CHAPTER

1

Emotions and Affect in Human Factors and Human–Computer Interaction: Taxonomy, Theories, Approaches, and Methods

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INTRODUCTION

Emotions and affect are known as a motivating and guiding force in our attention and perception (Izard, 1993). Psychologists even accept that it is impossible for people to have a thought or perform an action without engaging their emotional system, at least unconsciously (Nass et al., 2005). However, despite their importance and prevalence in everyday life, emotions and affect have had fewer chances to be a dominant topic of human factors (HF) and human–computer interaction (HCI) for a long time. Given that the information processing approach of traditional Cognitive Sciences has been a dominant paradigm of HF and HCI, there has not been much room for emotions and affect in the mainstream of human–machine system research until recently. However, affective elements allow for a systems approach (Czaja and Nair, 2006) and a more holistic view to understanding the human–machine system. For example, affective states have been known to play a major role in influencing all aspects of situation assessment and belief information, from cue identification and extraction to situation classification, and decision selection

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(Hudlicka, 2003). Therefore, embracing emotions and affect is expected to enrich human–machine system research even more.

There is a growing realization of this need to acknowledge emotions and affect in the design challenges of complex sociotechnical systems (Lee, 2006) and this is high time to look back on research on emotions. First, this trend has been reflected in publications in special issues of Ergonomics (Helander and Tham, 2003) and the *International Journal of Human-Computer Studies* (Hudlicka, 2003), the birth of IEEE Transactions on Affective Computing (Picard, 2010), books (Calvo et al., 2014; Norman, 2004; Picard, 1997), and book chapters (e.g., Lee, 2006). Thus, we have much more sources and resources than before in terms of theory, framework, and approach. Second, the traditional cognitive paradigm is being shifted. A recent new wave of embodied cognition—for example, special issues of embodied cognition (Davis and Markman, 2012) and embodied interaction (Marshall et al., 2013)—is good justification we need to include emotions and affect in human–machine system research. In addition, the development of physiological computing or aesthetic computing (Fishwick, 2006) is closely related to Affective Sciences and strongly encourages researchers to integrate emotional elements in their research. Finally, with the rapid advances of sensing technology, emotional research has appeared to be easier and more feasible. In fact, recent CHI conferences have had successive workshops and tutorials about affect detection techniques. Based on this background, this handbook tries to outline the big picture of emotions and affect research in HF/HCI. Providing taxonomy as a field guide would be, especially beneficial to domain novices and students, by listing and specifying the emerging frameworks of emotions and affect research in HF/HCI.

DEFINITION AND TAXONOMY

Affect research includes several relevant constructs, such as emotions, feelings, moods, and affect which are distinct, but frequently used as interchangeable terms. Specifying the terms would facilitate further discussion and clarify their usage. Emotions generally refer to the physiological response of the brain and body to threats and opportunities, whereas feelings are the conscious mental representation and interpretation of that bodily response (Damasio, 1994, 2001). Hence, feelings are known to follow emotions evolutionarily and experientially. Emotions have a salient cause, occur and diminish quickly and thus are relatively intense and clear cognitive contents (e.g., anger or fear). In contrast, moods are less intense, more diffuse, and more enduring and thus unclear to the individual experiencing them (e.g., just like feeling good or feeling bad) (Bodenhausen et al., 1994; Forgas, 1995). Although moods are more subtle, they often exert a more enduring effect on behavior (Forgas, 2002).

Affect is sometimes referred to as something weaker than emotions (Slovic et al., 2004). However, researchers currently agree that affect denotes any type of affective experience (Forgas, 1995; Hudlicka, 2003; Lottridge et al., 2011; Mayer, 1986). In this chapter, I would distinguish affect from unchangeable long-term characteristics, such as personality traits or temperament. Here, focus is on dynamically changeable affective states depending on contexts. Of course, where appropriate, I follow the traditional usage of the terms (e.g., the mood-congruent effects).

Sometimes, emotions can be categorized as background emotions, basic emotions (e.g., Ekman's emotion set), or social emotions (Damasio, 1999). Also, depending on the relationship between the source of the affect and the task-relevancy, integral affect (related to the task) and incidental affect (not related to the task) are differentiated (Bodenhausen, 1993). The most salient distinction among affect researchers is discrete versus dimensional approaches. For example, Ekman (1992) suggested basic emotions (happiness, sadness, anger, fear, surprise, and disgust) as a universal emotion set across the world. Similarly, Plutchik (1994) proposed a basic emotion set (happiness, sadness, fearfulness, anger, and tenderness). On the other hand, a common dimensional approach to understanding the experience of emotions is the circumplex model, in which emotions are arranged in a circle around the intersections of two core dimensions of affect (Russell, 1980). The circumplex model maps emotions according to their valence, indicating how negative or positive they are, and their activation, indicating how arousing they are. There is no clear cut answer about which approach is better. It depends on the research goal, the task, situations, and measurement methods.

MECHANISMS AND THEORIES

Relationship Between Affect and Cognition

Traditionally, psychological sciences have suggested various theories on the relationship among emotion, physiological arousal, and cognition [e.g., the James-Lange theory (James, 1884), the Cannon-Bard theory (Cannon, 1927), and the two-factor theory (Schacter and Singer, 1962)]. One of the unresolved issues is whether affective processes should be considered as a part of the cognitive representational system or as an entirely separate mental faculty (Fiedler, 1988; Hilgard, 1980; Salovey and Mayer, 1990). Researchers have shown with empirical findings that affect can be aroused without the participation of cognitive processes and thus, can function independently (Clore et al., 1994; LeDoux, 1996; Niedenthal, 1990; Schwarz and Clore, 1988; Strack et al., 1988; Zajonc, 1984). Therefore, it is important to assume that cognition and affect are distinct and dynamically interact with each other (Forgas, 1995).

Emotional Functions and Neural Mechanisms

The evolutionarily older part of the brain, such as brainstem and cerebellum and the newer cerebral cortex are separated by the limbic system. The brain structures in the limbic system are known especially important for controlling basic motivations, including emotions (Gazzaniga et al., 2010), while affect-related processing in the human brain is distributed across the brainstem, limbic, paralimbic, and neocortical regions. Even though some researchers consider affective processes as states of nonspecific autonomic arousal (e.g., Mandler, 1985), affective states take the form of patterns collaborated within and across the autonomic, endocrine, and motor systems (Derryberry and Tucker, 1992). Rosen and Levenson (2009) classified emotional functions into four categories: appraisal, reactivity, regulation, and understanding. Each of them has been addressed within the HF/HCI research domain.

The most well-examined emotional function is *appraisal*, which includes processing and interpreting external (e.g., visual, auditory, other perceptions, etc.) and internal (thoughts) stimuli. It is widely accepted that the amygdala is the most critical element of the appraisal system. The amygdala plays a role regarding responses to stimuli predicting potential harm (Bechara et al., 1995; LeDoux, 1992) or recognition of negative facial expressions (Adolphs and Tranel, 2004; Williams et al., 2005). The frontal lobes (medial and orbital portions) are also involved in emotional appraisal (Rolls, 2004; Sotres-Bayon et al., 2006).

Affect sometimes comes prior to, and directs, cognitive processes (Zajonc, 1984) and this is supported by the presence of two separate appraisal pathways. Information reaches the amygdala along two separate pathways (Armony and LeDoux, 1997). The first path is a "quick and dirty" system that processes sensory information nearly instantaneously. Sensory information travels quickly through the thalamus to the amygdala for priority processing. The second pathway is somewhat slower, but it leads to more deliberate and thorough evaluations. In this case, sensory material travels from the thalamus to the sensory cortex, where the information is scrutinized in greater depth before it is passed along to the amygdala. In brief, the fast system prepares people to quickly respond and the slower system confirms the threat. These two separate appraisal systems have been applied and conceptualized in the HF/HCI domain. For example, research has proposed that people apprehend reality and risk by two interactive, parallel processing systems: the experiential system and the analytic system (Epstein, 1994; Slovic et al., 2004). The experiential system is intuitive, fast, mostly automatic, and not very accessible to conscious awareness. In contrast, the analytic system is a deliberative, analytical system that functions by way of established rules of logic and evidence, such as probability calculation. This distinction is echoed as "primary" and "secondary" emotional processes (Damasio, 1994), or "experiential" and "reactive" cognition (Norman, 1993).

Reactivity includes psychological and physiological responses to emotional stimuli. This activity can be generated by subcortical regions (e.g., hypothalamic and brainstem structures and striatum) even without the modulation of higher cortical input (Panksepp, 1998). However, higher cortical regions (e.g., anterior cingulated) also play an important role in control of emotional reactivity. Again, the amygdala seems to organize behavioral and autonomic emotional reactions (Armony and LeDoux, 1997). Assistive technology research for people with autism has mainly addressed this reactivity issue—for example, affective prosody learning (Jeon and Rayan, 2011) or affective interaction with robots (Feil-Seifer and Mataric, 2008; Michaud and Theberge-Turmel, 2002). Emotional reactions are typically adjusted to match situational demands by a process, called emotion *regulation*. In terms of reappraisal (i.e., reexamining its meaning), studies have shown increased activation in dorsalateral and ventrolateral frontal structures and decreased activation in the hypothalamus and amygdala compared to unregulated emotion (Ochsner and Gross, 2005). In contrast, studies of emotion suppression have shown increased activation in the amygdala (Goldin et al., 2008). Regarding emotion regulation research in HF/HCI, see Bouchard et al. (2011) for learning and training in the army and Harris and Nass (2011), Hudlicka and McNeese (2002), Jeon (2012) for dynamic environments, such as driving.

Emotional *understanding* refers to our ability to recognize emotions in ourselves and in others, and is necessary for empathy. The amygdala is the most important structure in identifying emotion in both feeling own emotions and in others. Since cognitive processes also play an important role in empathy, parietal lobes and several parts of prefrontal cortex are included in this process (Decety and Jackson, 2004). Emotional understanding and empathy is one of the main topics in affective computing research (e.g., el Kaliouby, 2005).

Theories of Affective Effects

Psychological sciences have provided a number of affect theories and mechanisms to account for affective effects. However, applied researchers have tended to focus more on "how" (e.g., detection methods) to deal with emotions and affect, and they have picked a phenomenological approach to affect. Therefore, more theory-driven affect research with a balanced view of "what" (e.g., which emotion is important in a specific domain) and "why" (mechanisms) is required in the HF/HCI domain.

Affective Effects on Attention and Information Processing

With respect to the relationship between affect and attention, there have been numerous studies that show positive affect promotes a greater focus on global processing and negative affect promotes a greater focus on local processing. (Basso et al., 1996; Derryberry and Reed, 1998; Derryberry and

Tucker, 1994; Easterbrook, 1959; Fredrickson and Branigan, 2005; Gasper and Clore, 2002). Theorists have postulated several hypotheses to explain this tendency. A capacity explanation assumes that positive states activate a larger network of associations than negative states, thereby reducing the resources available for effortful processing (Mackie and Worth, 1989; Worth and Mackie, 1987), which means that positive affect leads to reduced cognitive processing. On the other hand, a motivational explanation assumes that people avoid expending effort on tasks that are not enjoyable to maintain their current positive states (Isen, 1987; Wegener et al., 1995). In the same line, the information provided by positive affect might signal that one's goal has already been achieved (Martin et al., 1993) or that further processing is unnecessary (Clore et al., 1994). However, there is no evidence that negative affect elicits more extensive processing than positive affect (Gasper and Clore, 2002). The affect-as-information approach can provide an alternative explanation (Schwarz and Clore, 1983, 1988, 1996) in which affective feelings are considered as consciously accessible information from ongoing, nonconscious appraisals. However, differences between positive and neutral states in global processing are not explained by this affect-as-information approach because people generally tend to be in positive moods and a global bias is considered normative. The broaden-and-build theory may be an alternative mechanism (Fredrickson, 1998, 2001), which predicts that the cognitive consequences of positive states are distinct from those evident in neutral states. According to the broaden-and-build theory: (1) positive emotions may broaden the scopes of attention, cognition, and action, widening the array of percepts, thoughts, and actions, and (2) people can build a variety of personal resources from positive emotional states, including physical, social, intellectual, and psychological resources. However, more longitudinal research is required to support the build hypothesis. The easing of inhibitory control might alter the quality of attention, resulting in a shift from a narrow focused state to a broader and more diffuse attentional focus. Positive states, by loosening the reins on inhibitory control, may result in a fundamental change in the breadth of attentional allocation to both external visual and internal representational spaces (Rowe et al., 2007). Nevertheless, there has been no underlying mechanism beyond those conceptual discussions, such as the neurological underpinnings of those effects.

Affective Effects on Judgment and Decision-Making

Considerable research has examined whether affect influences how people estimate the likelihood of future events (Johnson and Tversky, 1983) and how people actually select among different options. Research has generally shown mood-congruent effects in judgment and decision-making: participants in positive moods estimated positive events as more likely than participants in negative moods and vice versa. There are a couple of hypothetical mechanisms to explain the affective effects on judgment and decision-making. The availability (or accessibility) heuristic (MacLeod and Campbell, 1992; Tversky and Kahneman, 1973, 1974) denotes the process by which participants form estimates of likelihood based on how easily they can retrieve instances from memory. Similar to the availability heuristic, the affect-priming model also suggests that affect can indirectly inform judgments by facilitating access to related cognitive categories (Bower, 1981; Forgas, 1995, 2006; Isen, 1987). A number of studies supported this hypothesis based on mood-congruent memory facilitation (Derry and Kuiper, 1981; Greenberg and Beck, 1989). The affect-as-information hypothesis also accounts for the mood-congruent judgment. Clore and Huntsinger (2007) proposed that participants use the information delivered by affective states strategically during the judgment process. However, the affect-as-information model shows limited effects depending on the circumstances. For example, the mood influenced global judgments about overall life satisfaction (i.e., heuristic processing) but had no effect on judgments about specific life domains (i.e., direct access processing) (Schwarz et al., 1987).

Specific Affective Effects on Cognitive Processes

Despite general affective effects described previously, recent research has shown that a specific approach for each affect is needed beyond the valence dimension (positive vs. negative). Readers might notice that the affective effects in the attention level would not necessarily agree with the effects in the judgment or decision making level. For instance, in the attention level, positive affect seems to reduce the resources available for effortful processing, but in the judgment or decision making level, positive affect seems to result in positive estimates, which does not always correspond to the attention level case. Furthermore, research shows specified affective effects on each level. For attentional processing, anger may facilitate attentional circuits best suited for combat (Blanchard and Blanchard, 1988), fear may enable circuits best suited for evaluating danger and flight (Lang et al., 2000), disgust may be linked to circuits involved in expelling harmful bodily substances (Berridge, 2003), and joy and surprise may be linked to processing information in a global and fluent manner (Fredrickson, 2003). For judgment and decision-making, students with increased anxiety for a statistics exam showed an increase in risk perception for the exam but not for other tasks (Constans and Mathews, 1993). Even within the same valence, different affective states specifically influence judgments. A study found that happy participants made faster lexical decisions to happiness-related words, but not to other positive words (Niedenthal and Setterlund, 1994). Research also found that fear increased risk estimates, but anger reduced risk estimates (Lerner and Keltner, 2000). Sometimes, the different effects of negative affect can be explained by cognitive appraisal mechanisms (e.g., Ellsworth and Smith, 1988; Keltner et al., 1993). Ellsworth and Smith (1988) proposed eight appraisal dimensions that are important in differentiating emotional experience: pleasantness, anticipated effort, attentional activity, certainty, responsibility, control, legitimacy, and perceived obstacle. These cognitive appraisals are involved in particular affect because appraisals have important implications for the individual's well-being and the affect associated with those appraisals prepares the person to adaptively cope with those implications (Ellsworth and Smith, 1988). Subsequent studies have validated this cognitive appraisal mechanism with empirical data. To illustrate, Lerner and Keltner (2000) showed that fear is associated with uncertainty and situational control, but anger is associated with certainty and individual control. However, cognitive appraisals do not always work for every case. As discussed, affect often works prior to cognition or independently of cognitive processes.

All of these mechanisms and theories are good theoretical ingredients that affect-related HF/HCI researchers can apply to their own research and develop further. To develop a healthier theory, researchers need to identify a more elaborated common language, which has a clear relationship with existing domain constructs, including workload (Jeon et al., 2014), situation awareness (Jeon, 2012), automation (Lee, 2006), etc. By attempting to actively apply existing theories and to search for a robust new theory, this budding research field may be able to attain a suitable framework for potentially fruitful new avenues of research.

APPROACHES TO AFFECTIVE SCIENCES IN HF/HCI

Among many approaches to emotional and affective components in HF/HCI, four different approaches were selected in this handbook based on their pervasiveness and scholarly impact—Emotional design (Norman, 2004), Hedonomics (Hancock et al., 2005; Helander, 2002), Kansei Engineering (Nagamachi, 1995, 2002), and Affective Computing (Picard, 1997). Moreover, each of them has a different origin of area—design, ergonomics, mass production, and computing. Of course, these four might neither be mutually exclusive nor exhaustive. Nowadays, researchers in each area interchangeably use each other's methods.

Emotional Design

"Is usability alone sufficient?"

As he confessed in his book, *Emotional Design* (Norman, 2004), Don Norman did not take emotions into account when he wrote, *The Design of Everyday Things* (Norman, 1988), which is widely used in HCI classes over the world. To him, *Emotional Design* is a product of his "*re*cognition" about the importance of emotions and aesthetics in design, so that he can overcome a "usable but ugly" (pp. 8) situation, which designers would face when they were to follow Norman's prescriptions before emotional design. Therefore, from the first sight it seems that Norman betrays himself by returning to visual attractiveness and trashing usability that he has enthusiastically propagated. However, a closer look reveals that he has finally found the importance of balance between the different levels of design. He classified design into three different levels: visceral, behavioral, and reflective designs, which are equally important in design.

The visceral level wins in most cases. Simply to say, visceral design means that "attractive things work better" just as in nature. In fact, this has been supported by empirical research (e.g., Kätsyri et al., 2012). It is about symmetry and pretty appearance, and may not be about great art, but more enjoyable experience. The visceral design is dominated by physical features, such as look, feel, and sound. In other words, it is about immediate emotional impact, which traditional market research and visual designers have been involved with. When it comes to aesthetics theory, however, this is not equivalent to visual attractiveness. Given that the meaning of aesthetics has dramatically changed since Marcel Duchamp in the 20th century (i.e., from *visual attractiveness* to *shock*), the concept of digital aesthetics has not settled down yet (Tractinsky, 2004).

The behavioral design is all about "use," which HF and usability people (including Norman) have been actively involved with. Here, performance matters. Norman included four components of good behavioral design, such as function, understandability, usability, and physical feel. The first step is to understand how people will use a product, which is human-centered design. Norman's solution (or methodology) for this level is designers' "clever observations" (pp. 72) instead of having a conversation with users, such as focus groups, questionnaires, or surveys because these methods are poor at extracting their actual behaviors.

The reflective design is about "meaning" of a product or its use (e.g., message, culture, personal remembrances, or self-image, etc.), which seems compatible with contemporary user experience notions, such as value-sensitive design (Friedman et al., 2006). Norman acknowledges that beauty also comes from the reflective level (vs. attractiveness is mainly a visceral-level phenomenon). To him, product aesthetics is below the surface, coming from conscious reflection and experience, influenced by knowledge, learning, and culture. More importantly, the reflective level often determines an individual's overall impression of a product and influences the relationship between the user and the product. In conclusion, even though Norman has much room to be misunderstood, he does not solely focus on visual attractiveness of product appearance.

In (*Emotional Design*), Norman did not provide any specific methodologies that designers can pick up and apply to their emotional design. Instead, he provided many foods for thoughts, serving as an evangelist of emotional design. Further, he described his notions on affective computing and thus, he would embrace emotionally *adaptive* systems in his emotional design concept beyond premade products. That may also imply that product design for all (or general people, that is, nomothetic approach of generalization) can evolve into design for an individual (i.e., idiographic approach of specification) (Thomae, 1999). Given his influence, indeed, his work on emotional design has made researchers and practitioners look back on their design goals and processes and blew the age of *user experience*. It was also a very successful attempt to provide a general audience with a novel view about emotion and technology.

Practical recommendation:

- Balance between the three levels of design: visceral, behavioral, and reflective design.

Hedonomics

"How to design pleasurable products?"

At the similar time to Norman, but separately, Hancock (Hancock et al., 2005) and Helander (Helander, 2002; Helander and Tham, 2003) tried to make an agenda for "affective design" in the Human Factors and Ergonomics community. They coined the term, "hedonomics" in several venues and guest-edited a special issue of *Ergonomics* on Hedonomics and affective design. Hedonomics stems from the Greek "hedone" (i.e., pleasure) and "nomos" (i.e., laws, principles). Their direction is very clear in that they want to move from increasing performance and preventing pain, to promoting pleasure in addition. They contended that HF design has to move from identifying commonalities across all people to identifying an individual-based design, which is echoed in emotional design (Norman, 2004). That might imply design research should direct from a nomothetic approach to an idiographic approach.

Helander would embrace the design of products, human–computer interfaces, CSCW, and work tasks in the realm of hedonomics. Taking a Maslow's hierarchical needs model (1970) as an analogy, they created a hierarchy of ergonomic and hedonomic needs. From the bottom, three levels including safety, functionality, and usability are referred to as ergonomics and top two levels including pleasurable experience and individuation are referred to as hedonomics (Helander and Khalid, 2006). Helander and Tham (2003) prioritized the research issue in affective HF design as theory formation and affect measurement. Regarding theory, Helander proposed to start from activity theory (Leontjev, 1978) in that simple, operational, and intellectual activities are mapped onto affect, emotions, and sentiments. Measurement methods in hedonomics are delineated more in (Helander and Khalid, 2006) later on, and overlapped much with Kansei Engineering and Affective Computing as described in the next sections.

In terms of the practical application of hedonomic design, Jordan (1998) seems to serve a good role. In his paper, he simply adopted a semistructured interview technique to survey pleasure and displeasure in product use. He extracted pleasurable feelings: security, confidence, pride, excitement, satisfaction, entertainment, freedom, and nostalgia; and displeasurable feelings: aggression, feeling cheated, resignation, frustration, contempt, anxiety, and annoyance. He also analyzed when and from what users experience these feelings. In both pleasurable and displeasurable cases, "during use" was reported as the highest, compared to before or after use or other times, which supports the importance of Norman's behavioral design. Additionally, users experienced displeasure most with poor usability, whereas they experienced pleasure most with good features. He also showed that pleasure experiences can further influence users' behaviors. He cautiously suggested that users might use a product more because of the pleasure and it might serve as a benchmark (or negative benchmark) for a future purchase decision and be related to brand loyalty. One of the important points is that product pleasure can be independent of task pleasure, which implies design can make pleasurable products even associated with inherently disliked tasks. Finally, Jordan suggested developing a survey tool that can measure various feelings, such as pride or excitement in addition to simple user satisfaction.

Hedonomics seems to be a fresh attempt in Human Factors and Ergonomics society, and the innate evolution of the discipline. Especially, from the beginning it sought to build its theoretical foundation and practical methods, which is desirable. Based on this notion, designers might design a pleasurable product based on the analysis of pleasurable or displeasurable points. However, it might not promptly respond to users' dynamic situations unless the product contains dynamic adaptability, which is more discussed in Section "Affective Computing."

Practical recommendation:

- Analyze pleasurable and displeasurable experiences of the products.
- Take the whole life cycle of the product into account.

Kansei Engineering

> "How to design a product that fits to its target image (kansei)?"

Kansei Engineering (Nagamachi, 2002) or Sensibility Ergonomics (Lee, 1999) is defined as translating the customer's kansei (in Japanese, consumer's feeling and image in mind) into the product design field including product mechanical functions. Kansei Engineering refers to a specific design methodology. In contrast to using general taxonomies for emotions (e.g., Ekman, 1992; Plutchik, 1994), they construct a domain-specific affect dimension in Kansei Engineering. The "surveyed" kansei are transferred to physical traits, and these are transformed to the design. As the word "surveyed" reveals, "kansei" is people's aggregated feeling or image (e.g., looks graceful or intelligent) about products rather than an individual's own emotional response (e.g., sad or angry). That research tradition emerged first from Eastern Asia in 1970s, but nowadays it is pervasive over the world. For example, researchers from 25 countries attended the KEER 2010 (Kansei Engineering and Emotion Research International Conference, 2010) in Paris. It can be applied to the designs of anything, such as costume, cosmetics, cars, home appliances, office/construction machines, etc. (Nagamachi, 1995).

Sometimes, the Kansei Engineering process can be done by an expert system where the kansei keywords are input and these words are recognized by the system database. Then, the keywords are matched to the image database and calculated by an inference engine to find the best-fit design, which is shown on the display. The Kansei Engineering system has a flow from the kansei (keywords) to the design domain, called "forward kansei engineering." The hybrid kansei engineering also has a backward flow from the design sketch with the kansei keywords.

Kansei Engineering researchers have built even a virtual space (e.g., VIrtual Kansei Engineering, "VIKE" or "HousMall") to fit to customers' kansei and customers can investigate the appropriateness of a design for their kansei (e.g., Matsubara and Nagamachi, 1996). This concept has already been popular in Japan and is expected to be further linked to the use of 3D printers, nowadays.

There have been plenty of examples of the application of those methods to product design (Jeon et al., 2008; Kleiss, 2008), facial feature extraction (Park et al., 2002), web design (Sun, 2002), sound design (Jeon et al., 2004; Lee et al., 2003), and graphical mobility (Lim and Han, 2002).

Kansei Engineering has developed its distinct and robust methodologies, which have yielded many successful design outputs in real settings. As a result, it is now pervasive over the world and has got many followers. However, it seems to focus on a static image (kansei) of the product (or object centered) based on average data, rather than designing a personalized (or subject-centered) product.

Practical recommendation:

- Find out optimal kansei of the product and design products to fit to kansei.

Affective Computing

"How to design systems that can detect users' affect and adapt to it on the fly?"

Rosalind Picard (1997) coined the term, "affective computing," which is defined as computing that relates to, arises from, or influences emotions. The initial goal of affective computing is to design a computer system that at least recognizes and expresses affect. Then, the ultimate goal is to design further so that the computer can have emotions and use them in making decisions. As she describes in her invited paper, "Affective computing: From laughter to IEEE" in the first issue of the journal, IEEE Affective Computing (Picard, 2010), at first, it was considered just as an absurd dream. Note that she did not propose that the computer could measure human's affective state directly, but rather proposed to measure observable functions of such states. She considered affect recognition as a dynamic pattern recognition problem and wanted to model an individual's or group of individuals' affective states or mixture of such states based on machine learning or neural network algorithms. When it comes to display of recognized affective states, she proposed an "affective symmetry." Just as we can see ourselves via a small image in video teleconferencing, computers that read emotions can also show us what they are reading. This interactive affect display notion is supported by the affect-as-information hypothesis as discussed—that is, even just awareness of one's affective state or the source of the state can make the person less influenced by those affective states (Tiedens and Linton, 2001).

Application domains of affective computing that Picard envisioned and developed include computer-assisted learning, perceptual information retrieval, arts and entertainment, and human health, across which affective computing researchers are currently working. Specifically, Picard and her affective computing group at MIT developed various affective wearable computers for people with autism. Her first step to aid people with autism was to sense a person's affective-cognitive state. For example, Expression Glasses discriminates facial expressions of interest or surprise from those of confusion or dissatisfactions, allowing students to communicate feedback anonymously to the teacher in real time, without having to shift attention from trying to understand the teacher (Scheirer et al., 1999). The galvactivator is a skin-conductance sensing glove that converts level of skin conductance to the brightness of a glowing LED (Picard and Scheirer, 2001). StartleCam is a wearable camera system that saves video information based on a physiological response, such as the skin conductance arousal response, tagging the data with information about whether or not it was exciting (Healey and Picard, 1998). Then, as a framework for machine perception and mental state recognition, her coworkers, el Kaliouby (2005) developed a computational model of mindreading. This framework combines bottom-up vision-based processing of the face with top-down predictions of mental state models. This effort attempted to integrate multiple modalities, such as face and posture, to infer affective states, such as the level of engagement (e.g., interest vs. boredom). The other approach was to develop technologies that enhance empathizing. For instance, the affective social quotient project was to develop assistive technologies for autism using physical input devices, namely four dolls (stuffed dwarfs), which appeared to be happy, angry, sad, or surprised (Blocher and Picard, 2002). The system plays short digital videos that embody one of the four emotions, and then encourages the child to choose the dwarf that went with the appropriate emotion.

Affective Computing and Kansei Engineering have a similar philosophical tenet; we can detect or predict our "internal emotional state" or "feelings about objects" by a mathematical or computational approach. However, while Kansei Engineering seeks to find out commonalities of kansei of target customers, Affective Computing seeks to find out and adapt to an individual's idiosyncratic emotional elements. Compared to other approaches, Affective Computing looks more dynamic in terms of interaction with artifacts depending on a user's context (Table 1.1).

TABLE 1.1 Comparisons of Four Approaches

	Emotional design	**Hedonomics**	**Kansei engineering**	**Affective computing**
Background domain	UI/product design/ usability	Ergonomics	Mass production (car manufacturer)	Interactive Computing
Goals	Balance of visceral, behavioral, and reflective design	Design of pleasurable products	Design of a product fitting to customers' kansei	Design of a system to detect a user's affect and adapt to it
Methods	Emphasize "observation," not specified at the outset → all of the related methods	Analysis of pleasurable and displeasurable experiences of product use → all of the related methods	Kansei engineering	Data fusion of multiple sensors and machine learning
Approaches	Nomothetic → idiographic	Nomothetic → idiographic	Nomothetic	Idiographic → nomothetic
Adaptability	Static → dynamic	Static	Static	Dynamic

Practical recommendation:

- Design a system that can detect a user's affective state and adaptively respond to that state.
- For better detection, fuse sensing data from multiple modalities.
- Develop a system that can empathize with a user.
- Design a system that can have emotions and use them in decision-making.

METHODOLOGIES

Affect Induction Techniques

To investigate the effects of affect on sociotechnical contexts, researchers often need to induce users' emotional states. In traditional psychological research, they have had participants look at photos (Lang et al., 1990) or watch film clips (e.g., Fredrickson and Branigan, 2005), read scenarios or stories (e.g., Johnson and Tversky, 1983; Raghunathan and Pham, 1999), listen to music (e.g., Jefferies et al., 2008; Rowe et al., 2007), and write down their past experience (e.g., Gasper and Clore, 2002). These various induction methods can also be applied to HF/HCI research. However, in psychological lab research, participants were usually required to fill out a short questionnaire or conduct a simple judgment task immediately after affect induction. For research that requires a complicated or long-lasting task, researchers should cautiously select and apply their induction method. The other consideration is whether researchers are interested in integral (relevant to task) affect or incidental (irrelevant to task) affect. For example, in driving research, as integral affect induction, researchers have embedded frustrating or angry events on the driving scenarios (e.g., Jeon, 2012; Lee, 2010). As incidental affect, they have participants read emotional paragraphs and write down their emotional experience (Jeon, 2012; Jeon et al., 2011; Jeon and Zhang, 2013).

HCI research requests a system to induce more dynamic emotions to users and to respond to those users' affective states on the fly. To illustrate, researchers have slightly distorted users' facial expression on the mirror to examine affective effects on their preference of clothes and decision-making in purchase (Yoshida et al., 2013). Another experiment (Nass et al., 2005) showed that when in-vehicle voice emotion matched the driver's emotional state (e.g., energetic to happy and subdued to upset), drivers had fewer accidents and attended more to the road (actual and perceived), and even spoke more with the car. However, given that friendly interfaces or anthropomorphism (Rogers et al., 2011) has not always been successful (e.g., Microsoft's "at home with bob" or "clippy"), more case studies are still required.

Affect Measure and Detection Techniques

The ability to dynamically detect users' affective states is crucial in predicting their behaviors and performance, and exerting adaptive interactions. During the past decade, there has been a proliferation of research on emotion/affect detection. For example, a recent survey on affect detection (Zeng et al., 2009) included 160 references even though it addressed only very recent research. Researchers have applied a variety of methods to measure and detect users' affective states in each of their domains. Nowadays, they borrow and combine each other's methods or even create new ones (see more methods, e.g., Boehner et al., 2007; Helander and Khalid, 2006; Hudlicka, 2003; Isbister et al., 2006; Mauss and Robinson, 2009): self-report (for a dimensional framework), autonomic measures (e.g., electrodermal gland and cardiovascular for a dimensional framework), startle response magnitude (e.g., eye blink, EMG, etc. for valence), brain states (e.g., EEG, fMRI, PET for approach-avoidance related states), and behavior measure (e.g., vocal characteristics for arousal, facial behavior for valence, and whole-body behavior for discrete emotions), diagnostic tasks and expert observer evaluation (or knowledge-based assessment). In addition, HF/HCI researchers have employed novel methods, such as using body movements (Crane and Gross, 2007), mouse and keyboard inputs (e.g., Zimmermann et al., 2003), steering wheel grip intensity (e.g., Oehl et al., 2007), etc.

Each technique has its own advantages and disadvantages (Table 1.2). Facial detection is not intrusive and highly accurate in discrete emotional detection. However, it has some practical issues, such as light, head movement, angle, etc. in real environments. Speech detection is also nonintrusive and gets closer to natural language with higher accuracy rate. Nonetheless, music, conversation, or phone calls might interfere with voice commands and speech detection. If users are alone, they might not say anything or are not likely to initiate conversation with the system.

Researchers have tried to use more and more physiological sensors. However, it is certainly intrusive. The mapping between sensing data and a specific emotional state is not yet robust. There are also some practical issues observed in actual research, such as hairy skin, different size of body part, sweating in the summer.

A considerable number of affect detection applications have used combinations of these methods in a range of domains, including learning, agents, robots, games, and engaging people with autism (e.g., see *International Journal of Human-Computer Studie*, 59 special issue, Hudlicka, 2003). For example, Hudlicka and McNeese (2002) integrated a variety of user assessment methods involving knowledge-based assessments, self-reports, diagnostic tasks, and physiological sensing to detect a pilot's affective state. For a more accurate affect assessment, they also included personality traits and personal history (e.g., training, recent events) as

TABLE 1.2 Comparisons of Affect Detection Methods

	Intrusiveness	Accuracy	Robustness	Continuity (time resolution)	Cost
Self-report	No	Very good	No	No (pre–post test)	No
Heart rate/respiration rate	Intrusive	Good	Robust	Yes	Low
EEG/fMRI	Very intrusive	Not good	Not robust	Yes	Very high
Facial expression	No	Very good	Very robust	Yes	Developmental cost
Speech recognition	No	Very good	Very robust	Yes	Developmental cost
Body posture/motion	No	Not good	Not robust	Yes	Developmental cost

variables. Recently, researchers combine multiple sensor data and determine affective states using machine-learning algorithms (e.g., Gaponova and Benke, 2013).

ISSUES AND FUTURE WORKS

Despite active research in emotions and affect in HF/HCI, a number of theoretical and practical issues and research questions still remain unanswered.

First of all, constructing a robust, generic affect research model is required. In Cognitive Sciences, for example, there are several standardized computational models (e.g., Human Processor Model, ACT-R, EPIC, SOAR, etc.). In contrast, there are not many standardized models in Affective Sciences. With respect to the affect dimension, creating domain-specific affect taxonomy just as in Kansei Engineering seems to be promising in terms of its accuracy. Then, it needs to be answered whether researchers should construct their own affect taxonomy for every research. Meanwhile, it is also required to form the clear relationship between affect and other core concepts in HF/HCI, such as workload, situation awareness, automation, etc. "How affect is involved in such processes" or "whether affect is an independent construct of each of them" should be addressed based on empirical research. Emerging areas, such as embodied cognition or embodied interaction is closely related to Affective Sciences. Thus, understanding those areas together would also be helpful to understand Affective Sciences better and expand its boundary.

One of the primary issues related to the practical application of Affective Sciences include induction methodologies. For example, "what is the most appropriate affect induction for a certain research domain? and why?" Or "is it even ethically acceptable at all?" Another question involves, "How can we guarantee that the induced affective states in the research setting are equivalent to affective states in real world?" Situations are similar to affect measurement or detection. Some people are not very expressive, but reserved by nature. Other people still show aversion about machine's control (they might not want an artificial system to detect their emotional states and take control of them). Another issue includes security and privacy about emotional data. In the age of Internet of Things, people are likely to be concerned about data storage and further utilization even though they are told that the data are not going to be used for any other purposes. Implementation of the display of detected results is also a big design space. Furthermore, HF/HCI researchers might want to design a system to help people regulate their affective states or mitigate affective effects on their task. "How can we improve performance by enhancing emotional experience?" would be another core question in HF/HCI. See (Lottridge et al., 2011) for more related discussions.

CONCLUSIONS

This chapter described Affective Sciences in Human Factors and Human–Computer Interaction, including taxonomy, theories, historical approaches and repertoire, and various methods, followed by discussions on theoretical and practical issues. To advance the field of Affective Sciences further, first of all, a common ground is required in terms of terminology and standardized methodologies. As shown through the chapter, there is no overarching mechanism or theory that can account for complicated affective phenomena. However, there are considerable raw ingredients that HF/HCI researchers can borrow and make their own mechanisms on top of them. Historically, there have been several approaches to Affective Sciences in HF/HCI. Their background, goals, and methods are different. However, all of them clearly show that emotions and affect are not peripheral, but one of the necessary considerations in HF/HCI design and try to integrate all the methodologies for successful outcomes. This handbook is expected to begin to close the existing gap between the traditional HF/HCI research and the emerging field of Affective Sciences research, and to contribute to each. The balanced viewpoint and a more systematic approach may provide a legitimate framework of HF/HCI research.

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