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ORIGINAL ARTICLE

User experience in safety–critical domains: a survey on motivational orientations and psychological need satisfaction in acute care

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Abstract
The relevance of user experience in safety–critical domains has been questioned and lacks empirical investigation. Based on previous studies examining user experience in consumer technology, we conducted an online survey on positive experiences with interactive technology in acute care. The participants of the study consisted of anaesthesiologists, nurses, and paramedics ($N=55$) from three German cities. We report qualitative and quantitative data examining (1) the relevance and notion of user experience, (2) motivational orientations and psychological need satisfaction, and (3) potential correlates of hedonic, eudaimonic, and extrinsic motivations such as affect or meaning. Our findings reveal that eudaimonia was the most salient aspect in these experiences and that the relevance of psychological needs is differently ranked than in experiences with interactive consumer technology. We conclude that user experience should be considered in safety–critical domains, but research needs to develop further tools and methods to address the domain-specific requirements.

Keywords User experience · Healthcare · Eudaimonia · Hedonia · Need satisfaction · Meaning

1 Introduction

User experience (UX) addresses the perception and response of a specified user using a product to achieve a specified goal in a specified context (ISO ISO 9241-11 2018). UX measures go beyond typical usability measures such as effectiveness, efficiency, and the overall satisfaction of the user and address emotions, beliefs, or comfort (Hassenzahl 2018; Wright and McCarthy 2010). Often, UX is associated with fun, stimulating, and hedonic experiences when interacting with a product. UX has recently focused on eudaimonic aspects, such as meaning as well as values and well-being (e.g., Mekler and Hornbæk 2016, 2019). The concept of 'Well-being, health, and eudaimonia' has been named one of seven grand Human–Computer Interaction (HCI) challenges (Stephanidis et al. 2019), thereby broadening the understanding of the concept of UX and its correlates.

While UX, in general, is expected to be 'the main value driver in the future economy' (Nielsen 2017), its value in safety–critical domains like aviation, healthcare, process, or plant control has been questioned (Grudin 2016; Lee et al. 2017; Mentler and Herczeg 2016). In a well-known human factors textbook, Lee et al. (2017) mention 'satisfaction' as a goal that does not need to be accentuated in safety–critical domains. Similarly, Grudin (2016) stated in an HCI textbook that 'error reduction is critical, performance enhancement is good, and other goals are less important' (p. 92). One reason why the value of UX is being questioned may be that the initial UX concepts that emerged in the 2000s mainly considered seeking pleasure and fun in interaction with technology (Hassenzahl 2018). A second reason may be the strong focus on human factors, engineering psychology, and cognitive psychology of several authors, while UX and particularly modern UX theories emerged from the human–computer interaction community. Finally, some others consider safety

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as more important. Therefore, they neglect or even 'dismiss' user's experience (Mentler and Herczeg 2016).

In general, there are several arguments for investigating UX in safety–critical domains. First, following Wright and McCarthy (2010), humans always have an experience when interacting with technology. Considering and improving UX are one way to promote individual user well-being at work by applying knowledge of ergonomics and psychology, which are part of ISO ISO 9241-2 (1992). Second, as Grundgeiger et al. (2020) discuss, good UX in the form of need satisfaction and support to work in line with one's motivational orientation may support temporal safety management approaches by empowering staff to proactively close the gaps. Third, when considering performance as the result of the system (Hollnagel and Woods 2005; Hutchins 1995; Norman 1993), improving the UX of humans when using technology (i.e., two parts of the system) can improve performance. For example, providing the user with the experience of autonomy and competence when interacting with a clinical decision support tool makes its use more likely (Klüber et al. 2020). As a result, the decisions of the 'joint cognitive system' may be sounder. A further example is cognitive aids. In a very recent study, we have showed that using a cognitive aid has improved the attention distribution of the team leader during a simulated in-hospital cardiac arrest scenario (Grundgeiger et al. 2022). However, if cognitive aids are not accepted by staff, they are unlikely to be used. This is true despite cognitive and performance benefits (Marshall 2013).

However, only a few studies have examined the role of UX in safety–critical domains (e.g., Karvonen et al. 2012; Karvonen 2019; Klüber et al. 2020; Savioja et al. 2014; McCarthy and Wright 2005) or workplaces in general (e.g., Laschke et al. 2020a; Zeiner et al. 2018). Most of these studies have addressed the design of UX and used qualitative approaches. For example, Karvonen (2019) investigated user experience goals in design activities in safety–critical environments, such as rapid transit systems, container cranes in ports, command bridges for ships, and cars with driver-assistance systems. Klüber et al. (2020) designed and evaluated a decision support tool regarding user experience theory in the context of anaesthesiology. In the context of nursing, McCarthy and Wright (2005) considered nurses' experiences to address resistance, identity, and attachment when new technology is introduced. Quantitative approaches are less common to assess UX in safety–critical domains. For example, (Savioja et al. 2014) used a questionnaire to assess the experience of users with regard to the use of new technology in plant control. However, the authors also highlighted that more research is needed to understand what constitutes UX in these domains. Simonsen and Osvalder (2018) identified categories of measures to guide the choice of evaluation methods for socio-technical systems such as nuclear power plant control room systems. They included a UX category in their guide, but pointed out that UX is not adequately considered in the reviewed papers. To the best of our knowledge, in the safety–critical domain of acute care, there is a lack of studies investigating and quantifying the relevance of UX and its various aspects, such as hedonic and eudaimonic orientations.

In this study, we investigate the relevance of UX in the safety–critical domain of acute care using a quantitative approach that is not design-oriented. Acute care encompasses all aspects of care in which humans cannot survive on their own, but rather depend on acute care staff utilising acute care equipment. Typical examples of acute care situations include anaesthesiologists monitoring and supervising a patient during general anaesthesia for surgery, nurses working in the intensive-care unit, or paramedics attending to an emergency. Building on prior work (Hassenzahl et al. 2015; Huta and Ryan 2010; Mekler and Hornbæk 2016), we conducted a survey on episodes of positive experiences with interactive technology at work, including multiple psychological scales to measure, for example, the motivational orientation, experienced affect, and psychological need fulfilment during these episodes. Our specific aims and contributions were to: (1) provide empirical data rather than theoretical arguments to address the question of whether UX is relevant in safety–critical domains, (2) examine which aspects of UX, such as motivational orientations and psychological needs, were involved in positive experiences with interactive technology, and, (3) identify potential correlates with the eudaimonic, hedonic, and extrinsic motivational orientations.

1.1 Conceptualising user experience

The interaction with technology is the fundamental element of users' technological experiences. Interaction can, for example, be seen as *transmission* when a sender is sending a message over a noisy channel, as *tool use* when a human uses tools to manipulate and act in the world, or as *experiences*, i.e., an ongoing stream of expectations, feelings, and memories (Hornbæk and Oulasvirta 2017). The lack of a single widely recognised definition of interaction (Hornbæk and Oulasvirta 2017) and UX has led to different conceptualisations of UX (Bargas-Avila and Hornbæk 2011). The experiential dimensions that are investigated in UX research range from emotions and affect, enjoyment and aesthetics, to hedonic quality, engagement, flow, motivation, or frustration (Bargas-Avila and Hornbæk 2011), and recently, ethical dissonance (Vanderhaegen 2021). Often, the understanding of UX depends on the researchers' or practitioners' focus, such as inclusive design that focuses on the accessibility of technology (Clarkson and Coleman 2010). Given its wide range, it is not surprising that UX overlaps with other approaches

that assess technology, such as the Technology Acceptance Model (Hornbæk and Hertzum 2017).

From a UX researcher's viewpoint, the different conceptualisations may mirror the complexity and multidimensionality of UX; for engineers and practitioners, the different concepts may be interpreted as incomplete or unclear conceptualisations and may have contributed to disregarding the necessity for UX in safety–critical domains (Mentler and Herczeg 2016). Furthermore, in influential human factors (Lee et al. 2017) and HCI textbooks (Grudin 2016) and U.S. Food and Drug Administration recommendations (2016), UX is explicitly or implicitly deemed irrelevant in safety–critical domains. However, as we summarise below, there are other opinions on the role of UX in safety–critical domains, and design studies indicate the value of UX design in these domains. Our study's first goal was to collect quantitative and empirical evidence on the role of user experience in safety–critical sectors.

1.2 Psychological needs

Good UX has been operationalised as the satisfaction of psychological needs (Hassenzahl 2010; Hassenzahl et al. 2011). The satisfaction of psychological needs is seen as a source of positive experiences with interactive technology (Hassenzahl et al. 2011). For example, successfully completing difficult tasks can satisfy the need for competence; feeling close and connected to other people can satisfy the need for relatedness. Psychological need satisfaction has been extensively studied in the realm of consumer technology (e.g., Diefenbach et al. 2014; Partala and Kallinen 2011). Hassenzahl et al. (2011), for example, used the critical incident technique to examine positive experiences with technology. Participants were asked to report on a recent, outstanding, positive experience and subsequently rate the experience in terms of need fulfilment, affect, product perception, evaluation, and attribution of positive experience to the interactive technology. The findings indicated that prominent needs in positive experiences with consumer technology are relatedness, stimulation, and competence. Mekler and Hornbæk (2016) used a similar approach to investigate positive experiences with consumer technology and the association of need satisfaction with motivational orientations. They focused on eudaimonic orientation as well as hedonic orientation. Moreover, they found eudaimonic experiences to be characterised by increased need fulfilment and being associated with meaning.

Despite research on consumer technology, research on psychological need satisfaction and technology in workplaces and in safety–critical domains is rare (Laschke et al. 2020a). Lu and Roto (2015) examined meaningful experiences in work-related contexts and proposed a design framework for work tools based on two theories: the mechanisms of meaningful work and the positive design framework. Zeiner et al. (2016, 2018) studied positive user experiences and the role of technology in the workplace, resulting in experience categories to support designing for the workplace. Tuch et al. (2017) found that work and leisure experiences differ in terms of psychological need fulfilment. These results indicate that need fulfilment can be reliably used to distinguish between work and consumer technology (Tuch et al. 2017). For example, an experience that is rated highly on competence, security, and popularity is more likely to be in a work context, while high ratings on relatedness, pleasure/stimulation, and beauty favour are leisure context.

In healthcare, Laschke et al. (2020a) used psychological needs in a design study to develop well-being-driven software applications for the diagnosis and documentation of X-ray images. However, radiology lacks the fast-changing and dynamic characteristics of more typical socio-technical and safety–critical domains such as aviation and anaesthesiology (Grundgeiger et al. 2014). Klüber et al. (2020) focused on need satisfaction in developing and evaluating a decision support tool for critical events in anaesthesiology. These researchers started from the premise that UX is important and, therefore, targeted UX in their design ideas. In general, the results showed that users' psychological needs do indeed play an important role in workplaces and safety–critical domains. However, these design-oriented studies provided only qualitative data, and the sample sizes were small. The second goal of our research was to determine quantitatively which psychological needs are most essential for positive experiences with technology in a safety–critical domain such as acute care.

1.3 Motivational orientations: eudaimonia, hedonia, and extrinsic orientation

Finally, we were interested in motivational orientations in acute care, including hedonic and eudaimonic orientations, which represent different conceptual aspects of UX. Huta (2017a) distinguished between three categories and associated core elements of how people conceptualise and seek a good life: someone with an eudaimonic orientation strives for authenticity, meaning, excellence, virtue, and growth; someone with a hedonic orientation seeks pleasure, enjoyment, and comfort; or someone with extrinsic orientation aims for material wealth, status, power, fame, and popularity. While hedonic and eudaimonic orientations can be seen as healthy motivations, extrinsic orientations represent unhealthy ways of pursuing fulfilment in life (Huta 2017a). The distinction between the two healthy orientations, eudaimonia and hedonia, dates back to ancient Greece and Hellenic philosophy. Both concepts have been adopted by positive psychology (e.g., Huta and Ryan 2010), and have been discussed in the HCI literature (Desmet and Hassenzahl

2012; Mekler and Hornbæk 2019). Recently, empirical studies in HCI have complemented hedonic aspects of UX with a notion of meaningfulness (Mekler and Hornbæk 2016, 2019; Müller et al. 2015). Mekler and Hornbæk (2016) showed that eudaimonic and hedonic experiences exhibit different experiential patterns, including affect, needs, product quality, and meaning. They found eudaimonic experiences to be more strongly associated with positive affect and pragmatic product quality, and to be characterised by increased need fulfilment and a more pronounced experience of meaning. Experiencing meaning, as seen by Huta (2017b), consists of three interconnected elements: (1) sense, (2) value, and (3) implications. Associated experiences may (1) make sense in terms of coherence and clarity, (2) have value by being worthwhile and having priority, and (3) affect other aspects of one's life or the world in general. Laschke et al. (2020b) highlighted the potential of technology to increase meaning in the workplace, and Grundgeiger et al. (2020) argued that eudaimonic orientation, in particular, may be important for UX in safety–critical domains. The third aim of our study was thus to investigate the presence of the three motivational orientations during a positive experience with interactive technology in a safety–critical domain and to explore the correlations between the motivational orientations and other constructs such as psychological needs, affect, and the feeling of meaning.

1.4 The present study

We followed the approach and method of Mekler and Hornbæk (2016) and conducted an online survey using the critical incident method with healthcare personnel in acute care. The participants were specifically asked to remember and describe a positive experience with interactive technology at their workplace. Using the critical incident method (Flanagan 1954; Gremler 2004) ensured that we consider the experience of a specific healthcare professional interacting with technology to achieve a specified goal in a specified context. Subsequently, participants were asked to complete several questionnaires in relation to this experience. These questionnaires measured the motivational orientation, affect, need satisfaction, meaning, product quality, whether the experience was attributed to the interaction with the technology, and the future importance of the experience. As Mekler and Hornbæk (2016) have argued, the critical incident method offers the advantage that users can choose for themselves what constitutes a positive and meaningful experience. This approach is commonly used to investigate the positive and negative aspects of UX (Hassenzahl 2010; Mekler and Hornbæk 2016). Mekler and Hornbæk (2016) argued that it is particularly suitable to address meaning, because meaning does not become obvious at the very moment, but rather requires reflection and develops over time. In addition to the hedonic and eudaimonic motivation orientations investigated by Mekler and Hornbæk (2016), we included extrinsic motivational orientation. Furthermore, we addressed the feeling of meaning in the experience using the complete scale by Huta (2017b), distinguishing between feelings of sense, value, and implications. Using the same approach and measures (see Sect. 2.3 Measures) as in previous research will enable us to address the aforementioned aims of the study.

In relation to our first aim of whether UX is relevant in safety–critical domains, we considered hedonic and eudaimonic aspects, as well as psychological need satisfaction, to be part of the conceptualisation of UX. Similar to motivational orientations in interaction with consumer technology (Mekler and Hornbæk 2016) and research on the needs-based design of technology in healthcare (e.g., Klüber et al. 2020; Laschke et al. 2020a, b), we expected motivational orientations and psychological needs to be salient during positive experiences with interactive technology. To this end, we compared the ratings with the middle values of the scale and with means from research on positive experiences with consumer technology. Means above the scale's mean and close to ratings in research on consumer technology would indicate that need-based UX concepts are relevant for the interaction with technology in safety–critical domains.

In relation to our second aim of identifying which orientations and needs are important in a safety–critical workplace such as acute care, we followed the approaches of Hassenzahl et al. (2011, 2015) in the HCI context and Sheldon et al. (2001) in research on everyday life, and simply ranked the need ratings based on their means. Considering the need-based design of technology (e.g., Klüber et al. 2020; Laschke et al. 2020a, b), we expected that the needs for competence, autonomy, and relatedness would be most salient. We expected eudaimonic orientation—the actualisation of human potential, or activities that are congruent with a user's values—to be more pronounced than hedonic orientation, which is defined by enjoyment and pleasure. This expectation was based on the argument that eudaimonic orientation seems to be more relevant than hedonic orientation in safety–critical domains (Grundgeiger et al. 2020). Correspondingly, we do not expect extrinsic orientation to be rated very highly in the context of acute care. People who are extrinsically oriented strive for material wealth, status, power, fame, and popularity. Typical situations in acute care that involve interaction with technology rarely offer opportunities to strive for such attributes. Thus, we did not expect extrinsic orientation to be of particular importance, i.e., ratings below the middle point of the scale. Our third aim was tailored to the exploration of the relationship association between the three motivational orientations with other constructs.

2 Methods

2.1 Participants

Participants were recruited via staff mailing lists of three hospitals in Germany and by word-of-mouth. A total of 222 participants accessed the survey website, but only 140 started the survey. Out of 140, 51 participants dropped out when facing the first open-ended question, 32 responses were excluded, because they did not finish all the scales, and two were excluded, because their responses were exact duplicates of other responses. The final sample consisted of 55 participants (22 female, 32 male, and one unspecified) who were between 24 and 49 years old ($M = 34.30$ years, SD = 7.12). All participants were healthcare personnel in acute care, including 46 anaesthesiologists, four nurses, four paramedics, and one unspecified profession. Work experience in the respective professions ranged from 1 to 31 years ($M = 7.31$ years, SD = 6.19). Five euros were donated to Médecins Sans Frontières for each participant who provided their staff mail address. Additionally, participants could take part in a prise draw for a tablet computer. The study was reviewed by the local ethics committee, and each participant gave their informed consent.

2.2 Procedure

The online survey was created using LimeSurvey (www.limesurvey.org/). Based on previous studies on experience (Hassenzahl 2010; Hassenzahl et al. 2015; Müller et al. 2015; Partala and Kallinen 2011) and Mekler and Hornbæk (2016), in particular, the questionnaire included qualitative and open-ended questions, as well as quantitative scales.

After providing consent, participants were asked to 'bring to mind a single positive experience that involved interactive technology in the context of acute care'. Interactive technology could be software, monitoring devices, or any other working equipment used in acute care. Participants should 'think of the positive things in whatever way makes sense to you'. Besides describing their experience, participants were asked to report on when and where the experience happened, who was present during the experience, and what the experience meant to them. Subsequently, they rated their experience in terms of hedonic, eudaimonic, and extrinsic orientation, affect, need satisfaction, meaning, future importance, attribution, and product quality. The individual scales are described in the measures section. Finally, the participants were thanked for their time. The survey took approximately 25–30 min to complete. The procedure was piloted with several participants.

2.3 Measures

In the following, we report in detail how we applied or adapted measures from previous research that this study is based on. The measures are summarised in Table 1. We measured motivational orientations as conceptualised by Huta (2017a) and considered eudaimonia, e.g., seeking to do what you believe in; seeking to use the best in yourself; hedonia, e.g., seeking enjoyment; seeking pleasure; and extrinsic orientation, e.g., seeking to have high status and prestige; seeking power and dominance over others. In contrast to Mekler and Hornbæk (2016), we used the revised version of the Hedonic and Eudaimonic Motives for Activities (HEMA) scale, i.e., the HEEMA scale that includes extrinsic motives, adapted by Huta (2017a) from de Groot and Steg (2008) and Kasser and Ryan (1996). Huta (2017a) recommended using the revised version, since it includes one additional item, i.e., seeking to contribute to others or the surrounding world, acknowledging the pursuit of meaning as an integral part of eudaimonia (Hassenzahl et al. 2015; Huta and Ryan 2010). The eudaimonic and hedonic orientation items were translated into German by Bujacz et al. (2016). Furthermore, the extrinsic sub-scale was translated by us.

Following Huta and Ryan (2010) and Mekler and Hornbæk (2016), we were interested in potential correlates emerging in conjunction with eudaimonic or hedonic motives such as affect and meaning. The Positive and Negative Affect Schedule—Expanded Form (PANAS-X) (Watson and Clark 1994) was used to assess more nuanced aspects of positive affect, specifically the sub-scales of joviality, self-assurance, attentiveness, serenity, and surprise. We used the German translation of PANAS-X (Grühn et al. 2010). 'Meaningful affect' targets reflectiveness in meaningful interactions, such as feeling compassionate, introspective, or contemplative, and was measured using our own translation of the meaningful affect scale by Oliver and Raney (2011). Other than Mekler and Hornbæk (2016), we employed all four items of the original scale, which has primarily been used in media and entertainment research. In line with Mekler and Hornbæk (2016), we referred to the meaningful affect scale as 'contemplativeness' to avoid confusion with other scales measuring the experience of meaning.

Keeping in line with previous research (Hassenzahl 2010; Hassenzahl et al. 2015; Müller et al. 2015; Partala and Kallinen 2011), we included need fulfilment and technology perception as further variables of interest. Need fulfilment was measured with an abridged version of the scale by Sheldon et al. (2001), including the satisfaction of the needs for autonomy, competence, relatedness, self-actualisation-meaning (labelled self-actualisation within this work to avoid confusion with the experience of meaning),

Table 1 An overview of the measures employed, sorted from highest to lowest mean

Scale	Variable	Items	Range of scale	Cronbach's α	*M* (SD)
Motivation orientation (HEEMA)	Eudaimonia	5	1–7	0.80	5.05 (1.45)
	Hedonia	5	1–7	0.84	2.63 (1.44)
	Extrinsic orientation	5	1–7	0.77	1.58 (0.86)
Affect (PANAS-X)	Attentiveness	4	1–5	0.76	4.04 (0.78)
	Positive affect	10	1–5	0.80	3.07 (0.71)
	Joviality	8	1–5	0.86	2.54 (0.90)
	Serenity	3	1–5	0.82	2.53 (0.99)
	Self-assurance	6	1–5	0.67	2.43 (0.71)
	Surprise	3	1–5	0.84	2.12 (1.04)
	Contemplativeness	4	1–5	0.35	2.05 (0.69)
	Negative affect	10	1–5	0.76	1.46 (0.42)
Psychological needs	Competence	2	1–5	0.66	3.70 (0.90)
	Stimulation	2	1–5	0.80	3.08 (1.19)
	Autonomy	2	1–5	0.73	2.97 (1.18)
	Popularity	2	1–5	0.76	2.74 (1.21)
	Security	2	1–5	0.58	2.65 (1.16)
	Self-actualisation	2	1–5	0.61	1.66 (0.88)
	Relatedness	2	1–5	0.84	1.55 (0.96)
Feeling of meaning	Sense	4	1–7	0.80	4.78 (1.47)
	Value	4	1–7	0.81	4.72 (1.50)
	Implications	4	1–7	0.77	3.79 (1.52)
Product quality (AttrakDiff mini)	Pragmatic quality	4	1–7	0.51	5.70 (0.90)
	Attractiveness	2	1–7	0.30	5.59 (0.82)
	Hedonic quality identification	2	1–7	0.26	5.29 (0.98)
	Hedonic quality stimulation	2	1–7	0.56	4.40 (1.25)
Other	Attribution to technology	1	1–5	–	3.47 (1.20)
	Future importance	1	1–7	–	4.31 (1.76)

stimulation, security, and popularity. We used the German translation by Hassenzahl et al. (2011).

In addition to affect, the feeling of meaning has been identified as an essential characteristic of eudaimonic motives (Huta and Ryan 2010). We decided to examine meaning in more detail than Mekler and Hornbæk (2016), because of its close association with eudaimonia in the previous research (Hassenzahl et al. 2015; Huta and Ryan 2010). We used all 12 items from Huta and Ryan (2010) who divided the distinction of meaning into feelings of sense (e.g., meaningful; full of significance), value (e.g., precious; dear to me), and implications (e.g., contributing to various aspects of myself; playing an important role in some broader picture) (Huta 2017b).

We included two single items targeting future importance and attribution. Previous studies considering the temporal dimensions of pleasure and meaning (Huta and Ryan 2010; Kim et al. 2014) have found meaning to be more important in the distant future, rather than pleasure and its immediate nature. We, therefore, asked participants to rate the importance of their experience one year in the future and to give a brief explanation for their answer. To check whether participants' experiences were indeed caused by the interaction with the technology, participants were asked to rate 'to what extent the interaction with the technology was responsible for their experience' (i.e., attribution). Note that the wording targets the interaction with the technology (Hassenzahl et al. 2011) rather than the technology itself (Mekler and Hornbæk 2016).

Finally, we used the AttrakDiff mini (Hassenzahl and Monk 2010) to measure technology perception. Participants were asked to evaluate a technology using semantic opposites such as ugly-attractive, confusing-clear, or good-bad. In variation with Mekler and Hornbæk (2016), who employed the original version of the AttrakDiff, we decided to assess not only pragmatic quality, hedonic quality identification, and hedonic quality stimulation, but also attractiveness. Authors can provide a complete list of the questionnaire's scales and items upon request.

Table 1 provides an overview of all measures employed, including their internal consistency. Overall, Cronbach's alpha was acceptable to good, but there were some notable

exceptions. While the internal consistencies of the self-assurance, competence, and self-actualisation scales were questionable, the contemplativeness and security scales, and all sub-scales of the AttrakDiff mini resulted in poor internal consistency. We decided to exclude scales with values of Cronbach's $\alpha < 0.6$ from further analyses.

2.4 Thematic analysis of experience descriptions

Similar to Mekler and Hornbæk (2016), we included the actual content of the experience descriptions in the analysis. Qualitative data offer a less restricted and more open-minded method of data collection compared to predefined rating scales and enables us to consider information beyond the initially planned variables. Therefore, we planned to uncover aspects of experiences that people themselves found meaningful (Delle Fave et al. 2011). Experiences were manually coded, following an inductive approach, extracting categories from the material.

3 Results

3.1 Salience of motivational orientations and needs

As shown in Table 1, participants' experiences scored highest on eudaimonia ($M = 5.05$) compared to hedonia ($M = 2.63$), and extrinsic orientation ($M = 1.58$), indicating that the experiences differed in terms of motivational orientations. However, eudaimonia and hedonia correlated significantly ($r = 0.52$), as did eudaimonia and extrinsic orientation ($r = 0.40$) and hedonia and extrinsic orientation ($r = 0.42$). Given the moderate interdependency of eudaimonia, hedonia, and extrinsic orientation, we followed the approach of Mekler and Hornbæk (2016) and used partial correlations to control for the shared variance between the different orientations.

Considering the needs, three different levels of salience can be found in the descriptive data. (1) Competence showed the highest ratings ($M = 3.70$), followed by (2) stimulation ($M = 3.08$), autonomy ($M = 2.97$), and popularity ($M = 2.74$) in the medium range of the scale. (3) The remaining needs either showed poor internal consistency (security: Cronbach's $\alpha = 0.58$) or were rated low (self-actualisation: $M = 1.66$; relatedness: $M = 1.55$).

3.2 Correlates of eudaimonia, hedonia, and extrinsic orientation

Table 2 provides an overview of the calculated partial correlations, omitting scales with low internal consistency. We do not report the statistical comparison of the magnitudes of correlations for the various motive orientations, because we found only one (or no) significant correlation.

Table 2 Partial correlation for eudaimonia (controlled for hedonia and extrinsic orientation), hedonia (controlled for eudaimonia and extrinsic orientation), and extrinsic orientation (controlled for eudaimonia and hedonia)

Variable	Eudaimonia	Hedonia	Extrinsic orientation
Affect			
Attentiveness	0.50**	− 0.21	− 0.10
Positive affect	0.41*	0.10	0.17
Joviality	0.16	0.38*	0.19
Serenity	0.03	0.22	0.05
Self-assurance	0.11	0.18	0.20
Surprise	− 0.02	0.19	0.17
Contemplativeness	–	–	–
Negative affect	0.00	− 0.07	0.01
Needs			
Competence	0.61**	− 0.02	− 0.25
Stimulation	0.30*	0.15	0.09
Autonomy	0.29*	0.26	− 0.06
Popularity	0.26	0.11	0.20
Security	–	–	–
Self-actualisation	0.05	0.19	0.09
Relatedness	− 0.22	0.25	0.09
Feeling of			
Sense	0.35*	0.21	0.06
Value	0.33*	0.23	− 0.03
Implications	0.22	0.26	0.19
Product			
Pragmatic quality	–	–	–
Attractiveness			
HQ identification	–	–	–
HQ stimulation	–	–	–
Other			
Attribution to technology	0.25	0.07	− 0.01
Future importance	0.15	0.01	0.00

Due to poor internal consistency, some scales are omitted

*Significant at $p < 0.05$. **Significant at $p < 0.001$

Examining affect, eudaimonia correlated significantly with attentiveness and positive affect, while hedonia showed a significant association with joviality. When striving for eudaimonia, participants felt excited, determined, and attentive, while hedonia was associated with feelings of happiness, joy, and delight. In contrast, extrinsic orientation showed no significant correlations with any of the affect scales.

Examining need satisfaction, eudaimonia was correlated substantially with competence, stimulation, and autonomy, the three needs that were also rated highest descriptively.

Because our study is exploratory in nature, we also highlight correlations that approach the conventional significance threshold ($p < 0.05$), but do not pass it. Correspondingly, eudaimonia was associated with popularity, while hedonia was linked to autonomy and relatedness. Similarly, extrinsic orientation showed a small negative correlation with competence.

Regarding the feelings of meaning, eudaimonia was significantly correlated with sense and value, while hedonia showed a small correlation with implications. Descriptively, attribution to technology showed a small correlation with eudaimonia and no correlation with hedonia or extrinsic orientation. Future importance showed a similar, but less pronounced, correlational pattern, with no significant correlations.

3.3 Analysis of experience descriptions

Similar to previous research examining experience accounts (Hassenzahl et al. 2011; Mekler and Hornbæk 2016), the heterogeneous nature of the qualitative data complicated the analysis and made it difficult to connect qualitative and quantitative results. Experience descriptions varied in length, with a range from 26 to 146 words and an average of 50 words per account. We focused on three aspects to refine the data analysis: type of interactive technology, time pressure, and rated motivational orientation. First, based on experience descriptions, interactive technology was classified into medical devices ($n = 37$) and software such as documentation tools and cognitive aids ($n = 15$). Three statements did not specify the interactive technology (see Table 3).

Second, we differentiated between time-critical ($n = 30$) and non-time-critical experiences ($n = 25$). For example, typical time-critical experiences involved emergency medical care such as resuscitation, the treatment of patients in respiratory distress, or documentation in the trauma centre, while typical non-time-critical experiences involved the installation of new devices or monitoring and documentation tasks during routine operations. Being aware of the limited informative value due to small group sizes, we reanalysed the quantitative data based on this qualitative classification. Interestingly, correlations between motivational orientations and other measures were almost always significant in either time-critical or non-time-critical experiences, but not in both, and most of the significant correlations were found in non-time-critical experiences. The interested reader may find the analysis in full detail in Online Resource 1.

Table 3 Interactive technologies mentioned in the experience accounts are categorised as medical devices ($n = 37$), software ($n = 15$), or not specified ($n = 3$), sorted by frequency

Classification	Device	Positive experience	Frequency
Medical device	Video laryngoscope	Video laryngoscopy enables successful intubation in difficult airway management, supervision, or learning in team situations	9
	Ultrasonic device	Easy, fast, mobile, non-invasive way to 'look into the patient' to perform, e.g. peripheral venepuncture or clarify diagnosis in emergency situations	7
	Monitoring	Patient safety is increased even in stressful situations with the reliable handling of monitoring details like trends or optical and auditive alerts	7
	Defibrillator	Universal instructions and intuitive, autonomous use of the defibrillator facilitate resuscitation	4
	Ventilator	Patient safety through mobility, intuitive use, autopilot mode, and individual alerts on ventilators	3
	Chest compression system	Mechanical assistance when performing cardiopulmonary resuscitation reduces workload in lifesaving teams	3
	Syringe driver	Automated dosis calculation	1
	Massive transfusion system	Handle lethal bleeding	1
	Ventricular assist device	Mechanical circulatory support of the heart	1
	Bronchoscope	Place double-lumen tubus	1
Software	Documentation	Automated digital documentation is easy, accessible, more precise, time-saving, and reduces stress, workload, and distraction in comparison with the paper version	9
	Cognitive aid	Cognitive support by technically assisted resuscitation helps to coordinate the team and keep track	3
	Multilingual	Communicate with foreign patients	1
	Survey	Creating polls for training	1
	Patient data management system	Access to relevant patient data	1
Not specified	–	–	3

Third, we planned to examine the experience descriptions depending on ratings of eudaimonia, hedonia, and extrinsic orientation. We were interested in experiences that scored high in one motivational orientation exclusively. However, most experiences were excluded from the analysis, because ratings were low (i.e., < 4 and below the median of the respective motivational orientation; $n = 26$) or not exclusive (i.e., the ratings were > 4 and above the median on more than one motivational orientation, $n = 12$), leaving merely two hedonic experiences and 15 eudaimonic experiences. In eudaimonic experiences, participants reported that technology supported their work routines, which it was fast, or even time-saving and safe and efficient to use. Once more, being aware of the limited informative value due to small sample sizes, we report the analysis in detail in Online Resource 2.

4 Discussion

In this study, we collected quantitative and qualitative data on positive experiences with interactive technology in acute care. The first objective of the study was to provide quantitative, empirical data compared to theoretical arguments and qualitative data on the role of UX in safety–critical domains. Overall, the study findings support future consideration of UX in safety–critical domains such as acute care. To better judge the present ratings of needs and motivational orientations, we refer to findings on consumer technology that used the same methods and scales (Hassenzahl et al. 2011; Mekler and Hornbæk 2016). These serve as anchor points for evaluation, but do not imply comparability of consumer to safety–critical workplace technology. According to our expectations, ratings of needs were similarly high compared to consumer technology: the present ratings were between 1.55 and 3.70; Hassenzahl et al. (2011) reported ratings between 2.40 and 3.26 on the same need scales. The needs for competence and stimulation were above the scale mean, while the need for autonomy was close to the mean. Furthermore, the motivational orientation rating of eudaimonia in acute care exceeded the ratings of consumer technology [5.05 vs. 4.14 (Mekler and Hornbæk 2016)]. Considering that we used the same method and scales as the previous research on consumer technology (Hassenzahl et al. 2011; Mekler and Hornbæk 2016), we conclude that psychological need satisfaction plays a role during positive interactions with technology in acute care settings. In addition to usability metrics such as safety and efficiency, psychological needs-based UX concepts should be considered in the design of technology for safety–critical domains, as demonstrated by Klüber et al. (2020) and Laschke et al. (2020a).

The second objective of the study was to examine which psychological needs are most important in positive experiences with technology. Quantitative ratings of psychological needs resulted in a ranking of needs (see Table 1). Competence, stimulation, and autonomy received the highest scores for need satisfaction, while self-actualisation and relatedness were rated the lowest. These findings only partly match with our expectations that the needs for competence, autonomy, and relatedness would be most salient. Competence, measured as 'successfully completing difficult tasks and projects' and 'taking on and mastering hard challenges', was the most salient need for participants. In contrast, relatedness, in terms of feeling 'a sense of contact with people who care for me and whom I care for' and feeling 'close and connected with other people who are important to me', was rated the least salient. In comparison, Hassenzahl et al. (2010, 2015) reported that the top three needs during a positive interaction with consumer technology were relatedness, stimulation, and competence. Strikingly, relatedness was rated lowest in the context of acute care ($M = 1.55$), but highest when investigating consumer technology [$M = 3.26$ (Hassenzahl 2010); $M = 3.02$ (Hassenzahl et al. 2015)]. We believe that the wording of the relatedness items might have added to this discrepancy, because they covered a rather intimate type of relatedness, more akin to friends and family and life in general. When working in acute care, however, relatedness is more likely to occur in the form of team cohesion, such as feeling connected to other colleagues by relying on them as valuable team members (Klüber et al. 2020).

The quantitative results of the study on motivational orientations indicated that primarily eudaimonic aspects of UX need to be considered when examining positive experiences with interactive technology. As reported above, the mean score of eudaimonic orientation was higher in the acute care data compared to the data on consumer technology. In a study on consumer technology, the mean score of hedonic orientation was much larger compared to the present data [2.63 vs. 4.60 (Mekler and Hornbæk 2016)]. This supports the previously stated argument that the hedonic aspect of UX, which is prominent in consumer technology (Hassenzahl et al. 2011), is not as relevant in safety–critical domains (Grundgeiger et al. 2020). Regarding the qualitative results, participants reported on traditional usability measures like efficiency and intuitiveness, but they also mentioned personal growth enabled by the eudaimonic experience, as well as long-term benefits for their daily work. In agreement with the current shift in the HCI community towards well-being and meaningfulness (Mekler and Hornbæk 2016, 2019; Müller et al. 2015; Stephanidis et al. 2019), we advocate expanding the notion of UX by incorporating eudaimonia into research. Based on the present results, eudaimonic aspects of UX are particularly important in safety–critical workplaces, such as acute care. Therefore, considering eudaimonia will expand the scope of application for UX research and methods. It should be noted that this does not imply the abandonment of established usability measures,

but rather a broadening of perspectives on relevant positive aspects of UX.

Our qualitative data on need satisfaction in eudaimonic experiences aligned with our quantitative findings. For instance, participants reported on expertise gains and personal growth, which corresponded to the need for competence. Technological support was appreciated as long as participants were in control of the technology's usage, which corresponded to their need for autonomy. However, participants also reported on safety, which corresponds to the need for security, and feelings of connectedness in terms of an apprenticeship, which corresponds to the need for relatedness, although these needs did not score highly in the quantitative analysis. Similar to the wording of the relatedness items ('I felt a sense of contact with people who care for me and whom I care for'; 'I felt close and connected with other people who are important to me'), the items for security ('I felt glad that I have a comfortable set of routines and habits'; 'I felt that my life was structured and predictable') could be appropriate for describing interactions with consumer technology, but might not be suitable for technology in a safety–critical work context such as acute care or work contexts in general. Security and relatedness in, for example, acute care may refer more to medico-legal considerations such as documentation of interventions or the feeling of being supported by co-workers or supervising senior staff members. To adequately assess the experience of users, quantitative measures should either be tailored to the context (e.g., Savioja et al. 2014) or existing measures might need adaptation to fit safety–critical work contexts. For example, items for security could be reformulated from 'I felt that my life was structured and predictable' to 'I felt that my workflow was structured and predictable' and items for relatedness could be reformulated from 'I felt a sense of contact with people who care for me, and whom I care for' to 'I felt like I could rely on the people I work with'. However, items should not simply be adapted without a formal questionnaire construction process and testing quality criteria. Furthermore, Savioja et al. (2014) recommended conducting qualitative research prior to the development or adaptation of quantitative measures. The aim is to understand aspects that might only be present in these domains, such as cognitive as well as emotional safety aspects.

Our third aim was to examine the correlations of eudaimonic, hedonic, and extrinsic orientations with the remaining variables to identify experiential patterns in acute care. Examining affect, the link between eudaimonia and attentiveness seems plausible, because procedures that result in growth and meaning may require increased effort. In this case, the described eudaimonic experiences required high alertness. Similarly, the link between eudaimonia and positive affect, such as the positive feeling of mastery over a situation, is credible, as is the link between hedonia and joviality. Both of the motivational orientations cover different positive aspects of experiences that might also differ in their affective nature.

Considering need satisfaction, the strong correlations between eudaimonia and competence, as well as autonomy, are reasonable, since eudaimonia can be defined as the actualisation of one's own potential (Huta and Ryan 2010). Finally, the association of eudaimonia and stimulation is consistent with the connection of eudaimonic experiences to attentiveness, because both highlight the highly demanding context of acute care. In line with the previous research (Hassenzahl et al. 2015; Huta and Ryan 2010), our findings confirm that meaning is an integral part of eudaimonia, because sense and value were correlated with eudaimonia. Previous research on the temporal dimensions of eudaimonia and hedonia (Huta and Ryan 2010; Kim et al. 2014) found that in the long term, eudaimonia, rather than hedonia, is perceived as important. However, our results did not reveal any significant correlations between eudaimonia, hedonia, or extrinsic orientation with future importance. Again, the wording of the question may have triggered participants to consider life in general ('If you consider your life one year from now, how important will you find this experience'), which may have resulted in lower future important ratings compared to a more specific work-related importance (Schwarz et al. 1991).

Considering attribution in eudaimonic experiences rather than in hedonic or extrinsic experiences, the interaction with the technology was most likely seen as the cause of the positive experience. Interestingly, Mekler and Hornbæk (2016) found contrary correlations, as hedonia correlated significantly with attribution, while eudaimonia did not. This difference might be due to the formulation of the attribution question. In this study, we targeted the interaction with the technology ('to what extent was the interaction with the technology responsible for your experience'? Hassenzahl et al. 2011; Klüber et al. 2020)) rather than the (new) functionality of the technology itself ('to what extent was the interactive technology responsible for your experience?' Laschke et al. 2020a; Mekler and Hornbæk 2016)). However, examining qualitative data, participants reported on both functionality and interaction with the technology. It would be interesting to investigate whether participants differentiate between interaction and functionality, and whether this influences the association with eudaimonia or hedonia. Based on the findings presented here, we can conclude that actual interaction with technology contributes to the eudaimonic experience. This is important, because it highlights the fact that technology interaction design can satisfy users' eudaimonic needs. It should be considered in acute care technology design and potentially other safety–critical domains.

Previous research on general well-being and HCI demonstrated that motivational orientations do not contradict each

other (Huta and Ryan 2010; Mekler and Hornbæk 2016; Müller et al. 2015). It is, therefore, possible to have more than one active orientation in a single situation. Indeed, Huta (2013) stated that people need to pursue both eudaimonia and hedonia to achieve the greatest and most well-rounded personal well-being. In the present study, the interdependency of eudaimonia, hedonia, and extrinsic orientation indicates that the three motivational orientations are not entirely independent from each other. When comparing the correlation of eudaimonia and hedonia to previous studies [$r = 0.22$ (Mekler and Hornbæk 2016); $r = 0.36$, $r = 0.46$ (Huta and Ryan 2010); $r = 0.82$ (Müller et al. 2015)], the effect was moderate.

Overall, our findings resembled previous studies on consumer technology (Hassenzahl 2010; Hassenzahl et al. 2015; Mekler and Hornbæk 2016; Müller et al. 2015), but also showed clear differences. With the relevance of UX in safety–critical domains in mind, we revealed an interesting issue: the characteristics of experiences with technology in acute care clearly differed from experiences with consumer technology. Consistent with research by Tuch et al. (2017), need fulfilment in acute care differed from need fulfilment involved with consumer technology As highlighted by Grundgeiger et al. (2020), neglecting UX in safety–critical domains might impede the acceptance of technology, while considering UX in interaction might help to design tools that increase, for example, eudaimonic needs. In addition, our research suggests that findings should not be generalised across different domains, such as consumer technology and safety–critical domains. It would seem to be insufficient to incorporate the same patterns of psychological needs found in consumer technologies into the design of technologies for safety–critical work contexts. By providing quantitative and qualitative information on psychological needs and experiential patterns, our findings could serve as a useful foundation for user-centred design processes of medical devices or socio-technical equipment, similar to Klüber et al. (2020) and Laschke et al. (2020a).

4.1 Limitations and future work

First, due to the scarcity of the special user group, our sample size was limited. Contrary to previous research (Huta and Ryan 2010; Mekler and Hornbæk 2016), we could not conduct a principal component analysis to test the underlying factor structure of several scales, such as psychological needs. However, previous principal component analysis mostly confirmed the suggested structures (Mekler and Hornbæk 2016). Furthermore, there are potential limitations to statistical power regarding partial correlations. Future research should aim for a larger sample size to be able to conduct more detailed exploratory analyses, such as comparing different technologies that were reported in the experiences.

Second, the internal consistency of some questionnaire scales was insufficient. Unlike previous research (Oliver and Raney 2011), some scales, such as contemplativeness, did not provide sufficient internal consistency in this study. This may be due to the fact that the contemplativeness scale has been developed and employed in media and entertainment research and, therefore, might not be suitable in the present context (Oliver and Raney 2011). Similarly, the items assessing the need for 'security' and all scales of the AttrakDiff mini showed low internal consistency. As discussed above, this may be related to the wording of the items.

Third, informal feedback revealed that participants found our survey rather demanding. Some participants reported that it was hard to describe a positive experience. This difficulty was also indicated by the fact that about 120 participants quit the survey when faced with the open-ended question of describing the experience. Furthermore, participants were somewhat irritated by some items and found it hard to rate the items in relation to their work experience. Future work should address the development of measures with a better fit to safety–critical domains, for example, when assessing product quality or the need for security. The scales used in the present study were developed for contexts other than safety–critical domains. They focus on daily life and consumer technology.

Fourth, this study focuses on positive experiences. The aim of our research was to tackle the prevailing neglect of UX in safety–critical domains by providing empirical data. When collecting evidence for the relevance of UX, searching for bad UX seemed counterintuitive, especially when combining it with eudaimonia and hedonia. We figured that asking for a positive experience would provide the best chance to find evidence, and the absence of evidence would have also been insightful. As a result, in the spirit of experience design and its emphasis on pleasurable and meaningful moments provided by functionality or interaction (Laschke et al. 2020a), our approach is based on the previous studies that used the same method and also only examined positive experiences (Hassenzahl et al. 2011; Mekler and Hornbæk 2016).

Fifth, the reader may make the argument that any acute care task has a strong eudaimonic component due to the nature of the tasks (i.e., helping critically ill humans) and, therefore, the observed high eudaimonic orientation is not related to technology use. Undeniably, acute care tasks can have strong eudaimonic components. However, there are two counterarguments to consider.

Considering the first argument, UX involves the perception and response of a user using a product to achieve a specified goal in a specified context (ISO ISO 9241-11 2018). Not only in acute care technology but also in relation

to consumer technology, UX is always assessed for specific goals and in a specific context. As a result, the above argument does not question the results of this study but rather the definition of UX. For example, if the reader follows the above argument, the reader needs to question whether the hedonic experiences of using entertainment technology—which made up 60% of the experiences in a study on consumer technology (Mekler and Hornbæk 2016)—are due to the nature of the task and not the technology.

Considering the second argument, the previous research (Mekler and Hornbæk 2016) observed a correlation between eudaimonia and pragmatic quality, and suggested that instrumental experience may facilitate positive experiences (Tuch and Hornbæk 2015). Unfortunately, the poor internal consistency of the AttrakDiff did not justify the analysis of the correlation between eudaimonia and pragmatic quality. However, the attribution question (i.e., 'to what extent was the interaction with the technology responsible for your experience'?) showed that participants frequently reported that the interaction with the technology was responsible for their experience: 32 of 55 participants scored above the scale's middle point, $M = 3.47$ (see Table 1). Furthermore, eudaimonic orientation correlated positively with this attribution question (see Table 2). Within the correlational research limitations, the interaction with technology seemed to contribute to the eudaimonic experiences in acute care.

5 Conclusion

Technology users always have an experience when interacting with technology (Wright and McCarthy 2010), but only a few studies have addressed this experience in safety–critical domains (e.g., McCarthy and Wright 2005; Savioja et al. 2014). Our contribution is to provide empirical support for previous theoretical work that highlights the importance of UX when interacting with technology in acute care (Grundgeiger et al. 2020). Previous empirical research in safety–critical domains has taken a qualitative and design-focused approach to UX (e.g., Karvonen 2019; Klüber et al. 2020). In this study, we collected qualitative as well as quantitative data to investigate UX in acute care. To this end, we conducted an online survey on positive experiences with technology in acute care and examined UX aspects such as motivational orientations and psychological needs. Analysing quantitative and qualitative data, we underscored the importance of the recent focus on eudaimonia and meaningfulness in HCI research, and our results showed that these concepts are important in positive interactions with technology in safety–critical work. Furthermore, we showed that experiences with interactive technology in acute care differ from experiences with consumer technology in terms of the ranking of psychological needs and experiential patterns. However, well-established measures, used to examine experiences with consumer technology, might not be suitable for safety–critical domains. Correspondingly, future research should not only address the differences between domains but also develop suitable UX measures adapted to safety–critical domains. Finally, researchers should attempt to conduct experimental studies that investigate the benefits of UX design on staff experience but also on safety and efficiency.

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Availability of data and materials All data and materials as well as software application support the published claims and comply with field standards.

Code availability Not applicable.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose. Anna Hohm declares that she has no conflict of interest. Oliver Happel declares that he has no conflict of interest. Jörn Hurtienne declares that he has no conflict of interest. Tobias Grundgeiger declares that he has no conflict of interest.

Ethical approval The presented research was approved by the Ethics Committee of the Institute Human–Computer-Media (31.05.2019). All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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