

Review

Making Order in User Experience Research to Support Its Application in Design and Beyond

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Abstract: The term User Experience (UX) was introduced to define the dynamics of the human-product interaction, and it was thought that design would have been a main recipient of UX research. However, it can be claimed that the outcomes of UX studies were not seamlessly transferred into design research and practice. Among the possible reasons, this paper addresses the fragmentary knowledge ascribable to the field of UX. The authors reviewed the literature analyzing the conceptual contributions that interpret UX, proposing definitions and/or a theoretical framework. This allowed the authors to provide an overview of recurring elements of UX, highlighting their relationships and affecting factors. This research aims to clarify the overall understanding of UX, along with its key components (the user, interaction, the system, and context) and dimensions (ergonomic, affective, and the cognitive experiences). The authors built a semantic construction inspired by the structure of a grammatical sentence to highlight the relationship between those components. Therefore, UX is defined by a subject/user who performs an action-interaction towards an object-system. A complement-context better defines the condition(s) where the action-interaction takes place. This work is expected to lay the foundations for the understanding of approaches and methods employed in UX studies, especially in design.



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Keywords: user experience; UX; UX definitions; semantic framework; UX studies; UX dimensions; UX fundamental elements; UX influence factors

1. Introduction

A shared, comprehensive, and exhaustive view on the meaning of UX is currently lacking. According to the literature, UX is multifaceted and multidisciplinary [1–4]. It is studied in a variety of heterogeneous subjects such as psychology, anthropology, philosophy, computer science, as well as technical subjects like engineering, and design. Thus, such a broad concept is difficult to synthesize [5,6]. Therefore, the question “What is UX?” can have a variety of answers depending on many different circumstances (e.g., the field of the study or the meaning given to “emotions” and “context”, as it will become apparent in the residual of the paper). The answers provided by the literature are not actually in strong contrast with each other, but they mostly shed light on the limitations of UX without addressing them concretely. This represents a fundamental hindrance to the application of UX in design, which is characterized by the demand for clear and unambiguous concepts and methods [7].

Moreover, the reviews of the literature concerning UX do not provide an overall view of this concept due to various limitations. In particular, many contributions are rather dated [8,9]. On the other hand, recent reviews focus on specific approaches or aspects of UX only [10,11]. These works do not contribute to an overall view of UX, especially if we focus on design, where a holistic and comprehensive understanding of product experience represents a pressing need [12,13].

The literature reports a “holistic user experience approach” [14–16] but it does not provide a holistic understanding of the main elements of UX. The holistic UX approach com-

biner heterogeneous UX methods [15] to dive into UX complexity and discover conflicts and synergies between the anticipation of use and the actual UX of a system [14]. In particular, Gasparini [14] claims that a holistic perspective of UX is neglected despite UX interactions with systems that are situated in different contexts. Furthermore, Hussain et al. [17] individuated a deficiency of studies addressing the dimensions of UX in a comprehensive way. The scholars recognize every UX as unique due to its time and context dependency. Therefore, they identified a set of dimensions related to interactive systems to comprehensively design interactive applications. However, they shed light only on UX dimensions neglecting other fundamental elements or key components involved in the human-product interaction (e.g., the user, system and context) and the different outputs arising from that interaction (e.g., ergonomic, cognitive, and affective experiences) [18]. Moreover, Hussain and colleagues refer to a specific niche of UX regarding interactive digital artifacts (related to the field of Human Computer Interaction (HCI) and not concerning tangible products). A holistic and comprehensive picture of UX regarding the evaluation of tangible design products is still lacking.

The objective of this paper is to map and give a structure to the knowledge about UX in terms of its definitions, attributions, constituting elements, and involved phenomena. Making order in UX research is expected to add clarity to the complexity of the UX domain, which is inherently characterized by tangled relations and intertwined constructs. Researchers and practitioners can benefit from an organized structure including constituting elements and dimensions of UX, so that they can consciously manipulate them during experiments.

With this objective in mind, the authors analyzed conceptual contributions that interpreted UX providing definitions and/or theoretical frameworks (more details are provided in Section 2). Specific attention on the field of application of UX was not in the scope of this paper; however, design appears as the main field where UX is studied. Therefore, the authors claim that the present work could be particularly useful to researchers and practitioners dealing with UX in design research and product development, as mentioned above.

This paper is structured as follows: Section 2 provides a general background of the UX concept with a particular focus on different UX interpretations. UX key components (fundamental elements of UX) are identified based on definitions. Those are organized into a semantic framework in Section 3, while, in Section 4, the focus is on the different UX outputs and defining them as dimensions of UX (qualities of the experience). Conclusions are drawn in Section 5.

2. General Background

2.1. Procedure Followed for the State-Of-The-Art Analysis

The search for relevant articles was performed using Google Scholar as a reference database. The most used search terms were “definition”, “User Experience”, “UX”, and “Framework”. The authors initially analyzed about 300 papers, which emerged by combining search terms and search fields. The first phase of the search was interrupted when different combinations did not allow the authors to identify new relevant contributions in a reasonable time. In a second phase, the number of gathered contributions was extended through a snowballing process; namely, forward and backward citations of already available papers, and other contributions of the most important authors were checked. This process helped the authors to find other keywords to be used as search terms, e.g., “product experience”, which was useful for the identification of further pertinent and impacting papers.

In the selection process, as aforementioned, the authors focused only on conceptual contributions providing definitions or theoretical frameworks for the UX concept. The UX fields of application were not considered among the main selection criteria since the scope of this review is to analyze the UX concept at a theoretical level.

2.2. Overall Understanding of User Experience and Issues in Research Thereof

In this section, the authors will analyze the definitions of UX to identify recurring elements and their relationships. Fundamental and influence factors as well as UX dimensions will be defined. In this paper, the authors use the term “key components” to identify the main or fundamental elements shaping UX and allowing the experience to take place. Yet, “dimensions” are meant as the fundamental qualities or attributes that characterize the experience.

As aforementioned, UX is a concept that cannot be sharply defined. Its boundaries are fuzzy [19], since UX is studied and applied in heterogeneous disciplines. Moreover, UX is difficult to quantify. Human-product interaction involves concepts that have affective, hedonic and aesthetic variables, which are often difficult to measure in an objective way [20].

This partial indefiniteness when it comes to UX has pushed some scholars to clarify what UX stands for. For instance, Hassenzahl revised his previous definition of UX [21]. He simplified it as a “momentary, primarily evaluative feeling (good-bad) while interacting with a product or service.” [22]. Law et al. [5], drew a picture of the main dualisms of UX in the introduction of the workshop, “UX Manifesto”. Quantitative-qualitative, persona-social, reductive-holistic dichotomies, among the others, have been used to characterize the papers resulted from the workshop activity. All these contributions are positioned on a theoretical level, without giving insights into how UX is operationalized. Bargas-Avila and Hornbæk [23] overviewed empirical research on UX conducted from 2005 to 2009 to understand how topics and trends in UX studies have changed over time. They identified emotions, enjoyment, and aesthetics as the most frequently assessed dimensions through qualitative methods. Those methods were often customized for their specific scopes, and therefore could lead to non-reliable results; moreover, these methods could be non-generalizable in different contexts.

In this context, despite the international standard on ergonomics of human-system interaction, ISO 9241-11 [24], a shared model for studying UX has not been established yet. However, the ISO 9241-11 [24] synthesized three important UX aspects that recur in most UX definitions and interpretations. First, an experience is the result of the users’ perception while they are using a system, or even before using it. Second, those perceptions involve subjective and human-related variables such as emotions, preferences, behaviors, and accomplishments, among others. Third, UX is a dynamic concept since users can perceive a product before, during and after its use. Markedly, the above standard defines UX also as “a consequence of brand image, presentation, functionality, system performance, interactive behavior, and assistive capabilities of a system, product or service. It also results from the user’s internal and physical state resulting from prior experiences, attitudes, skills, abilities and personality; and from the context of use”.

2.3. Definitions and Interpretations of UX

The term “User Experience” was coined by Donald Norman, who introduced it in 1995. The original meaning of this concept was related to the experience as a consequence of the interaction between humans and systems beyond the idea of “human interface” and “usability” [25]. Subsequent revisions widened this definition including affective and behavioral factors, embedded in the idea of “joy to use” and “joy to own” [4].

Human-product interaction was of great interest even before the birth of the term “User Experience” itself. Belk [26] interpreted it as the consumer-possession paradigm after looking at this relationship from a more marketing-oriented perspective, with a focus on consumer behaviors and choices.

Other scholars gave to UX a wider or a narrower meaning depending on different approaches and dualisms. Two fundamental approaches are found in the literature: the holistic, and the reductive approach. The former considers the phenomenological aspect of UX. In particular McCarthy and Wright [27–29] claim that it is not possible to take thoughts, ideas, and emotions apart from each other because everything contributes in forming the

experience between humans and technology. The scholars refer to “technology” with a wider meaning including everything that can be considered a product, artifact, or a system. The complexity of UX is strongly stressed by the fact that factors such as perception, sensory engagement and emotions cannot be analyzed separately.

On the other hand, the reductive approach attempts to reduce this complexity through the identifiable and measurable constructs that usually belong to cognitive psychology. These constructs are usability, aesthetics, emotions, and pleasure among the others [30].

However, other dualisms that juxtapose these constructs can be identified in the literature. These can be synthesized in the following approaches: hedonic or non-instrumental, contrasted to pragmatic or instrumental [31,32].

- The hedonic or non-instrumental approach refers to the subjective qualities of the human-product interaction. This perspective considered UX definitions that include or stress the importance of emotions and the affective response of users [2,3,25,27,28,33], or the consequent pleasure of using a product [29,34]. In particular, the affective aspect related to memories and meaning triggered by the product are highlighted by Norman [35] and Desmet and Hekkert [33]. Some scholars consider as hedonic everything that goes beyond mere usability [1,29,36].
- Under the umbrella of pragmatic or instrumental approaches, it is possible to find aspects such as usability, ease of use [27,34], usefulness, and effectiveness [27–29] in their definitions. These aspects are more easily measurable, and some can be assessed in an objective way. Section 2.4 provides major insights into the role played by utilitarian dimensions in UX.

Hassenzahl and Tractinsky [37] classified the UX components into three macro-categories: users’ internal state and their previous experiences, the properties of the systems or interactive products, and the situation or usage context.

Looking at the distinction between pragmatic and hedonic UX has parallels with approaching UX with a focus on different UX key components, i.e., user, product, and context. It is difficult to distinguish these two sides of the concept in the definitions provided in the literature. Thus, many scholars described these key components as influence factors while attempting to define the UX concept. This is evident from the definitions that follow.

- Subjective aspects referred to the way a user can affect the UX, namely, users’ expectations and their internal state or dispositions [1,3,28,37–39]. UX can be influenced also by the meaning users give to the product and the feeling of stimulation and personal growth derived by that interaction [21]. Since each individual has different perceptions, aspects such as perception and cognition have also been pointed out by [2,27,28,40,41].
- The system or product affects UX mainly through its appearance. Hence, the aesthetic dimension was identified as the most impactful characteristic of the product-system in [21,29,33,42].
- The context or the situation within which the interaction takes place is the most recognized impact factor for the UX [1,27,37–39,43]. This aspect is particularly complex since it presents many different interpretations. Therefore, it will be further analyzed in Section 3.4.

As for properties, other scholars stress the importance of the dynamic nature of UX [1–3,22,43–46]. Some scholars focused more on UX as a multidisciplinary concept [1,2,47]. In particular Ortiz and Aurisicchio [3] and Sun and Teng [4] list the main disciplines where UX is involved. Psychology, anthropology, computer science and engineering as well as product design are the fields where UX research has major relevance.

Based on the above discussion, the main visions about UX are summarized in Figure 1.

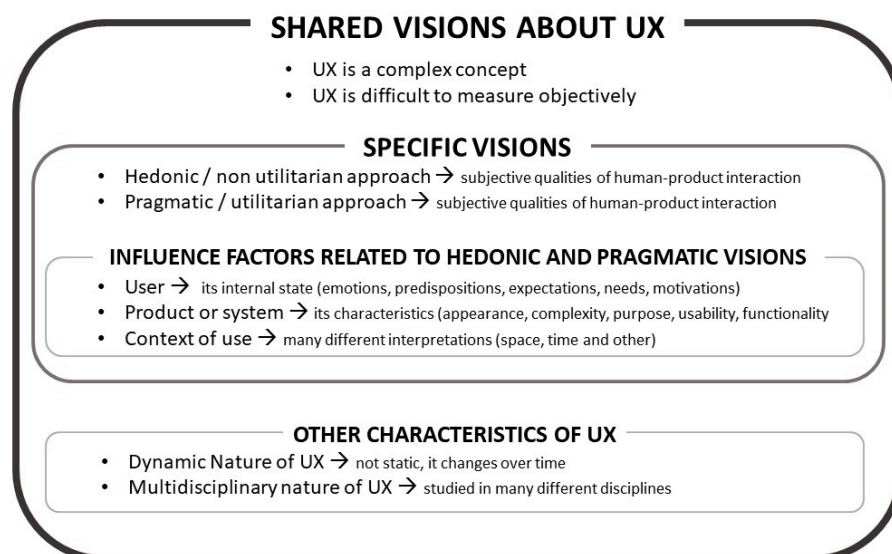


Figure 1. Graphical representation of the main visions of UX, and the influence factors related to the UX concept.

2.4. The Relation between UX and Usability

Despite all the nuances and perspectives adopted to define UX characteristics, the actual relationship between the concept of “usability” and that of “user experience” must be fully established. This section is devoted to this relationship, which deserves particular attention.

In an interview, Donald Norman stated that he needed a term with a wider meaning than “usability” to express the relationship between a user and a system [48]. According to Norman, the experience includes many aspects that go beyond usability and ease of use. However, Norman himself admitted that the term UX has been overused over time. This led to a general misinterpretation and confusion about the boundaries of these two concepts throughout the literature.

Some definitions are more focused on usability, while others seem to extend the meaning of UX beyond the mere usability concept. Alben [27] considers all the aspects of the interaction between humans and interactive products with a stronger focus on usability than on the affective side. Sutcliffe [34] deliberately focused on usability and efficiency of use with regards to product quality assessment. A more comprehensive definition is provided by Kuniavsky [28]. The scholar juxtaposed the affective satisfaction and the expectations created while the user is experiencing the product with the concept of effectiveness and efficiency. Other scholars prefer to consider UX in a broader way [1,29,36]. Miki [49] provides a differentiation of these concepts based firstly on time span, and secondly on the objectivity/subjectivity of measurements. Miki claims that scholars usually consider usability only during the interaction, while UX should be considered “over time” from “before the interaction” to “after usage”. Usability can be measured objectively through “effectiveness” and “efficiency”, while UX is evaluated through subjective measures that deal with subjective feelings, emotions, and preferences.

The problems of the complicated relationship between UX and usability concepts in the literature was partially solved by Følstad and Rolfsen [50] who divided literature contributions into three different domains depending on how those concepts were considered in the literature. These three domains were that UX included usability; UX completed usability; or UX was intended just as one of the elements that feature usability.

Sauer et al. [6] tried to clarify the boundaries between UX, usability and accessibility as well. They introduced another term: Interaction Experience (IX). They also specified that IX as a general concept should be considered as an umbrella term since it cannot be measured.

The measurability is an important point in the relationship between UX and usability. Often, usability is thought to be more objectively measurable than UX. This consideration influenced the methodological approaches used to measure and evaluate UX and usability. Indeed, usability can be evaluated by implementing a larger spectrum of methods, while there are fewer methods and instruments to target UX [6].

In a nutshell, we can state that while it is established that the UX concept extends beyond usability, the latter is often used as a substitute of UX for practical reasons, i.e., it represents the UX component that can be assessed and dealt with in a sufficiently rigorous way.

3. A Semantic Framework

Considering what arose from Section 2, some key components of the human-product interaction have been identified. These components are generally recognized in the literature without contrasts. However, the contributions that follow stress or focus more on some of these components, which are accordingly considered as key elements in UX in such sources. The authors created a semantic framework where the key elements of UX were identified, defined, and characterized. Many of these key components have been identified by Law and colleagues [51], who divided them into the categories of user, system and context of use. The developed framework is semantically inspired by the grammatical structure of a sentence (subject, verb, object, and complements), as the main identified UX constructs could be ascribable to the elements included in the sentence, “the user interacts with a system in a context”. Otherwise said, each key component is metaphorically associated to an element of a sentence to semantically describe its relationship and role within UX.

The “subject” is defined as the protagonist of the action in grammar. Otherwise said, it is who/what performs the action. In the UX perspective, the subject can be ascribed to the user.

The verb is the action performed by the subject. The object, toward which this action is directed, can be ascribed to the system. Usually, sentences are not so simple; they need complements to enrich the narration. In this case, our complement can be identified as the context in all its meanings. These are the components that define UX. If one of these elements is missing, it is not possible to have a “User Experience”. In the following sections, all the elements of the grammar are described and analyzed separately.

In Section 3.1, the authors provide a detailed description of the user, its needs and preferences. Users’ perception of a product is fundamental for designers during the development phases of design. Thus, it is useful to observe how users deal with products during the interaction and beyond. In Section 3.2, user-system interactions are analyzed. Due to the dynamic nature of experiences, it is not possible to focus only on the usage moment in UX, but the overall experience needs to be considered over time as well. The product, also defined as system, will be described and clarified in the following Section 3.3. The typology of the product and the way it is represented and showed to the user can affect the users’ perception and the overall interaction. Subject-users always interact with an object-systems in a specific context of use. Therefore, this aspect will be better dealt with in Section 3.4.

The authors graphically represented each key component through a mind map to synthesize the knowledge of the components in the semantic framework. Such graphical output offers a straightforward understanding of definitions and characteristics of the key elements of human-product interaction identified in the literature.

3.1. Subject–User

“Who interacts with a system or product” is usually described as the “user” of “final user” by most of the contributions in the literature [3,28,29,33,36–38,40–44,52]. However, other terms are diffused to feature the “user”.

It can be intended in a more general way as “human” [42], “person” [27], or “individual” [40]. A specific market-oriented perspective refers to the “user” as a “consumer” or “costumer” [26,53]. It can also be considered as a single individual [40] or a collectivity [54]. A whole evolution of the “user” is provided by Kuutti [52]. In human-computer interaction (HCI) the “user” is thought of as just a cog in a rational machine and a source of errors, and it has subsequently evolved to become a social actor and consumer. These were a series of terms used in the literature to define the “user.”

Beyond the used terms, it is necessary to describe the main characteristics of the subject-user. Yoon et al. [46] provides a list of the attributes that characterize the “user”. They summarized the attributes encountered in the literature; namely “demographic factors”, “medical conditions”, “personality”, “socio-economic circumstances”, “technology/literacy”, “anthropometry”, “physical and cognitive capabilities”, “expectations”, “memory and past experiences”. In this paper, the authors prefer the term “user” or “final user”, since these terms are the most shared ones. As mentioned in the second bullet list in Section 2.3, everything concerning the involved person and their inner state, is related to the “user” [1,28,37–39,55].

Figure 2 synthesizes the terminology referring to the user based on the definitions above. On the right-hand side, the authors list all the terms referring to “user” identified analyzing the literature, while on the left-hand side, the main attributes that characterize the subject-user are reported.

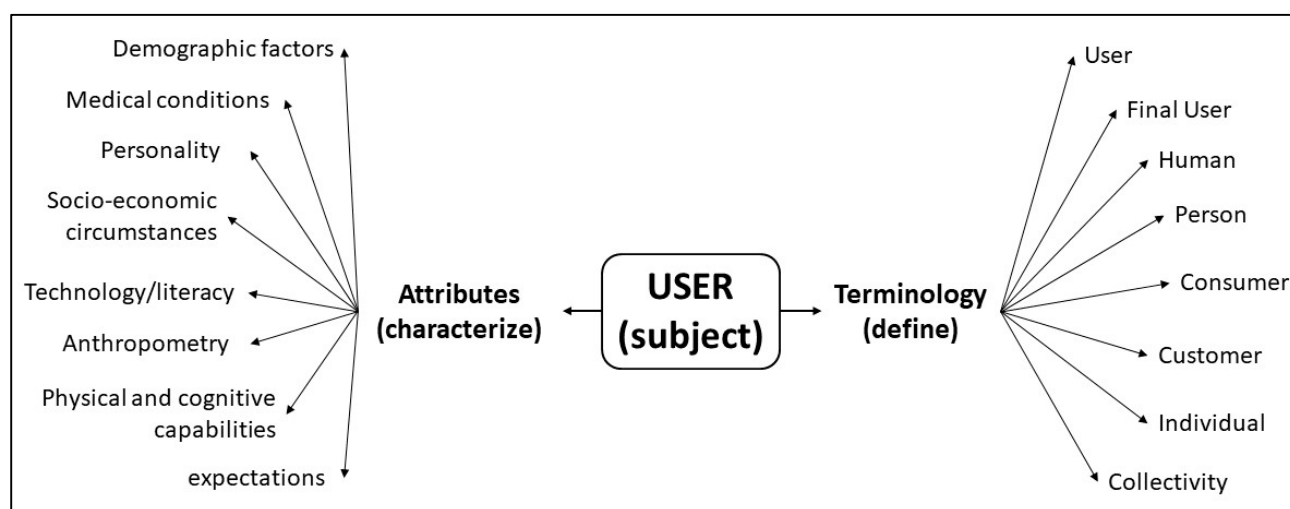


Figure 2. Terms used in the literature to define the user and to describe the attributes that characterize it.

Defining the “user” and its main attributes and characteristics (Figure 2) allows for a better understanding of its role in the human-product interaction. Furthermore, in this case, different scholars have a slightly different vision:

- According to Forlizzi and Ford [56], the user is an influence factor. Its prior experience, knowledge, emotions, values, and expectations as well as its perception, cognition and interpretation of the product have a huge impact on the interaction.
- Desmet and Hekkert [33] give to the user an active role just when it comes to perception, cognition, and interpretation of the product. Users can assign a certain meaning, personality, and significance to products through these processes.
- Hellweger and Wang [47] do not consider the user at all in their framework. Emotions, mental state, predispositions, expectations, mindset, and people among the others are just considered as variables belonging to the context where the interaction takes place.

3.2. Verb-Interaction

Interaction deals with perception through human senses. The first contact users have with a product is typically visual. Sight is commonly associated to the experience of product

appearance and aesthetic. However, Desmet and Hekkert [33] give to the “aesthetic of interaction” a broader meaning. With “beauty of use”, sight is not the only sense that comes into play; a closer attention is given to the tactile and kinesthetic domain. Locher et al. [57] defined “aesthetic interaction” as the dynamic bottom-up/top-down interaction between the form and the functionality of a product, the sensory perceptual process of the users, as well as their cognitive elaboration of that information.

More generally, McCarthy and Wright [2] identified four threads that characterize interaction and affect the experience, namely: sensual, affective, compositional and spatio-temporal. The first one deals with the sensory engagement and perception, the second with the emotions caused by the interaction. The emotions are influenced also by external factors such as the space and time where the interaction takes place. Every interaction can have different consequences due to the compositional nature of the interaction, which offers a certain range of action possibilities.

All these scholars focused only on the evaluation of the moment when the interaction takes place, however, as mentioned in Section 2.3., since UX is dynamic and can change over time, it is better to extend the study of the user-product relationship beyond the short-term interaction. However, just a small number of contributions analyzed how the interaction and the related experience evolves over time [45]. Among them, Karapanos et al. [44] built a framework to understand the usage phases which UX can be divided into, their impact on the user, and the consequent perception of the user of the overall product quality. To better understand the structure of the phases identified by the scholars, a brief description is reported in the following bullet list.

- Anticipation refers to the expectation the user builds before the actual interaction about a certain product. Indeed, the name of this phase refers to the anticipation of the experience.
- Orientation refers to the initial contact the user has with the product. This phase is characterized by a twofold feeling of excitement and frustration due to the learnability process.
- Incorporation coincides with a familiarization phase where the product becomes of common use and meaningful for the user.
- Identification happens when the product helps the user to show its self-identity to the rest of the community.

A similar work of phase individuation was carried out by Yoon et al. [46]. However, in this case, the scholars divided the product usage lifecycle in an increased number of phases, from “before purchase” to the “disposal/repurchase” moment.

Figure 3 summarizes all the main interpretations of interaction provided by the literature. The scheme is based on the four threads individuated by McCarthy and Wright [2] and has been extended considering other scholars’ interpretations. Here, interaction and experience are strongly related since the interaction leads to the experience. It is acknowledged that a multisensorial way to perceive a product can elicit a complete experience, which would be impossible to achieve just through sight. As a result, it is possible to claim that the interaction is the core of the experience.

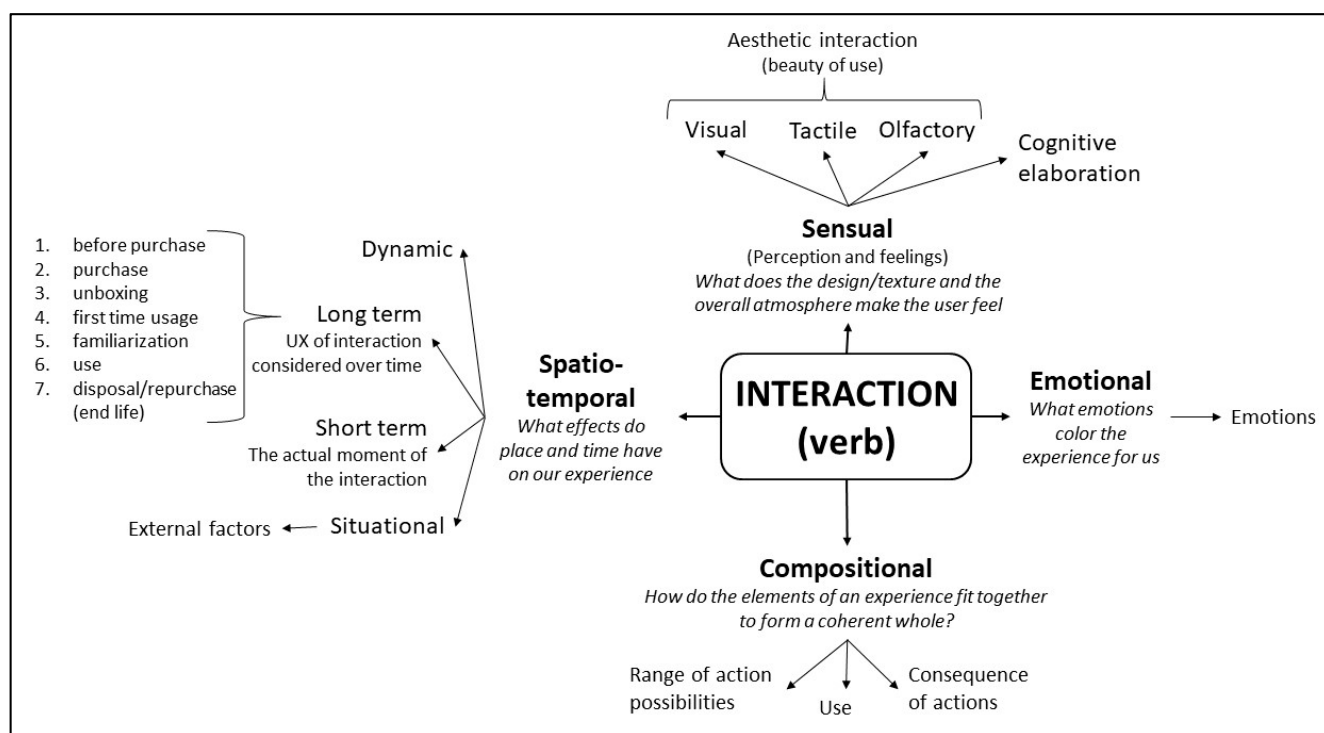


Figure 3. Scheme based on the four intertwined threads individuated by (McCarthy and Wright, 2004) and enriched with other scholars' interpretations.

3.3. Object-System

The “system” can be found in the literature with different interpretations and described with different terms. The most common ones are “product” or “interactive product” [27,36,44], but it can also be called “artifact” [1,26,58] and “interface” [59]. Since the product can also be intended as “technology” and “service”, authors adopted the term “system” used by Norman. The term “system” synthesizes both concrete and abstract aspects of a product [60]. The bullet list that follows shows these aspects in detail.

- As for the predicate-interaction, a strong focus was given to the appearance as it represents the concrete aspect of the system. In the current section, contributions are listed that stress the dominant role of the system during the interaction. Thus, appearance has a strong impact on the product-user interaction with consequences on the commercial success of the product [61]. Shape, geometry, dimensions, textures, materials, colors, graphics, and detailing characterize the physical and visible aspect of a system. Desmet and Hekkert [33] focused more on the ability of the system to trigger human senses through its aesthetic appearance. The scholars do not consider aesthetic simply as a static characteristic of the system; therefore, it has an active role in stimulating a response from the user. Appearance can be classified as a pragmatic quality of the system, as well as usability and functionality since it can be measured easily in an objective way through the analysis of visual behavior.
- Among the abstract aspects, Bongard-Blanchy et al. [60] consider semantics, symbols, emotions, and sensations or feelings. Desmet and Hekkert [33] discuss the affective experience triggered by the system as an affective phenomenon that causes both positive and negative emotions (e.g., love and disgust, fear and desire, pride and despair). These scholars also consider the symbolic meaning of systems in the “experience of meaning”. The affective and perceptual side of the product is prevalent in the literature, while the symbolic and semantic meaning are less recurrent. These abstract properties can be included among the hedonic qualities of the experience. They refer to the subjective, intimate, and deep relationship between systems and users, thus

such qualities are difficult to be precisely measured. Hellweger and Wang [47] list a series of product properties where both concrete-pragmatic and abstract-hedonic aspects have been included.

However, the product must be shown to users to be experienced and evaluated. During the design process, a system is not always presented as an end use product. Due to the iterative nature of the design process, designers often provide the users only with prototypical forms of the system with different degrees of abstraction and complexity. Since different forms of representations can influence the perception of the main features of a product [62], it is important to understand how products and systems can be represented. Forms of representations can be distinguished in physical and virtual representations.

- Among physical representations, it is possible to find end-use products, 3D printed objects or some of their parts, handmade artifacts, and prototypes, that can be further divided in 3D printed prototypes, low-quality or high-quality mockups, depending on their level of complexity. The importance of prototyping methods for the design-making process is stated also by Kim [63]. The scholar suggests designers acquire advanced technological skills to deal with interactive physical prototypes with a high-level of complexity.
- Virtual representation includes a large variety of degree of abstraction ranging from text description to virtual interactive models that can be experienced through immersive VR technologies [43]. In the middle of the scale, there are also images (sketches, renderings, and photos), videos and a combination of images or videos with descriptions, and static virtual models.

Based on the above, Figure 4 clusters the main terms that define the object-system, its attributes, and how it can be represented providing a complete overview of this key component.

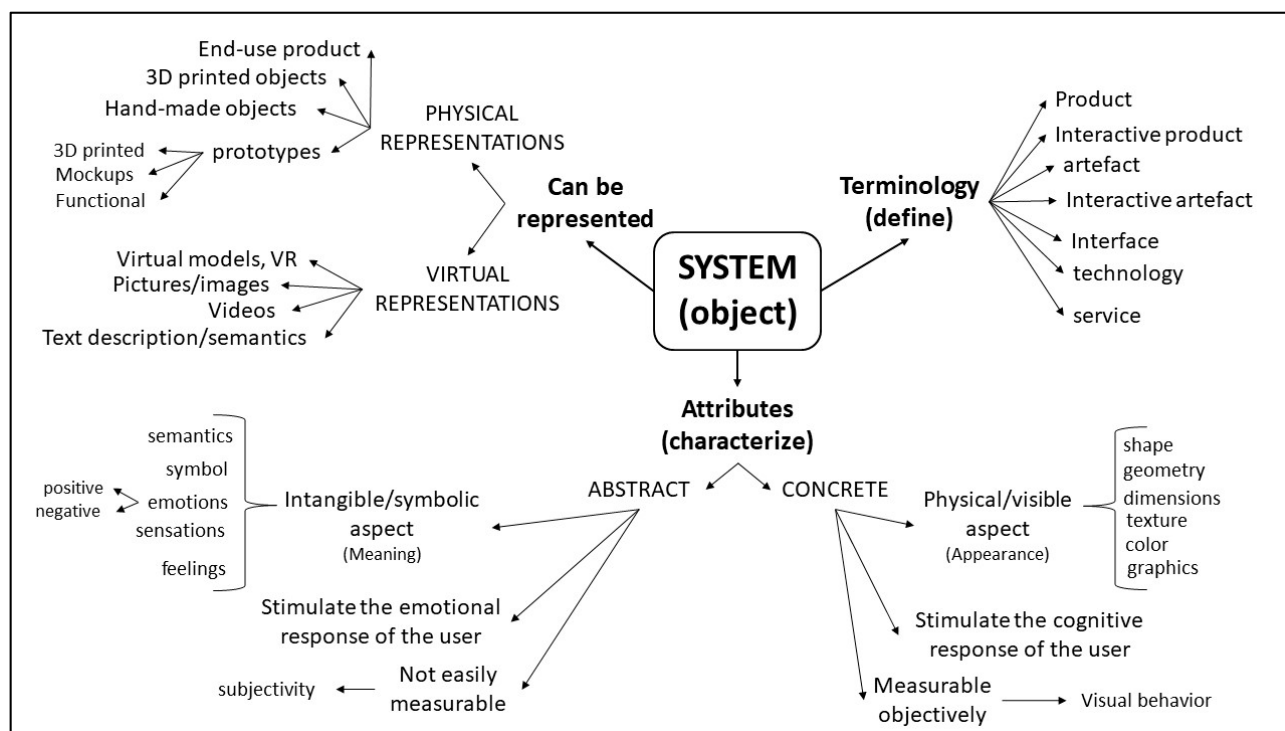


Figure 4. Graphic representation of the elements that define, characterize, and form representations of the system based on literature contributions.

3.4. Complement-Context of Use

The context of use completes the user-system picture, providing the frame where the interaction takes place, just as complements enrich the meaning of the sentence in grammar. Bargas-Avila and Hornbæk, [23] claim that the context of use is a key factor in UX; overall, this idea is widely recognized by the literature [1,2,27,37–39,43]. The impact of the context is due to the variety of elements that are considered within this concept. “Context” can be interpreted as (Figure 5):

- A broad meaning considering socio-economic aspects, cultural influence, the users’ background knowledge, among the other factors [3,43].
- Space and time [2,39,59]
 - (time, temporality) when the focus is on the moment at which the action is performed.
 - (physical space) where the interaction takes place. According to [61], this can be further subdivided into
 - environment and physical space [2,37,39,49,59]. This is featured by the physical condition that can influence user perception.
 - or as an instrumental physical context, where technologies are involved to facilitate the user-system interaction [43]. In other words, it can be considered as a form of representation used to depict the system.

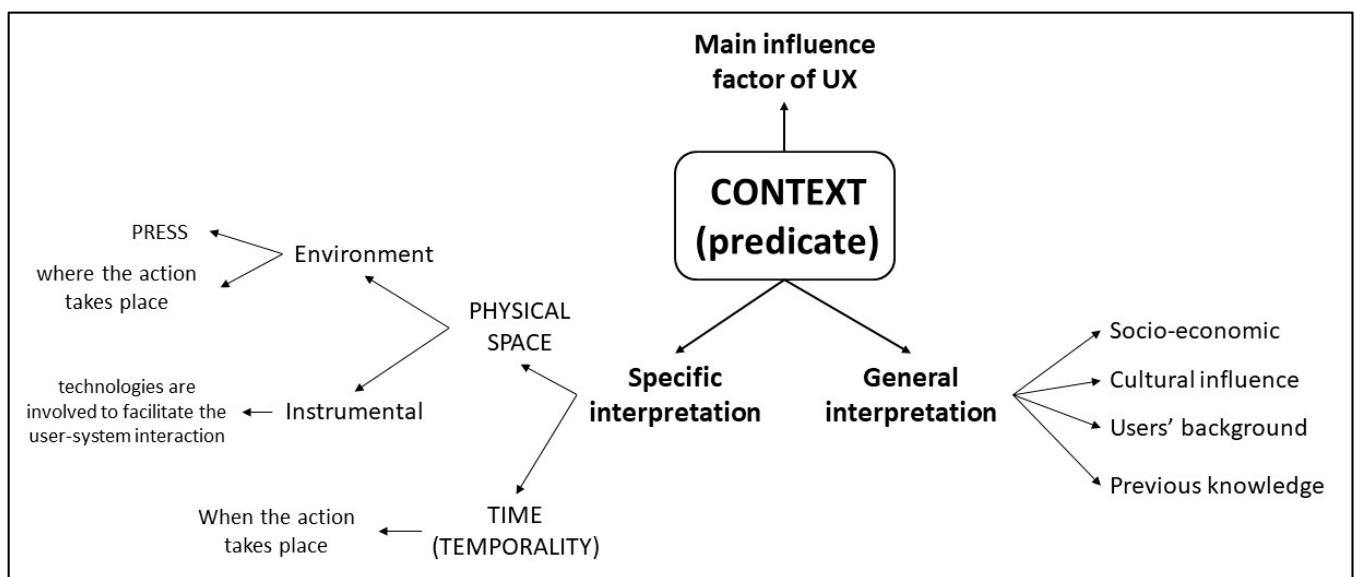


Figure 5. Graphic representation of the main interpretations of the context of use.

As for the other key element, a mind map (Figure 5) is provided as an output of the main definitions and interpretations of the context-predicate as well.

3.5. Overview of the Key Components in User Experience

So far, the authors have analyzed the key components of UX, providing a detailed understanding of their main definitions, interpretations, and characteristics. This has been organized into a semantic framework represented in Figure 6. Here, the key components described in Figures 2–5 have been simplified to highlight the relationship occurring during the verb-interaction (described in Figure 3) between the subject-user (described in Figure 2) and the object-system (described in Figure 4) within the complement-context (described in Figure 5). In other terms, Figure 6 extracts from previous depictions the relationship between key components in order to underline, in an overall representation, those relationships rather than the different interpretations of those key components.

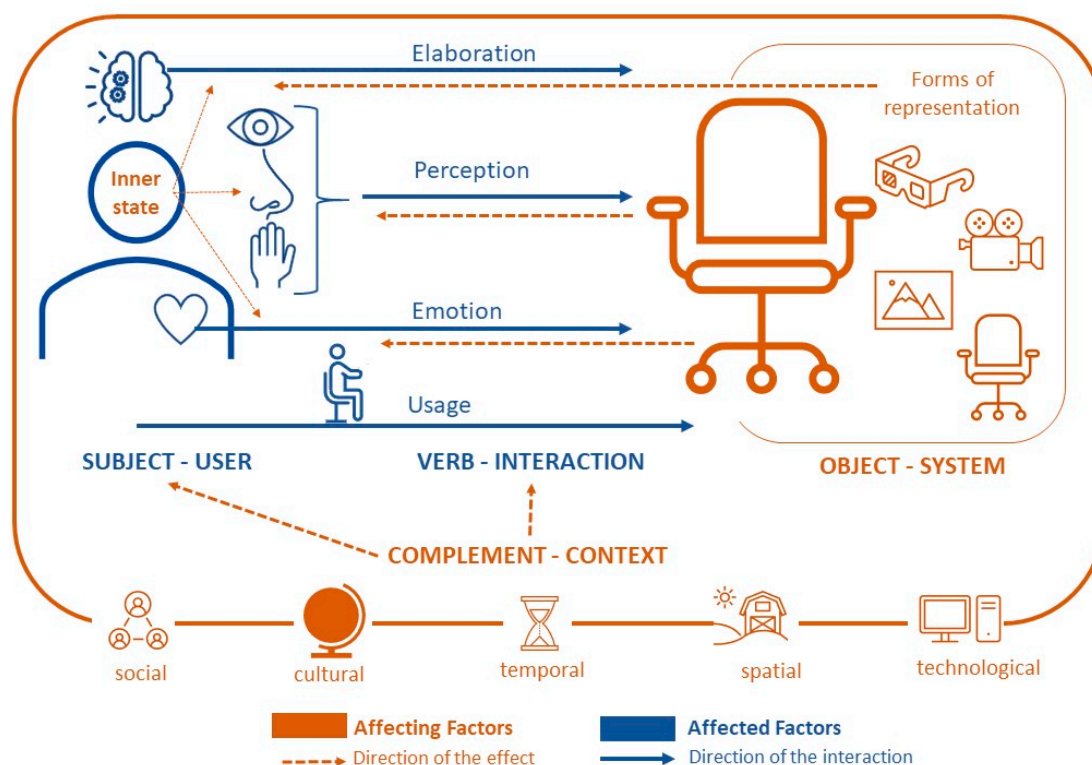


Figure 6. Graphical representation of the relationships between the main elements that characterize UX, shown in the semantic framework. Different colors represent the elements that affect (orange) or that are affected (blue).

Markedly, in Figure 6, the affect-effect relationships have been represented through different colors (blue indicates the affected factors, orange is for the affecting elements). The orange dashed arrows indicate the direction of the effect, while the continuous blue ones show the direction of the interaction. For instance, the presence of the continuous blue line connecting the verb-interaction and the object-system is based on the description reported in Section 3.3 with regards to the impact of the appearance of the system on the user interaction [61]. In particular, the dotted orange line under the “perception” continuous blue line highlights the ability of the system to trigger the user’s senses through its aesthetics [33]. Likewise, the presence of the continuous blue line connecting the “emotion” verb-interaction and the object-system is based on the description reported in Section 3.3 about how the abstract aspects of the system can be an affecting factor for the user’s emotion [33]. The framework shows that the inner state of the user affects all the different typologies of the verb-interaction (elaboration, perception, emotion, and usage) [56], which are also affected by the appearance [61] and abstract aspects [33] of the product, and the forms through which it is presented to the user (image, video, final product, 3D model, and VR, among the others) [43,63]. Moreover, social, cultural, temporal, spatial and technological factors of the complement-context affect the overall subject-user and the verb-interaction, which results the most affected key component in UX.

4. Dimensions of UX

The proposed grammar of UX is the basis of the overall experience that is triggered by certain combinations of subject-user, predicate-interaction, object-system, and complement-context. Experiences can be positive or negative. Investigating which factors lead to a positive or negative experience is important for designers during the design process to revise the concept and plan effective iterations. Both positive and negative experiences have been studied in literature, however scholars do not always agree on which of these two aspects is the most useful to improve the designed products.

For example, Kim and Christiaans [64] and Kim [65] developed a framework focusing on an empirical cross-cultural study aimed at understanding which users' characteristics in relation to certain products can lead to users' negative experiences. This work is helpful in foreseeing unwanted negative experiences and avoiding them. According to Yoon et al. [46], it is better to seek the elements that arouse a positive experience, rather than just mitigating or avoiding unwanted ones. This view is strengthened by Hassenzähl [59], who claims that eliminating suffering and frustrations caused by undesired features can improve a product but it does not ensure a positive experience.

Three dimensions of experience can be identified besides the general subdivision between "positive" and "negative". Ergonomic, cognitive, and affective dimensions are here defined as fundamental qualities which characterize the overall experience. Such dimensions will be described in the following sections.

4.1. Ergonomic Experience

The term "ergonomic experience" was chosen to include all those characteristics of the system that are not ascribable to the field of perception and emotion. For instance, aspects such as "safety" or "comfort" are assessed by the user exploring the functioning of the system. These concepts go beyond the perception of senses and feelings; they are a consequence of the system usage, where the users' behavior plays a key role in the assessment. All of these aspects are considered by [66], who claims that ergonomics aim to improve comfort, safety, efficiency and satisfaction occurring during the human-product interaction. These elements help designers to understand how to improve a system to better fit the users' needs.

Therefore, we can define an experience as an "ergonomic experience" when the user performs the function of the system, exploiting its expected functionality. Aspects such as usability and functionality [27,34], effectiveness and efficiency [27–29], user needs and affordances [58], are ascribable to this category.

4.2. Cognitive Experience

In general, systems transmit signals that are perceived by the users through the physiological senses. Among the senses, vision is of primary importance for the perception of the form of the system [61]. The product appearance is the key aspect for cognition since the visualization of the structure represents the first contact in the user-product interaction, which leads to subsequent expectations in terms of product behaviors and functions [67]. Siu et al. Great relevance to users' visualization capabilities was given in [68]. After users perceived the appearance and aesthetics of a system, they then perceive it through touch, smell, and hearing.

Therefore, it is reasonable to define the "cognitive experience" as the way users perceive and get to "know" the system. The key factors that define an experience as "cognitive" are the perception, [2,27,28,41] and the exteriority and aesthetics of the system [21,29,33].

4.3. Affective Experience

The visual appreciation of the aesthetics of a system is influenced by the extent to which it makes sense to the user, and it cannot be reduced merely to cognitive perception. Crilly et al. [61] claim that the personality perceived in a system influences the users' perception and thus affects their understanding of the system and their related judgements.

Authors refer to "affective experience" to describe how the users feel while they use and perceive a system, with special focus on their inner state and their "engagement" (feelings, empathy, hedonic, pleasure, aspirations, hedonistic values, social values, affection, and appreciation). Affective experience includes all of the affective responses [2,25,27,28,33] and hedonic aspects, such as pleasantness of use and possession, enrichment and personal growth [21], and expression of personal values [26].

Investigating users' affective responses is useful for designers to understand if users go through a positive or negative experience. In this respect, Yoon et al. [69] developed the

Emotion Prism, a design tool that communicates 25 pleasurable human-product interactions. Detecting what users feel during the interaction with a product can yield important insights into its features. It becomes easier to understand which features or functions of the system lead to a positive or a negative affective state influencing the overall experience. Chitturi [70] claims that negative or positive emotions are strongly bounded with users' expectations. When a system fails to meet users' expectations, they experience negative emotions.

4.4. Complete Overview

In the previous sections, the authors analyzed ergonomic, cognitive, and affective qualities of UX providing a detailed description of the three different possible experiences that can be elicited by a user-system interaction. As Figure 6 demonstrates, there are various ways in which the user may interact with a system depending on which aspect is involved during the interaction itself (senses, emotions, or functionality). The authors clarified which user-system interactions lead to specific experiences in Figure 7.

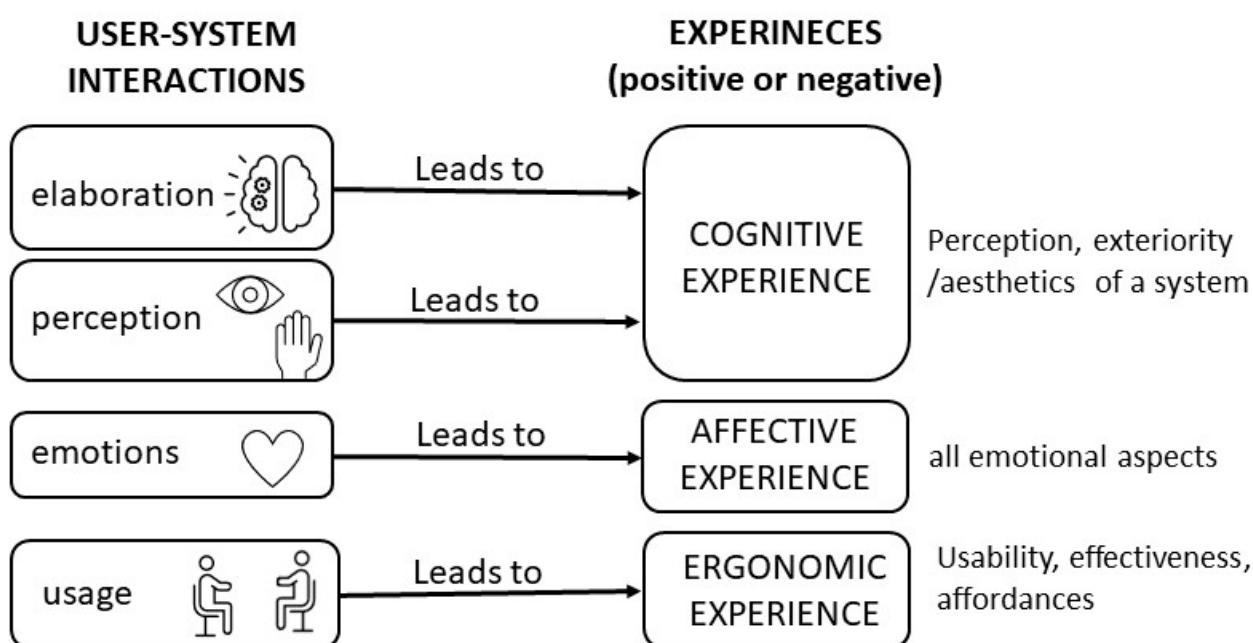


Figure 7. Representation of different experiences caused by different typologies of user-system interaction.

Sensorial interaction and consequent mental elaboration lead to a cognitive experience, since it is related to the perception of the exteriority and aesthetics of a system. The emotional interaction related to the affective sphere of the user-system relationship leads to the affective experience. The ergonomic experience, related to the sphere of usability and affordances, takes place when the user uses the system, which consequently performs its (expected) function. The scheme in Figure 7 aims at clarifying user-system interactions and the dimensions characterizing UX without considering effects of affective factors.

5. A Proposal for a Holistic View on User Experience

Eventually, by joining previous frameworks, Figure 8 provides a complete picture of the relationships occurring between the key components and UX dimensions. In particular, the “affecting factors” in the orange box on the left-hand side have been synthesized considering the dotted orange arrows representing the affecting-relations in Figure 6. The “user-system interaction” box and the “experiences” box include the same elements represented in Figure 7 (Section 4.4). The big boxes have been chosen to better divide the three different parts (affecting factors, interactions, and experiences) in order to highlight

their relationships, represented by the arrows (both the dotted orange and the continues black ones).

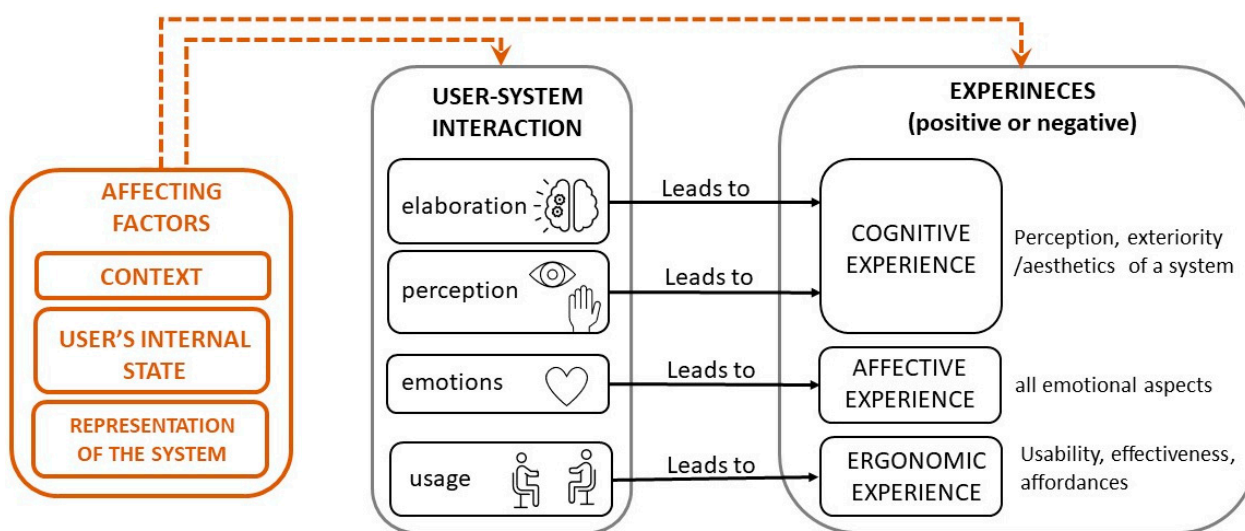


Figure 8. Representation of user-system interactions, the derived different experiences (cognitive, affective, and ergonomic) and the influence factors that affect the overall UX.

In this proposed holistic view of UX, the authors summarized the main elements as affecting factors (the system representation, and a user's internal state and context), which affect both the typologies of interaction (elaboration, sensorial perception, emotional, and usage) and the different experiences aroused by those interactions. The framework in Figure 6 revealed that the interaction is the most affected component, as it is impacted by the context, the user's internal state, and the system. Cognitive, affective, and ergonomic experiences are strongly related to the typology of interaction (see Figure 7). Consequently, they are subjected to the effect of the affecting factors as well.

6. Conclusions

UX is a concept introduced to better define the dynamics of human-product interaction. The literature provided many contributions dealing with UX definitions and interpretations. Despite the recognized importance of UX, this concept is still poorly adopted in design, although design represents the domain in which UX is cited. The reason supposedly lies in the complexity of UX and the large amount of research leading to fragmentary knowledge. UX interpretations provided by literature contributions are not strongly contrasted; however, the authors identified a series of issues that justify the need of a comprehensive view on UX.

UX limitations are highlighted by several scholars. However, the corresponding contributions are dated or incapable of addressing the limitation towards a concrete direction, as pointed out in Section 2. The need for a holistic and comprehensive analysis of UX is particularly stressed by Hussain et al. [17], who identified a set of dimensions related to digital and interactive system design. However, these dimensions alone are not sufficient to provide a complete picture of UX since the fundamental elements of UX, influence factors and their impact on the interaction outputs, are not provided.

Given these deficiencies, the authors analyzed the literature to unify and organize UX interpretations uncovering the elements that compose UX. Conceptual contributions were considered in this work. Papers which provided UX concept-providing definitions and/or theoretical frameworks were particularly targeted.

Such an investigation gave insights into how the UX concept is largely understood in the literature. Recurring elements have been identified and their relationships have been investigated as well. The result of this work has been the identification of focus

and influence factors (key components) which define UX, as well as UX dimensions (experiences) which characterize UX.

The authors built a semantic framework inspired by the grammatical structure of a sentence to highlight the relationship between these components. Therefore, UX is defined by a subject/user who performs a verb-interaction towards an object-system. A complement-context better defines the condition(s) where the verb-interaction takes place (see Figure 6).

The output of the human-product interaction coincides with the dimensions that characterize UX. Besides the generic positive and negative experiences, the authors identified ergonomic, cognitive, and affective nuances of experiences. The former is elicited when the user performs the function, cognitive experiences refer to the way users know and perceive a system, while the affective experience is related to the emotional aspects and the feelings aroused during the interaction.

To summarize, the paper's outcomes can provide several benefits. First, mapping and organizing the knowledge on UX clarified the tangled relationships and intertwined constructs involved. The authors paved the way for a better understanding of approaches and methods employed in UX studies.

Second, a research direction towards the application of UX studies in the design practice is offered. Researchers and practitioners can benefit from an organized structure including constituting elements and dimensions of UX, so that they can consciously manipulate them during experiments. In other terms, the now elucidated elements composing UX can be leveraged and controlled in design research.

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