen, 2000) respondents were asked to observe pictures of faces with incongruent vocal expressions. The results of two experiments showed a tendency to evaluate emotions based on the voice tone, even when participants were told to ignore it and focus on the image. However, a third experiment showed an inverse effect, where emotion was evaluated on the face instead of the vocal expressions. This shows that both modalities relate, and have mutual influence, prevailing one or another depending on the situation.

5.4.2   Facial and body manifestations

Sometimes the body movements can be the first parameter to assess emotions and predominate in its manifestation. Nonetheless, in any everyday conversation we note that they emerge together. Even when there is limited physical mobility, for example, by the position of a seated person, arms and hands frequently complement the facial gestures that express our emotions, and often emphasize certain aspects. Recent studies (Aviezer, Trope, & Todorov, 2012) based on pictures of faces and bodies performing day-to-day activities, report that emotions perceived only on facial expressions changed systematically when body expressions were shown. These findings emphasize the importance of the body in the interpretation and expression of emotions.

Gunes and Piccardi (2005) present a proposal to integrate signals from face and body with video clips. They capture gestures and movements at the same time and with different cameras. They later integrate the footage in one video clip. By following this approach, they can train participants to adequately express their emotions in both modes, as separate entities, and in an integrated way. The authors documented improvements on emotion recognition when both modes were integrated instead of using only one modality, that is, facial gestures.

Finally, De Gelder et al. (2015) reported studies that showed that participants made incorrect assessments of anger and fear when the information was inconsistent between face gestures and body language.

5.4.3   Body and vocal manifestations

These two aspects may be felt less connected from each other than facial and vocal manifestations. However, body and vocal manifestation enhanced emotion integration and contribute to its recognition.

Stienen, Tanaka, and De Gelder (2011) suggest that human postures and vocal manifestations influence each other and are independent of gestures. The authors conducted an experiment in which interviewees observed images of bodily expressions of joy and anger with congruent and incongruent vocal manifestations. The images were shown at different periods of time. The results indicated that the congruence between vocal and

body manifestations influences the overall evaluation of the emotion (see Stienen et al., 2011). Previously, De Gelder and Vroomen (2000) in their study on faces and vocalizations mentioned that there were no reasons to believe that body movements and vocal expressions could be related. Recent research suggests that there is a link between these modalities (Stienen et al., 2011; Van den Stock, Grèzes, & de Gelder, 2008).

5.4.4 Facial, body, and vocal manifestations

In addition to the bimodal manifestations, recent research on emotion recognition is developing systems that integrate facial, body, and vocal manifestations. Nelson and Russell (2011) conducted a study with preschool children in which the task was to recognize four emotions, that is, happiness, sadness, anger, and fear. The emotions were shown in different video clips with four conditions: (1) only faces, (2) only body, (3) only voice, and (4) multimodal manifestations. The authors suggest that the recognition of emotions develops first on the basis of visual information (faces and body postures), then integrating vocal manifestations. A second comparison that included adults also evaluated the videos and the results indicated that adults had a high rate of success in general, and almost perfect results with the multimodal clip.

Adult's ability to properly integrate signals from different modalities of behavioral expression in the context of emotional research seems to be consistent. Caridakis et al. (2007) report that the multimodal manifestation systems increase by 10% the success of emotion recognition in comparison to unimodal systems.

There are cases in which scholars aim to integrate the three behavioral modalities in tools and tests, for example the *Multimodal Emotion Recognition Test* (MERT) (Bänziger, Grandjean, & Scherer, 2009) or *MultiMedia-enhanced Affect Semantic Indexing* (SAMMI) (Paleari, Benmokhtar, & Huet, 2009; Paleari, Huet, & Duffy, 2007). Scholars are aiming to integrate the three modalities and this is indicative of the importance of fulfilling this task in the near future.

6 Products and behavioral characteristics of emotions

During the last two decades product developers have started to become interested in human behavior. This may have occurred for at least two reasons. First, there is a shift in design from products and objects to the person who is going to use them. For example, a typical way to design a product was to define its form, manufacturing process, and material selection. Now, designers can intentionally aim to enhance particular behaviors, emotions, or experiences. Secondly, the influence of global problems in the current context has permeated the design disciplines. At present, we know that sustainability is a relevant issue for humankind and designers have reacted accordingly. For example, designers aim to change the behavior of the product or to adapt the product to match current users' behavior (Wever, van Kuijk, & Boks, 2008). For example, it is common for people to use a TV to listen to the news, therefore a new product can be designed to adapt to this behavior by, for example, switching off the screen to avoid the use of extra energy (Rodriguez & Boks, 2005).

Behavior also plays a key role in emotional design. For example, it has been used to justify the inclusion of emotions in design, for example, solutions that trigger positive emotions are consumed more often than those that elicit negative emotions (Desmet, 2012). Designers also aim to improve people's health and to accomplish it they can focus on enhancing a healthy behavior (Ludden & Hekkert, 2014) or making a person feel better, for example, well-being. Scholars have also suggested that emotions are key to stimulating a long-term relationship between users and objects (Chapman, 2005).

Research in industrial design has pointed out the relevance of analyzing emotions to create integral solutions for humans. Considering emotions is beneficial to product design because designers include the human affective side during the design process. The latter, however, involves new challenges. For example, the theory on emotional design is borrowed from psychology (see eg, Norman, 2004). Therefore, designers have to select and adapt the relevant theories to the discipline of design. Furthermore, designers are usually not trained to use complex methods and equipment to measure emotions and they do not have access to it (as neuroscientists or physicians have). Therefore, designers tend to rely upon qualitative methods to study emotions, such as ethnography, observational research, and self-report methods. For example, in 1999 cultural probes were introduced (Gaver, Dunne, & Pacenti, 1999). This tool helps gather insight from the user's perspective. With the collected data designers can emotionally empathize with users. This affective connection may help designers create products that are aligned to human needs.

Behavior is an issue of interest in the field of emotional design. Norman (2004) introduces an emotional model based on three dimensions: *visceral*, *behavioral*, and *reflective*. The visceral level is related to the immediate reactions that we feel with an object. The behavioral is related to the way a person interacts with a product. The reflective level is linked to the thoughts that an object stimulates in a person. Although Norman's theory does not offer a clear guide to implement emotional design in practice, it is a great starting point to discuss and reflect on the role of emotions in user–product interactions. For example, if a mobile phone is difficult to use the user may reject it. Therefore, designers have to focus on the behavioral level to improve the design solution. Another strategy to consider behavior in emotional design was defined by Jacob-Dazarola, Martínez Torán, and Esteve Sendra (2012). These authors suggest a model that includes 16 *interaction situations* that are often established between users and products. They report that interaction is strongly focused on usage, and the overall experience is hardly considered. Therefore, they suggest interaction events, which could be considered "events" in the overall experience, for example, the first contact that a user has with a particular product. The authors also argue that interaction events trigger emotions, for example, in the first contact emotions of surprise or satisfaction may be triggered. These emotions are also accompanied by behavior. The latter is a design opportunity and it can be used by analyzing the 16 interaction events to identify recurrent behaviors that help create integral solutions.

Behavior is also involved when studying emotions in product design. Desmet (2003) for instance, suggested five classes of product emotions: *instrumental*,

aesthetic, *social*, *surprise*, and *interest* emotions. These classes are elicited by different triggers and it is also expected that different behaviors accompanied them. Take for instance aesthetic emotions, which are related to the gratification of the senses (Hekkert, 2006). They delight or offend the senses and this can be reflected on approaching or rejecting the object that triggers the aesthetic emotions.

There is research that aims to develop a thorough understanding of particular positive emotions (Ortiz Nicolás, 2014; Ortíz Nicolás, Aurisicchio, & Desmet, 2013a; Desmet, 2012). By studying emotions based on appraisal structures and thought–action tendencies, it has been possible to identify behavioral tendencies that accompany particular emotions. For example, in the case of confidence, it was identified that a product that enhanced this emotion influences a person to maintain the product. When experiencing inspiration, a person is stimulated to be creative. And when experiencing anticipation, a person is eager to get their hands on the product that triggers this emotion. Designers can define the most relevant emotion for the project at hand by considering the behavior that they aim to stimulate in users.

Behavior is also relevant to measure emotions. Desmet (2002) developed a tool called *PrEmo*. It shows animations of a cartoon character. In each animation, the character expresses 1 of the 14 emotions in approximately 1 second that includes movement, facial expressions and gestures, and sound, for example, voice tone (see also chapter: Emotion-driven Product Design).

Potential behaviors result from human–product interactions when positive emotions have also been identified. In previous research in which two populations (users and designers) were involved and the aim was, on one hand, to identify the potential benefits that users foresee when experiencing positive emotions with a product and, on the other, the reasons that designers have to stimulate positive emotions through a design solution, the following results were indicated: users would like to experience positive emotions because they are pleasant, expected, and indicative of good product choice. Designers, on the other hand, would like to evoke these emotions because they are of interest, appropriate to their designs, and their elicitation is perceived as a responsibility (Ortíz Nicolás, Aurisicchio, & Desmet, 2013b). These results indicate the potential behaviors and motives that users and designers seek when interacting or designing products that elicit positive emotions. The results indicate the relevance to consider positive emotions in human–product interaction.

7 Conclusions

In this chapter we have focused on the behavioral characteristics of emotions and the measurement methods and systems that have been developed based on behavioral manifestations on single and multimodal ways. This chapter offers a detailed review of the state of the art in behavior and emotions. We also discuss the role of behavior in emotional design. A conclusion of this research is that measurement methods that rely upon behavior are incomplete for understanding and identifying the emotions experienced by an individual at a certain time and place. These methods, however, do not necessarily involve technology or questionnaires to identify emotions, and they

can be used in the context in which the event is occurring. Methods that rely upon technology and are used in labs can influence the emotional experience.

We also identified the three behavioral aspects that are involved when experiencing emotions, that is, voice, gestures, and body manifestations have been studied in an unbalanced manner. The three manifestations deliver information that influences emotion recognition and in some cases each manifestation has more weight than the others. In some cases, gestures may be more significant to identify emotions than voice tone, however this is not always the case. It is therefore relevant to consider the three behavior manifestations in the study of emotions.

In line with several scholars, we acknowledge that experiential, physiological, and behavioral measures are all relevant to understanding emotion. It is important, therefore, to acknowledge that methods that focus on one aspect are limited in principle. Furthermore, the components of emotions cannot be assumed to be interchangeable; this is that behavior does not automatically consider the subjective experience and vice versa.

Finally, design relies upon emotional theory developed in psychology; therefore, emotional design is limited to the progress of theory in other disciplines.

References

Adolphs, R. (2002). Recognizing emotion from facial expressions: Psychological and neurological mechanisms. *Current Opinion in Neurobiology*, *12*(2), 169–177. http://dx.doi.org/10.1016/S0959-4388(02)00301-X.

App, B., McIntosh, D. N., Reed, C. L., & Hertenstein, M. J. (2011). Nonverbal channel use in communication of emotion: How may depend on why. *Emotion (Washington, DC)*, *11*(3), 603–617. http://dx.doi.org/10.1037/a0023164.

Argyle, M. (1988). *Bodily communication* (2nd ed.). London, UK: Methuen.

Assael, H. (1999). *Comportamiento del Consumidor* (6th ed.). Ciudad de México D.F., México: International Thomson Editores.

Aunger, R., & Curtis, V. (2013). The anatomy of motivation: An evolutionary–ecological approach. *Biological Theory*, *8*(1), 49–63. http://dx.doi.org/10.1007/s13752-013-0101-7.

Aunger, R., & Curtis, V. (2015). *Gaining control. How human behavior evolved*. Oxford, UK: Oxford University Press.

Averill, J. R. (1979). A selective review of cognitive and behavioral factors involved in the regulation of stress. In R. A. Depue (Ed.), *The psychobiology of the depressive disorders: Implications for the effects of stress*. New York: Academic Press.

Averill, J. R. (1980). A constructivist view of emotion. In R. Plutchik & H. Kellerman (Eds.), *Emotion: Theory, research and experience: Vol. I. Theories of emotion* (pp. 305–339). New York: Academic Press.

Aviezer, H., Trope, Y., & Todorov, A. (2012). Body cues, not facial expressions, discriminate between intense positive and negative emotions. *Science (New York, NY)*, *338*(6111), 1225–1229. http://dx.doi.org/10.1126/science.1224313.

Bachorowski, J. -A. (1999). Vocal expression and perception of emotion. *Current Directions in Psychological Science*, *8*(2), 53–57. http://dx.doi.org/10.1111/1467-8721.00013.

Bänziger, T., & Scherer, K. R. (2007). Using actor portrayals to systematically study multimodal emotion expression: The GEMEP corpus. *Affective Computing and Intelligent Interaction*, 476–487. http://dx.doi.org/10.1007/978-3-540-74889-2_42.

Bänziger, T., Grandjean, D., & Scherer, K. R. (2009). Emotion recognition from expressions in face, voice, and body: The Multimodal Emotion Recognition Test (MERT). *Emotion*, *9*(5), 691–704. http://dx.doi.org/10.1037/a0017088.

Bänziger, T., Tran, V., & Scherer, K. R. (2005). The emotion wheel. A tool for the verbal report of emotional reactions. Poster presented at the Conference of the international society of research on emotion, Bari, Italy. In: *Proceedings of the conference of the international society of research on emotion* (p. 5). (Poster), Bari, Italy.

Barrett, L. F. (2006). Are emotions natural kinds? *Perspectives on Psychological Science*, *1*(1), 28–58. http://dx.doi.org/10.1111/j.1745-6916.2006.00003.x.

Bartlett, D. L. (1999). Physiological responses to music and sound stimuli. In D. A. Hodges (Ed.), *Handbook of music psychology* (pp. 343–385) (2nd ed.).

Benedek, J., & Hazlett, R. L. (2005). Incorporating facial EMG emotion measures as feedback in the software design process incorporating facial EMG emotion measures as feedback in the software design process. *HCIC Consortium*, *2005*, 1–9.

Bernhardt, D. (2010). *Emotion inference from human body motion. Technical Report*. Cambridge, UK. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.174.7258&rep=rep1&type=pdf>.

Beyond Verbal (2016). Retrieved January 27, 2016, from <http://www.beyondverbal.com/>.

Bradley, M. M., Codispoti, M., Sabatinelli, D., & Lang, P. J. (2001). Emotion and motivation I: Defensive and appetitive reactions in picture processing. *Emotion*, *1*(3), 276–298. http://dx.doi.org/10.1037/1528-3542.1.3.300.

Busso, C., Deng, Z., Yildirim, S., Bulut, M., Lee, C. M., Kazemzadeh, A., et al. (2004). Analysis of emotion recognition using facial expressions, speech and multimodal information. In: *Proceedings of the 6th international conference on multimodal interfaces—ICMI '04*, 205. http://dx.doi.org/10.1145/1027933.1027968

Caridakis, G., Castellano, G., Kessous, L., Raouzaiou, A., Malatesta, L., Asteriadis, S., et al. (2007). Multimodal emotion recognition from expressive faces, body gestures and speech. *IFIP International Federation for Information Processing*, *247*, 375–388. http://dx.doi.org/10.1007/978-0-387-74161-1_41.

Chapman, J. (2005). *Emotionally durable design. Objects, experiences & empathy* (1st ed.). London, UK: Earthscan.

Cohn, J. F., Ambadar, Z., & Ekman, P. (2007). Observer-based measurement of facial expression with the facial action coding system. *The Handbook of Emotion Elicitation and Assessment*, 203–221. http://dx.doi.org/10.1007/978-3-540-72348-6_1.

Coulson, M. (2004). Attributing emotion to static body postures: Recognition accuracy, confusions, and viewpoint dependence. *Journal of Nonverbal Behavior*, *28*(2), 117–139. http://dx.doi.org/10.1023/B:JONB.0000023655.25550.be.

De Gelder, B., de Borst, A. W., & Watson, R. (2015). The perception of emotion in body expressions. *Wiley Interdisciplinary Reviews: Cognitive Science*, *6*(2), 149–158. http://dx.doi.org/10.1002/wcs.1335.

De Gelder, B., & Hadjikhani, N. (2006). Non-conscious recognition of emotional body language. *Neuroreport*, *17*(6), 583–586. http://dx.doi.org/10.1097/00001756-200604240-00006.

De Gelder, B., & Vroomen, J. (2000). The perception of emotions by ear and by eye. *Cognition & Emotion*, *14*(3), 289–311. http://dx.doi.org/10.1080/026999300378824.

De Silva, L. C., Miyasato, T., & Nakatsu, R. (1997). Facial emotion recognition using multi-modal information. In: *Proceedings of the international conference on information, communications and signal processing* (Vol. 1, pp. 397–401). http://dx.doi.org/10.1109/ICICS.1997.647126

DeBruicker, F. S. (1979). An appraisal of low-involvement consumer information processing. In J. C. Maloney & B. Silverman (Eds.), *Attitude research plays for high stakes* (pp. 112–132). Chicago, IL: American Marketing Association.

Den Uyl, M. J., & Van Kuilenburg, H. (2005). The FaceReader: Online facial expression recognition. In: *Proceedings of measuring behavior '05* (pp. 589–590). Wageningen, The Netherlands.

Desmet, P. M. A. (2002). *Designing emotions*. (Unpublished doctoral dissertation). Delft University of Technology, Delft, The Netherlands.

Desmet, P. M. A. (2003). A multilayered model of product emotions. *The Design Journal, 6*(2), 4–11.

Desmet, P. M. A. (2012). Faces of product pleasure: 25 positive emotions in human–product interactions. *International Journal of Design, 6*(2), 1–29.

Dillman-carpentier, F., & Potter, R. F. (2007). Effects of music on physiological arousal: Explorations into tempo and genre. *Media Psychology, 10*(3), 339–363.

Du, S., Tao, Y., & Martinez, A. M. (2014). Compound facial expressions of emotion. *Proceedings of the National Academy of Sciences, 111*(15), E1454–E1462. http://dx.doi.org/10.1073/pnas.1322355111.

Ekman, P. (1965). Differential communication of affect by head and body cues. *Journal of Personality and Social Psychology, 2*(5), 726–735.

Ekman, P. (1999). Basic emotions. In T. Dalgleish & M. J. Power (Eds.), *Handbook of cognition and emotion*. Chichester, UK: John Wiley & Sons. http://dx.doi.org/10.1002/0470013494.

Ekman, P. (2003). *Emotions revealed. Recognizing faces and feelings to improve communication and emotional life* (1st ed.). New York: Times Books.

Ekman, P., & Friesen, W. V. (1978). *Facial action coding system*. Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., & Oster, H. (1981). Expresiones faciales de la emoción. *Estudios de Psicología, 7*, 116–144.

Ekman, P., Sorenson, E. R., & Friesen, W. V. (1969). Pan-cultural elements in facial displays of emotion. *Science. New Series, 164*(3875), 86–88.

EMOSpeech. Speech emotion recognition. (2015). *Emospeech*. Retrieved November 17, 2015, from <http://emospeech.net/>.

Ferrand, C. T. (2002). Harmonics-to-noise ratio. *Journal of Voice, 16*(4), 480–487. http://dx.doi.org/10.1016/S0892-1997(02)00123-6.

Frijda, N. H. (1986). *The emotions (Studies in emotions and social interaction)* (1st ed.). New York: Cambridge University Press.

Frijda, N. H., Kuipers, P., & ter Schure, E. (1989). Relations among emotion, appraisal, and emotional action readiness. *Journal of Personality and Social Psychology, 57*(2), 212–228. http://dx.doi.org/10.1037/0022-3514.57.2.212.

Gaver, W. W., Dunne, T., & Pacenti, E. (1999). Design: Cultural probes. *Interactions, 6*(1), 21–29. http://dx.doi.org/10.1145/291224.291235.

Gobl, C., & Chasaide, A. N. (2003). The role of voice quality in communicating emotion, mood and attitude. *Speech Communication, 40*(1–2), 189–212. Retrieved from <http://linkinghub.elsevier.com/retrieve/pii/S0167639302000821>.

Gunes, H., & Piccardi, M. (2005). Fusing face and body display for bi-modal emotion recognition: Single frame analysis and multi-frame post integration. *Lecture Notes in Computer Science (including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 3784 LNCS* (pp. 102–111). http://dx.doi.org/10.1007/11573548_14.

Hasan, R., Jamil, M., Rabbani, G., & Rahman, S. (2004). Speaker identification using mel frequency cepstral coefficients. In: *3rd international conference on electrical & computer engineering ICECE 2004* (December) (pp. 28–30).

Hekkert, P. (2006). Design aesthetics: Principles of pleasure in design. *Psychology Science, 48*(2), 157–172.

Izard, C. E. (1972). *Patterns of emotions*. New York: Academic Press.

Jacob-Dazarola, R. H., Martínez Torán, M., & Esteve Sendra, M. C. (2012). Interaction for Emotion. The different instances and events of interaction between people and products. In: *Proceedings of the 8th international conference on design & emotion 2012*. London, UK.

James, W. (1884). What is an emotion? *Mind*, *9*(34), 188–205.

Johnstone, T. (2001). *The effect of emotion on voice production and speech acoustics* (Ph.D. Thesis). University of Western Australia & University of Geneva.

Johnstone, T., van Reekum, C. M., Oakes, T. R., & Davidson, R. J. (2006). The voice of emotion: An FMRI study of neural responses to angry and happy vocal expressions. *Social Cognitive and Affective Neuroscience*, *1*(3), 242–249. http://dx.doi.org/10.1093/scan/nsl027.

Juslin, P. N., & Scherer, K. R. (2008). Vocal expression of affect. In J. Harrigan, R. Rosenthal, & K. R. Scherer (Eds.), *The new handbook of methods in nonverbal behavior research* (pp. 65–135). Oxford, UK: Oxford University Press.

Kapur, A., Kapur, A., Virji-Babul, N., Tzanetakis, G., & Driessen, P. F. (2005). Gesture-based affective computing on motion capture data. In: *Proceedings of the 1st international conference on affective computing and intelligent interaction*, *3784* (pp. 1–7). http://dx.doi.org/10.1007/11573548.

Kent, R. D. (1997). *The speech sciences*. San Diego, CA: Singular Publishing Group Inc.

Kent, R. D., & Kim, Y. (2008). Acoustic analysis of speech. In: *Handbook of clinical linguistics*, 396–416. http://dx.doi.org/10.1002/9781444301007.ch22.

Kring, A. M., & Sloan, D. M. (2007). The Facial Expression Coding System (FACES): Development, validation, and utility. *Psychological Assessment*, *19*(2), 210–224. http://dx.doi.org/10.1037/1040-3590.19.2.210.

Lang, P. J. (1968). Fear reduction and fear behavior: Problems in treating a construct. In J. M. Shlien (Ed.), *Research in psychotherapy, vol I*. http://dx.doi.org/10.1037/10546-004.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2013). Motivated attention: affect, activation and action. In P. J. Lang, R. F. Simons, & M. Balaban (Eds.), *Attention and orienting: Sensory and motivational processes*. New York: Psychology Press.

Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology*, *30*(3), 261–273. http://dx.doi.org/10.1111/j.1469-8986.1993.tb03352.x.

Laukka, P., Neiberg, D., Forsell, M., Karlsson, I., & Elenius, K. (2011). Expression of affect in spontaneous speech: Acoustic correlates and automatic detection of irritation and resignation. *Computer Speech and Language*, *25*(1), 84–104. http://dx.doi.org/10.1016/j.csl.2010.03.004.

Laver, J. (1980). *The phonetic description of voice quality*. Cambridge, UK: Cambridge University Press.

Lazarus, R. S. (1982). Thoughts in the relation between emotion and cognition. *American Psychologist*, *37*, 1019–1024.

Lazarus, R. S. (1991). Emotion and adaptation. In L. A. Pervin (Ed.), *Handbook of personality: Theory and research* (pp. 609–637). New York: Oxford University Press.

LeDoux, J. E. (1999). *El Cerebro Emocional* (2nd ed.). Barcelona, España: Ariel-Planeta.

Lewinski, P., den Uyl, T. M., & Butler, C. (2014). Automated facial coding: Validation of basic emotions and FACS AUs in FaceReader. *Journal of Neuroscience, Psychology, and Economics*, *7*(4), 227–236. http://dx.doi.org/10.1037/npe0000028.

Ludden, G. D. S., & Hekkert, P. (2014). Design for healthy behavior. Design interventions and stages of change. In: *Proceedings of the colors of care: 9th international conference on design & emotion* (1992) (pp. 482–488).

Ma, Y., Paterson, H. M., & Pollick, F. E. (2006). A motion capture library for the study of identity, gender, and emotion perception from biological motion. *Behavior Research Methods*, *38*(1), 134–141. http://dx.doi.org/10.3758/BF03192758.

Matsumoto, D., & Hwang, H. S. (2011). Reading facial expressions of emotion. Basic research leads to training programs that improve people's ability to detect emotions. *Psychological Science Agenda*, Retrieved November 16, 2015, from <http://www.apa.org/science/about/psa/2011/05/facial-expressions.aspx>.

Matsumoto, D., Keltner, D., Shiota, M. N., Frank, M. G., & O'Sullivan, M. (2008). What's in a face? Facial expressions as signals of discrete emotions. In M. Lewis, J. M. Haviland, & L. F. Barrett (Eds.), *Handbook of emotions* (pp. 211–234). New York: Guilford Press.

Mauss, I. B., & Robinson, M. D. (2009). Measures of emotion: A review. *Cognition & Emotion*, *23*(2), 209–237. http://dx.doi.org/10.1080/02699930802204677.

Memotion (Emotion Analysis). (2015). *Google play*. Retrieved November 17, 2015, from <https://play.google.com/store/apps/details?id=com.brandall.memotion>.

Mordkovich, A., Veit, K., & Zilber, D. (2011). Detecting emotion in human speech. Retrieved from <http://cs229.stanford.edu/proj2011/VeitZilberMordkovich-DetectingEmotionInHumanSpeech.pdf>

Muda, L., Begam, M., & Elamvazuthi, I. (2010). Voice recognition algorithms using Mel Frequency Cepstral Coefficient (MFCC) and Dynamic Time Warping (DTW) techniques. *Journal of Computing*, *2*(3), 138–143. Retrieved from http://arxiv.org/abs/1003.4083.

Nelson, N. L., & Russell, J. A. (2011). Preschoolers' use of dynamic facial, bodily, and vocal cues to emotion. *Journal of Experimental Child Psychology*, *110*(1), 52–61. http://dx.doi.org/10.1016/j.jecp.2011.03.014.

Noldus. Facial action coding system. (2015). *Noldus Information Technology*. Retrieved November 19, 2015, from <http://www.noldus.com/human-behavior-research/application-areas/facial-action-coding-system>

Norman, D. A. (2004). *Emotional design: Why we love or hate everyday things*. New York: Basic Books.

Notarius, C. I., & Levenson, R. W. (1979). Expressive tendencies and physiological response to stress. *Journal of Personality and Social Psychology*, *37*(7), 1204–1210. http://dx.doi.org/10.1037/0022-3514.37.7.1204.

Oberst, L. (2014). Matching of facial and body emotion recognition in infancy (Master's Thesis). University of Kentucky. Retrieved from <http://uknowledge.uky.edu/psychology_etds/48/>.

Ortiz Nicolás, J. C. (2014). *Understanding and designing pleasant experiences with products* (Ph.D. Dissertation). Imperial College London, UK.

Ortíz Nicolás, J. C., Aurisicchio M. & Desmet, P. M. A. (2013a). Designing for anticipation, confidence, and inspiration. Designing pleasurable products and interfaces, New Castle, UK. http://dx.doi.org/10.1145/2513506.2513510

Ortíz Nicolás, J. C., Aurisicchio, M., & Desmet, P. M. A. (2013b). Differentiating positive emotions elicited by products; an exploration of perceived differences between 25 positive emotions by users and designers. *Proceedings of the international conference on engineering design, ICED13* (pp. 1–10). Seoul, Korea.

Paleari, M., Benmokhtar, R., & Huet, B. (2009). Evidence theory based multimodal emotion recognition. *MMM 2009, 15th international MultiMedia modeling conference*, January 7–9, 2009, Sophia Antipolis, France. http://dx.doi.org/10.1007/978-3-540-92892-8_44.

Paleari, M., B. Huet, & Duffy, B. (2007). Semantic affect-enhanced multimedia indexing. In: *Proceedings of the 2nd international conference on semantic and digital media technologies*. Genoa, Italy.

Pantic, M., & Rothkrantz, L. J. M. (2003). Toward an affect-sensitive multimodal human–computer interaction. *Proceedings of the IEEE, 91*(9), 1370–1390.

Planalp, S. (1999). *Communicating emotion: Social, moral, and cultural processes*. Cambridge, UK: Cambridge University Press.

Plutchik, R. (2003). *Emotions and life: Perspectives from Psychology, Biology and evolution* (1st ed.). Washington, DC: American Psychological Association Inc.

Porter, S., & Ten Brinke, L. (2008). Reading between the lies. *Psychological Science*, *19*(5), 508. http://dx.doi.org/10.1111/j.1467-9280.2008.02116.x.

Prinz, J. (2004). Which emotions are basic? In D. Evans & P. Cruse (Eds.), *Emotion, evolution, and rationality*. Oxford and New York: Oxford University Press.

Reeve, J. (1994). *Motivation y Emoción*. Madrid, Spain: McGraw Hill.

Rodriguez, E., & Boks, C. (2005). How design of products affects user behaviour and vice versa: The environmental implications. *Appliance*, 54–61. http://dx.doi.org/10.1109/ECODIM.2005.1619166.

Scherer, K. R. (1993). Studying the emotion-antecedent appraisal process: An expert system approach. *Cognition & Emotion*, *7*(3–4), 325–355. http://dx.doi.org/10.1080/02699939308409192.

Scherer, K. R. (2000). Psychological models of emotion. In J. C. Borod (Ed.), *The neuropsychology of emotion* (pp. 137–162). New York: Oxford University Press.

Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social Science Information*, *44*(4), 695–729. http://dx.doi.org/10.1177/0539018405058216.

Scherer, K. R., & Zentner, M. R. (2001). Emotional effects of music: Production rules. In P. N. Juslin & J. A. Sloboda (Eds.), *Music and emotion: Theory and research* (1st ed.). New York: Oxford University Press.

Secord, P. F. (1958). Facial features and inference processes in interpersonal perception. In R. Taguiri & L. Petrullo (Eds.), *Person perception and interpersonal behavior* (1st ed.). Stanford, CA: Stanford University Press.

Severin, F., Bozkurt, B., & Dutoit, T. (2005). HNR extraction in voiced speech, oriented towards voice quality analysis. In: *European signal processing conference* (pp. 1–4).

Skinner, B. F. (1938). *The behavior of organisms: An experimental analysis*. Oxford, UK: Appleton-Century.

Slaughter, V., & Heron, M. (2004). Visual habituation studies: Infants' responses. *Monographs of the Society for Research in Child Development*, *69*, 24–57. http://dx.doi.org/10.1111/j.1540-5834.2004.00288.x.

Slaughter, V., Heron, M., Jenkins, L., Ulrich, E., Müller, T., & Liebermann, D. (2004). Origins and early development of human body knowledge. *Monographs of the Society for Research in Child Development*, *69*(2), 1–113. Retrieved from <http://www.jstor.org/stable/3701402>.

Smith, C. A., & Kirby, L. D. (2001). Toward delivering on the promise of appraisal theory. In K. R. Scherer, A. Schoor, & T. Johnstone (Eds.), *Appraisal processes in emotion: Theory, methods, research*. Oxford, UK: Oxford University Press.

Sprengelmeyer, R., Young, A. W., Schroeder, U., Grossenbacher, P. G., Federlein, J., Büttner, T., et al. (1999). Knowing no fear. *Proceedings. Biological Sciences/The Royal Society*, *266*(July), 2451–2456. http://dx.doi.org/10.1098/rspb.1999.0945.

Stekelenburg, J., & De Gelder, B. (2004). The neural correlates of perceiving human bodies: An ERP study on the body-inversion effect. *Neuroreport*, *15*(5), 777–780. http://dx.doi.org/10.1097/01.wnr.0000119730.93564.

Stepper, S., & Strack, F. (1993). Proprioceptive determinants of emotional and nonemotional feelings. *Journal of Personality and Social Psychology*, *64*(2), 211–220. http://dx.doi.org/10.1037/0022-3514.64.2.211.

Stienen, B. M. C., Tanaka, A., & De Gelder, B. (2011). Emotional voice and emotional body postures influence each other independently of visual awareness. *PloS One*, *6*(10), e25517. http://dx.doi.org/10.1371/journal.pone.0025517.

Tomkins, S. S., & Mc Carter, R. (1964). What and where are the primary affects? Some evidence for a theory. *Perceptual and Motor Skills*, *18*(1), 119–158. http://dx.doi.org/10.2466/pms.1964.18.1.119.

Tracy, J., & Robins, R. (2004). Putting the self into self-conscious emotions: A theoretical model. *Psychological Inquiry*, *15*(2), 103–125. Retrieved from <http://www.tandfonline.com/doi/abs/10.1207/s15327965pli1502_01>.

Tsaur, S. -H., Luoh, H. -F., & Syue, S. -S. (2015). Positive emotions and behavioral intentions of customers in full-service restaurants: Does aesthetic labor matter? *International Journal of Hospitality Management*, *51*, 115–126. http://dx.doi.org/10.1016/j.ijhm.2015.08.015.

Van den Stock, J., Grèzes, J., & de Gelder, B. (2008). Human and animal sounds influence recognition of body language. *Brain Research*, *1242*, 185–190. http://dx.doi.org/10.1016/j.brainres.2008.05.040.

Van den Stock, J., Righart, R., & De Gelder, B. (2007). Body expressions influence recognition of emotions in the face and voice. *Emotion*, *7*(3), 487–494. http://dx.doi.org/10.1037/1528-3542.7.3.487.

Van Gorp, T., & Adams, E. (2012). *Design for emotion* (1st ed.). Boston, MA: Morgan Kaufmann, Elsevier.

VICON. (2015). VICON motion systems. Retrieved December 7, 2015, from <http://www.vicon.com/>.

Vogt, T., André, E., & Bee, N. (2008). EmoVoice—A framework for online recognition of emotions from voice. In: *Lecture Notes in Computer Science (including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 5078 LNCS (pp. 188–199). http://dx.doi.org/10.1007/978-3-540-69369-7_21.

Vrana, S. R., Spence, E. L., & Lang, P. J. (1988). The startle probe response: A new measure of emotion? *Journal of Abnormal Psychology*, *97*(4), 487–491. http://dx.doi.org/10.1037/0021-843X.97.4.487.

Wagner, J., Andre, E., Lingenfelser, F., & Kim, J. (2011). Exploring fusion methods for multimodal emotion recognition with missing data. *IEEE Transactions on Affective Computing*, *2*(4), 206–218. http://dx.doi.org/10.1109/T-AFFC.2011.12.

Wagner, J., Lingenfelser, F., & André, E. (2011). The social signal interpretation framework (SSI) for real time signal processing and recognition. In: *Proceedings of the annual conference of the international speech communication association, INTERSPEECH* (pp. 3245–3248).

Watson, J. B. (1913). Psychology as the behaviorist views it. *Psychological Review*, *20*, 158–177.

Watson, J. B. (1925). *Behaviorism*. New York: People's Institute.

Weatherley-White, R. C. A., Stark, R., & DeHaan, C. R. (1966). Acoustic analysis of speech: Validation studies. *Cleft Palate Journal*, *July*(3), 291–300.

Wever, R., van Kuijk, J., & Boks, C. (2008). User-centred design for sustainable behaviour. *International Journal of Sustainable Engineering*, *1*(1), 9–20. http://dx.doi.org/10.1080/19397030802166205.

Yildirim, S., Narayanan, S., & Potamianos, A. (2011). Detecting emotional state of a child in a conversational computer game. *Computer Speech and Language*, *25*(1), 29–44. http://dx.doi.org/10.1016/j.csl.2009.12.004.

Zhang, X., Yin, L., Cohn, J. F., Canavan, S., Reale, M., Horowitz, A., et al. (2014). BP4D-Spontaneous: A high-resolution spontaneous 3D dynamic facial expression database. *Image and Vision Computing*, *32*(10), 692–706. http://dx.doi.org/10.1016/j.imavis.2014.06.002.