Approaches of the User-System-Environment Triptych Classifying the Definitions and Models of Context in User Experience Research

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Abstract. This paper provides a framework for understanding the various interpretations of the term "context" within User Experience (UX) and Human-Computer Interaction (HCI) research. Numerous studies examine how context influences interactions and user evaluations, often proposing different definitions or models. The reasons behind these variations are not always clear. Typically, differences are highlighted by comparing the division of context into subcategories, but there is little classification of these definitions. Discussions around subcategories do not necessarily address the varying relationship between the Environment, the User and the System. Additionally, questions about including or excluding disputed subcategories (e.g., internal context) and the confusion between "context" and "environment" remain. We propose classifying definitions by the scope attributed to the term "context", ranging from the complete inclusion of both user and system characteristics to their entire exclusion. We identify four distinct approaches to defining context. We discuss a few definitions for each approach. By delineating these approaches, we aim to clarify the term "context" and explain the differences behind the variation of its meanings for UX and HCI research.

Keywords: UX · Usability · HCI · Definitions · Context

1 Context in UX

The third era in the history of computing, ubiquitous computing [59], has brought about a myriad of new usages. The omnipresence of smartphones, laptops, and other "wearable" devices has enabled usage anywhere, whereas previously, a computer could only be found in two places: at the workstation or in a specific room of the house (e.g., in the living room, office, bedroom). This

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new form of nomadic interaction results in a greater diversity of usages and, therefore, contexts of use. Consequently, a larger number of variables exist that can influence human-technology interaction, warranting further study.

The study of the effect of certain situations on consumer decision-making seems to trace back to Belk [9] (in his case, it concerned consumer choice regarding food products). In this publication, the author asserts that "[...] explicit recognition of situational variables can substantially enhance the ability to explain and understand consumer behavioral acts". These insights were later adopted into the field of ergonomics. For instance, the ISO 9241 standard [24] references the influence of context through the environment in the following definition: "Usability is the extent to which a product can be used effectively and satisfactorily by specific users to achieve specific goals *in specific environments*[1]".

The inseparability of UX from context is a view shared by specialists in the UX field, as evidenced by a survey of UX professionals conducted in 2008 [35], in which the authors note a certain consensus: "the respondents understand UX as dynamic, context-dependent, and subjective, stemming from a broad range of potential benefits users may derive from a product". A replication of this survey in 2012 by Lallemand, Gronier, and Koenig [33] shows that surveyed UX specialists largely agreed with the statement that "UX occurs in and is dependent on the context in which the artifact is experienced".

For Maguire [36], another reason to consider the context in human-computer interaction studies is the low predictive capacity of laboratory experiments. These limitations could be mitigated by taking context into account, and more specifically, by experimenting in real-world conditions [38,45].

From a more conceptual standpoint, Lallemand and Koenig [34] mention that UX is inherently contextual as it emerges from fields emphasizing the essential role of context, such as situated action[2] and user-centered design[3], the latter requiring "to understand and specify the context of use" (the authors respectively cite Suchman [57] and the ISO 9241 standard from 2010 [26]). The consideration of context in UX has been an incremental process in the broader history of the human-computer interaction field. Shortly after the emergence and dissemination of the concept of User Experience, the importance of the context of use is recognized as a variable to be taken into account in product design [24]. However, Karat and Karat [30] stated that "We may know that context is important, but we still do not know exactly what to do about it". At that time, these authors contended that taking context into account rarely lead to methodological applications or concrete technological solutions. They also emphasized that contextual analyses often remained superficial or too general, thus reduc-

[1] Emphasis added.

[2] A psychological approach asserting that human behavior is conditioned by the material and social resources of a situation, making it non-generalizable. Each action is considered emergent, contingent, and improvised.

[3] A design approach in which end-users are at the heart of the development process. The goal is to minimize user behavior change by adapting the product around their capabilities, needs, and desires. This type of approach is often structured iteratively around user feedback.

ing their utility in guiding designers' decisions. Around the same time, Dey [15] noted that "many believe they understand the notion of context but are rarely able to verbally express its meaning or clearly distinguish context from non-context". And indeed, some ambiguities on the subject persist. There is no indication that the understanding of the concept has radically improved and the ambiguities faded, despite significant progress in the context-awareness field, leading to major changes in human-computer interaction since the beginning of the century [43].

We suggest that the challenge confronted by many in the definition of context leads to the present multiplicity of definitions. This multiplicity has often been addressed by proposing new definitions, either by trying to delineate more clearly the concept of context, or by proposing broader definitions. However, and as we will see later, we suggest that the differences between approaches emerge from different *raison d'être*, i.e., diverging needs and objectives. Therefore, to resolve the problem of definition multiplicity, these differences must be explicitly discussed. By illuminating the causes of these differences, we hope to guide the semantic choices of future works in UX and HCI more broadly.

We begin by discussing previous work addressing the different definitions of context. We then present our own classification into four approaches of conceptualizing context. Subsequently, we illustrate our proposition by discussing multiple definitions belonging to each of the approach we define. Finally, we attempt to explain the differences between approaches by synthesizing their causes and implications.

2 Related Work

To address the lack of clarity surrounding the term of context, proposals can take the form of (i) definitions, (ii) models, (iii) analysis of definitions and models.

Definitions (i) seek to conceptually delineate the term "context" with general terms. While examples of what is included are often provided, their enumeration is generally not exhaustive.

Models (ii) are another way to define context, aiming to compensate for the brevity and lack of clarity of simple definitions. They aim to represent context in a simplified form by presenting its categories and subcategories [20]. Sometimes, authors try to *model* existing *definitions* (e.g., Zainol and Nakata [62] models Dey, Abowd and Salber [5]), or to refine preexisting models (e.g., Truillet [58] refines Schmidt, Beigl and Gellersen [51] through the detailing of categories).

Some authors propose *analyzing* (iii) the numerous *conceptualizations* (i.e., definitions and models; this is how we will refer to them henceforth) of context that coexist in the field of HCI to understand and identify the differences between them. It can serve to characterize conceptualizations (e.g., [29]) as well as to introduce new models (e.g., [7,12]). Conceptualizations can range from "any type of information" to only a few categories, and these categories can be few and at a high level of abstraction, or enumerate a large number of concrete contextual elements as subcategories. Bazire and Brézillon [8] posit that this

substantial variability in definitions of context arise from their dependence on the scientific discipline and research objectives they are connected with. In this regard, the ISO 13407 standard [25] did already suggest that "The relevant aspects of the context and the level of detail required will depend on the scope of the issues being addressed". However, Bazire and Brézillon argue that an objective ("decontextualized") definition is possible.

In this matter, Bradley and Dunlop [12] propose a classification of definitions of context, segmented into three *types*, based on what the authors call "their primary focus": (i) the application, (ii) the user, or (iii) any other entity of interest. The first type defines context based on what surrounds the system with which the user interacts. The second approaches it from the user's perspective, questioning their characteristics and the information they hold about their environment. The third is characterized by the inclusion of any entity of interest that allows describing the situation; however, the "interesting" nature of the entities to include in the context varies between definitions.

Bauer and Novotny [7] propose a ranking based on the level of detail of context models. To this end, they calculate a detail index based on the number of categories included in the context and the number of levels they encompass (what the authors call respectively *breadth* and *depth* of models). The authors list different context models to extract common categories, with the aim of proposing a comprehensive synoptic model.

Without proposing a formal classification, some authors highlight the differences between certain conceptualizations of context. Jumisko-Pyykkö and Vainio [28] identify, for example, a shift in the conception of context in HCI research from a set of objective, physical, and external factors to a viewpoint considering it as relational, dynamic, and action-dependent. This distinction between these two different context approaches is similar to that presented a few years earlier by Dourish [16]. Chalmers [13] summarizes it as follows: "The key distinction or dichotomy he [Dourish] puts forward is between physical or positivist notions of context, which center on objective representation of social and interactional phenomena, and social or phenomenological notions of context, which center on a view of context as a subjective and situated aspect of people's interaction". For their part, Lallemand and Koenig [34] differentiate between approaches that include the user's internal context and those that simply distinguish the user from other contextual variables. Barnard et al. [6] distinguish user-centered definitions from those that are more technology-centered. Furthermore, Novotny and Bauer [39] identify several axes along which definitions vary: some researchers adopt a "process" approach to context, considering it as an open and dynamically constructed concept, while others adopt an approach that considers context can always be specified and represented in clearly defined categories; some take the system's perspective to define context, while others take the user's perspective; some models are highly specific to a certain system or domain, while others are abstract and generic; some models include a significant number of categories and subcategories, while others contain only a few.

In light of the previously cited works, we make two observations. On the one hand, the concrete advent of ubiquitous computing-and the associated new conceptualizations-postdates the classification proposed by Bradley and Dunlop [12], thereby rendering it somewhat obsolete. On the other hand, the proposal by Bauer and Novotny [7] (as well as the discussions of the concept of context [13,16,28,34,39] mentioned earlier) does not clarify the reasons for the differences between approaches, nor the nuances between the terms "context", "environment", "situation", or the concepts they integrate.

3 Different Approaches to Context

Our description of each of the four context approaches in centered around the structuring of the relationship between the elements of the "User-System-Context" triptych. The elements of this triptych are sometimes referred to as "influencing factors" [37,44], "pillars" [34], "UX factors" [46], or "dimensions of UX" [11]. UX is considered to be the product of this triptych [21]. However, Roto et al. [46] mention that the individual description of these three elements is insufficient to describe UX. This analysis is also shared in the field of Quality of Experience [44].

We identify four context approaches based on how each addresses the elements of this triptych: *maximalist*, *selective*, *system-centered*, and *minimalist*. What distinguishes them is essentially the broader or narrower meaning attributed to the concept of context. We will present them from the most encompassing to the most restrictive. These different context approaches and their relationship with the elements of the triptych are summarized in Fig. 1. Note that we will henceforth refer to the aforementioned triptych as User-System-Environment rather than User-System-Context. We consider this permutation necessary to disambiguate the terms "context" and "environment", as the former has often a broader meaning than the latter.

The maximalist approach includes everything that allows describing the interaction in the context (see Sect. 3.1). The most restrictive definitions, described by the *minimalist approach*, are characterized by the exclusive consideration of "everything that is not the user or the studied system" (see Sect. 3.4). Between these two poles exist two approaches. The first, the *selective approach* which considers as contextual any variable that could significantly affect UX (see Sect. 3.2). The second, the *system-centered approach*, positions itself within the system's framework and defines as context anything to which it could adjust (see Sect. 3.3).

3.1 Maximalist Approach

According to Dictionnary.com[4], context is the "the set of circumstances or facts that surround a particular event, situation, etc.". Thus, an experience of something inevitably takes place in specific coordinates of space-time and must therefore be considered as imbued with a particular context. An experience is also a

[4] https://www.dictionary.com/browse/context last accessed on 2024/12/04.

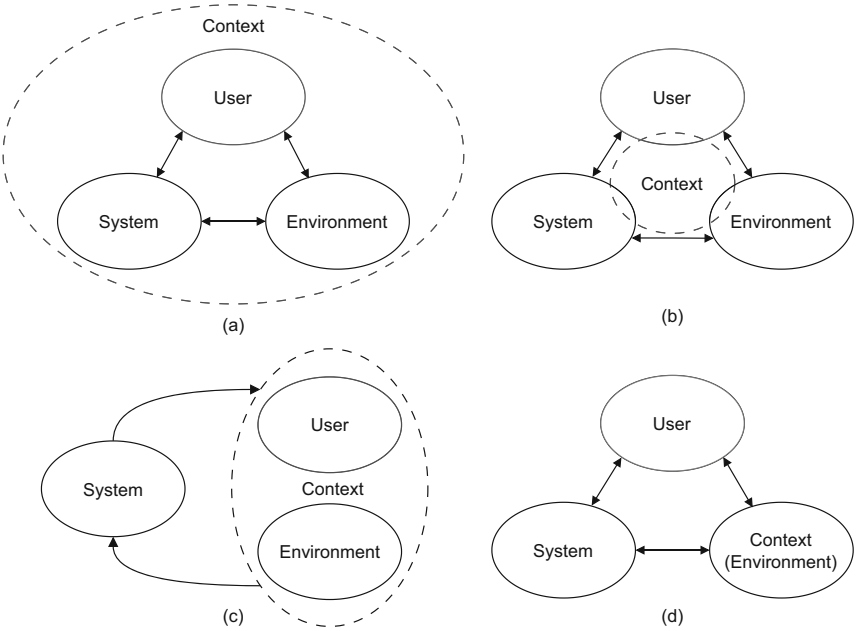

Fig. 1. Representation of the structure of the relationship that unites the elements of the User-System-Environment triptych underlying the different approaches to the definition of context. (a) Represents the maximalist approach to context; (b) the selective approach to context; (c) the system-centered approach; (d) the minimalist approach to context.

psychological phenomenon that occurs in the mind of an individual, becoming tinged by their state of mind. Furthermore, while consistency and predictability are sought-after qualities in design, certain unforeseen phenomena can render a human-computer interaction unique (e.g., bugs).

In the field of human-computer interaction, Funk and Miller [17] argue that it is "everything surrounding an item of interest, including the 'mindset' of any humans involved in the context". Pascoe [41] states also: "context could be generally described as the subset of physical and conceptual states of interest to a particular entity". Equally general, Abowd et al. [1] (Dey reuses the same in another publication [15]) propose a broad definition of context: "Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves". Here, the term "situation" is employed to refer to something that "context" describes. Still, Dey, Abowd and Salber [5] seem to differentiate these two notions from the term "environment": "By context, we refer to any information that characterizes a situation related to the interaction between humans, applications, and

the surrounding *environment*[5]". The authors imply something further down in the abstraction hierarchy with it, as a concept comprised among others in the situation. However, the confusion between environment, situation and context is frequent, as has been noted by Wobbrock [61]. This amalgamation is sometimes deliberately made, as in Akpinar [3].

Bradley and Dunlop [12] criticizes the broadness of some definitions (i.e., [1, 17,50]): "*They imply that context is anything that is relevant (or matters) to an entity or interaction of entities. Because it is not explicitly described how relevant dimensions of context can be identified and quantified, it would be very difficult to transfer or operationalize these definitions [...]. It would also be uneconomical and tedious to identify from scratch which entities are germane to more than one situation*".

Despite the presumed difficulty noted by Bradley and Dunlop [12] in deploying such an approach, Bevan and Macleod [10] have sought to operationalize a maximalist model by illustrating with an example of breaking down what corresponds to each of the categories of their context of use model: (i) users, (ii) tasks, (iii) equipment (i.e., system/service/product), and (iv) environment. The authors adopt a description of seemingly exhaustive ambition for each of these categories. They include in users both durable personal characteristics (e.g., gender, intellectual abilities) and more transient ones (e.g., motivation, knowledge of the system); enumerate various levels of detail for the task (e.g., physical and mental demands, task frequency) as well as for the for the equipment. As for the environment, they mention specific elements (e.g., atmospheric conditions, health hazards) as well as much broader and more general ones (e.g., managerial structure, working hours[6]). User and system characteristics are fully integrated to the context.

Barnard et al. [6] (interpreting Sears et al. [52]) propose a contextual model composed of three categories: (i) the environment, (ii) applications, and (iii) the human. These three categories describe elements similar to what is traditionally included in each of the elements of the User-System-Environment triptych. By identifying explicitly categories included in the context, this model is close to what we present in Fig. 1 (a).

In a work aimed at synthesizing context models from several fields of study, Bauer and Novotny [7] introduce their own (titled *Graphical Representation of Consolidated Results on Context*). The authors propose to distinguish between domain-specific (i.e., that allow for the description of situations in specific fields of application, such as the hospital, sports, automotive, etc.) and generic context elements. The generic context is composed of social context, technological context, and physical context. These components are also close to what each of the elements of the User-System-Environment triptych means. This model appears broad and exhaustive, mentioning, for example, the demographic and socio-economic aspects of the user, the atmospheric of the environment, as well as the privacy properties of the system. The model presented by Sigg, Haseloff and

[5] Emphasis added.
[6] The example seems to focus on usability in a professional setting.

David [53] is quite similar in its exhaustiveness and thus in the variables encompassed, but differs in that its refers to more first level components: Identity (i.e., durable user characteristics), Constitution (i.e., transient user characteristics), Location, Time, Activity (elsewhere referred to as task) and Environment.

3.2 Selective Approach

The present approach differs from the previous one by a merely partial inclusion of characteristics related to each of the three elements of the triptych. The demarcation between characteristics of the user, the environment, and the system that are integrated into the context and those that are not constitutes the primary issue in the discussion of conceptualizations of the selective approach.

For Belk [9], the separation between situational determinants (what we call context) and non-situational ones is the transient versus durable aspect of a characteristic. Therefore, Belk argue that a transient characteristic of the user (or *person* for the author), such as mood or having headache, would be part of the context, while a durable characteristic (e.g., personality, intellect, sex, and race) would not be. Belk extends also this reasoning to the system (or *object* for the author), separating what a general feature of its brand from something specific to a time and place (his field being consumer behavior, he takes the example of a special sale; in UX, it could be the event or temporary feature of a service, like a holiday special theme of a software's interface, common in video games). Quite similarly, for Spool [56], context consists of "[...] attributes *specific*[7] to the current context-attributes independent of the specific user and tool". "Attributes" are what we refer to as "characteristics" in the present work, and "tool" is analogous to what is generally referred to as "service," "product," or "system". This definition implies, for example, the exclusion of the idiosyncratic characteristics of the user from the context.

The partial inclusion of user characteristics in the context is made through the "Internal Context" component for Lallemand and Koenig [34]. The authors refer with this concept to all situational or dynamic properties of the user defined by Bauer and Novotny [7]: "their mood, motivation and interest in the system, as well as previous expectations and opinions about the system.", as opposed to stable properties (e.g., demographics). Kim et al. [31] also use the concept of "Internal Context" to refer to the aforementioned transient user characteristics. In addition, they include another element in the "Personal" Context, the category they use to refer to user characteristics. What they call "External Context" refers to the transient state of the physical body of the user (e.g., performing a motor task, being in movement). In a different manner, Bradley and Dunlop [12] define *user context* as the factors that affect the emotional state of the user (goals, tasks, intentions, history, preferences), thus making a claim on its consequences rather than on its nature.

[7] Emphasis added.

Regarding the environment, Lallemand and Koenig [34] choose not to include overly broad contextual variables (such as culture[8]) and suggest focusing on those that have a direct impact on UX. They justify this approach by selecting contextual variables whose effect seems to have been documented or studied. They add to follow the "best practices on summated rating scale construction" proposed by Spector [55]. The criterion for including a variable in the context is what significantly affects UX, and thus relies on an empirical criteria. However, certain cultural differences-a very "broad" aspect of context-could lead to significant differences in judgment (at least aesthetic) regarding a product. For example, de Souza and Bernardes [54] note that most studies examining the impact of culture and cultural differences on UX conclude that such an effect exists. Far from constituting a flaw, the decision not to take into account all contextual variables that may have an effect on UX is a practical choice. The authors aim to estimate the effect of *certain* contextual factors: the transient characteristics of the user, the technical inconsistencies of the system, and what could be called the direct (in the sense of immediate) environment (see Fig. 2). This undoubtedly rests on the need to operationalize their approach to context. Indeed, since Lallemand and Koenig are constructing a questionnaire, it is easy to think that they did not want it to be too burdensome to implement, hence their lack of exhaustiveness. In the present approach, context can be understood as what directly and significantly influences the collected UX at large (e.g., perceptions or reactions). The precise variables of interest affected by the context vary. Kim et al. [31] declare to be primarily interested in user behavior. In the case of Lallemand and Koenig [34], it is primarily about judgment, since the analysis is based on the influence of context on the AttrakDiff, a questionnaire allowing users to evaluate their perception of pragmatic and hedonic qualities of a system. Therefore, the characteristics of the system mentioned in their model are those to which that can appear to the perspective of the users, namely, technical inconsistencies. The inclusion of elements into the context follows the same logic in the ISO 13407 standard [25], i.e., a concern about the effect of such elements on a variable of interest. Indeed, at least twice in the standard, there is a particular emphasis on the effect of the described aspects of context on usability: "The description of the context needs to be sufficiently detailed so that those aspects of the context which may have a significant influence on usability could be reproduced"; or further, "Annex A gives examples of how the components of the context of use can be described in terms of characteristics which may be relevant to usability".

In their effort to formalize context, Alonso-Rios et al. [4] do not explicitly include characteristics related to the system. The authors identify three "attributes" of the context of use: the characteristics of the user, the environment, and the task. However, what they include in the attributes of the task is identified elsewhere as dependent on the system (e.g., "workflow controllability" could be included in the in the *the computing context* category of Bradley and

[8] This is a variable sometimes attributed to the user [4,11,37], and other times to the environment [28,36,60].

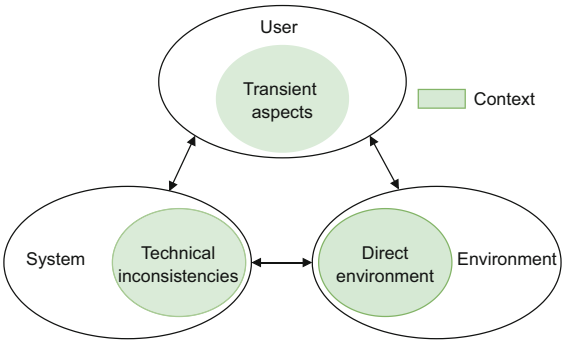

Fig. 2. Representation of our interpretation of Lallemand and Koenig's [34] conceptualization.

Dunlop's model [12]), or even on the user (e.g., "complexity," or "difficulty of task execution," which refers for other authors to the user's capabilities) or to components of the environment ("safety," attributable to the environment in which the task or interaction takes place). It should be noted on this last point that, for example, Jumisko-Pyykkö and Vainio [28] and Lallemand and Koenig [34] place task-related context on the same level as, among others, physical context or social context, i.e., characteristics of the environment.

3.3 System-Centered Approach

According to Bauer and Novotny [7], the complexity of context requires its formalization to enable the design of system that can adapt to it, i.e., *context-aware* (or intelligent) systems. Dey [15] defines this type of systems as follows: "A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task". Bauer and Novotny [7] later add: "In pervasive, context-aware, and mobile computing, context is an essential source of information for intelligent systems: context influences the system's behavior".

The approach we describe in this section positions itself from the perspective of a "context-aware" system: everything that is to be considered (in the situation) to adjust its own "behavior" can be regarded as "context". We thus qualify this type of approach as *system-centered*, as did Barnard et al. [6]. Chen and Kotz [14] implicitly expressed a similar view a few years earlier, claiming: "*Context is the set of environmental states and settings that either determines an application's behavior or in which an application event occurs and is interesting to the user*".

What is included in the context regularly takes the form of at least two categories, one corresponding to environment characteristics and the other to user characteristics. This distinction often takes the form external and internal context [18,19,40,42]. The external dimension of context pertains to what can be measured by sensors such as light, location, proximity to other objects, temperature, time, etc. The internal dimension of context integrates, for example, the

goals, tasks, emotions, and physical states of the user. In a similar logic, Hofer et al. [23] differentiate between physical and logical (or abstract) aspects of the environment. The former are those that can be directly perceived by the system (e.g., GPS coordinates), while the latter constitute the semantic aspects of context that must be inferred (e.g., street name). Schmidt's model [51] distinguishes two facets of context: "context related to human factors in the widest sense, and context related to the physical environment". They include in human factors variables related to the user, social environment, and task; and in the physical environment, conditions (light, noise, etc.), infrastructure, and location. We claim that the main feature of these conceptualizations (as represented on Fig. 3) is that it tends to be composed on the one hand, of environment characteristics and, on the other hand, of user characteristics.

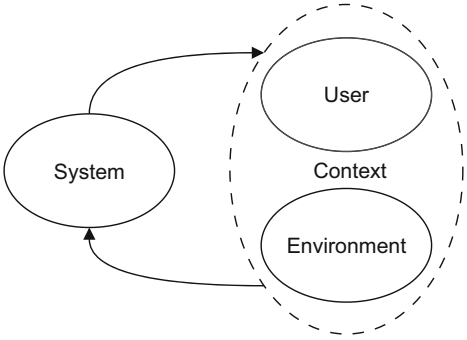

Fig. 3. System-Centered Approach.

In one of the first publications discussing the notion of context awareness by a system, Schilit and Theimer [49] do not precisely describe what context means or its composition: "In general, location information enables software to adapt according to its location of use, the collection of nearby people and objects, as well as the changes to those objects over time. We use the term context-aware computing to describe software exhibiting these general capabilities". However, in another publication [48], the authors, including Schilit, recall these three important aspects of context in the form of three questions: where, with whom, and with what resources.

Chen and Kotz [14] propose to add a *Time context* category to what they describe to be the division of context into three categories by Schilit et al. [48]: the computing context (network connectivity, communication costs, bandwidth, surrounding resources such as printers, screens, or workstations), user context (user profile, location, surrounding people, current social situation), and physical context (lighting, noise level, traffic, temperature).

Abowd and Mynatt [2] propose to define context as the answer to the five "Wh-" questions: "*Who*", "*What*", "*Where*", "*When*", "*Why*", allowing respectively to describe the user, their tasks/goals, environment, time, and finally their

motivations. Hess and Campbell [22] also adopt a particular line of reasoning, which involves enumerating the categories of information allowing a system to "know" its environment: "*location, identity, activity, space, time, device*".

In their analysis of different definitions of context, Bazire and Brézillon [8] offer a synthesis that also expresses the dichotomy between context and system: "The context acts like a set of constraints that influence the behavior of a system (a user or a computer) embedded in a given task". However, the authors seek to construct a universal definition of context, applicable outside the framework of interaction with a digital service. This description of context is close to what we describe in the present approach, although the terms in parentheses suggest that it could be declined in a more general version within the framework of psychology[9], differentiating it from a strictly system-centered definition.

Some conceptualization we consider fitting in the present approach integrate contextual variables absent in other approaches. This notably includes information relevant-and available-to a system but not directly to the user and their experience, such as GPS position, speed of movement, or pulse (Jameson [27]; Krogstie [32]).

3.4 Minimalist Approach

Jumisko-Pyykkö and Vainio [28], guided by the desire to reduce a form of overload weighing on the term context, propose a separation of the system and the user from other components considered to be part of context. This minimalist approach of context thus relies on a more explicit partitioning between context, system characteristics, and user properties (see Fig. 4).

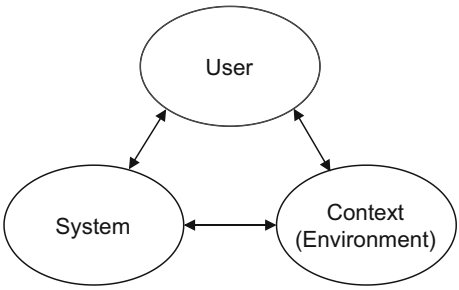

Fig. 4. Minimalist Approach to Context.

In their definition of UX, Hassenzahl and Tractinsky [21] convey, in regards to the categories we have defined, a strictly minimalist approach. They acknowledge that UX is influenced by each of the three elements of the triptych that characterize interaction, but do not qualify all three elements as "context"-unlike

[9] That is, by considering the user as a system influenced by constraints.

the approaches seen previously. Moreover, they express explicitly a synonymy between context and environment.

Roto [47] takes up this model and adds that besides a reciprocal interaction between the system and the user in a context, the context is likely to affect both the user and the system. This is not a detail, as Hassenzahl and Tractinsky's definition implies a model without mutual interaction between the three triptych elements (see Fig. 5). In contrast, Roto mentions these reciprocal influences, notably highlighting the potential influence of context on the user (e.g., the effect of the weather on the users' mood) as well as on the system (notably in cases in which the system's behavior adjusts based on external variables), and thus on the interaction between the user and the system. Although the author does not mention the influence of the system or the user on the context, we still illustrate this influence between the elements in our graphical representation of this approach (see Fig. 4).

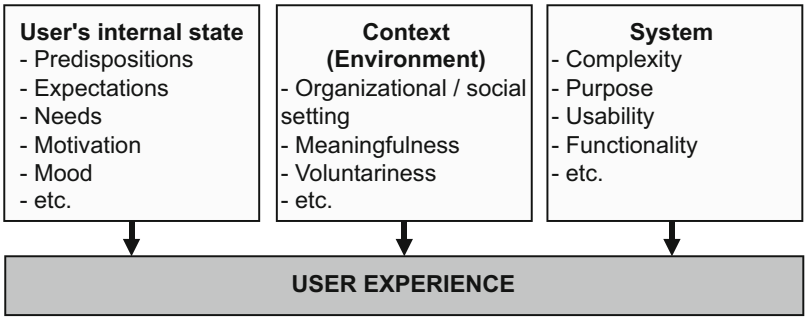

Fig. 5. UX Model Representation of Hassenzahl and Tractinsky [21] by Roto [47] (reproduction).

The characterization of context by Jumisko-Pyykkö and Vainio [28] is based on the two previous approaches presented in this section. Their "CoU-MHCI" (*Context of Use in Human-Mobile Computer Interaction*) model is even more explicit regarding the separation of the three concepts. The authors define context as what is neither the user nor the system : "*Therefore, we take another approach from the recent context HCI research [...] by focusing on context components that are external and separating these other context components from user and system.*".

For Roto et al. [46], there are three categories of factors that influence UX: what surrounds the user and the system, which is considered as context, the internal state of the user, and the properties of the system. Thus, unlike the selective approach seen previously, the authors consider that any variable related to the user, including transient and interaction-specific characteristics (authors mention "*a person's motivation to use the product, their mood, current mental and physical resources, and expectations*"), does not belong to the context. Unlike

the other approaches seen previously, the environment and context are synonymous, and refers here to "*a mix of social context (e.g. working with other people), physical context (e.g. using a product on a desk vs. in a bus on a bumpy road), task context (the surrounding tasks that also require attention), and technical and information context (e.g. connection to network services, other products)*".

4 Discussion

4.1 On the Context-Environment Ambiguity

Among the proposed approaches, we observe some ambiguity between the terms "context" and "environment," and sometimes even "situation". This can be explained, in our view, by the more indeterminate aspect of the term *context* compared to *environment*. More specifically, the environment refers to something external to both the user and the system. This idea is not conveyed by the term context. In this regard, we conjecture that the popularization of the triptych in the form "User-System-*Context*" and not "User-System-*Environment*" (notably via the ISO 9241 standard [24]) has contributed to the definitional heterogeneity of these terms, hence their ambiguity. The adoption of maximalist, selective, and system-centered interpretations of context thus amounts to considering that context and environment are distinct concepts (see (a), (b), and (c) in Fig. 1). According to our representation of the maximalist and system-centered approaches, "context" is a notion encompassing all parameters that allow characterizing the interaction, making it almost synonymous with "situation". For the selective approach, "context" is a more restricted concept, including at least part of the environment, but not the entirety of what is considered to be the situation for the previously mentioned approaches. For the minimalist approach, since the characteristics of the user and the system are distinct from the context, environment and context are thus synonymous. Some conceptualization from the maximalist and selective approaches differ solely due to this semantic ambiguity. What is called "context" in one could be called "situation" in the other.

4.2 *Raison D'être* of Each Approach

The proposal of a universal and consensual conceptualization of context is not a goal of the present work. Rather, we propose to consolidate the knowledge on the diverse conceptualization of context. So far, we have presented a descriptive dissertation. Yet, we contend that each of the four approaches has a particular *raison d'être*, and thus responds to different objectives, such as research questions or practical issues in the development of a product, system or service.

Conceptualizations adopting a *maximalist approach* recognize the unique nature of each interaction, context is therefore everything that allows the characterization of the situation. As a result, they are general and allow for the inclusion of a large number of variables as well as the specification of the precise conditions of interaction, i.e., the three elements of the User-System-Environment triptych are fully integrated. In the case of designing context-aware systems (a concern

appearing in the conceptualizations we consider belonging both to the maximalist and the system-centered approaches), they allow for the consideration of any variable of interest for system designers or researchers. In the study of an interaction, *any related independent variable that may characterize it* is therefore potentially contextual. Conversely, it bars only those elements unrelated to the interaction from being deemed contextual (e.g., a room distinct from the one in which the interaction takes place and unknown to the user). This could prove useful given experimental procedures for which the context cannot be completely anticipated, such as longitudinal or "in the wild" studies. Some authors seek to operationalize their conceptualization of context, but this is far from systematic. Observations and their generalization are not a cardinal concern among the works we attribute to this approach.

The selective approach questions the influencing factors of UX[10]. It is parallel to the development and democratization of mobile phones, which lead to a great variety of contexts of use. Context then becomes a crucial object of study for the design of systems, as it becomes dynamic, varied, and thus affects the goals, expectations, and needs of the user as well as their capabilities (as suggested by Wobbrock [61] through the *Situation Induced Impairments and Disabilities* or SIID[11]). We observe two pragmatical aspects to this approach which, paradoxically, are in tension with each another. First, it seems to attach importance in recognizing as contextual all situational variables that induce a proven effect on an interaction (or the experience of an interaction). Second, it also seems to be concerned by discerning what is context from what it is not, through the presence of a demarcation criterion (e.g., stable versus transient characteristics). Operationalization as well as observations and their generalization are widespread in works adopting this approach. This is manifested, for example, by the existence of recommendations, methods to control and analyze the effects of context, or questionnaires to quantify them.

The system-centered approach offers designers of *context-aware* systems the opportunity to recognize the signals to which the developed system should respond or adapt [15]. It resembles the maximalist approach due to the significant emphasis to context awareness, integrating elements related to the environment and user characteristics. However, it differs from it through a more particular relationship with these elements external to the system, considering primarily what it must capture, understand, and to which it must adapt. Consequently, the characteristics of the system are distinct from those of the context, since the context encompasses what is external to the system but crucial in the interaction with the user. Categories of contextual elements are also more numerous to formalize the types of variables to which the system must be able to respond.

[10] Or any other variable of interest allowing for an interaction analysis.

[11] Wobbrock [61] specifies that the context in which an interaction between a user and a product takes place can induce SIID. Although his article does not address questions around UX, it highlights factors that could influence it, namely, situational and environmental factors that induce incapacitation or a decrease in the user's ability to interact with a system.

The minimalist approach, on the other hand, responds to a need to clarify the terms used to characterize the study of human interaction with technology in a given setting. The conceptualizations we associate with this approach aim to eliminate the ambiguity that exists elsewhere between the terms "context", "environment", and "situation". To this end, environment and context are synonymous. The influence of variables related to the user or the system is not neglected, but is simply not recognized as part of the context.

5 Conclusion

We have presented a classification of the different approaches in defining and modeling context. Based on our reading of the existing literature, we identified different concerns underpinning the relationships between the elements of the User-System-Environment triptych. We synthesized these concerns, which we referred to as the *raison d'être* of each approach

A few caveats should be noted. First, this work is not the result of a systematic literature review. We have chosen to primarily revisit the conceptualizations cited in the works discussing the notion of context mentioned above (i). Second, we are focusing here on conceptualizations that address context within the framework of human-computer interaction. Other fields of study (e.g., food-related) also address these questions of the influence of context and thus seek to define what they include under this concept. We have chosen not to include them in our analysis (ii). Third, the different approaches we presented are not mutually exclusive (iii).

Consequently, exhaustive (i), cross-disciplinary (ii) works using more systematic criteria of classification (iii) are still needed to consolidate knowledge on the different context approaches. Further research on conceptualization classification (i.e., identifying different approaches based on the lines along which definitions vary) is therefore still necessary to help better guide choices of HCI researchers and practitioners in their semantic choices.

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