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Ordinary User Experiences at Work: A Study of Greenhouse Growers

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ABSTRACT

We investigate professional greenhouse growers' user experience (UX) when using climate-management systems in their daily work. We build on the literature on UX, in particular UX at work, and extend it to *ordinary UX at work*. In a ten-day diary study, we collected data with a general UX instrument (AttrakDiff), a domain-specific instrument, and interviews. We find that AttrakDiff is valid at work; its three-factor structure of pragmatic quality, hedonic identification quality, and hedonic stimulation quality is recognizable in the growers' responses. In this paper, UX at work is understood as interactions among technology, tasks, structure, and actors. Our data support the recent proposal for the ordinariness of UX at work. We find that during continued use UX at work is middle-of-the-scale, remains largely constant over time, and varies little across use situations. For example, the largest slope of the four AttrakDiff constructs when regressed over the ten days was as small as 0.04. The findings contrast existing assumptions and findings in UX research, which is mainly about extraordinary and positive experiences. In this way, the present study contributes to UX research by calling attention to the mundane, unremarkable, and ordinary user experiences at work.

CCS CONCEPTS

•Human-centered computing~Human computer interaction (HCI)~HCI design and evaluation methods~User studies•Human-centered computing~Human computer interaction (HCI)~HCI design and evaluation methods~Field studies•Applied computing~Computers in other domains~Agriculture

KEYWORDS

User experience, UX at work, Greenhouse growers, Horticultural workplace, Continued use

1 Introduction

It can be difficult to design for a good user experience in the workplace (i.e., for UX at work). Because UX at work is a key outcome of people's everyday workplace system use [26,65,67,86,91,100], it is crucial that UX at work is well understood. By analyzing rich data from a case of horticultural climate management, we link workplace system use to UX at work, explore how well an existing UX instrument captures UX at work, and characterize UX a work as ordinary. Thus, we reach back to the workplace studies so dominant in HCI in the 1990s (e.g., [6,24,40,42]) and look forward into a digital workplace future [7,14,44,54,79].

The horticultural workplace is rapidly becoming a digital workplace where the employees do their work away from the greenhouse (e.g., [12,55,68]). Understanding horticultural work requires multidisciplinary research (in, e.g., horticultural plant models for decision making systems [46], horticultural UX design [85], horticultural workplace design [4], design of horticultural IT technologies [55] and horticultural mobile devices [61]). There is a great need for understanding the psychological phenomena, including UX, that mediate between the digital workplace and the employees' wellbeing and productivity [7]. Good UX has traditionally been seen as strong, often dramatically strong, positive experiences, but this may not be the case in all contexts. Among the many measures of UX, AttrakDiff [31] has gained popularity as a measure that captures positive experiences with products [84].

The idea behind AttrakDiff is that UX consists of pragmatic (e.g., effective, efficient) as well as hedonic (identification, stimulation) qualities [28,31]. In this study, we continue the exploration of the use of AttrakDiff in the workplace. Literature about workplace technology use tends to refer to UX constructs without applying them in detail [5,77]; conversely, UX literature rarely considers the work context [3,26]. Combining frameworks for work analysis with UX theory promises to establish UX as embedded in the work and organization [26].

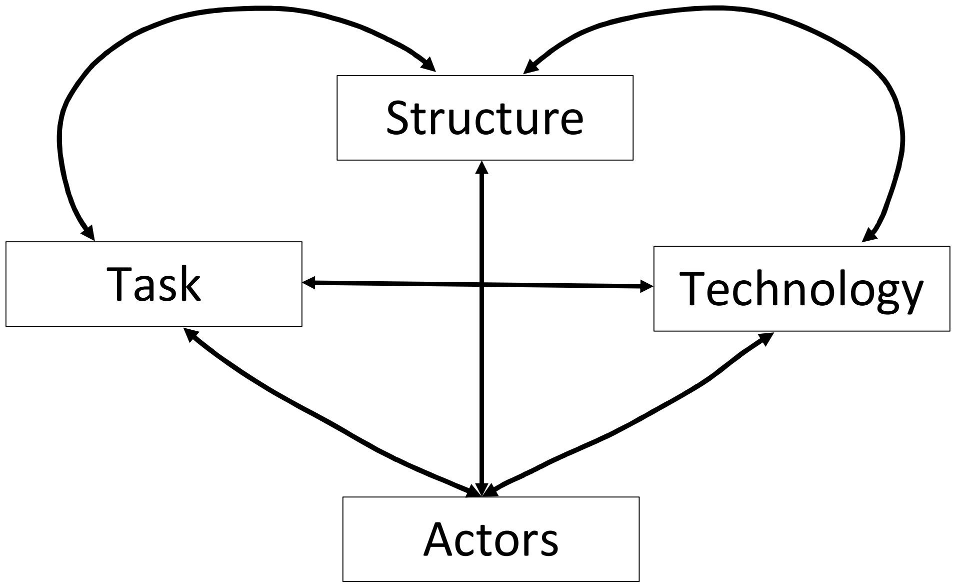


Figure 1. Leavitt's [60] diamond model for organizational analysis reinterpreted as a UX heart model.

Existing knowledge about UX at work is scarce, but hints at its complicated nature and at how it might violate assumptions about predominantly positive experiences [47,70,110]. Mobile workers, for example, use technologies to be constantly connected to work, and some of them experience emotional exhaustion by constantly relating digitally to other people [90]. Organizations that introduce digital technologies face the challenge of designing for UX at work. To do so they must understand the complexity of the digital workplace and the relations between its elements and UX at work. In this paper, we examine whether an existing UX instrument also can be used for assessing UX in a work context, and we explore the defining features of ordinary UX at work in terms of degree, evolution over time, and variation across use situations. We ask the questions:

- How well does AttrakDiff capture the hedonic and pragmatic qualities of UX at work?
- What patterns in these qualities characterize ordinariness in UX at work?

In the remaining parts of this paper, we first review related work on UX, AttrakDiff, and the notion of ordinary UX at work. Then we present our empirical study and discuss its contributions toward understanding and designing for UX at work. In the empirical study, diary data are collected over a ten-day period and supplemented with interviews. The diaries consist of a tailor-made, domain-specific questionnaire filled in three times a day and a day-retrospective questionnaire in the form of AttrakDiff. The findings about the ordinariness of UX at work should be useful to UX researchers and to design-oriented managers in digital workplaces.

2 Related work

There are extensive bodies of literature about UX and about how people experience their work. We do not try to provide full coverage of this literature, which spans different disciplines beyond HCI, but try to situate our research in this literature. We focus on:

- Professional growers as work domain experts [22], not on leisure gardening or urban farming [11,38,81]
- Climate-management tasks related to caring for plants [25], not on the indoor comfort of people [1,50]
- Commercial, present-day horticulture [74], not on futuristic alternatives [69,88] or interaction design for the international development of agricultural practices [108]
- Climate-management technology as a professional tool [66], not on leisure tools such as open-source sensors for urban gardens or urban installations involving plants [18,19,41]

2.1 UX at work

Research on UX defines it as related to the use of systems and other technological artifacts [58]. In work contexts, this research draws on a notion of work as a meaningful, pleasurable, need-fulfilling activity [26]. In particular, UX at work may involve both pragmatic qualities and strong positive features such as hedonic qualities [16,105]. A series of recent studies of UX in industry contexts has found indicators and examples of the hedonic qualities of technology use in workers' UX [26,37,110–

112,66,70,80,83,92,94,96,105]. Therefore, we would expect that hedonic qualities and positive experiences loom large in the four elements of UX at work (Figure 1).

Designing for positive UX in work contexts has become the subject of recent research in HCI and related fields (e.g.,[65,91]). This research builds on earlier research on workers' experiences in the workplace. For instance, their frustration with computer systems was documented in 2006 by Lazar et al. [59], who used time diaries to assess how frustration correlated with lost time and task importance. However, studies of negative experiences with computer technology date back considerably longer than 2006. For example, in 1993 Dunlop and Kling [52] wrote about 'controversies about computerization and the character of white-collar work life'. Mumford's [73] work on the Effective Technical and Human Implementation of Computer-based Systems (ETHICS) method also sprang from frustration with the technologies of the time (1970s). Thus, there was both an early promise of research into usability and a more recent aim for UX to deliver an understanding of the relations among users' experiences, system use, and workplaces [26,98].

More is known about usability, UX evaluation methods, and UX professionals than about UX in work contexts [10]. In the usability and UX literature, specific work domains tend to be discussed merely as 'application domains' [39]. However, some research addresses usability and UX in specific work domains, such as administration [9], health [53], manufacturing [45], and maritime work [27]. The work domain that we study in this paper is horticulture, or more broadly agriculture, which is an emerging area in HCI research (e.g., [25,64,85,88]). In the following, we structure the presentation of related work around the four elements of Figure 1 and, wherever possible, limit our examples to the studies most relevant to the horticultural domain.

2.1.1Technology

The worker using a technological system may experience pragmatic product qualities, in the sense that the system supports particular "do-goals" (e.g., to check the temperature development in a specific greenhouse). The worker may also experience hedonic product qualities, in the sense that the system supports "be-goals" such as pleasure in use and professional identity (e.g., to be seen as competent by colleagues for mastering the climate-management system) [33,36]. Furthermore, the UX of complex systems may be more than the sum of the individual subsystems [2], so that workers may experience both subsystem-specific hedonic qualities and broader positive experiences during work [36].

Climate-management technology has pragmatic qualities when used as a problem-solving intervention to ensure a greenhouse climate optimal for plant growth; it is less obvious whether it has hedonic qualities. In an early study of UX in the factory, Obrist el al. [80] found that the absence of stress constituted 'a perfect workday', which was one of the emotion cue cards that they asked clean-room operators to fill out. Negative emotions like fear and anger were mentioned by the operators, while positive emotions were not. Nonetheless, other researchers have pursued the idea of designing for work experiences that are not just meaningful but also pleasurable. However, they point to the lack of a framework for specifying the types of hedonic experiences that fit workplace contexts [66]. Schaufeli et al. [95] propose to use indicators of work engagement from work psychology, such as vigor, dedication, and absorption. Thus, an example of goals for positive UX at work may be that employees are engaged in their work, measured as high levels of vigor, dedication, and absorption [91].

Technologies that increase awareness of nature could support growers' hedonic UX at work by, for example, allowing them to experience direct interactions with plants. Public installations involving plants have instilled increased awareness of nature in users (e.g., [18,41]). Fastnach et al. [19] studied the hedonic value of touching plants to trigger light in urban interactive installations and found that festival visitors experienced more pleasure (as measured by AttrakDiff) from longer interactions (i.e., touching plant longer). Holstius et al. [41] did a field trial in a cafeteria in which pot plants were connected with interactive displays that were linked to recycling boxes. The experiences of 13 interviewees indicated that they enjoyed the plants and realized that recycling was a way to give the plants light. Such studies could potentially be relevant to the redesign of climate-management visualizations and interactions, in particular if we can show that hedonic qualities are important not only in public interactive displays during festivals or lunch time but also in professional climate-management work in greenhouses.

2.1.2Actors

Professional growers work in horticultural firms that shape the knowledge, norms, qualifications, roles, skills, and values that enter into performing the work. Applying Nielsen's [76] dimensions of differences among users, we are particularly interested in professional growers who are work domain experts, but who are also high on the dimensions of specific system experience and general computer experience. Hedonic experiences may involve both deep work-domain knowledge and much system and computer proficiency, thereby leading to questions such as: Are the decisions made by the system understandable to me, the grower? What possibilities do these new controllers afford me and my colleagues? Can the models really be trusted? [101]. However, actors can also be novices (e.g., apprentices, guests, students) or even non-human actors such as 'companion species' (e.g., plants, molds, bacteria [64]).

Plaskoff [87] defines the total employee experience as the employees' holistic perception of their relations with the employing organization derived from all their encounters with digital and non-digital touchpoints in their organization. However, actors' total employee experience, including wellbeing at work, is not clearly brought out in the HCI literature. Klapperich et al. [51] have suggested that the link between technology use and wellbeing could be social practices and, in particular, the individual actor's fulfillment of basic psychological needs during these practices. They developed and tested a way for designers to collect data on people's social practices and basic psychological needs. In the context of increasing office workers' physical activity, they collected anecdotes of positive practices and linked them to design ideas for employees' health and wellbeing at work. However, they acknowledge that "practices may be too wild to be tamed in a way we suggest" [51]. Hence, it is not yet clear how to make the link from the practical use of technology to the employee's experience of wellbeing at work.

2.1.3 Tasks

In relation to usability and UX, work tasks are often conceptualized as goal-driven combinations of low-level operations. Conceptualized in this way, work tasks are important to the quantitative assessment of the usability of work systems [62]. From a practice-based perspective, work tasks are however more than low-level operations because they are embedded in social practices and must be interpreted by workers [89]. For example, Norros and Savioja [78] suggest that work tasks have experience dimensions such as the instrumental experience of appropriate functioning, the communicative experience of a joint culture, and the psychological experience of competence and trust. Thus, work tasks have experience dimensions beyond pragmatic goal fulfilment.

While the outcome of work tasks matter to UX at work, so does the manner in which the tasks are performed (e.g., the grower spending time exploring visualizations because this is enjoyable and interesting to do). Liu et al. [64] argue that a radical focus on instrumentality, such as task efficiency, is very different from approaching agricultural work tasks as sustainable and collective caring from which actors derive immediate pleasure and meaning. Although a task may have produced the desired outcome, there might still be problems with the way in which this outcome was reached, such as expending resources excessively or involving tedious interaction sequences [78]. Hassenzahl and Klapperich [34] provide examples of how to design joyful use experiences by meeting the users' psychological needs and automating the boring parts. UX at work may also be supported by designs that support non-work needs, such as doing physical activity during work [51] and keeping in contact with family during the work day [32]. Gamification research has explored how to design for both productivity and worker engagement [75,106]. Gamified job elements have led to improvements in motivation, job satisfaction, and performance [63,106].

2.1.4 Structure

The use of many business applications is mandated. Workers will only have positive experiences with such applications if business goals and user goals overlap [74]. Business goals are related to the work tasks and to the high-level expectations and wishes for how a system supports a business in fulfilling its mission. Hornbæk and Frøkjær [43] had students evaluate a website after half of them had been provided with a list of business goals for the website. Compared to the students who had evaluated the website without access to business goals, the students who had been provided with the business goals reported usability problems that were rated higher in utility by the company owning the website. This difference shows that though business goals and user goals may overlap, they emphasize different parts of a system and its use. User goals – the standard focus in usability evaluation – are related to the employees' personal needs [74].

In horticultural work, the structure element includes the growers' job descriptions, the instructions about how to use the climate-management system, the procedures for how growers and other actors communicate with each other about their tasks, and so forth. Much of this is captured by the notion of organizational usability, defined as "the match between a computer system and the structure and practices of an organization, such that the system can be effectively integrated into the work practices of the organization's members" [17]. For example, Gutiérrez et al. [25] found that an important reason for the modest use of agricultural decision support systems was that their terminology and logic were designed by agricultural scientists and IT developers and failed to consider the work-domain expertise and practical needs of farmers. These systems met neither business goals, nor user goals, and were far from providing good UX at work.

Structure also includes temporal contexts of use. Shaw et al. [99] proposed that a technology will stay in use for a long period of time if it repeatedly satisfies the user's motivation and continually extends the user's capabilities and identity. That said, it appears that the UX at the time of introducing a novel system differs from that of long-term use [56]. Over time, situational contexts (e.g., different work locations) become more predictive of technology use [99].

2.2 Measuring UX with AttrakDiff

Despite the value of sound models for measuring UX, an overview of UX studies [3] highlights that many of the employed UX questionnaires lack validation. In this context, it is noteworthy that a psychometric tool, AttrakDiff [31], has proven valid for capturing the pragmatic and hedonic qualities of interactive products. AttrakDiff has been used to assess the hedonic aspects of UX and how they interact with pragmatic aspects such as perceived usability and goodness [30,104]. When compared to other UX questionnaires such as VisAWI [72] and several aesthetics scales, AttrakDiff remains one of the most reliable tools to measure the hedonic aspects of UX [84]. However, AttrakDiff on its own cannot fully explain the variation in UX. For example, Walsh et al. [109] compared how well AttrakDiff and iScale explained changes in UX over time. They found that supplementing the quantitative AttrakDiff data with the qualitative and retrospective iScale [48] data yielded more insightful explanations of why UX changed over time in different product contexts.

To qualify the study of UX over time, Roto et al. [93] propose to distinguish among four different time spans: momentary, episodic, cumulative, and anticipated. Fischer et al. [20] have demonstrated the value of AttrakDiff in assessing the UX of interactive facades over short, near momentary time spans such as 90 seconds. AttrakDiff has also been used to gain insights into UX over much longer, cumulative time spans. For example, Karapanos et al. [49] investigated product adoption in a five-week study and found, using AttrakDiff, that the users' experiences differed across the three phases orientation, incorporation, and identification. In a work context, AttrakDiff has been used to study how UX was influenced by user attributes (playfulness, computer expertise) and product attributes (pragmatic quality, hedonic quality) over a 13-week period [26]. UX changed over time and these changes were influenced considerably by product attributes and, as time passed, increasingly by user attributes.

Schrepp et al. [96] also applied AttrakDiff to a work system. They demonstrate that pragmatic and hedonic qualities impact the attractiveness of user interfaces and that attractiveness ratings correlate with user preferences, thereby validating the AttrakDiff ratings. Morales et al. [71] contend that it takes little time to complete the AttrakDiff instrument, that completing it does not interfere with the work, and that the results appear to be reliable for complex equipment. On that basis, they conclude that AttrakDiff can be applied in work settings.

2.3 Ordinary UX at Work

While the focus of this paper is on UX in the workplace, the research discussed so far on AttrakDiff has mainly focused on extraordinary experiences with a strong hedonic component. However, recent work by Meneweger et al. [70] demonstrates the importance of studying workers' ordinary user experiences. These authors define ordinary UX as experiences that have no specific value, are hardly memorable, do not attract attention, and happen when users interact directly as well as indirectly with a system. They illustrate how UX at work is a highly situated phenomenon that fluctuates from the ordinary (repetitive and everyday work routines) to the unordinary (first-time interactions with new technology, infrequent tasks, interventions in everyday routines). Fluctuations between the ordinary and unordinary may happen fast (as when errors occur) or develop slowly due to habituation over time. Once a system has entered into continued use, ordinary UX is the more common state.

The ordinary aspects of UX stand in contrast to extraordinary UX and may, in addition, make ordinary UX harder to measure. Meneweger et al. [70] argue that because no strong value or memory tends to be attached to ordinary experiences then ordinary UX is harder to assess. Meneweger et al. [70] take a fundamentally qualitative approach and attempt to capture nuanced aspects of workers' UX in a factory. They propose the use of diary studies and day reconstruction to allow workers to report and reflect on concrete experiences and interactions with a system. These qualitative methods presuppose that people have memories of these experiences and interactions. Furthermore, they recommend that researchers who investigate the ordinariness of experience should consider how their method deals with the ordinary and how different nuances of ordinariness can be addressed. It is precisely this deeper attention to the notion of ordinary UX at work that motivates our research presented in this paper.

3 Method

To answer the research questions we conducted an empirical study in small and medium-sized groweries in Denmark. Twelve experienced greenhouse growers provided data about their user experiences during ten days of work. Data were collected by means of AttrakDiff questionnaires, a tailor-made Grower-eXperience (GX) questionnaire, and interviews.

3.1 Work setting: climate management in greenhouses

Greenhouses provide a milieu in which the climate can be managed. The objectives of climate management in greenhouses include keeping the plants healthy, controlling their rate of growth, aligning their bloom with seasonal fluctuations in demand, and efficiently developing new species. The horticultural industry has lowered its energy consumption, but additional energy savings are necessary to make the industry environmentally sustainable and to counter increasing energy costs. Advanced climate-management systems aim to meet this challenge by enabling growers to optimize the greenhouse milieu, while minimizing energy consumption. These systems involve (a) microclimate sensors throughout the greenhouse, (b) various actuators to adjust the temperature, humidity, fertilization and so forth, (c) visualizations of the current state of the greenhouse, (d) control facilities for maintaining or changing this state, (e) climate models to provide decision support, and (f) communication facilities for data sharing and the like. In addition to the sophistication of the systems as such, they must be tailored to the conditions, plants, and production schedules of the specific greenhouse. Thus, the effective use of the systems also requires detailed knowledge of the local particulars.

The main part of day-to-day climate management is monitoring and regulation. This task involves that the grower forms and maintains an overview of the condition and settings in a given greenhouse via the climate-management system. On the basis of this overview, the grower makes necessary adjustments. These adjustments are, however, 'invisible' to the grower's colleagues because the climate-management system displays the current settings only and have no log of the changes made. Thus, the growers inform each other of changes made to support their colleagues in maintaining an overview. Another important climate-management task is problem solving. It involves making ad hoc data views in the climate-management system to extract and inspect the data the grower is interested in. The climate-management system collects a wealth of data and presents them in grower-defined views, which can be set up to support daily monitoring or targeted problem solving. Finally, climate management involves production planning. This task requires the extraction of other data and, therefore, the definition of additional views. It also involves reusing greenhouse settings from previous production processes.

The climate-management work takes place in the office, in the greenhouse, and on the growers' mobile phones. For the most part, tasks performed in the greenhouse can also be performed in the office. However, when the growers are in the greenhouse, it may be more meaningful for them to make any necessary climate adjustments on the spot. As an example of the use of the climate-management system, the growers accept an increase in energy consumption to prevent the plant disease grey mold. However, the grey-mold risk varies with many parameters, such as the past and current climate, the plants, and the soil. Based on models of fungus development and plant behavior, the climate-management system can, if properly configured, monitor the microclimate data from the sensors and provide grey-mold warnings or automatically adjust the climate in the greenhouse. The growers need, in turn, to monitor the system, react on warnings, and continuously fine tune the system to avoid, for example, false alarms.

3.2 Participants

To recruit the study participants, we engaged with a horticultural climate-management consultant, who contacted potential candidates. This convenience strategy was qualified by a requirement for participants to be experienced because climate management in greenhouses is highly specialized work. The resulting sample consisted of 12 participants, see Table 1. We acknowledge that with 11 male participants and one female participant the study predominantly reflects a male view on UX at work.

All participants worked full-time in greenhouses in positions spanning from grower through production manager to teacher. The greenhouses were mainly growing flowers. All participants had a vocational education in horticulture or agriculture and several had additional educations in commerce or management. Furthermore, all participants were seasoned professionals with an average of 16.5 years of experience in climate management in greenhouses; the minimum was 7 years of experience. In their current positions, eleven participants used the Superlink system (version 4 or 5) for managing the greenhouse climate; the last participant used the DGT H240 system. The participants had an average of 30 months of experience with the system and estimated that they spent an average of 39 minutes a day using it. It is their user experience of this system we investigate.

Table 1. Participants.

Job position	Education	Gender	Years of age	Years of education [a]	Work experience [b] (years)	System experience [c] (months)	Daily use of system (min)
Grower	Horticulturist	Male	53	3.5	10	24	45
Horticultural technician	Horticulturist, horticultural technician	Male	45	7	16	36	15
Production manager	Horticulturist, bachelor of commerce	Male	41	10	18	8	90
Foreman	Agriculturist	Male	67	4	17	2	15
Grower	Horticulturist, operations manager	Male	52	4	26	14	20
Grower	Horticulturist	Male	54	3.5	16	152	15
Production manager	Horticulturist, MBA in organization	Male	43	10	16	12	30
Student	Horticulturist, agricultural technician	Female	25	7.5	7	3	25
Foreman	Horticulturist, horticultural technician	Male	43	6	17	8	15
Technician	Horticultural technician, operations manager	Male	47	6	16	72	30
Crop manager	Horticulturist, operations manager	Male	36	5	16	20	45
Teacher	Horticulturist	Male	55	4	23	5	120

[a] Beyond ninth grade, [b] Years of professional climate-management experience, [c] Months of experience with current climate-management system.

3.3 Procedure

The participants were visited at their individual workplaces and instructed about the study. This instruction served both informative and motivational purposes. In addition, the visits provided us with an opportunity to see the greenhouses and thereby get a sense of the work context. Participation in the study involved three activities:

- *The GX questionnaire* to be filled out three times a day for ten days, triggered by system use. This questionnaire consisted of five questions about the use situation and 18 questions about the participants' user experience.

- *An AttrakDiff* [96] *questionnaire* to be filled out at the end of the day on the same ten days. In answering this questionnaire, the participants were to look back over the day and rate "their most important experience with the climate-management system during that day".
- *An interview* conducted after the ten days had ended. These interviews served to obtain additional information about the participants' experience of the climate-management system, to validate their responses to the GX and AttrakDiff questionnaires, and to debrief the participants.

During the initial visit, we walked through the GX and AttrakDiff questionnaires to explain their content and answer any questions the participant might have. Each participant also filled out a demographic questionnaire and a consent form. During the study, the participants filled out the GX and AttrakDiff questionnaires online on their phone or computer. Thus, we could monitor their responses and, when needed, follow up with further instructions and motivational communication. For most participants responding to the GX questionnaire three times a day corresponded roughly to how often they used the system. However, participants occasionally used the system less than three times a day, or for other reasons did not fill in three GX questionnaires. As a token of our appreciation, each participant received a gift card of DKK 500 at the end of the study.

3.4 GX questionnaire

The GX questionnaire was tailor-made for this study based on substantial empirical work. During 2011-2013, the first author did fieldwork to study climate management in Danish greenhouses. As part of this fieldwork, three greenhouse growers and three horticultural consultants were interviewed about the user experience associated with the use of climate-management systems. The analysis of the interview data yielded a list of emotions that growers experience during climate management. To further qualify the words used in describing these emotions, a word-choice test was conducted with two additional greenhouse growers and another horticultural consultant. The outcome of this analysis was the 18 user-experience questions in the GX questionnaire. The user-experience questions were supplemented with five questions about the characteristics of the use situation. These questions were derived from the fieldwork and concerned where the participants were, what they were doing, which system facility they were using, what else they were doing, and whom they were with.

The participants were requested to fill out the GX questionnaire in relation to situations in which they were using the climate-management system. That is, the three daily instances of filling out the GX questionnaire were triggered by system use. To avoid ordering effects in the participants' responses, the 18 user-experience questions appeared in random order each time the GX questionnaire was filled out by a participant. The user-experience questions consisted of these 18 items: simple to use, business oriented, simple design, good displays, adequate graphs, reassuring, exciting, challenging, demanding, easy to use, fills me with awe, controlled by me, difficult, transparent, interesting, useful, enjoyable, and intelligent and smart. Each of these items was answered on five-point rating scales with the labels "Not at all" (1), "to a small extent" (2), "to some extent" (3), "to a large extent" (4), and "to a great extent" (5). An additional option enabled the participants to answer "Don't know"; such answers were treated as missing values in the analysis.

3.5 AttrakDiff questionnaire

AttrakDiff resulted from a series of studies on how users' perceptions of the hedonic and pragmatic qualities of a system contributed to their perception of its attractiveness [29–31,35]. We used the AttrakDiff2 version of the questionnaire, which we translated into Danish on the basis of the German and English versions provided by Schrepp et al. [96]. This questionnaire had 28 items, seven for each of its four constructs:

- *Hedonic quality identification* (HQI), which "addresses the human need to express one's self through objects" [30]. This function of objects is extensively social; individuals seek to present themselves in specific ways to shape how they are seen by relevant others.
- *Hedonic quality stimulation* (HQS), which "focuses on the human need for personal development" [96]. For example, an object can support this need by stimulating creativity, providing opportunities for learning, or presenting information in new ways or contexts.
- *Pragmatic quality* (PQ), which is "connected to the users' need to achieve behavioral goals" [30]. While HQI and HQS are primarily about the user's self, PQ taps the traditional usability aspects of effectiveness, efficiency, and learnability.
- *Attractiveness* (ATT), which "results from an averaging process of the perceived pragmatic and hedonic quality" [96]. That is, ATT is the user's overall perception of how attractive an object, such as a software system, is in a specific situation.

The seven items for each construct were semantic differentials. That is, a pair of anchors, such as "Pleasant" and "Unpleasant", indicated the end points of a seven-point rating scale. For the full list of 28 items, see Appendix A. Before the questionnaire was presented to the participants, half of the items were reversed to vary whether the positive anchor was at the left or right end of the scale.

3.6 Interviews

The interviews were conducted at the individual participants' workplace and completed their participation in the study. To align the interviews with the questionnaires, the interviews were structured around the questionnaire items. The participants were handed a copy of the GX and AttrakDiff questionnaires and asked to elaborate each item in turn. In an effort to avoid ordering effects, the questionnaire items were randomly reordered for each interview. The participants commented on all items and, whenever possible, provided examples and elaborations. For some items, their responses were little more than a verbally reported rating, for others they were able to give more detail. The examples and details provided additional information about the participants' work and about their use and experience of the climate-management system. Because the participants knew the questionnaire items, few explanations were necessary. The participants were, however, prompted for elaborations. In some cases, the participants also commented on how they had interpreted the items. The interviews were audio-recorded and lasted approximately 30 minutes.

3.7 Data analysis

We analyzed the AttrakDiff data using factor analysis and regression. For the factor analysis, we chose common factor extraction because it does not require that the factors are orthogonal, a requirement rarely met by social science data [13]. After the factor analysis, we regressed the HQI, HQS, and PQ factors on the ATT factor to assess how well ATT was predicted by the pragmatic and hedonic qualities. We also regressed the daily averages of each factor (HQI, HQS, PQ, and ATT) to investigate the extent to which the AttrakDiff data indicated ordinary user experiences.

The GX data were analyzed using regression and non-parametric significance tests. Like for the AttrakDiff factors, we regressed the daily averages of each of the 18 user-experience items to investigate whether these items indicated ordinary user experiences. This analysis tested for variation over time. To test for variation across situations, we derived three binary variables from the five questions about the use situation: who (whether the participant was *alone* or *with someone*), where (whether the participant was in the *office* or *greenhouse*), and what (whether the participant was gaining an *overview* of the greenhouse climate or *adjusting* it). These variables were used to test the 18 user-experience items for differences across situations. The remaining use-situation questions contained too many 'Other' responses to enable meaningful analysis.

In the analysis of the interviews, we concentrated on the participants' elaborations of the AttrakDiff items. Two of the authors independently coded the transcribed interviews using the 28 AttrakDiff items as codes. They agreed on 78% of their codings. Disagreements were resolved through discussion and a consensus was reached. On the basis of the codes, we extracted illustrative quotes about each item and analyzed the four AttrakDiff factors (ATT, HQI, HQS, and PQ) with respect to ordinariness. We also extracted quotes about the four elements of the UX heart model (Figure 1): actors, task, technology, and structure. This was done more informally and served to contextualize the analysis of the AttrakDiff factors.

4 Results

In the following, we first analyze the AttrakDiff data to examine their factor structure; we specifically seek to determine whether AttrakDiff can be used to measure UX in the work context of greenhouses. This analysis (Sections 4.1-4.3) addresses the first research question. Then we analyze the AttrakDiff, GX, and interview data to examine whether the greenhouse growers' experience can be characterized as ordinary. This analysis (Sections 4.4-4.7) addresses the second research question.

4.1 Factor analysis of AttrakDiff data

We tested the suitability of the AttrakDiff data for structure detection. Barttlet's test of sphericity indicated factorability; that is, the items were significantly related in some way or another ($\chi^2_{(210,\ N=120)} = 1301.545$, $p < .001$), and the Kaiser-Meyer-Olkin (KMO) measure showed good sampling adequacy, as it indicated that a high proportion of variance in the items could be caused by underlying factors. Across items, the measure of sampling adequacy (MSA) was 0.799, which is in the recommended range of 0.5-1.0.

Visual inspection of the 'elbow' in the Scree Plot suggested 3-5 factors, which was consistent with our theoretical assumption of three factors: HQI, HQS, and PQ (we did not include the outcome factor ATT in the factor analysis). Therefore, following [13], we did a search for the cleanest factor structure by running multiple factor analyses with preset numbers of factors, first to the number based on theoretical assumptions, then to the number of factors suggested by the Scree test, and finally to numbers above and below those numbers. To identify the cleanest factor structure, we compared the item loadings with regard to the following criteria: item loadings above .30, no or few item cross-loadings (items that load .30 or higher on multiple factors), and no factors with fewer than three items. Table 2 shows that a solution with three factors gives the cleanest factor structure, with only one item with a loading below .30 and few cross-loadings. Therefore, we continued our common factor analysis with three factors.

Table 2. The cleanest factor structure.

	Number of factors				
	2	**3**	4	5	6
Item loadings below .30	2	**1**	1	0	0
Number of cross-loadings	3	**5**	7	9	9
Factors with fewer than three items	0	**0**	0	0	0

Note: The cleanest factor structure is in bold.

Visual inspection of the data with QQ plots and Mardia tests for multivariate normality (Skewness = 148.85, z = 2977.03, $p < .001$; Kurtosis = 560.10, z = 13.59, $p < .001$) indicated that the data were non-normal. Therefore, following best practices [13], we used principal axis factoring (PAF) for factor extraction. The three extracted factors had Eigenvalues greater than 2.062 (factor 1: 6.377, factor 2: 2.755, factor 3: 2.062) and explained 53% of the shared variance. We chose Direct Oblimin as rotation method because it allows for correlations among factors and because such correlations are common in social science data [13,15,113]. The results showed factor correlations ranging from .140 to .261.

Table 3 shows the factor loadings and communalities of all 21 items. With five exceptions, the extracted communalities for the 21 items were above the recommended value of 0.40 [13], which indicates sufficient relations among the items in a factor. The five exceptions were (see Table 3): HQI2, HQI3, HQS6, HQS7, and PQ7. However, only two of these (HQI3 and HQS7) had communalities below the 0.30 threshold recently used by some authors in the CHI community [8]. Overall, the item communalities were satisfactory and did not suggest additional factors. Our inspection of the pattern matrix in Table 3 revealed five cross-loading items (HQI7, HQS6, HQS7, PQ4, PQ7). Among these five items, HQI7 and HQS6 were the most obvious candidates for re-wording or removal, because they did not load on their AttrakDiff-designated factors, but instead on the other factors. However, we retained all 21 items in our analysis.

Overall, the factor analysis indicated that the original factor structure of AttrakDiff could be rediscovered in our data, but that it appears somewhat fragile. Though the three-factor structure is recognizable in the item-factor loadings in Table 3, not all 21 items loaded substantially on the factor they were supposed to load on, and there were five cross-loadings, as discussed above. Table 4 shows the factor correlations and internal consistencies. While HQS and PQ appear as separate factors, HQI correlates somewhat with PQ. The internal consistency (Cronbach's alpha in Table 4) is good for PQ and acceptable for HQI, but questionable for HQS; the latter may be due to the cross-loadings for items HQS6 and HQS7.

Table 3. The factor structure of the AttrakDiff data, *N* = 120. Loadings of all 21 items are shown, if they are above 0.30.

Item	Anchors (in English translation)		Mean	Std. Dev.	Factors			Communalities
					HQI	HQS	PQ	
Hedonic Quality Identification								
HQI1	Isolates	Connects	3.63	1.408	0.764			0.591
HQI2	Unprofessional	Professional	4.65	0.837			0.530	0.350
HQI3	Lacking style	Stylish	3.76	0.944		0.376		0.203
HQI4	Poor quality	High quality	4.31	0.877			0.494	0.464
HQI5	Excludes	Draws you in	3.35	1.663	0.587			0.411
HQI6	Separates me…	Brings me closer…	3.99	1.293	0.616			0.402
HQI7	Not presentable	Presentable	4.35	0.923		0.323	0.321	0.395
Hedonic Quality Stimulation								
HQS1	Conventional	Original	4.02	0.907				0.422
HQS2	Unimaginative	Creative	3.99	0.912		0.605		0.578
HQS3	Cautious	Bold	4.03	0.804		0.778		0.266
HQS4	Conservative	Innovative	4.06	0.938		0.497		0.546
HQS5	Dull	Absorbing	3.82	0.917		0.623		0.585
HQS6	Harmless	Challenging	4.46	1.159	0.421		-0.720	0.308
HQS7	Conventional	Novel	3.88	1.139		0.460	-0.345	0.271
Pragmatic Quality								
PQ1	Technical	People-centric	3.15	1.430			0.498	0.767
PQ2	Complex	Simple	3.39	1.330			0.676	0.432
PQ3	Impractical	Practical	4.32	1.347			0.769	0.743
PQ4	Cumbersome	Facile	3.48	1.223	0.342		0.355	0.734
PQ5	Unpredictable	Predictable	4.10	1.325			0.826	0.669
PQ6	Confusing	Clear	3.64	1.314			0.635	0.591
PQ7	Unmanageable	Manageable	4.16	1.402	0.453		0.591	0.350

Table 4. **Reliability, convergent, and discriminant validity indications.**

Factor	Mean and Standard deviation		Internal consistency	Composite reliability	Average Variance Extracted	Average Shared Variance	Maximum Shared Variance	Factor correlations & Square Root AVE		
	M	SD	Cronbach α	CR	AVE	ASV	MSV	HQI	HQS	PQ
HQI	4.01	1.14	.71	.54	.21	.07	.07	.452	.199	.261
HQS	4.04	0.97	.68	.75	.27	.03	.04	-	.517	.140
PQ	3.75	1.34	.88	.82	.41	.04	.07	-	-	.639

4.2 Reliability, convergent, and discriminant validity

It appears that AttrakDiff was a reliable, though somewhat fragile, tool in the horticultural work domain. There were issues with convergent validity and hence a questionable discriminant validity. As shown in Table 4, the three-factor structure was reliable in that Cronbach's alpha was close to or greater than the commonly accepted threshold of .70 for all three factors. The three-factor structure had convergent validity issues, because the Average Variance Extracted (AVE) was less than .50 for all three factors, indicating low item loadings on parent factors. Furthermore, the AVE values for only one of the factors (PQ) was above the recommended minimum of .30. The composite reliability (CR) was above .70 for PQ and HQS, so these factors were acceptably explained by the observed items [23]; this was not the case for HQI. Because the Square Root AVE for each factor was higher than any of its correlations with the other factors, and the Average Shared Variance (ASV) and Maximum Shared Variance (MSV) values were lower than their corresponding AVE values, discriminant validity was established albeit on a modest level.

4.3 HQI, HQS, and PQ explained 74% of the variation in ATT

To assess the extent to which hedonic and pragmatic quality explained attractiveness, we regressed the 120 ratings of HQI, HQS, and PQ on the ratings of ATT. The regression model was significant, $F(3, 116) = 110.79$, $p < .001$, and explained 74% of the variation in ATT, thereby supporting the contention in the AttrakDiff literature that hedonic and pragmatic quality explain attractiveness. The standardized coefficients (i.e., beta coefficients) in the model were 0.562 (PQ), 0.343 (HQI), and 0.163 (HQS). Formally, beta coefficients indicate how many standard deviations the dependent variable (here, ATT) will change per standard-deviation change in the predictor variable (HQI, HQS, or PQ). Because beta coefficients, unlike unstandardized regression coefficients, are independent of the unit of measurement, they allow for direct comparison of which of a set of predictor variables has the greater relative effect on the dependent variable [97]. That is, the effect of PQ on ATT was about three times that of HQS, and the effect of HQI was about twice that of HQS.

4.4 The AttrakDiff data indicated ordinary user experiences

Figure 2 shows the ten days of AttrakDiff data. For all four constructs, the values centered on the middle of the scale (i.e., around 4) throughout the ten days. Because the two grey lines give the mean plus/minus the standard deviation, the band between these two lines by definition contained 68% of the data. The bands ranged from above 3 to about 5, a narrow range, for ATT, HQI, and HQS. The band for PQ was slightly wider and centered on slightly lower mean values. For the two hedonic qualities, the minimum and maximum values were close to the bands spanned by the grey lines; thus, all data for HQI and, especially, HQS were within a narrow range. We contend that with their fairly narrow range around the middle of the scales the data for the four AttrakDiff constructs indicated ordinary user experiences. To substantiate this contention, Table 5 gives the details for the linear regressions shown as trend lines in Figure 2. With mean absolute errors below two tenths of a scale point, the regression models fitted the data well. The slopes of the four regression models were near 0, thereby indicating that the mean of the data across the ten days was a good prediction of the value at any specific day. The low R^2 values reflected this finding by quantifying the limited ability of the regression models to predict values beyond what the mean alone could do. That is, the AttrakDiff data displayed little variation over time and thereby remained close to the intercepts, which were around 4.

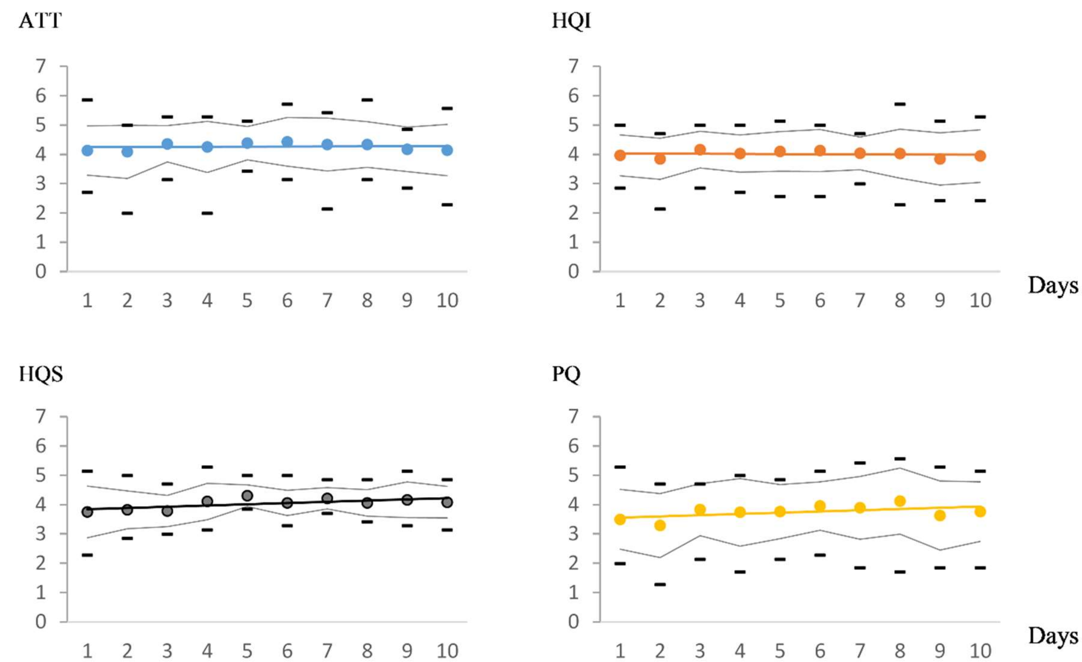


Figure 2. Daily average for attractiveness (ATT), hedonic quality identification (HQI), hedonic quality stimulation (HQS), and pragmatic quality (PQ). Each dot gives the average across the twelve participants. The straight line is the trend line from a linear regression. The two grey lines are the average plus/minus the standard deviation. The bars show the minimum and maximum values.

Table 5. Linear-regression models of the daily averages of attractiveness (ATT), hedonic quality identification (HQI), hedonic quality stimulation (HQS), and pragmatic quality (PQ).

Construct	Intercept	Slope	MAE	R^2
ATT	4.232	0.005	0.104	2%
HQI	4.033	-0.005	0.086	2%
HQS	3.801	0.042	0.110	44%
PQ	3.519	0.042	0.162	29%

Note: MAE – mean absolute error

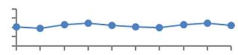
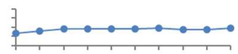
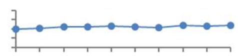
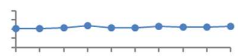
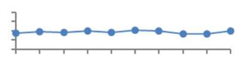
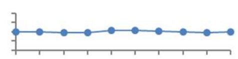
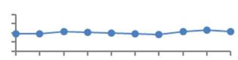
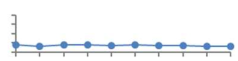
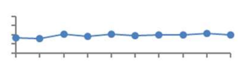
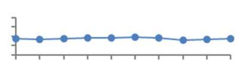
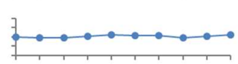
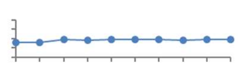
4.5 The GX data indicated ordinary user experiences

Table 6 shows the 18 user-experience items from the GX questionnaire. For all but two items, the mean was at most 0.26 scale point from 3, the middle of the scale. These 16 items were simple to use, business oriented, simple design, good displays, adequate graphs, reassuring, exciting, challenging, demanding, easy to use, controlled by me, intelligent and smart, difficult, transparent, interesting, and enjoyable. Only 168 (3%) of the 5386 ratings of these 16 items were 1 and only 139 (3%) were 5. That is, 94% of the 5386 ratings were one of the three middle values 2 (23%), 3 (48%), and 4 (24%). We take this to imply that the participants overwhelmingly had ordinary user experiences.

The two items with mean values more than 0.26 from the middle of the scale were ‘Fills me with awe’ and ‘Useful’. For ‘Fills me with awe’, the ratings were low. There were almost as many 1-ratings for this item alone (140) as for the 16 above-mentioned items together (168). The low ratings for this item further strengthened the finding of ordinary user experiences. For ‘Useful’, the mean rating was 3.66. This item had the highest number of 5-ratings (23, i.e. 7%) among the 18 items and by far the highest number of 4-ratings (197, i.e. 57%). That is, the ordinariness of the user experiences did not prevent the participants from simultaneously experiencing the climate-management system as fairly useful in their work.

Table 6 also shows the day-by-day evolution of the items and a linear regression of these daily averages. With mean absolute errors below two tenth of a scale point, the regression models fitted the data well. Like for the AttrakDiff data, the slopes of the regression models were near 0. The largest slope was as small as 0.040 (simple design). That is, the items varied little from one day to another. For all 18 items, the mean was a good prediction of the value at any specific day. Moreover, the means were close to the middle of the scale, except for ‘Fills me with awe’ and ‘Useful’.

Table 6. Means and day-by-day evolution of the 18 user-experience items in the GX data. The day-by-day graphs show the daily average of the twelve participants' three daily GX questionnaires. The regression models give the results of a linear regression of the daily averages shown in the graphs.

Item	Mean	SD	Day-by-day graph	Regression model		
				Intercept	Slope	MAE
Simple to use	3.19	0.74		3.06	0.024	0.14
Business oriented	2.75	0.99		2.54	0.039	0.11
Simple design	3.12	0.70		2.89	0.040	0.14
Good displays	3.22	0.70		3.02	0.036	0.06
Adequate graphs	3.21	1.00		3.10	0.020	0.06
Reassuring	3.00	0.74		2.79	0.039	0.05
Exciting	2.86	0.84		2.87	-0.002	0.13
Challenging	3.01	0.91		3.01	0.001	0.07
Demanding	2.92	0.97		2.89	0.004	0.07
Easy to use	3.03	0.69		2.91	0.021	0.10
Fills me with awe	1.71	0.79		1.79	-0.014	0.04
Controlled by me	3.00	0.91		2.94	0.011	0.07
Intelligent and smart	2.91	0.72		2.71	0.037	0.09
Difficult	2.74	0.93		2.77	-0.006	0.08
Transparent	3.16	0.75		2.99	0.030	0.11
Interesting	3.06	0.77		2.95	0.021	0.09
Useful	3.66	0.69		3.57	0.016	0.07
Enjoyable	2.81	0.69		2.64	0.030	0.06

Note: *SD* – standard deviation, *MAE* – mean absolute error

4.6 Variation across use situations

We also tested the 18 user-experience items for variation across use situations. Using conservative (i.e., nonparametric) Mann-Whitney tests, we found significant differences in the distribution of the item ratings for a series of items, see Table 7. With respect to whether the participants were alone or with someone when using the system, we found that when alone they experienced the system as simpler to use, less business oriented, simpler in its design, having better displays, less challenging, less demanding, easier to use, more under their control, and more transparent. A likely reason for these differences was that when the participants were with someone it was normally superiors, clients, and other people in front of whom the participants wanted and needed to appear sharp. With respect to whether the participants were in the office or greenhouse when using the system, we found that when they were in the office they experienced the system as simpler to use, more business oriented, having more adequate graphs, less challenging, less demanding, easier to use, and more transparent. A likely reason for these differences was that the greenhouse presented specific issues that required localized action, whereas the office was more often used for general issues and monitoring. With respect to whether the participants used the system for gaining an overview of the climate in the greenhouse or for adjusting the greenhouse climate, we found that when they used it to gain an overview they experienced it as simpler in its design and more under their control.

While the variation across use situations is informative, the magnitude of the differences was modest. The largest difference was 0.36 scale point for adequate graphs in the office versus greenhouse. In addition, 8 of the 18 items (reassuring, exciting, fills me with awe, intelligent and smart, difficult, interesting, useful, and enjoyable) did not vary significantly with any of the three situational variables. Thus, the analysis of variation across use situations further supports the finding of ordinary user experiences.

Table 7. Variation in the 18 user-experience items across three use-situation variables in the GX data. For each variable, the columns give the mean item ratings and the result of a Mann-Whitney test

Item	Who?			Where?			What?		
	Alone	With someone		Office	Greenhouse		Overview	Adjustment	
Simple to use	3.26	3.07	*	3.32	3.04	***	3.30	3.15	
Business oriented	2.66	2.99	*	2.86	2.61	*	2.84	2.70	
Simple design	3.20	2.97	**	3.17	3.05		3.22	3.05	*
Good displays	3.28	3.12	*	3.28	3.15		3.28	3.18	
Adequate graphs	3.25	3.14		3.35	2.99	*	3.22	3.23	
Reassuring	3.06	2.90		3.07	2.92		3.01	3.02	
Exciting	2.82	2.93		2.88	2.85		2.86	2.88	
Challenging	2.93	3.17	*	2.90	3.21	***	3.02	3.02	
Demanding	2.82	3.08	**	2.80	3.11	**	2.94	2.90	
Easy to use	3.09	2.93	*	3.12	2.90	**	3.08	3.00	
Fills me with awe	1.78	1.58		1.68	1.73		1.72	1.69	
Controlled by me	3.09	2.85	**	2.95	3.09		3.11	2.91	*
Intelligent and smart	2.89	2.95		2.90	2.96		2.96	2.89	
Difficult	2.70	2.81		2.66	2.87		2.72	2.75	
Transparent	3.22	3.05	*	3.28	2.98	***	3.16	3.16	
Interesting	3.00	3.17		3.13	2.98		3.04	3.11	
Useful	3.68	3.61		3.65	3.68		3.72	3.62	
Enjoyable	2.80	2.84		3.32	3.04		3.30	3.15	

* $p < .05$, ** $p < .01$, *** $p < .001$ (Mann-Whitney test)

4.7 The interview data indicated ordinary user experiences

The interview data confirmed and elaborated the AttrakDiff and GX data. An important elaboration was that the ordinary user experiences owed to the participants' expertise. It was on the background of having worked in greenhouses for years that the participants experienced the use of the climate-management system as ordinary. Their work for example involved that the conditions in an individual greenhouse could differ even though the system provided centralized access to all the greenhouses, as explained by one participant:

> The greenhouses are not built at the same time. So, in some of them there are many watt [for heating], in others there are fewer. Some have large rooms, others have small rooms. That makes a difference. Even if it is the same temperature and humidity outside, you can have ten different climates in ten different greenhouses, if they are built differently or badly oriented with respect to shade or what not. *(Participant 15)*

Thus, adjusting for differences among greenhouses was central to their work. To adjust the climate in the greenhouses, the system provided codes for reading sensors and setting actuators (e.g., "308" for closing the windows in a greenhouse). Some climate-management tasks merely involved the use of a few codes, but because the participants often needed fine-grained control of the greenhouse climate, they made frequent use of a variety of codes.

With respect to the participants' overall experience of how attractive the climate-management system was to use, they repeatedly described it by rejecting positive as well as negative characterizations. They, for example, stated that "*It is neither bad, nor good*" (ATT5, Participant 6) and "*It is not motivating but not directly demotivating either*" (ATT7, Participant 12). These indirect statements of ordinariness were supplemented with explicit statements such as "*There is nothing special about it [i.e., the system]*" (ATT2, Participant 3). In these examples, the participants expressed that the system was unremarkable and nothing out of the ordinary. In other statements, the participants expressed difficulty in even applying the AttrakDiff terms to the climate-management system. For example, Participant 6 considered the repulsive/pleasing item (ATT6) foreign to the system: "*Repulsive or pleasing? No. It is a work tool.*" By being a work tool, the system was, according to this participant, neither repulsive, nor pleasing. Apparently, these terms were too emotion-laden – too out of the ordinary – to describe the participant's experience of the climate-management system.

Regarding the hedonic quality of identification, the participants did not experience it to any considerable extent. The reasons varied across participants. Participant 3 found the system modestly presentable (HQI7) in social situations: "*If I, for example, have the other growers up here to discuss climate and I want to show them something, then they almost fall asleep because of all the things I have to press before I get to show anything.*" Participant 13 experienced the system as professional (HQI2), but only up to a point: "*It is professionally made, I can't say it's not. There are no errors as such. But it could, I think, be easier for a grower to approach; I don't think it always is [easy].*" And Participant 9 had, with increasing expertise, come to experience the system as neither connecting him with others, nor isolating him from them (HQI1): "*In the beginning, back in 1986, I was very outgoing to hear how others did things, but after using the system for all these years I am neutral [regarding whether the system isolates or connect].*" While these participants were not enthusiastic about the system, it is important to note that they were not disgruntled either. They had reservations, but these reservations were set against a generally pragmatic attitude. This pragmatic attitude toward the climate-management system was expressed succinctly by Participant 15 who commented that: "*It is okay… I mean, it is what it is*" (HQI7). Furthermore, Participant 13 noted that the nature of the work made some things difficult, irrespective of the system. Specifically, it took time before climate changes had consequences for the plants. This delayed feedback made climate management difficult, and there was little the system could do about that (HQI4).

Regarding the hedonic quality of stimulation, the participants continued to describe their experience of the climate-management system as mundane and ordinary. For example, they commented that "*It is absolutely not creative, but I wouldn't say it is unimaginative either*" (HQS2, Participant 9), "*It is fairly conservative*" (HQS4, Participant 3), "*It is a bit on the boring side*" (HQS5, Participant 6), "*It is not a particularly challenging system*" (HQS6, Participant 9), and "*Actually, it is somewhat traditional*" (HQS7, Participant 1). At no point did they associate the use of the system with dramatic positive stimulation or with dramatic negative stimulation. Furthermore, their comments were not stated as criticism but rather as informed description. In detailing why the system was neither creative nor unimaginative (HQS2), the participants mentioned that its "*screens look very similar*" (Participant 13) and that "*It lacks the final touch*" that would require designing it in collaboration with a grower (Participant 3). To bring out his experience of the climate-management system, Participant 10 contrasted it with a product he considered extraordinary: "*It is not like opening an iPad or feeling that you are sitting with an Apple product and thinking 'wow'. Climate management is a little more old-school, a little more conventional*" (HQS1). When talking about challenges (HQS6), the participants focused on the potentially severe economic consequences of harming the plants through faulty climate management. However, this risk was perceived as small because the day-to-day use of the system relied on a tested-and-tried configuration of codes.

Regarding pragmatic quality, the participants experienced their use of the system as unremarkable, but they also emphasized that it required experience to use the system. Because the participants were experienced, they rarely found themselves in situations that were out of the ordinary. The codes used for operating the system featured prominently in the participants' experience of its pragmatic quality. While Participant 11 commented that "*When you use the same codes, it is a fairly simple system*" (PQ2), Participant 9 found the system "*a bit confusing owing to the codes you constantly need to refer to*" (PQ6). As a consequence, the participants experienced the system as "*indispensable*" (PQ3, Participant 10) but also as requiring that "*you work with it often*" (PQ5, Participant 13). The participants worked with the system every day. Therefore, they generally experienced it as predictable, though with occasional unpredictable episodes (PQ5). Participant 15 summarized the views of many participants with his statement that "*It is simple to make changes, but there are many things you can change. So, it is sort of in the middle*" (PQ2).

5 Discussion

Our results indicate that AttrakDiff reliably captures the hedonic and pragmatic qualities of greenhouse growers' work. We have also characterized their experience of their work by identifying several patterns that indicate ordinariness. In the following, we discuss these two findings and contextualize them by returning to the heart model of UX at work.

5.1 Capturing UX at work with AttrakDiff

Our data show that AttrakDiff can be used to measure professional greenhouse growers' UX at work. The three-factor structure of AttrakDiff is recognizable in the growers' responses, and the three factors (HQI, HQS, and PQ) explain 74% of the variation in the attractiveness of the climate-management system. These findings support Schrepp et al. [96], who report that AttrakDiff can be used to measure and explain differences in the attractiveness of business software. Consistent with the assumptions of AttrakDiff, we find that the attractiveness of the climate-management system is not determined solely by the instrumental and goal-directed concerns captured by pragmatic quality, but also by the hedonic qualities of identification and stimulation. That said, the effect of pragmatic quality on attractiveness was about three times that of hedonic stimulation, and it was also larger than that of hedonic identification. The strong effect of pragmatic quality on attractiveness is consistent with previous studies of UX at work [26,74,96]. However, while Schrepp et al. [96] hypothesized that pragmatic quality would have the stronger effect on attractiveness, they found that the three AttrakDiff factors had similarly large effects on attractiveness.

Like Walsh et al. [109], we wish to point out that AttrakDiff alone does not explain the causes of a change in UX. To elicit explanations, AttrakDiff results must be supplemented with richer data such as interviews. Furthermore, we want to point out that the AttrakDiff factor structure in our data is somewhat fragile in the sense that five items loaded on another factor than the one they were supposed to load on (Table 3). Specifically, four of the seven HQI items loaded more strongly on HQS or PQ, and one of the seven HQS items loaded more strongly on HQI. In contrast, all seven PQ items loaded most strongly on PQ, thereby indicating that PQ was a more robust construct than especially HQI. We contend that the growers had some difficulty applying the hedonic AttrakDiff items to their horticultural work. Hassenzahl et al. [36] find that hedonic quality depends on the extent to which the use of a system creates meaningful experiences that contribute to the fulfilment of psychological needs. On that basis, the application of AttrakDiff in work settings can be seen as a measurement of people's experiences of need fulfilment in interactions with work systems.

5.2 Ordinary UX at work

Recent work by Meneweger et al. [70] demonstrates the importance of the study of ordinary UX for understanding how technology enters into shaping workers' experiences. In this study of greenhouse growers, we find that ordinariness is a key characteristic of UX at work. We provide evidence of three ways in which UX at work is ordinary: It leads to middle-of-the-scale ratings, it remains largely constant over time, and it varies little across use situations.

First, UX at work is ordinary in the sense of leading to middle-of-the-scale ratings. In the GX data, the vast majority of the ratings were within the three middle values of the five-point scale. In the AttrakDiff data, the ratings centered around the middle of the scale even though the participants rated the day's most important experience with the system. And in the interview data, the participants gave middle-of-the-scale descriptions by repeatedly rejecting positive as well as negative characterizations of their experience. These findings are in contrast to the previous UX literature, which has mainly focused on extraordinary and memorable experiences [58]. For example, gamification studies explicitly aim to induce stronger emotions in workers [106], and Kujala et al. [57] find dramatic shifts in UX within a 1.5 hour session. Meneweger et al. [70] propose that ordinary encounters with technology will tend to be repetitive and based on routine. The GX data strongly support this proposition. Though the collection of the GX data was event-driven (i.e., the growers responded immediately after interacting with the climate-management system with the experience still fresh in their mind), the mean value for all but two of the 18 GX items was at most 0.26 scale points from the middle of the scale.

Second, we find that UX at work remains largely constant over time. For the four AttrakDiff constructs as well as the 18 GX items, the largest slope over the ten days was as small as 0.04. That is, the value at any specific day differed little from the mean across the ten days. The 'flatness' of the data supports the observation by Meneweger et al. [70] that ordinary UX at the factory floor consists of the experiences where workers consider their interactions with work systems unremarkable in that they do not stand out from other experiences with the systems. However, the literature on UX over time mostly argues that prolonged use is motivated by qualities different from those that provided positive initial experiences [49]. In their study of UX at work, Harbich and Hassenzahl [26] argue that "Rather than understanding UX as static, we emphasize its dynamic, 'growth'-oriented nature". They find that the UX of work products changes over weeks of use, influenced by user attributes such as expertise and by product attributes such as attractiveness. On this basis, they conclude that time is an important predictor of the UX of work products. We find no support for such a conclusion in our data, see Figure 3. While the previous literature on UX over time has studied the adoption stage of a new technology (for an exception, outside the HCI literature, see [82]), we took a 'longitudinal snapshot' of UX at work during continued use. All the average UX trends (i.e., the red lines in Figure 3) show little change over time in UX at work. Similarly, but contrary to Harbich and Hassenzahl's [26] own conclusion, we would argue that the average UX trends in their Figure 1 also show little change over time. The individual differences in, for example, business orientedness (Figure 3) pose interesting questions for future research.

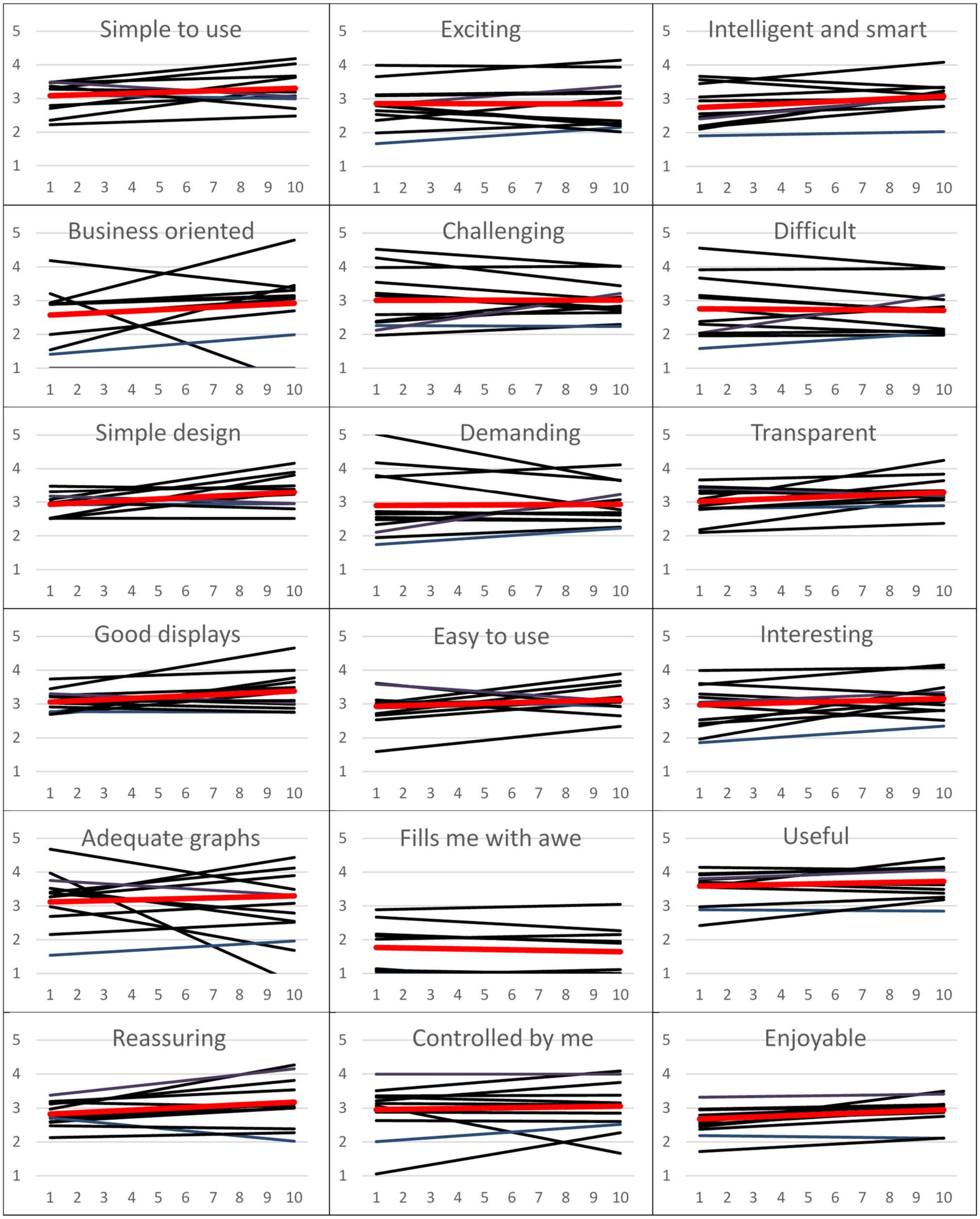


Figure 3. UX trends over the ten days for the 18 GX items. The graphs show the trend for each participant (black) and the average trend for all participants (red). The trend lines are determined by linear regression.

Third, we find that UX at work varies little across use situations. While we found significant variation across use situations for about half of the GX items, the size of these situational differences was modest; the largest difference was 0.36 scale point for adequate graphs in the office versus greenhouse (Table 7). In addition, nearly half of the GX items did not vary significantly with any of the three situational variables. These findings do not contradict the proposition by Shaw et al. [99] that situational contexts influence UX during continued use but suggest that the resulting differences in UX are small, at least during continued use at work. Furthermore, the growers' non-negative – though also non-positive – experience of the climate-management system sufficed in making them use the system without questioning its quality. Shaw et al. [99] presume that a different set of factors becomes predictive of technology use when the adoption stage has ended and the technology entered into continued use. To that end, the GX data showed that the growers' UX was mainly influenced by whether they were alone or with someone when using the system and whether they were in the office or greenhouse when using it. Notably, being with someone influenced the growers' UX negatively, probably because it was associated with the social stress of performing in front of superiors and clients. One of the participants also found the system modestly presentable in social situations with peers, who had to wait a lot because operating the system involved issuing numerous commands.

Meneweger et al. [70] point out that what is experienced as ordinary by one person may be experienced as unordinary by another. We do not want to argue against that point but to suggest a couple of systematic sources of such variation. First, it appears likely that ordinariness becomes increasingly common with increasing work experience because still more situations resemble previously experienced situations, and still fewer situations stand out as presenting novel experiences. While the experienced growers in this study overwhelmingly had ordinary user experiences with the climate-management system, we would imagine that novice growers experience the system differently. Second, ordinary UX is more likely during continued use than during the adoption stage where all users have little experience with the system and frequently find themselves in novel situations. The adoption stage is, however, brief compared to the extensive period of time during which many work systems are in continued use. Thus, ordinary UX may be the more common, but easily overlooked, kind of UX. Third, we would expect some level of commonality in UX at work. Within a stakeholder group such as professional growers, there are shared norms, practices, and cultural models for interacting with the climate-management system [12]. These shared norms, practices, and models shape the individual grower's experiences and, thereby, create commonalities in their UX at work. For example, our data show substantial commonalities in the participating growers' ordinary UX.

In their work, Meneweger et al. [70] define ordinary UX by contrasting it with unordinary UX. Conceptually, this contrast captures an important difference between the emerging studies of UX at work and the existing UX literature with its primary focus on extraordinary and memorable experiences. There is, however, an important caveat. The contrast runs the risk of portraying ordinariness as a quality on its own, thereby for example suggesting that the conceptual contrast translates into a measurement item (e.g., a semantic differential with the end points ordinary and extraordinary). We believe that ordinariness is not so much a quality on its own as it is the way in which an experience fails to exhibit other qualities. An experience is ordinary when it is neither good nor bad, neither pleasing nor repulsive, and so forth – that is, when it is middle of the scale. With the middle-of-the-scale conceptualization, ordinary UX is an absence rather than a presence. It is an absence of experiential qualities rather than a presence of ordinariness. This conceptualization maintains the unremarkable character of the ordinary by defining ordinary UX without shifting ordinariness into the foreground. Yet, the middle-of-the-scale conceptualization still shows how ordinary UX can be measured. With respect to measurement, this conceptualization of ordinary UX suggests that concurrent, or near concurrent, data collection is crucial to avoid that averaging processes produce middle-of-the-scale responses by cancelling out real variation. In addition, it is important to use all three AttrakDiff factors in evaluations because variation may occur in any of them.

5.3 A heart model of UX at work

While the existing literature on UX tends to conceptualize technologies as standalone products (e.g., axes [109] and mobile phones [57]), the technologies used in workplaces are woven into issues about the division of labor, competences of staff groups, coupling of work tasks, and so forth. In addition, workplaces are becoming increasingly digital. Digital workplaces [14] are rapidly emerging as places where employees work virtually some of the time, shift among different times and locations, and often work in new ways. First, the growers in this study work virtually when they sometimes monitor the greenhouses remotely from their homes. Second, they do climate management at flexible times during the day and from the office as well as by touring the greenhouses. Third, they work in new ways when they employ digital tools such as smartphones to monitor the climate while they are mobile. Thus, designing for UX at work requires that the entire digital work environment is taken into consideration; it does not suffice to consider an IT system a standalone entity. The heart model of UX at work (Figure 1) aims to provide such an encompassing approach.

Conceptually, the heart model positions UX at work in between usability and employee wellbeing. First, UX at work is more than usability. While the two concepts share a focus on how users experience technology in use, most definitions of usability restrict it to the pragmatic qualities of this experience [39,103]. In contrast, UX at work is about its pragmatic as well as hedonic qualities. In AttrakDiff, these two kinds of qualities are explicitly present as separate factors. In our empirical data, the findings about HQI and HQS (e.g., that the climate-management system is neither creative, nor unimaginative) extend beyond usability by incorporating what the system is felt like, rather than merely how effectively and efficiently it supports the attainment of specified goals. Furthermore, the heart model makes the structure of the workplace an explicit element in UX at work. By including the structure, the heart model emphasizes that UX at work is also shaped by the division of labor, managerial hierarchy, organizational culture, norms for expressing emotions, and so forth. These aspects are absent in most discussions of usability, even though the concept of usability recognizes the importance of the context of use. When structural aspects are included in discussions of usability, it is typically with the intention of turning the standard concept of individual-focused usability into one of organizational usability [17,39]. Regarding structure, our data for example showed that having superiors present in social situations affected UX at work negatively.

Second, UX at work is a narrower concept than wellbeing at work. Fisher [21] conceptualizes wellbeing at work as consisting of eudaimonic wellbeing, hedonic wellbeing, and social wellbeing. Eudaimonic wellbeing is about engagement, meaning, and intrinsic motivation; hedonic wellbeing is about job satisfaction and positive affect; and social wellbeing is about quality connections, social support, and satisfaction with coworkers. There are similarities between the pragmatic qualities of UX at work and eudaimonic wellbeing, between the hedonic qualities of UX at work and hedonic wellbeing, and between the structural element of the heart model and social wellbeing. However, UX at work aims to conceptualize and understand the experiences associated with the use of work technologies, while employee wellbeing does not prioritize technology over any other factor that influences wellbeing. In any concrete situation, technology may or may not matter to employee wellbeing. In digital workplaces, technologies are, however, increasingly important to how employees perform and experience their jobs. Thus, research into UX at work can contribute substantially to understanding employee wellbeing. For example, our data showed that the growers experienced the climate-management system somewhat differently depending on whether they accessed it through the desktop computers in the office or the touchscreen control boxes in the greenhouses. This finding provides evidence of several modest, but informative, effects of the desktop computers with their larger screen, better pointing devices, and so forth.

We recognize that the heart model of UX at work should be enhanced with psychological theory to be more thoroughly linked to employee wellbeing [51]. One inspiring idea from work psychology is the notion of job crafting [102], which assigns the individual employees a proactive role in reshaping their jobs. This idea combines the measurement and understanding of UX at work with efforts to change it in ways deemed attractive by the individual employee.

5.4 Limitations

Four limitations should be remembered in interpreting the results of this study. First, this study is about horticultural work, and the study results may in subtle ways be specific to this work domain. For example, horticultural work has a caring component (i.e., caring of pot plants and vegetables) that appears to differentiate it from many other manufacturing workplaces. We acknowledge the need for investigating UX at work in a range of work domains and, especially, for investigating its possible ordinariness in a range of work domains. Second, our sample of participants consisted of eleven male participants and one female participant. This gender bias partly reflects that the horticultural industry is male-dominated (in Denmark it employs about four times as many male as female employees). However, previous studies have shown that technology acceptance [107] and website design [104] are gendered. On that basis alone, it appears likely that UX is also perceived in gender-specific ways. The present study reflects a predominantly male view on UX at work and should be complemented with studies of other user groups. Third, the GX data are concurrent (i.e., collected during the workday, triggered by system use), while the AttrakDiff data are retrospective (i.e., collected at the end of the workday). On the one hand, it has strengthened the analysis of the ordinariness of UX at work that the concurrent as well as the retrospective data show strong evidence of ordinary UX. On the other hand, the two kinds of data collection preclude direct comparison of the AttrakDiff and GX data. Fourth, by themselves neither the GX data nor the AttrakDiff data explain why the growers experience the climate-management system the way they do. The interviews and the three use-situation variables (Table 7) begin to tease apart situational factors that influence the growers' GX responses, though only modestly. We acknowledge that additional data are needed for an in-depth analysis of the reasons for the growers' ratings.

6 Conclusion

This study reports findings from a diary study of greenhouse growers' UX at work while they are using a climate-management system. The analysis shows that AttrakDiff validly and reliably captures the hedonic and pragmatic qualities of UX at work, but also that the link to the work domain of interest can be strengthened by the use of a domain-specific instrument. In addition, our data on patterns in hedonic and pragmatic qualities lend support to a recent proposal that UX at work is often rather ordinary. Our findings of ordinary UX stand in contrast to the widespread characterization that UX is positive – often dramatically so – and evolves dynamically over time. This study suggests that UX at work during the continued use of a central work system tends to be middle-of-the-scale and fairly unchanging over time. That is, the primary contribution of our analysis is the finding that UX at work may first and foremost be ordinary.

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Appendix

Table 8. Items of the AttrakDiff2 questionnaire and their English and Danish translation. Adapted from [96]. All items are presented with negative on the left and positive on the right. The Danish translation of items is added by us; note that it simply is our translation from German, we have not done a validation study. For our study, some items were reversed in the questionnaire.

Item	Original German items		English translation		Danish translation	
ATT1	Unangenehm	Angenehm	Unpleasant	Pleasant	Ubehagelig	Rar
ATT2	Hässlich	Schon	Ugly	Pretty	Grimt	Smukt
ATT3	Unsympathisch	Sympathisch	Unappealing	Appealing	Utiltalende	Tiltalende
ATT4	Zurückweisend	Einladend	Rejecting	Inviting	Afvisende	Inviterende
ATT5	Schlecht	Gut	Bad	Good	Dårligt	Godt
ATT6	Abstoßend	Anziehend	Repulsive	Pleasing	Frastødende	Tiltrækkende
ATT7	Entmutigend	Motivierend	Discouraging	Motivating	Demotiverende	Motiverende
HQI1	Isolierend	Verbindend	Isolates	Connects	Isolerer	Forbinder
HQI2	Laienhaft	Fachmännisch	Unprofessional	Professional	Uprofessionel	Professionel
HQI3	Stillos	Stilvoll	Lacking style	Stylish	Manglende stil	Stilfuld
HQI4	Minderwertig	Wertvoll	Poor quality	High quality	Dårlig kvalitet	Høj kvalitet
HQI5	Ausgrenzend	Einbeziehend	Excludes	Draws you in	Udelukker	Inkluderer dig
HQI6	Trennt mich von Leuten	Bringt mich den Leuten naher	Separates me from people	Brings me closer to people	Adskiller mig fra mennesker	Bringer mig tættere på folk

HQI7	Nicht vorzeigbar	Vorzeigbar	Not presentable	Presentable	Ikke præsentabel	Præsentabel
HQS1	Konventionell	Originell	Conventional	Original	Konventionel	Original
HQS2	Phantasielos	Kreativ	Unimaginative	Creative	Fantasiløs	Kreativ
HQS3	Vorsichtig	Mutig	Cautious	Bold	Forsigtig	Modig
HQS4	Konservativ	Innovativ	Conservative	Innovative	Konservativ	Innovativ
HQS5	Lahm	Fesselnd	Dull	Absorbing	Kedelig	Engagerende
HQS6	Harmlos	Herausfordernd	Harmless	Challenging	Harmløs	Udfordrende
HQS7	Herkömmlich	Neuartig	Conventional	Novel	Konventionel	Ny
PQ1	Technisch	Menschlich	Technical	People-centric	Teknisk	Menneske-orienteret
PQ2	Kompliziert	Einfach	Complex	Simple	Kompleks	Simpel
PQ3	Unpraktisch	Praktisch	Impractical	Practical	Upraktisk	Praktisk
PQ4	Umständlich	Direkt	Cumbersome	Facile	Omstændelige	Direkte
PQ5	Unberechenbar	Voraussagbar	Unpredictable	Predictable	Uforudsigelig	Forudsigelig
PQ6	Verwirrend	Übersichtlich	Confusing	Clear	Forvirrende	Klart
PQ7	Widerspenstig	Handhabbar	Unmanageable	Manageable	Uhåndterlig	Håndterbar

Note: ATT: attractiveness, HQI: hedonic quality – identification, HQS: hedonic quality – stimulation, PQ: pragmatic quality