

ASSESSING EMOTION IN INTERACTION: SOME PROBLEMS AND A NEW APPROACH

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ABSTRACT

This paper reviews some of the tools available for the measurement of emotion in product design. These tools are organized using the five components of emotion: feelings, expression, behavior, physiological activation and appraisal. Several problems specific to the measurement of user experience during interaction with products are also described and a coherent approach to address them is sketched.

This approach includes several components: self-confrontation (video-supported self-report) to collect data about users' feelings, using tangible interaction principles and approach/avoidance tendencies to map the quality of the experience on the device used to report it, psychophysiological and facial expression recording to provide continuous measures of emotional arousal and valence. Finally, questioning users about appraisal processes underlying their affective responses is recommended as a useful inspirational tool at the beginning of the design process.

Keywords: User experience, continuous measurement of emotion, self-confrontation

1 INTRODUCTION

Research on user experience and emotion in design is flourishing. Many tools and techniques have been used to test and measure the experience elicited by products. While they are usually thought of as research tools or as evaluation tools to be applied at the end of a design process, these techniques have proved to be powerful means to gain insight early on about users' explicit and implicit desires and to inform the design of new products. Alas, the diversity of approaches in the field makes it difficult to attain a coherent view of the tools available to measure emotion. Furthermore, despite the number of available tools, several problems are still inadequately addressed: it is much more difficult to find appropriate ways to study emotions experienced while interacting with products than to focus on reactions to product appearance, or to measure aesthetic or sensory experience. We propose to use a multi-componential view of emotion to organize and understand the various techniques for the assessment of emotion with products. We also try to sketch a coherent approach to the measurement of emotion in interaction, based on this framework.

2 EMOTION AS A MULTI-COMPONENTIAL RESPONSE

Finding a consensual definition of emotion is in itself not an easy task. Research on emotions – in psychology, neuroscience or design – focuses on different phenomenon and what binds them together is not always clear. Reviewing the literature at the beginning of the 1980s, [1] found over 90 definitions of emotion and attempted to integrate them in a “model definition” of emotion as “a complex set of interactions among subjective and objective factors, mediated by neural/hormonal systems, which can (a) give rise to affective experiences such as feelings of arousal, pleasure/displeasure; (b) generate cognitive processes such as emotionally relevant perceptual effects, appraisals, labeling processes; (c) activate widespread physiological adjustments to the arousing conditions; and (d) lead to behavior that is often, but not always, expressive, goal-directed, and adaptive.” What is striking about this definition is the breadth of phenomenon included under the heading of “emotion”. This complexity might reflect our spontaneous everyday theories of emotions as responses including many of these elements.

Basic emotion theories offer one influential way to link these elements (see e.g. [2]). Basic emotions are pre-wired responses associating specific patterns of bodily activation, instrumental and expressive behavior (especially facial expression) and feelings. Another approach trying to account for the different facets of emotion are multi-componential models [3]. Emotions are conceived as episodes of synchronized changes in five subsystems: a cognitive evaluation (appraisal) component, a behavioral component (action tendencies), an expressive component (facial and vocal expressions), a physiological component (bodily activation) and a subjective component (feelings).

Components models are useful to organize the measurement techniques available to HCI or design-oriented research and to consider all facets of emotional responses. The approach described in this article aims at integrating these components and at considering carefully their potential contributions to the measurement process.

3 EMOTION MEASUREMENT TOOLS

The multi-componential view of emotion provides a useful model to organize emotion measurement tools and consider their applicability to design research. Table 1 provides an overview of the measurement tools associated with each component. Of the five sub-systems or components of emotion, measurement tools most often tap feelings and expressive behavior. Many researchers use self-report questionnaires or facial expression coding (manual or automatic) to assess affective responses to products and computer systems. A considerable amount of research has focused on affect-related physiological activity but it has not produced any standard technique for the measurement of emotion. Instrumental behavior has long been recognized as an integral part of emotional responses but its impact on the measurement of emotion seems rather neglected until now. Appraisal is not usually mentioned in discussions of emotion measurement techniques but it is also one of the main components of emotional responses and has been used successfully in design research. The rest of this section provides some details on each of the components.

Table 1. Overview of the main components of emotion

Autonomic activity	Psychophysiological measurement
Expression	Facial expression coding Autonomic recognition of facial expression
Behavior	Automatic approach or avoidance
Feeling	Self-report questionnaires
Appraisal	Self-report of appraisal

Feelings

Different standardized scales and questionnaires are available to measure feelings, reflecting different views on the structure of emotional experience. A broad distinction can be made between questionnaires based on descriptors of discrete emotions (« basic » or not) and questionnaires developed to assess the main dimensions of feelings or core affect [4]. [5] provides a review of several of these self-report instruments, with an emphasis on their use in design-research and in cross-cultural contexts.

When considering self-report tools for the measurement of emotion, researchers face a trade-off between the length of the scale and the quality and richness of the measurement. Selecting an appropriate tool involve several choices and will condition the type of data that can be collected.

The first choice concerns the underlying emotion model: dimensional or categorical. Many results converge on a limited number of dimensions to describe mood and emotions. Self-report tools based on these dimensions are available to broadly sample affective responses. However, simple dimensional instruments often lack inspirational value for design-oriented research, especially in the early phases of the design process. Assessment of existing products with self-report instruments based on categorical emotions are usually much more effective in informing further design efforts. One disadvantage of these tools is their length as a lengthy questionnaire can be less acceptable for the

research participants and be too taxing to be administered repetitively (for example to compare several products or evaluate affective responses to different tasks).

The second choice is between single-item instruments and psychometric scales. Traditional scales enable researchers to assess the psychometric qualities of the questionnaire (factorial structure, internal consistency) and provide a more sensitive measurement. The obvious drawback is the increased length of these psychometric questionnaires, especially for instruments based on categorical emotions, as they require several items for each emotion or dimension. Perhaps for this reason, self-report tools that stand out in the literature as particularly useful in user experience research are all based on single-item scales.

The self-assessment manikin (SAM, see [6]) provides a quick assessment of valence (how positive or negative a person feels), arousal (a calm-excited scale) and dominance (or feeling of control on the situation). It is a non-verbal scale, using schematic manikins to represent the different feelings states, which makes it easier to use across cultures. With only one item per scale, the SAM is also very quick to administer, making it easier to integrate in different research designs or product tests. Examples of use in user experience research include [7,8,9,10].

Several questionnaires based on categorical emotions have been used in design-oriented research. The Geneva Emotion Wheel [3] is a verbal self-report instrument that includes 20 emotion families and is available in several languages. [5] used it to evaluate affective responses to two different consumer products. PrEmo [11] is a non-verbal measurement tool developed specifically for design-oriented research consisting of between 10 and 14 animations representing different emotions that can be used by test participants to describe their experience. Several publications illustrate the use of this tool as a starting point in design projects by asking potential users to report their feelings about existing products to inform the design process [12,13].

One of the limitations of PrEmo is that it was developed to assess affective responses to product appearance. While it has been used successfully in other context (such as food experience in airplanes), more data is needed on emotions elicited during interaction with products. LEMtool is another tool based on the same principles but geared toward the evaluation of websites [14]. Unfortunately not much data is available either on the relevance to user experience of the emotions assessed.

Expressive behavior

Expressive behavior, especially facial expression, took a prominent role in basic emotion theories and in the research program started by Silvan Tomkins and continued by Paul Ekman and Carroll Izard. This work resulted in the development of systematic observation tools such as the FACS [24]. These tools are however seldom used as measurement techniques for the evaluation of affective responses to interactive systems. One possible reason for this lack of use in design-oriented research is that manual coding methods demand a very consequent investment in time and expertise, while their usefulness for the measurement of the typically mild emotions elicited by product interaction remains to be established.

A lot of effort has also been devoted to the development of techniques for the automatic recognition of expression, often within the framework of affective computing. On a practical level, automatic recognition of facial expression possesses several characteristics which make it particularly interesting for the study of user experience during interaction: facial expression can be recorded continuously and unobtrusively in naturalistic setting with relatively simple equipment (at least in settings in which the participant is mostly static, e.g. computer use).

Until recently, automatic recognition algorithms were typically tested on sets of posed facial expression and were generally not available to potential users as ready-to-use packages. Such products are however beginning to appear and to be applied to assess user's emotion during usability testing [25]. Published results suggest that this particular software package is able to detect differences in the valence of facial expressions correlated with the user's level of experience and the task at hand (web

surfing, game, instant messaging) [26]. Further validation studies are needed to test whether this type of tools can discriminate between affective states elicited by different products within a category (e.g. different websites catering to similar needs) or between phases during interaction with a single product. If that turns out to be the case, automatic facial expression recognition holds a great potential for the continuous measurement of affective processes in user-product interaction.

A related approach is facial electromyography. Electromyography (EMG) is based on the recording of the electrical signal generated by bursts of action potentials in the motor neurons controlling muscles. EMG is recorded with electrodes placed on the surface of the skin. Specific electrode placements (*loci*) are used to record the activity of different facial muscles. While the equipment and expertise involved are quite similar to those required by the other psychophysiological techniques detailed below, facial EMG as an emotion measurement technique grew from the hypothesis that affective responses that were too weak to prompt a discernible movement of the facial tissue did nonetheless generate measurable activation of the motor neuron (“microexpressions”) [27]. While some uncertainty remains regarding the specific patterns of muscle activation and their cause, facial electromyography seems to discriminate reliably at least between positive and negative emotions.

The HCI literature also provides a number of promising examples of use of this technique, with passive exposition to software mock-ups and use of a media player [28], and interaction with portable audio player prototypes [29] and computer games [30, 31]. On a practical level, ambulatory recording equipment allows a recording of facial EMG without restricting the movement of the participants, even if carrying electrodes on one’s face might feel a bit awkward. Finally, as with other psychophysiological measures, the complexity and relative obtrusiveness of the technique and the inconsistency of the findings might be an obstacle to its use as a routine tool for user experience research.

Instrumental behavior

Instrumental behavior and action tendencies form another major component of affective responses, figuring prominently in theoretical discussions of emotion but less often discussed when it comes to its measurement. Tendencies to approach or avoid its object are thought to be a fundamental aspect of emotion and to account for its adaptive value as a system allowing a quick response to threat and opportunity in the environment.

Research in experimental psychology and neuroscience suggest that these behavioral tendencies, together with visceral and expressive responses are engaged even when perceiving, thinking about or remembering emotions [32]. Evaluation of a stimulus also seems to be reliably associated with a behavioral tendency to approach pleasurable stimuli and to avoid negatively valenced stimuli [33]. Similar effects have been reproduced with abstract pictures, facial expressions or photographs of everyday scenes [34].

Berridge and Winkielman [23] provide an intriguing use of instrumental behavior as an index of emotions. In their first experiment, the amount of orange juice drunk by the participants depended on the emotion expressed in a photograph presented to them for a few milliseconds. They interpret this difference as an evidence of an unconscious emotional response, manifest in its influence on instrumental behavior.

Physiological activation

Physiological activation has been a mainstay of emotion research, both empirical and theoretical, since the nineteenth century [37] and remains an important aspect of neuroscience research [38]. A wealth of empirical research describes the correlation between different physiological systems and emotion [27] or related phenomena (core affect, stress).

Some examples of use of psychophysiology in user experience research were mentioned earlier ([29,30,31]). These techniques have some practical advantages: they yield continuous measures that do not demand the users’ attention. The “objective” nature of the measurement is also appealing, as physio could avoid some of the biases influencing self-reports.

One obstacle to the generalization of psychophysiological techniques is probably the need for specific expertise and complex equipment and the relative obtrusiveness of the sensors (usually adhesive electrodes attached to the skin with cables running to the amplification and recording device), reducing the freedom of movement of the participants. Purpose-built devices could however open the way to integration of physiological measurements in typical usability lab settings, recording skin conductance with a mouse or heart rate with a chair [39].

However, the main difficulty of psychophysiological measurement lies in its interpretation. Emotion is not the only process to affect visceral activity and the research failed to uncover unambiguous associations between specific emotions and patterns of bodily activation. Results will vary depending on the particular stimulus used and from test participant to test participant. Therefore, as of today, it seems extremely difficult to use psychophysiological recording on its own to provide an assessment of users' emotions while interacting with a product. As a consequence, the bulk of the published research with these techniques supplements them with self-report data and focus on the physiological activation itself.

Appraisal

The last component included in current theories of emotion is appraisal. An appraisal is a quick evaluation of a situation that can direct emotional responses at threat or opportunities in the environment. While it is not usually mentioned in discussions of the measurement of affect, it is a crucial component of emotion in several influential theories of emotion (for a brief overview and an application of this concept in the product design field, see [43]).

Like feelings, appraisal is typically probed via self-report, with open-ended questioning or more structured instruments. However, the assessment of appraisal processes is facing several extra difficulties because it is usually thought to be automatic and potentially unconscious [44] and because self-report about appraisal can be affected by other processes such as attribution [45]. Still, investigating appraisal patterns elicited by different product can play an important inspirational role at the beginning of a design process.

Coherence between components

A fundamental problem for the measurement of emotion is the relatively low coherence between physiological activation and other components [40,41]. Attempts to integrate self-report and psychophysiology in an explicitly multi-componential measurement of emotion in HCI also resulted in only modest correlations [29]. Obviously many technical and methodological difficulties can account for these disappointing results but they still have important consequences for the measurement of emotion in research and practice. Several interpretations have been proposed, suggesting for example that response coherence might only be a characteristic of folk concepts of emotion, therefore not necessarily present in non-prototypical emotional episodes [4]. Other authors suggest that some emotions are unconscious, completely decoupling subjective experience from other components, including visceral reactions and approach/avoidance behavior [42].

While these hypotheses about the link between components are intriguing, the weakness of the empirical correlations raises a number of practical questions for the evaluation of user experience. It is necessary to define which facet of the users' affective response should be targeted and what processes influence any potential "measurement of emotion". Most importantly for design research and actual product tests, it is important to make sure that the components used to measure users' response align with the experiential goals of the design.

In this respect, the most obvious component of emotion is probably the subjective experience of emotion itself. As far as the person experiencing an emotion is concerned, the phenomenal experience *is* the emotion itself and the notion of "pleasure" or "design for experience" almost by definition refer to the subjective feelings of the users.

Obviously, subjective experience is impossible to access directly for the researcher and the most straightforward way to study emotion is to task users or research participants about their feelings. Much criticism has been directed against introspection and self-report techniques, one of the most notable being the work of [46]. While this does not address all issues, it is important to note that many objections actually pertain to introspection about cognitive processes. Self-report of affective experience is somewhat different in that participants are not asked to analyze their thought process but to report the content of their experience, which is by definition conscious.

Other components of emotion, especially expressive behavior and physiological activation are generally less useful from a design perspective. The patterns of physiological activation associated with affective processes are obviously interesting in themselves for psychophysiology and neuroscience, but their role in user experience research needs to be considered in the light of the low correlation between emotion components. In most cases, physiological changes or facial expressions are interesting as measures only inasmuch as they can inform us on the subjective feelings of the user. For example, obtaining specific patterns of bodily arousal independently of the broader user experience will seldom be the objective of design practice and research – it could however still be valuable for health applications. These issues need to be weighted carefully in any approach to the assessment of user experience.

AN APPROACH TO THE MEASUREMENT OF EMOTION

Following the overview of available tools and techniques to measure emotion, the last part of the paper will present an approach to the measurement of users' emotions when interaction with products. Figure 1 sketches how the main steps of the approach.

Compared to the evaluation of product appearance or sensory qualities and to general emotion research, research on the experience of interaction with products is fraught with difficulties. On the one hand, the intensity of the response to be expected is mild in most cases, making the use of facial expressions and psychophysiological recording especially difficult. On the other hand, self-report can itself interfere with the experience and obtaining repeated ratings can quickly become burdensome for research participants. Finally, outcome measurement or overall ratings of the experience only provide limited insight into the course of the interaction and the designer's options to shape it.

Our approach is based on the combination of several available techniques to collect continuous data on the experience as it unfolds in time. Its goal is to help designers identify the key episodes in the interaction and the time points they can act on to impact the user experience.

Continuous self-report tools (usually based on one or two dimensions such as “warmth” or arousal and valence) are widely used in fields like music perception [15] and advertisement research [16]. However, unlike interaction design, these researches deal with stimuli that viewers or listeners receive somewhat passively, in the sense that one does not need to interact with the television when watching an advertisement clip. Even before considering potential interference with the user's goals or the extra attentional and cognitive load, concurrent self-report severely limits test participants' ability to interact with products simply because it usually requires that the participants operate some device with their hands.

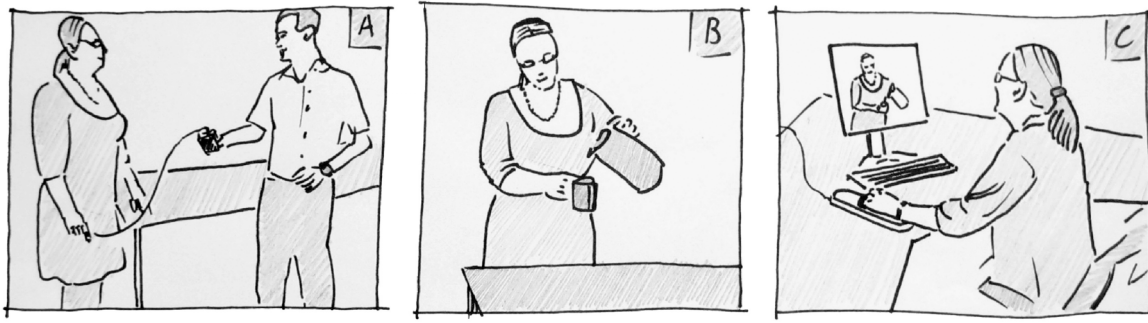


Figure 1. Approach to the measurement of emotion

A: ambulatory physiological measurement, B: interaction with the product, C: self-confrontation and self-report with the emotion slider

A promising approach to handle these situations is called self-confrontation. The basic principle is that participants are filmed while interacting with each other or with artifacts and are asked to report about their experience while watching the video of the interaction immediately after it ended. The video provide a support to the self-report, helping the participants to remember their experience and allowing them to report more accurately on the time-course of the interaction. This technique has been used in human-computer interaction [17, 20] and user experience research [18, 19, 21, 22]. Depending on the research questions or the stage of the design process, it can be adapted by using different data collection approaches: open-ended questioning or more structured questionnaires.

Self-confrontation could potentially provide valuable data to design researchers and practitioners. However, several questions remain open about this technique and its value. First, presenting test participants with a video of the interaction might distort their reports and the impact of the form of this video (e.g. camera angle, screen capture versus subjective view including keyboard and mouse when interacting with a software product, sound or not, etc.) on the results need to be better understood. Our experience with the technique [22] involved a quasi first-person view (the participant is on the picture but seen from the back and not in a frontal third-person perspective). A small camera mounted on a light helmet or pair of glasses could also be used to provide a completely subjective view. In any case, it is important that researchers using the technique specify in more details the content of the self-confrontation cue.

Self-confrontation studies also vary in response format: researchers repeatedly prompt users to report their feelings with various brief questionnaires. An alternative approach involves collecting continuous report on one or two dimensions such as valence or arousal. The type of device used to report the valence of the experience should also be considered.

Despite the growing literature on congruence between instrumental behavior and affect mentioned in the first part of the paper, it seems that little attention has been paid to the type of motor responses required from participants in user experience research and any impact it might have on the data collected. This is especially relevant for studies in which test users are asked to report their feelings using physical devices such as dials or sliders [35] instead of paper and pencil questionnaires. A basic methodological precaution, common in other fields such as music perception, is to invert the self-report scales for half of the participants, for example by switching the positions used to report positive feelings and negative feelings.

Another approach to this problem is to treat these processes not as a threat but as a component of the measurement process. Following the principles of tangible interaction, we developed a device (the emotion slider) to make continuous self-report of emotion as intuitive as possible. Based on the experimental results on the facilitation of approach and avoidance movements by affective experiences of different valence, interaction with the device is designed to map emotional valence and operation of the device and to maximize the congruence between the physical response and the content of the

feelings being reported (see figure 1 for a picture of the device and [36] for more details on the design process).

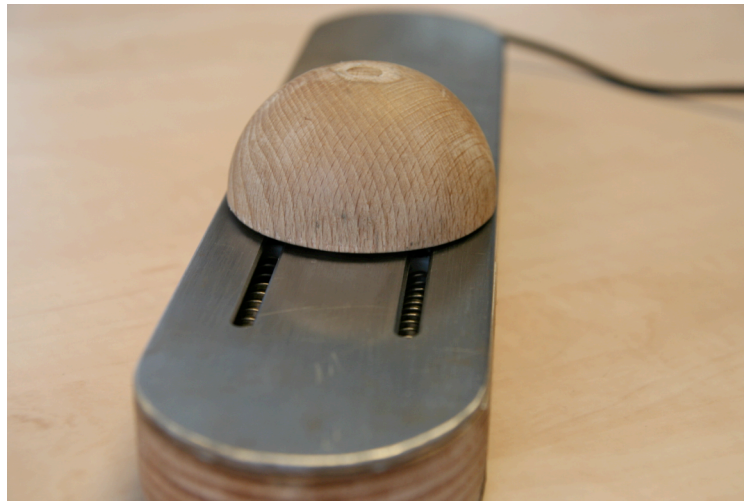


Figure 2. Emotion slider

This device was designed to be combined with the self-confrontation procedure to collect continuous data on affective responses when interacting with products. Test users would use a product and then report how positive or negative they felt while watching a video of the interaction. This procedure would produce a “valence curve” showing how pleasantness (or frustration) varies over the course of the use and allowing designers to refine the product by identifying low point or key events in the interaction.

Despite the difficulties noted earlier, psychophysiological recording and facial expressions should still play a role in the assessment of user experience when interacting with product. Instead of looking at these tools as objective measures of emotion bound to replace self-report in the near future, it could therefore be useful to consider other ways to combine it with other approaches. Physiological data could for example be used to identify key episodes during the use of a system. It would then be possible to ask the users if they indeed experienced stronger feelings at that time and to probe further about the content of these feelings, either online with some form of short questionnaire or offline during self-confrontation. False positive or ambiguity could be compensated by the self-report data, while the other streams of data could help the research to decide at what time to probe for more detailed self-report and increase the validity of the results.

CONCLUSION

We presented an overview of tools and techniques for the evaluation of emotion elicited during interaction with product and organized them using multi-componential models of emotion. We sketched an approach to combine some of these techniques. Self-report appears indispensable at this time, self-confrontation is a useful technique to collect time-dependent affective self-report about interaction. It can be supported by devices capitalizing on fundamental behavioral tendencies associated with affective responses. Facial expression and physiological recording can supplement it by providing unobtrusive continuous assessment of some affective processes, maybe allowing the identification of key episodes of emotional arousal. Additionally, investigation of concurrent appraisal processes can also provide useful input of the design process.

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