# Comparing Two Approaches to Context: Realism and Constructivism

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**ABSTRACT**
During the last few years, there have been debates over what is context and how computers should act upon it. Two disparate camps of thought can be recognized. First, Realism, having its roots in natural sciences, believes that contexts exist out there and that, if properly instrumented and programmed, computers can correctly recognize and adapt to them. Second, Constructivism, having its roots in human and social sciences, believes that contexts are human creations, mental and social, and that computers ought to provide resources for managing them. We reveal some fundamental differences between the two in three different application domains. We show that despite the deep-going controversies, both camps benefit from considering the alternative approach and a middle ground can be found.

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Context, constructivism, realism, context-awareness, social navigation, ethnomethodology, ubiquitous computing.

**ACM Classification Keywords**
H5.2. User Interfaces: Theory and methods.

**INTRODUCTION**
Innovation of use scenarios and applications for context-aware computing has been both inspired and constrained by developments regarding *the concept of context*; that is, what is being conceived of being context [5-7,18-22]. Although Weiser [22] never intended it to be interpreted narrowly as static, immediately observable features of user's surroundings, his followers thought context mainly as location. After roughly five years, the restrictiveness of this view was realized and broader views were proposed (e.g., [5,6,18,20]).

Some called this *the context debate*, a debate still going on. However, context was and is still mainly pursued by computer scientists and regarded as something that must be "recognized" and adapted to. More recently, inspired by human and social sciences, a new approach has emerged that emphasizes the role of people in creating and utilizing contexts with the help of computers.

At this point, then, the field seems to be divided into two camps holding disparate views on what context is and how it should be harnessed. The first, called here *Realism*, believes that contexts exist, ontologically, and that, if properly instrumented and programmed, computers can correctly recognize and adapt to them. The second, called here *Constructivism*, believes that contexts are human creations, mental and social, and that computers ought to provide resources for managing these contexts.

In this paper, our goal is to analyze the two approaches in order to explicate and compare their underlying assumptions, examine practical implications to context-awareness, and discuss possibilities for reconciliation.

**REALISM**
*Realism* holds that there are properties that can be applied to many things, rather than denoting a single specific individual. According to realists, these properties, so called *universals,* really exist. *Naïve* Realism, particularly, believes that objects and universals are as we perceive them, independently of our observation. It is naïve in the sense that scientific descriptions and models (here: of contexts) are taken at face value. Its ontological and epistemological assumptions and knowledge interest have their roots in positivistic philosophies, which provide a basis for natural sciences (e.g. naïve realism of perception).

The following set of beliefs can be recognized:

- *Ontological*. Context is real, it is structured, and the structure can be modeled by a learner. Contexts share properties (or universals) that exist independent of human interpretation
- *Epistemological*. Computers can perceive (i.e., recognize based on sensor data) context universals
- *Pragmatic*. If correctly recognized, computers can adapt their behavior to the requirements of the context.

### Applications

The main promise of applications that adhere to Realism is the delivery of context-sensitive automation.

*Ubiquitous computing* is the key area that has taken on the realistic perspective. According to Tennenhouse [21] there will be thousands of processors per each person in the environment, and these processors will be communicating, trying to build up patterns of recognition of what each one of us is doing and from those predict what we are going to do next. Consider, for example, a pillow that inflates before we realize that we need it, or an agent that appoints meetings to a medical doctor, or a video projector that prevents slides recognized as being "sensitive" from being shown.

In *affective computing*, we find several examples of applications building on the assumption that it is possible to correctly recognize and then adapt to user's emotional state. It is assumed that it will be possible to recognize users' inner emotional states from for example face recognition systems or biosignals. Many application ideas build on results such as Ekman's six basic emotions that can be seen and recognized irrespective of culture, or on findings that biosignal data recognizing heart rate or sweat can be used as stable indications of arousal. For example, Expression Glasses [17] measure the movement of facial muscles and classify the resulting expression into a small, discrete set of emotions. Emotion Mouse [1] extends a normal computer mouse to deduce users' emotional states from physiological information such as pulse and galvanic skin response.

Similarly, in *interruptablity research*, some have proposed a secretary-like agent that estimates your level of interruptability and based on that blocks or permits incoming phone calls (see [9]). A presumption is that people have a mental state of interruptability that is independent of the intentions of the person who is calling you, and of your representations of her, and, more importantly, that can be reliably detected from immediately observable data (e.g., phone call activity, body posture etc.).

### Challenges and Limitations

In general, Realism has a zero tolerance for multiple simultaneous interpretations of context as it tries to attain the "truth". There is no room for epistomological pluralism in this culture of thought. This is a particularly difficult assumption when the to-be-recognized context is mental or social state. A consequent challenge is related to the absence of ways for *repairing* or *renegotiating* the computational suggestions of contexts once they have gone wrong, as Suchman [19] has argued.

Because realism holds that successful interaction consists of communication of information between the computer and the user, interaction is defined simply as information exchange. This is why "context" is presupposed to exist and to surround interaction, rather than seen as an evolving outcome of it. For realists, then, an interlinked challenge is to define the *markers* of context: the start and end conditions for a contextual state and the markers of transition between contexts, which should be recognized *before* the actual interaction happens. Thus, the challenges related to recognizing and repairing interaction are the result of contradictory presuppositions about the nature and relationship between the concepts of context and interaction.

For example, emotions are *not* stable states to be recognized but part of on-going interactions. People's affective interaction consists of much more than what can be understood from simplistic local measurements of their bodily reactions. Significant emotions (beyond elemental experiences such as of surprise, disorientation, or disgust) are to a large extent social phenomena that take place in specific cultural settings, taking on particular expressions colored by the culture and the group of people at a particular place. The meaning and expression of emotions like guilt, shame, are given both by their local social as well as by their cultural context. They are part of a communication process where we are trying to make ourselves understood to others, where their reciprocal reactions will modify our own emotional processes in turn, and where initial bodily reactions are reflected upon consciously, filtered through our attitudes and personality, and thereby continuously modified (see [8]).

## CONSTRUCTIVISM

An alternative to Realism is *Constructivism*. Constructivism recognizes that all our knowledge is "constructed", it does not reflect any external "transcendent" realities, but is contingent on convention, human perception, and social experience. It gives credit to different kinds actors as active constructors of contexts, not just passive reactive agents to environmental aspects and new technologies. In fact, it provides a standpoint from which multiple interpretations and understandings of contexts are legitimized and from which these understandings can be imported into the design process. In addition, it values the member's point of view to the concrete use situations without this being as problematic to the epistemic-ontologic configuration as it is for the realists. It also frees the researches from "one truth" to do critical, reflective evaluations of research/design processes in terms of power relations, etc. (cf. [10]).

The following set of beliefs can be recognized:

- *Ontological*. Contexts are constructed socially, in interaction with other agents in the world, and psychologically, in making sense of sense data.
- *Epistemological*. Interpretation of context is always constituted within a frame of reference.
- *Pragmatic*. Instead of labeling contexts, computers can provide resources for people themselves to create and maintain contexts in their action.

### Historical Background

Constructivism is a general category including various research strategies and philosophical orientations. It has its intellectual roots in many social scientific and philosophical branches, of which the larger HCI community knows mainly phenomenology and ethnomethodology. They have

offered alternative perspectives in HCI and influenced the move from single-user systems, ergonomics, and cognitive sciences. Curiously enough, anthropological studies of computing systems also inspired Weiser's vision of ubiquitous computing, but these origins were soon forgotten in the main current of the field.

### Applications

The design of systems that follows a constructivist stance will not infer the inner psychological state of the user (e.g., "interruptability"), or outer social state (e.g., "meeting"), or in general label sensor data into particular higher-level "meaningful" states to which the system can adapt. Rather, such a system will be designed to offer its state to users for interpretation and, through their individually constructed understanding, make it useful in their life, empowering them to do a multitude of different things – most of which may not be anticipated at the design moment. Meaning is not something that resides in our brain as a result of our conscious processing, but is created and re-created through being in and interacting with the world [6].

In *affective computing*, a constructively oriented system may well use biosensors and similar, but the interpretation is offered to the user who can use it to construct new contexts [2]. For example, Fagerberg et al.'s [8] SMS input system recognizes pen gesture patterns and maps those as affectively loaded background pictures (e.g., red for excited) that are shown to the receiver. If the image suggested by the system does not suit the sender, it can be changed. Thus, no "semantic" category is imposed to the pattern of gestures, rather the color, texture, and shape of the background image is provided as an extra "context" in constructing an interpretation of sender's mood or intentions.

In *interruptability research*, instead of agents that block incoming notifications, users can be supported in how they manage their time and tasks themselves. For example, MicroSoft has explored the possibility of visualizing incoming notifications by their urgency and type (e.g., email, IM) in a radar-like presentation and giving the user several tools for selecting and organizing the view [4].

Yet another example is *social navigation* where the social trails of others are left in order to allow for richer interpretation of the meaning of the system. These trails also change the system functionality so that the original intentions created by the designer will not be what the system ends up being. As users walk certain paths more frequently, they get more "worn", and increase in importance. Thus, the system changes with its usage, reflecting its usage, but without any real interpretation of what this might mean besides what the trails "are" in themselves [13].

## DISCUSSION

The goal of this paper has been to bear in a significant way on the context debate. Constructivism contradicts Realism, and explicating and analyzing the differences is crucial to bring unity to the otherwise disparate research. Importantly, we have shown that the dichotomy is not just hand waving but manifests itself in the applications in fundamentally different ways of thinking about uses of contexts.

It seems that realists view "context" simply as a new buzzword for "environment"—something that can be dealt with old, natural sciences based, concepts, methods, and techniques. Constructivists believe that context entails more than just a location or task. Context is all about situational sense-making, both by humans and interactive systems. Thus, context could be viewed as a sum of situational actions and resources (plans, emotions, technologies, other people) about how different resources integrate to the fabrics of given interactions between actors. Contexts emerge from actions; they are emergent properties (achievements) negotiated in reciprocal relationships between actors (inter-subjectivities and -objectivities) in complex interactions among humans and computers (see also [14]).

We conclude the paper by analyzing the relationship of the dichotomy proposed here to previous ones, its relationship to user-centered design. We then discuss how one might find a balance between the two approaches.

### "Constructivism" or "Phenomenology"?

Dourish has recently presented similar arguments and a divided approaches to context to three different camps [7]. A critical reader might ask why we picked different terms.

Our Realism maps loosely to his Positivism that views context as a representational problem (how can one best represent context to a computer). On the contrary, our concept of Constructivism wider than Dourish' Phenomenological approach that maybe overly emphasizes the role of individual, first-person experiences and simple human-computer interactions in the construction of contexts. Dourish´s analysis deduces all attempts to see contexts as constructed, or as "interactional achievements", to phenomenological roots. However, this analysis does not account adequately for different strands and philosophical underpinnings of constructivism both within ethnomethodology (e.g. [12]) and constructivism at large (for an excellent overview see [11]). By choosing the term Constructivism, we want to highlight that contexts are constructed in complex interaction and interpretation chains that include not only computers but also other resources and people.

### User-Centered Design and the Two Approaches

One of the observations we did is that the most representative applications examples of Realism are some sort of autonomous agents that make decisions on behalf of the user. This naturally triggers UCD issues like user veridicality (correctness of interpretations), transparency, control, privacy, trust, and empowerment.

Interestingly, veridicality of context inference is a non-issue for Constructivism, almost by definition, as context information is a resource for human action and has to be accounted by their users in social situations. This shifts the

focus from improving the "correctness" of the machine inference to their repairability in social interaction.

### Towards Reconcilication

Labeling contexts does not have to imply obtrusive behaviors, however. Salovaara and Oulasvirta [14] have distinguished between six types of proactive behaviors according to a resource management scheme. Proactive behaviors can prepare, optimize, suggest, manipulate, inhibit, or finalize user's resources. Given that categorizing and labeling contexts often fails, we believe that the labeling approach might be especially suitable for the three first types operations as they are potentially *un*obtrusive to the user. Preparing new resources, optimizing on-going ones, or suggesting new ones to the user can be harmless, be it based on realistic or constructivistic idea of context.

A good example of "resource preparation" is "best guesses" in a context-aware annotation system. Sarvas et al. [16] developed a system where context-interpretations fill in mobile image metadata annotation fields (e.g., name of the location) that can be easily overridden by the user if they are wrong. There are naturally other design remedies to the design challenges—for example, context can be faked by the user [3]. This has the potential of turning labels into resources for users themselves to construct interaction.

We conclude the paper by noting that not all researchers fall into either of the two categories—our goal has been to stir up a theoretical debate over the foundations of the field, yet keeping in mind its practical interest. We regard it of utmost importance that a balance can be found between the two approaches. This begins by admitting the fact that automatic context-interpretations are often arbitrary and wrong, especially when they concern mental and social states. As we have argued, automatic actions based on sensor data should be negotiable and repairable, and only provided as a controllable and transparent resource, starting point, or option for users to amplify their action.

### REFERENCES


1. Ark, W., Dryer, D., and Lu, D. The emotion mouse. *Proc. HCI International 1999*, Munich, Germany.
2. Höök, K. User-centred design and evaluation of affective interfaces. In Pelachaud, C. and Ruttkay, Z. (Eds.), *Evaluating ECAs*, Kluwer (forthcoming).
3. Brown, P.J., and Jones, G.J.F. Context-aware retrieval: exploring a new environment for information retrieval and information filtering. *Personal and Ubiquitous Computing, 5*(4), 2001, 253-263.
4. van Dantzich, M., Robbins, D., Horvitz, E. & Czerwinski, M. Scope: Providing awareness of multiple notifications at a glance. *Proc Advanced Visual Interfaces 2002*, Trento, Italy, 2002.
5. Dey, A. K. and Abowd, G. D. Towards a better understanding of context and context–awareness. *Technical report GIT-GVU-99-22*, 1999, Georgia Institute of Technology, Atlanta, GA.
6. Dourish, P. *Where the Action Is: The Foundations of Embodied Interaction*. Cambridge, MIT Press (2001).
7. Dourish, P. What we talk about when we talk about context. *Personal and Ubiquitous Computing, 8* (1), 2004, 19-30.
8. Fagerberg, P., Ståhl, A., and Höök, K. Designing gestures for affective input: an analysis of shape, effort, and valence. *Proc. MUM 2003*, Norrköping, Sweden.
9. Fogarty, J., Hudson, S.E., and Lai, J. Examining the robustness of sensor-based statistical models of human interruptibility. *Proc. ACM CHI 2004*, Vienna, Austria, ACM Press (2004), pp. 207-214.
10. Friedman, B. and Kahn, P.H. Jr. New directions: a value-sensitive design approach to augmented reality. *Proc. Designing Augmented Reality Environments,* (2000), pp. 163-164.
11. Hacking, I. *The Social Construction of What?* Cambridge, MA, Harvard University Press (1999).
12. Mehan, H, and Wood, H. *The reality of ethnomethodology*. New York, Wiley (1975).
13. Munro A., Höök, K., and Benyon, D. *Social Navigation of Information Space*. London, UK, Springer (1999).
14. Oulasvirta, A., Tamminen, S., Roto, V., Kuorelahti, J.. Interaction in 4-second bursts: The fragmented nature of attentional resources in mobile HCI. *Proceedings of CHI'05*, Portland, OR, ACM Press (2004), pp. 919-928.
15. Salovaara, A. and Oulasvirta, A. Six modes of proactive resource management: A user-centric typology for proactive behaviors. *Ext. Abstr. NordiCHI'04* (2004).
16. Sarvas, R., Herrarte, E., Wilhelm, A., and Davis., M. Metadata creation system for mobile images. *Proc. MobiSys 2004*, Boston, MA, USA. ACM Press (2004).
17. Scheirer, J., Fernandez, J., and Picard, R. Expression glasses: a wearable device for facial expression recognition. *Proc. CHI '99*, Pittsburgh, PA (1999).
18. Schmidt, A., Beigl, M. and Gellersen, H.-W. There is more to context than location. *Computers & Graphics, 23* (6), 1998, 893-901.
19. Suchman, L. *Plans and situated actions: The problem of human-machine communication*. Cambridge, Cambridge University Press (1987).
20. Tamminen, S., Oulasvirta, A., Toiskallio, K., and Kankainen, A. Understanding mobile contexts. *Personal and Ubiquitous Computing* 8 (3), 2004, 135-143.
21. Tennenhouse, D. Proactive computing. *Communications of the ACM 43*, 5 (2000), pp. 43–50.
22. Weiser, M. The Computer for the 21st Century. *Scientific American, 265* (3), 1991, 66-75.