Story #1: Mom and boy

A phone is ringing. She picks it up from her desk. Him again. Hey. A boyish voice comes through loud and clear, laughing with someone before he realizes that she had answered. It’s her son, cheerfully shouting in her ear because his buddies are teasing him. He should be home for supper in 30 minutes. By the way, the presentation went well; even Mr. Kim thought so. See! There and then, she receives a picture of her son standing proud beside a patient looking teacher. Silly boy! She folds the phone back into her hand. How amazing, she thinks, that such a small object, that otherwise looks cool, professional and low key—all qualities she identifies with—can erupt into life, taking on the voice and carrying the boisterous presence of a twelve year old boy. She smiles. Here UX is not only the result of interactions between a person and a system. Actually, the system often has a support role in a human play, where human relationships are the central issue (see Wright and McCarthy 2004). In this case, the cellphone supports their relationship, augments the sense of presence, acts as “a virtual elastic band” and allows her to follow his coming and going.

UX story #2: The stockbroker

A stockbroker returns a call to one of his regular customers interested in selling stocks. As a top broker for a big bank, he uses an up-to-the-second stock information application that pools all data (stock performance, quarterly results, industry reviews, etc.) from the 10 best securities brokerage firms. While on the phone with his customer, he can quickly question someone on his team through the application’s internal chat window. He has streamlined the application with shortcuts of his own for surveying portfolios, checking specific stocks, filling up forms. The thrill of making the right moves and making big gains for himself and his clients all depends on information. This application feeds him timely pertinent information, making his job a little less stressful and enabling him to really play the market with some confidence (limiting the gamble). Here evaluating usability does not capture the essence of the interaction with the application. One should take into account the satisfaction of interacting with a high-performance system that empowers the user, the thrill of betting along with the assurance of being well informed, the sense of being competent and the satisfaction of being recognized as such by his peers.
UX story #3: The mountain biker

JP is a serious cross-country (XC) cyclist, the most common discipline of mountain biking. He enjoys XC for the fun of giving it all he's got: the sheer physical effort required by the climbs and the dare of crazy fast technical downhill trails (some so hard, he would be scared after the fact, looking at them from below). In the midst of the action, his bike becomes a smart, well-engineered extension of himself. The pride, fascination, and gratefulness for the extreme fun this high-tech bike provides are obvious. But JP’s true reward comes from meeting harder challenges every time. The initial frustration of not achieving a technical pass only makes its mastery more satisfying. He specifically enjoys those short challenging segments that require all his attention, physical abilities and wits, for minutes on end; and lead him to total, exhilarating exhaustion after two hours or so. The usability of the bike, although essential, is obviously just a part of the interaction with the device. UX is more a question of extreme fun, strong emotions, hard challenge, pride, intense physical effort, acquisition of abilities, and self-accomplishment.

Figure 1 Cyclist biking through rough terrain joyfully

1. Introduction

These stories illustrate the wide variety of User eXperiences (UX) and reveal the rich and complex reality that goes far beyond the strict functional aspect of a system. They are not only about interacting with a system, but also about doing things that make sense in our life, that bring pleasure and satisfaction and relate to our emotions, interests, motivations, values, lifestyle, in short, all that make us human. Although the Human-Computer Interaction (HCI) and the interaction design communities have readily accepted UX, their ability to design for and evaluate it is limited by the lack of consensus on what is UX and how it is created, and the lack of design methods and evaluation tools adapted to UX.
A brief review of key elements of UX is necessary as a start. In light of several definitions of UX (Alben 1996; Shedroff 2001; Hassenzhal and Tractinsky 2006; UPA 2006; Nielsen and Norman 2009; Wikipedia 2009) and because we deemed essential to mention some characteristics of UX, we proposed the following definition of UX:

**UX is a multidimensional construct that defines the overall effect over time on the user of interacting with a system and service in a specific context.**

Here are comments on some terms of the definition and a summary of the characteristics of UX (same as those in the ‘Summary of what makes UX’ in Robert and Lesage, 2010):

- UX is multidimensional and holistic; its six dimensions are: functional, physical, perceptual, cognitive, social, and psychological; two meta-levels are related to each of them: sense making and aesthetics. Each experience has as unique and coherent set of dimensions meeting together according to variable ratios.

- UX is subjective: it partly depends on what the user brings to the interaction with the system in terms of moods, sensitivity, attitudes, prejudice, interests, knowledge, motivation, etc. This is the basis for sense making and for attributing weigh to each dimension of UX. It also partly depends on the subjective emotional response to the interaction with the system. All this sets the stage for having an aesthetic experience.

- UX is an overall effect on the user (hence the overall UX): it cumulates the effects (in terms of knowledge and emotions) experienced at each point of contact with the system, the services and related artefacts. Furthermore it cumulates the (perceived) results of activities, which are made of two concurrent strands, one answering to extrinsic needs and goals, the other to intrinsic needs and goals.

- UX spans in and over time (so it is not static): it covers the expected UX that built up to the actual use of system and the in-progress UX; these two cumulate in an overall UX.

- UX depends on four basic elements: the User interacting with a System for doing an Activity in a specific Context;

- UX is situated in a specific context (or is context-dependent): it depends on the characteristics of the context in terms of location, time, people, opportunities and constraints, technology, incidents, stakes, etc.

UX applies to an individual or a team.

UX can be considered at different granularity levels.

This article consists of two main sections. The first one (section 2) is about designing for UX; we show how a user-centred system design (UCSD) approach, with some
adjustments, can be used to design for UX. Section 3 is about UX evaluation; it covers two topics: UX dimensions and emotions. In the conclusion, we propose some promising research avenues to improve the design and evaluation of UX.

2. Designing for UX

We cannot design a UX because it is internal to the user, yet we can design for a UX. It remains a challenge to design for UX because our understanding of the relations between design elements, sense making, emotions and UX is still incomplete. Yet to have a framework for research as well as an overview, we propose a model of the inputs and outputs of UX (see Figure 2). It will help focusing the discussions on specific aspects of UX, and hopefully make progress. In this section we present four design elements of UX and their relationships, and we show how a user-centred system design (UCSD) approach can help designing for UX.

![Figure 2 The inputs and outputs of UX](image)

**Design elements**

We consider four design elements of UX: the User, the System, the Activity, and the Context, and we examine the control the design team has over.

The **user**: the design team selects the human factors aspects that will be taken into account into design and decides about the type and level of user participation into design;

The **system**: the design team exerts full control on the system functionalities and qualities;

The **activity**: through system functionalities and related artefacts, the design team exerts a control on what the user can do with the system and how s/he does it; to a certain extent,
through the functionalities that are offered, it has also an influence on when, with whom and where the system can be used;

The context: the design team is influenced by the context as well as it exerts an influence on it through its innovations.

The design team is not the only unit of an organization having an input on UX; Figure 2 shows four of them:

• the design team through its work on design elements;
• the marketing through information about the system presented to users in the media;
• the sale service through information about the system presented to the future users;
• the after-sale service through the quality of assistance, training, maintenance, … offered to users.

Also:
• the management through its culture, values, strategies, policies, and programs that affect the users; its influence on the user filtrates through the different units of the organization.

In this article, we only focus on the input of the design team.

Even though several authors (including ourselves Lesage and Dorta 2008; Robert 2008) talk of a paradigm change when we pass from usability to UX, we do not see a rupture in the work to be done when designing for UX. We rather see a continuity in the activities of analysis, design, and evaluation that are required for designing good interactive systems, with an opportunity of enrichment. So our approach is to build on well-established knowledge, and propose enrichments where there are needed.

Coming from the disciplines of human factors, HCI and the industrial design, we have access to a large pool of knowledge (e.g., theories, models, approaches, principles and guidelines, best practices, methods, tools) for designing good quality interactive systems. In the next paragraphs, we present the central part of this knowledge, i.e. the UCSD approach with its principles and activities, and its application to UX
User-centred system design

In the first half of the 1980s, Gould and Lewis (1985) set the foundation of a UCSD approach that has always been a solid reference in the field of HCI. It encompasses four design process principles:

- Early -- and continual -- focus on users (and on their task and context) [N.B.: the text in parenthesis is ours];
- Empirical measurement
- Iterative design
- Integrated design -- wherein all aspects of usability evolve together.

These principles are at the hear of the UCSD or usability engineering process of several authors in HCI (e.g., Pagulayan et al., 2003; Wixon and Wilson, 1997), and their underlying philosophy is now part of the norms ISO13407 and ISO 18529. The reader can refer to Gould et al. (1997) for a detailed presentation on what they consist in and how to apply them.

In the next paragraphs, we show what adjustments are necessary to use the UCSD approach to design for and evaluate UX.

User For obvious reasons, the emphasis of HCI on the importance of knowing the user remains highly relevant for UX. In HCI, seven categories of human factors were to be taken into account:

- anthropometric: e.g., the size of keys on a keyboard, of a touch on a screen
- motor: e.g., typing speed, reaction time
- perceptual: e.g., visual information presentation
- cognitive: e.g., situated cognition, decision-making, situation awareness
- social: e.g., communication, sharing, and teamwork through collaborative technologies
- cultural: e.g., international and intercultural interfaces
- psychological: e.g., opinions, attitudes, satisfaction.

With UX, two additional categories of factors are to be taken into account:

- motivational: e.g., social encounters, curiosity, recognition by others, self-identity, self-achievement, pleasure, value;
- emotional: e.g., fun, pride, attachment, enchantment.

With UX, there are also new objects of interest for design, namely aesthetics and sense making; they are discussed below.
In the UCSD approach, depending on the project, the user participates to the design process in different manners, at different moments, for different periods of time, with different level of involvement, and with different levels of participation to decisions. Robert (2003) defined four different roles of the user which correspond to four levels of participation to the design process (the first three levels can be cumulative):

- **Informative**: the user participates to interviews, observations, or surveys in order to define system requirements: here his/her involvement is low, at the very beginning of design, for a short period of time, and with no participation into decisions;
- **Consultative**: the user evaluates interfaces through walkthrough and usability tests: here his/her involvement is low or medium, during the design process, for a short period of time, and with no participation into decisions;
- **Participative**: the user participates to the design of the system; his/her involvement is high, during all the design process, for a long period of time, and s/he participates to decisions.
- **Designer**: the user designs him/herself the system for his/her own usage. This often happens for sophisticated tools used for instance in research.

In the UX approach, the participation of the user is expected to cover the three first levels. See Muller (2003) for a review of the advantages and critics of different forms of user participations in design.

Finally, traditional HCI is mainly (but not exclusively) associated to serious users operating in work or study environments whereas UX, from its very beginnings, also includes discretionary users doing all kinds of activities (e.g., work, leisure, travel, daily life chores).

**System** Several qualities are expected to be present in good interactive systems. They are the following:

- **Usefulness** (or appropriate functionality) to do our activities and reach our goals; it includes the functionalities for doing primary as well as related activities;
- **Reliability**: it permits the user to count on the product over time and develop trust;
- **Security**: it is essential in various domains such as transport, medicine, process control, and defence;
- **Efficiency** (and capacity): we are used to interact with more and more high-performance systems in terms of response time, memory space, screen resolution, etc.;
• Accessibility for handicapped people, for people with little education, for people equipped with previous versions of applications;
• Compatibility (connectivity) with different versions of a software application, different products of a same manufacturer and of different manufacturers;
• Usability for the ease of learning and ease of use, and the user satisfaction;
• Good design for the look and feel, the smoothness of the interaction, the beauty, the novelty.

It is essential to continue insuring these qualities for UX. To guide us, there are standards, guidelines, methods and tools available for several of them: for instance, on accessibility, see W3C (2005, 2008); on usability, see Dumas (2003), ISO 9241, Rubin (1994); on good design, see Cross (1984), and on the reflexive approach, see Schön (1983).

All these qualities are instrumental for obtaining objective results and are likely to be perceived as such by the user. For instance, adequate functionality, to do different activities; efficiency, to do them rapidly; accessibility, to be able to do them even with a handicap; usability, to do them with a system that is easy to learn and use; good design, to increase user performance and satisfaction. One of these qualities, good design, is also non-instrumental because it could be appreciated for itself by the user. Indeed, a user may have great pleasure, satisfaction, or pride to use a system that is beautiful, cool, classy, original, well-designed, at the cutting edge of technology, full of intelligence, etc.

**Activity** There are at least four important differences between traditional HCI and UX concerning the user activity.

• First, the change of terms. Historically, HCI has been mainly associated to work (done at the office), and this explains why the term task was used. In UX, the term activity is deemed more appropriate because it is more inclusive. It covers all kinds of activities (work, education, leisure, daily life chores) done in all kinds of settings (office, home, school, transport, outside, etc.). That being said, one should continue to use the term task in UX when it is question of work.
• Second, in traditional HCI, we mostly take into account the attainment of extrinsic goals, i.e., that are external to the person. Objective measurements of the result may be taken: e.g., user execution time, number of errors, number of requests for help, etc. Here the user is fully conscious of the goals. Note that in HCI we also consider the user satisfaction with the system. In the UX, in addition to the extrinsic goals, we also take into account the attainment of intrinsic goals, i.e., that are internal to the person; for instance, have fun, learn, make progress, have the inner satisfaction of doing an activity in harmony with own values, reinforce self-
image, etc. The user may not be fully conscious of all these goals. The relation between these extrinsic and intrinsic goals contributes to the creation of sense making by the user, and to the aesthetic experience.

• Third, in traditional HCI, the focus is mostly on the use of the system for doing the “tasks” for which the system was designed. In the UX domain, since the overall UX depends on each single experience the user has at each point of contact with the system, we consider the user activities during the entire lifecycle of the device. This means designing for related activities as well: for example, carrying, installing/deinstalling, learning, connecting/disconnecting, operating, upgrading, doing the maintenance, repairing, cleaning, etc. So the span is much larger.

• Fourth, in traditional HCI, the input of the marketing service to the design of the system is rarely mentioned in the literature. In the UX domain, since the overall UX also depends on expected UX, the marketing plays a significant role. The images and messages about the system that will be presented in the media to the future users have an impact of expected UX, and therefore on overall UX.

The quality of analysis of the user activities is important for designing good interactive products. There is an abundant literature on task analysis for interactive system design (e.g., Hackos and Redish 1998, Hollnagel 2003). And over the last 15 years or so, ethnography and ethnomethodology have also greatly contributed. They have much to offer with their global approach, their consideration of the context, their studies “in the wild”, and the participant-observation activities (Button 2003, Nardi 1997). The input of these disciplines is important for UX.

Context The careful analysis of the context (e.g., technological, economic, social, environmental, etc.) is essential for good system design; so it is with UX. The difference between traditional HCI and UX is that the latter does not only depend on the impact of the quality of system design on the users. It also depends on the impact of numerous other factors that determine the context of usage of the system once it is designed and is used in the field. For example, the design of the Bixi (the public bike service in the city of Montreal) could be great. But the UX with the Bixi could be globally negative if there was a financial scandal about the Bixi, if the users knew the service in charge of the operation was controlled by the Mafia, if they learned that Bixi components came from companies that hire children, if the location was deemed too expensive, or if the maintenance service was insufficient, etc. So to optimize the UX, both the context for design and the context of usage of the product must be taken into consideration.
3. UX Evaluation

Evaluation is part of the design process since it provides feedback to designers for making corrections and improvements. It is highly demanding because it requires having a clear understanding of the object of interest as well as sound criteria, methods, and tools. In practice, there are good reasons to evaluate the UX:

- designers will have a portrait of the UX in the pre-design situation and will use it as comparison with the improved post-design UX;
- designers will know if their decisions about different design elements have a positive, neutral, or negative impact on the UX, and if the level of UX with the new system is satisfying; and
- the management will know if its decisions made in different phases of the lifecycle of the system have a positive, neutral, or negative impact on UX.

Evaluation will make it possible to compare the UX with different versions of a system, different systems, on different groups of users, at different periods of time, and in different contexts.

On a research ground, the evaluation of UX offers the opportunity to:

- define and validate evaluation criteria;
- develop evaluation methods and tools; and
- provide empirical data on the relations between design elements, sense making, emotions, and UX;

Like any other measures of human states, the methods and tools used to measure UX should satisfy several criteria:

- validity: really measure the UX, all the UX and only the UX;
- reliability: the measures should be the same if taken in the same conditions at two different moments with the same user; (N.B.: this is difficult to apply because UX evolves with time);
- sensitivity: the measure is sensitive to the change of level of UX in time;
- diagnosticity: the measure reveals the categories of causes that are involved in the UX;
- selectivity: the measure indicates which aspects of the causes are at work in UX;
- obstruction: the use of the tool does not change the UX;
- span: the tool rapidly provides a measure of UX.

Furthermore, in order to be widely used, measures of UX need to be acceptable for the users, standardized, easy and rapid to use, and easy to interpret (low cognitive complexity).
At least three challenges will be faced when attempting to evaluate UX:

- evaluate the UX for a system that does not exist yet; indeed, it could be relatively easy to evaluate the UX with an existing system, but a real challenge with a concept of system, a non-interactive mock-up, or a low-level prototype;
- evaluate the UX for the mid- and long term; since UX evolves with time, it is necessary to try anticipating UX over time;
- averaging the evaluations coming from different people; even though UX is subjective, no one designs a product for a single user, so there must be a way to aggregate several evaluations.

A major difference between traditional HCI and UX concerning evaluation is that in the former, the quality of a system is evaluated in terms of usefulness, efficiency, and usability. In the latter, we go beyond that and include sense making, aesthetics, and emotions. In the next paragraphs we focus on the dimensions of UX which are at the basis of sense making and aesthetics, and on emotions which are at the heart of UX.

3.1 The dimensions of UX

When one analyzes the three UX stories presented in this article and the three others in Robert and Lesage (2010 (this book), one discovers that the overall UX is not homogeneous, it is rather a combination of different types of experiences for the user (hence the multidimensional nature of UX). We extracted six dimensions of UX and two meta-levels; Table 1 shows them with the kinds of user motivation that might be behind each dimension from our UX stories. These dimensions are not mutually exclusive and their relative weigh vary from a UX to the next, depending on the user’s perception, to the point that some dimensions may be absent for some users.
Table 1  Dimensions of UX involved when doing activities with various systems

<table>
<thead>
<tr>
<th>User's Motivations</th>
<th>Dimensions of UX</th>
<th>Story 1 Bixi users*</th>
<th>Story 2 Wii players*</th>
<th>Story 3 Air travellers*</th>
<th>Story 1 Mom &amp; boy</th>
<th>Story 2 Stock broker</th>
<th>Story 3 Mountain biker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get an objective result (e.g., move from A to B, make a phone call, follow a therapy)</td>
<td>Functional</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Exercise</td>
<td>Physical</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Have fun</td>
<td>Psychological</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Have the satisfaction of using a system that is well-designed and looks cool</td>
<td>Perceptive</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Do an activity in harmony with my values (health, environment, money)</td>
<td>Psychological</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Meet with other people</td>
<td>Social</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Learn about the system / consolidate knowledge about the system</td>
<td>Cognitive</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Learn how to do an activity / consolidate competence</td>
<td>Cognitive</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participate to a movement or interest group (e.g., societal, extreme sport)</td>
<td>Cognitive</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Reinforce my self-image (as young, active, urban, bright, good parent, good citizen ...)</td>
<td>Psychological</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Scale: nothing = not significantly positive; 1 = a little; 2 = average; 3 = strong; 4 = very strong

Dimensions of UX involved when doing activities with various systems

Here is a description of the dimensions. Each of them may be perceived as negative, neutral, or positive by the user. There is no tool yet to evaluate them.

**Functional:** This UX dimension is grounded in the system and is inevitably part of every UX. The user is aware of the instrumentality of the system s/he is using for doing activities and achieving extrinsic or intrinsic goals. There are situations where the user may not perceive anything special besides doing what s/he has to do with the system; in this case s/he has a neutral functional experience. There are also situations where the number, intelligence, or novelty of functionalities may be remarked and either highly appreciated or criticized by the user; in this case s/he has a great or deceiving functional experience.

**Physical:** The user may have to make significant physical efforts for doing the activity and interacting with the system: for example, when going cycling, playing with the Wii console, using a haptic control device. These efforts which deal with postures, displacements, and movements vary in terms of muscular sites involved, magnitude, frequency, duration, and coordination requirements.

**Perceptual:** This dimension is present in every UX because the point of contact of the user with the system is inevitably through the senses (visual, auditory, gestural, touch, etc.). Although perception is required in every other dimension, it pertains mainly to the “look
and feel”, which includes sound and surfaces, the smoothness of the interaction, and the beauty of the system.

**Cognitive:** This dimension responds to the activities of analysis, appraisal, reflection, learning, and creation, which allow one to understand, accumulate knowledge and experience, make progress, consolidate competence, and create through the interaction with the system. It also addresses the desire to develop oneself and grow. This dimension is essential for making sense of an experience, and for living an aesthetic experience.

**Psychological:** The user does activities that may be due to or have a significant impact on his/her psychological state, i.e. on mood, attitudes, opinions, motivation, self-image, self-identity, feeling of belonging, well-being, etc. The pleasure of doing an amusing activity and the satisfaction of doing an activity in harmony with one’s values or that contributes to self-development are good examples.

**Social:** The user may work or meet with and relate to other people through the interaction with the system and these encounters may contribute significantly to the overall UX. They could even be the primary reason for doing an activity with the system. The computer-mediated social interaction between gamers, the belonging to a virtual group or network, the participation to a societal movement as well as blogging and twitting are all opportunities of social interactions.

We consider sense making and aesthetics as meta levels, the former because it is a basic requirement for every other dimension (it is difficult imagining a positive experience for a meaningless physical or social activity), and the latter because for some users, it acts as higher octave of one or several dimensions at a time, and because researchers have observed users referring to it as an expression of their overall UX.

**Sense making (meta level):** This meta level runs through all dimensions, since we are constantly processing information, interpreting in order to understand our experience. Many authors in psychology (e.g., Bruner 1990) see the urge we have to interpret and understand our experience as one of the characteristics of being human. Game designers Salen and Zimmerman (2003) have set this meta level up as their guiding principle by establishing that meaningful play is the primary objective of game design. “…play is more than a mere physiological phenomenon or psychological reflex. (...) It is a significant function—that is to say, there is some sense to it. In play there is something “at play” which transcends the immediate needs of life and imparts meaning to the action. All play means something” (Huizinga 1955 as cited by Salen and Zimmerman 2003, p.32).

Designing and evaluating such a widespread and holistic phenomenon as sense making are a challenge. Wright and McCarthy (2004) have developed an analysis framework that
considers six processes participating to sense making. They warn that there is no linear causal relationship between each process, as they can be paired any which way. They are:

- anticipation (the continuous process of expectation),
- connecting (the immediate, pre-conceptual and pre-linguistic sense of a situation encountered),
- interpreting (an unfolding experience involving discerning the narrative structure, the agents and action possibilities, past and future),
- reflecting,
- appropriating (making an experience our own), and
- recounting (telling the experience over).

**Aesthetics (meta level):** Beyond the basic perceptual experience that comes from the senses, there is the possibility for the user of having an aesthetic experience when the overall experience based on one dominating dimension or several dimensions at a time is perceived as particularly rich, intense, pleasant, stimulating, etc. The level of aesthetic experience can be found in the UX literature, based on the aesthetic philosophic tradition. McCarthy and Wright (2004) state, following Dewey (1934) and Bakhtin (1990) that the aesthetic experience is the key to understand how rich all experience can be. They argue that it is in the aesthetic experience that our need for sense of the meaningfulness and wholeness of our action is fulfilled (Wright and McCarthy 2004, p.57). Here is an example of aesthetic experience: a colleague, needing to do some calculations, pulls out his IPod calculator. The vertical brings up a basic calculator, which was too basic for the job; he flips the IPod sideways, and gets a full-blown scientific calculator on the horizontal screen. This for him was beautiful. He was won over by the elegance of the design thinking that made a digital device rely not on menus and commands, but on direct, intuitive physical movement to deliver two very acceptable alternatives. This beauty owed little to the look and feel.

Table 1 clearly shows that several dimensions are simultaneously present in any UX. The presence and relative weigh of a dimension will depend on the user's perception at a certain time. If one dimension stands out significantly, either because it is clearly dominant or the others around are weak, this UX will take the colour of that dimension and could be named after it. So one could talk for instance of a functional, or physical, or cognitive, or social UX. If at least two dimensions stand out significantly at the same time and with similar weighs, the overall UX will take the mixed colours of these dimensions and could be named differently: for instance, a technological experience.

The six dimensions defined above will have to be validated with a larger number of UX stories in order to know if they are complete and refined enough. Depending on the UX
story, some of them can be easily (or objectively) identified by the designer (e.g., the physical dimension of the UX with the mountain bike, the social dimension of the UX in the Mom and son story) whereas others can only be pinpointed by the user since they depend on his/her perception. These dimensions, in our view, not only are a pertinent way to understand what goes on in the UX, but they could be the foundation of an evaluation tool for UX, to be developed in future research.

3.2 Emotions

Emotional reactions are an essential part of the UX so they should be taken into account when designing for UX. To do so we need to identify and name emotions, define their characteristics, understand their relationship with the experience in each dimension, and be able to evaluate them.

Humans have access to a large variety of emotions. Although the concept of emotion appears to be understood, unfortunately, there is no common definition and the name, number, characteristics, and categories of emotions vary from one author to another. This may have an impact on the choice of the methods used for collecting data on the emotional state of the person. We examine a few categories of emotions.

Several authors adopt the basic emotion theory, which assumes the existence of a certain number of universal (culture independent) emotions that can be distinguished clearly from one another (Ekman 1992). These are anger, disgust, fear, happiness, sadness, and surprise. Another approach is to classify emotions on two or three dimensions: Valence (positive/negative), Arousal (high/low), and Dominance. For instance, Russell (1980) and Lang (1995) proposed two-dimensional models that vary along the axes of hedonic valence (pleasure/displeasure) and arousal (sleepy/activated). These are seen are relevant dimensions for rapid evaluation of emotions. Other authors distinguish primary and secondary emotions. Primary emotions allow us to make rapid judgments of what is good or bad, safe or dangerous, and send appropriate signals to the muscle (for fight or flight) and to the rest of the brain; they correspond to the visceral level of Norman’s (2004) model. Secondary emotions include the full range of emotions, such as happiness, sadness, anger, trust, fear, surprise, contentment, etc. (Damasio 1994). For his part, Desmet (2003), who developed the evaluation tool PrEmo, defines two categories of emotions:

- Seven are pleasant: desire, surprise, inspiration, amusement, admiration, satisfaction, fascination;
- Seven are unpleasant: indignation, contempt, disgust, unpleasant, surprise, dissatisfaction, boredom.
Several psychological theories emphasize the multifaceted character of emotions. This appears in Scherer (1984)'s model, the one mostly used on the HCI context, which encompasses five components (see Figure 3). At the centre of the model is the “the emotion triad” of Izard (1977) which comprises three components: subjective feelings, physiological reactions, motor expressions; the two other components are cognitive appraisals and behavioural tendencies. This model shows two important characteristics of emotions: they influence our behaviours as well as they are the results of actions, and they influence our cognitive appraisals as well as they are the results of these appraisals. Three other characteristics of emotions that do not show in this model are worth mentioning because of their relevance for UX: they are situated in context, they are ephemeral or transient (they last a short period of time), and the emotional episodic memory appears to be non-linear. Indeed there is a “peak and end” effect (Kahneman, 1999) according to which a measure of emotion reaction taken just after an interaction with a system is not an average of the emotions felt at each moment of that interaction. The experience of the peak emotion and of the emotion felt at the tail end of the interaction strongly influences final assessments.

Figure 3 The component model of emotions according to Scherer (1984)

There is no standard way to measure emotions. Yet the components of Scherer’s model suggest five categories of measures based on the types of data collected. These are the following:

- Physiological reactions: heart rate, electromyography, electrodermal activity (EDA), pupil dilatation, systolic and diastolic blood pressure, breathing rate, facial expressions (measured through muscle contractions). Mahlke and Minge (2008) see the measure of EDA as the most promising way to determine emotional connotations. Physiological reactions are to be measured during the interaction.
with the system (otherwise they do not make sense) and provide moment-to-moment ratings.

- **Motor expressions**: these are related to facial and body expressions, gestures and speech characteristics. The relation between emotions and facial expressions (e.g., smiling, frowns) has been studied extensively. Some of the speech characteristics studied in relation with emotions are its speed, intensity, melody, and loudness. Motor expressions are to be observed during the user interaction with the system and also provide moment-to-moment ratings.

- **Behavioural tendencies**: their role is to prepare for reactions (Scherer 1984). They include speed of reaction, accuracy of reaching a goal, number of errors, and number of creative ideas. The subject’s intentions of use and for instance of purchase, which can be collected by interviews or questionnaires, are indicators of behavioural tendencies.

- **Cognitive appraisals**: since cognition plays a role in the development of emotions, the assessments of cognitive appraisals by the individual are deemed relevant for evaluating emotions. Quantitative methods can be used: for instance the Geneva appraisal questionnaire of Scherer covers the five dimensions of Scherer’s cognitive appraisal theory: intrinsic pleasantness, novelty, goal/need conduciveness, coping potential, norm/self compatibility. Qualitative methods can also be used to gain appraisal-related information: for instance, the thinking aloud method where the individual is encouraged to describe every emotional reaction s/he feels during the interaction with the system.

- **Subjective feelings**: e.g., feeling amused, annoyed, excited, engaged in flow of action, etc. The postulate behind these measures is that the individual is the best source of information on the emotions s/he experiences. Several self-assessment scales are available: for instance, the SAM scales (Self-Assessment Manikin) introduced by Lang (1980), which consists of pictures of manikins for each of the dimensions valence, arousal and dominance. The manikins represent five emotional states (e.g., from happy to unhappy) with which individuals rate their feelings. Csikszentmihalyi’s flow is a complex psychological state that describes a perceived optimal experience characterized by engagement in an activity with high involvement, concentration, enjoyment and intrinsic motivation. It is an example of known and measurable positive psychological experience. It is characterized by clear goals and quick feedback, focused attention, loss of self-consciousness, altered sense of time, a sense of control, a merging of action and
awareness, a match between participants skills and the activity's challenges. Flow state is determined by the balance between challenges and skills (Csikszentmihalyi and Larson 1988). The relation between perceived skills and challenges gives eight possible dimensions (Massimini and Carli, 1989): apathy, worry, anxiety, arousal, flow, control, boredom, and relaxation. The evaluation of the user's psychological states can serve as a barometer, reflecting on the perceived success of the activity from the point of view of the user, thus avoiding the subjective pitfall of evaluating the quality of the end results. Experience Sampling Method (ESM) (Csikszentmihalyi and Larson 1988) is a trusted method to measure the flow and neighbouring states.

4. Conclusion
In this article, we presented a definition and a summary of what makes UX; we proposed a model of inputs and outputs of UX that gives an overview of the process of UX; we suggested to adopt the USCD approach to design for UX but with adjustments to take into account the new context of UX; we suggested evaluating UX through six dimensions of UX and two meta levels, and we showed how the evaluation of emotion, which is considered essential in UX, can be approached. Theoretical and empirical research is still necessary to better understand the relations between design elements, sense-making, emotions and UX; this would help knowing what variables manipulate for increasing UX. Furthermore, we need to develop evaluation methods and tools: to identify the elements of a user's activity and interaction with the device that lead to sense making, the subjective weight of each dimension of UX, the presence and type of aesthetic experience, and the overall UX with the possibility of knowing how expected UX and in-progress UX combine.

References


