The Compass Menu—A Radial Menu Technique for Augmentative and Alternative Communication Tailored to Intensive Care Patients During Mechanical Ventilation

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Abstract. Approximately 20% of intensive care patients in Germany require mechanical ventilation due to illness or post-operative conditions, which impairs their ability to communicate effectively. This poses significant challenges for patients and their caregivers. Augmentative and alternative communication concepts from other fields can be adapted to the context of intensive care to support ventilated patients. We developed an assistive system designed for the needs of the user group that is controlled by a ball-shaped interaction device. In this paper we introduce the central element of the assistive system, a radial menu technique called Compass Menu. It is systematically described using a taxonomy of menu properties. Our prototype was evaluated by six HCI experts in a pilot study. They evaluated how well design decisions made in development met previously identified menu design objectives as well as usability, applicability, user experience, and aesthetics. For the evaluation, we developed a comprehensive questionnaire tailored to menu design. The results indicate that the menu design could be suitable for implementation in interactive systems that support mechanically ventilated intensive care patients.

Keywords: human computer interaction · interaction design · graphical menu design · radial layout · gesture-based interaction · expert evaluation· mechanical ventilation · augmentative and alternative communication

1 Introduction

Due to respiratory insufficiency caused by illness or postoperative conditions, approximately one in five patients treated in intensive care units (ICUs) in Germany requires mechanical ventilation [4]. Once their condition has stabilized, patients are gradually weaned off the ventilator. The weaning process can be physically and psychologically challenging for the patient and in some cases can last from days to weeks or even longer [12]. Because weaning patients require an artificial airway (intubation or tracheostomy tubes), they cannot speak, which creates a significant communication barrier. This barrier not only affects the patients themselves, who may experience frustration and anxiety due to their inability to express themselves, but also complicates the efforts of healthcare providers and family members involved in the recovery process [1,10,32]. In fact, communication is critical for recovery and must be established as soon as possible, as positive communicative activities with ventilated patients have been associated with improved patient-related outcomes [26].

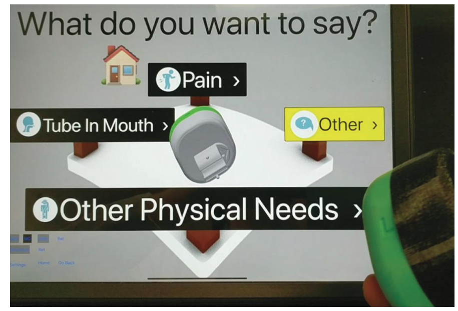
To facilitate communication with these patients, various Alternative and Augmentative Communication (AAC) approaches are adapted to the context of intensive care. Notably, there is no consensus in the research community on a systematic approach to the evaluation and outcome measurement of AAC interventions for ventilated patients, nor on a standard care regarding effective communication for mechanically ventilated patients [38]. Furthermore, it has been reported that current practice does not adequately address the need of intensive care patients to effectively express their needs to medical staff, allowing them to respond promptly to critical situations (cf. [30,31]).

In contrast, modern technical approaches can provide solutions that can be tailored to very specific needs. We presented a novel approach based on an interactive assistive system tailored to the needs of intensive care patients in our previous work on this topic [14,15,16,18,19,20,21]. The system, which complies with hygiene regulations, consists primarily of an all-in-one computer for displaying the graphical user interface (GUI) and an interaction device for control. The computer is integrated into a 23.8-inch monitor mounted on a roll stand that can be adjusted in height and angle. The interaction device, designed specifically for use on a hospital bed, features a sealed surface based on wireless charging and data transmission. Since intensive care patients' hands are often severely limited in strength and precision, we opted for a simple gesture-based control that allows discrete tilt (left or right) and press gestures. These gestures can be performed on the surface of the bed, eliminating the need for the user to lift their hand or arm.

In general, interactive approaches for AAC usually refer to a menu-driven selection system, where graphical menus can be considered the primary interaction technique for exploring and selecting commands to communicate current concerns (see Fig. 1 for examples). Though, graphical menus are typically characterized as transient [13] and quasimodal [28], meaning they are temporary and require user action to remain active. Transient visualizations temporarily display information, making it easily dismissible [13]. Menus typically remain hidden until needed and are immediately closed after item selection. Upon menu activation, the application enters a specific mode that remains active until the selection process is complete [3].

Notably, these menu characteristics may not be suitable for all application contexts, especially when user abilities are impaired or fluctuating. Alternatively, menus can be the central element of the user interface, providing continuous guidance when needed. In particular, applications for AAC fall into this category.

(a) The LifeVoice System [24]



(b) The Manually Operated Communication System [9]

Fig. 1: Exemplary interactive AAC approaches showing the range of designs

However, designing effective AAC systems for the user group of mechanically ventilated patients in the context of the ICU remains an open research question.

Therefore, we present a core component suitable for the aforementioned assistive system: the circular *Compass Menu* tailored to the user group and operated by discrete inputs of a ball-shaped interaction device. It is designed specifically for the use case, not universal application or an advancement of existing techniques.

We used the menu technique to address the following research questions:

- RQ.1 How can a menu technique be designed to meet the following requirements? (a) Support easy-to-use interaction with a hierarchical menu structure adapted to the needs of weaning patients, and (b) adapt to the gesture control of a spherical interaction device.
- RQ.2 Do the design decisions made for the Menu align with graphical menu design goals of the Menu Performance Criteria Model[34]?
- RQ.3 Does the Menu meet menu design quality criteria for usability, user experience, applicability, and aesthetics?

2 Background

Several review articles on menu research categorize previous work thoroughly [23,27] but lack straightforward guidelines for essential menu design questions (e.g., guideline importance, goals, trade-offs) [34]. Our work builds upon two articles describing design spaces for menus [3,34].

2.1 Taxonomy of Menu Properties

Bailly et al. present a design space for visual menus in interactive applications, addressing the challenge of characterizing menus across multiple dimensions [3]. Their taxonomy systematically analyzes menus in a hierarchical way: items

Table 1: Taxonomy to characterize visual menu properties in novice mode [3]

		Sub-dimension	Properties
Dimension	Menu	Geometry	Layout, Positioning
		Semantics	Wording Consistency, Relevant Menu Title
		Temporality	Browsing Menus, Selecting Items in Sub-menus
	Menu Item	Visual Representation	Conveying Information, Saliency, Visual Context
		Semantics	Relevant Naming, Character Length
		Geometry	Distance, Size
	Menu System	Semantics	Semantic Relationships, Menu Hierarchy
		Menu Breadth	Increasing Breadth
		Menu Depth	Increasing Depth, Logical Grouping

within menus within menu systems. It distinguishes between novice and expert modes, with expert modes providing direct access via shortcuts or gestures. We used this taxonomy to describe our Compass menu, but only focus on dimensions, sub-dimensions, and properties of the novice mode (see Table 1). The visual menu properties of the taxonomy are used to classify and discuss our design decisions in Section 3.

We excluded an expert mode since intensive care setting patients rarely gain real expertise due to short ventilation periods (typically hours/days). Prioritizing novice usability over uncertain efficiency gains, we avoided added complexity from extra gestures and implemented common actions (e.g., return to previous menu level/main menu) as menu items. Thus, patients can initially be classified as novices. They are not familiar with the interaction device or the menu system. Though, over time, their level of experience may increase gradually.

Although the taxonomy effectively classifies menus, it does not connect to actual design goals needed for menu design.

2.2 Menu Design Goals

Few guidelines enable informed menu design decisions [35], often lacking information about significance, objectives, or necessary trade-offs [34]. Addressing this gap, Samp developed a design space comprising design goals, menu features, and guidelines for graphical menus [34]. Samp applies these guidelines to compare two menus, emphasizing that results are indicative rather than absolute. While his guidelines favor pointer-based rather than gesture-based interaction [2], the underlying design goals (see Table 2) are sufficiently abstract for gesture-based menus. These goals formed our foundation for developing the Compass Menu and formulating items for our expert evaluation (Section 4).

2.3 Menu Performance Criteria

Bailly et al. also contributed a performance criteria model with two factors—usability and applicability—each with three criteria [3]. These factors relate to

Table 2: Menu Design Goals based on [34]. Key aspects are highlighted in italics.

Context		Category	Design goals
Context	Novice Behavior	Ease of Use	Visual structure should *clearly communicate* the concepts of menu *levels*, *depth*, *items*, and *item groups*. Visual representations of the commands should be *readable* and *meaningful*. The selection mechanism should be *simple* and *familiar*.
		Guided Exploration	To guide the novice the menu should *decrease the information load* and *enable exploration*. It should *prevent disorientation* and support the behavior when novices make mistakes and need to *explore multiple locations* in the command space.
		Effective Visual Search	A menu should allow to *quickly search menu content*: previous and newly visited locations.
		Effective Navigation	A menu should allow *quick and direct navigation* between all menu locations and items.
	Expert Behavior & Novice-to-Expert Transition	Support Learning Menu Content	A menu should avoid forcing experts to return to novice behavior. It should *avoid unnecessary changes of global visual features*, such as item location, size, and color.
		Effective Navigation	Extension of novice goal: A menu should allow *quick navigation*, require little navigation precision, and reduce the number and consequences of navigation errors.
	Miscellaneous	Quantity	A menu should *accommodate menu hierarchies* and *hundreds of commands*.
		Reduced Screen Consumption	A menu should *limit its screen consumption*. This is especially important for devices with small screens such as smartphones.

users' practical acceptance of menu techniques. Usability addresses menu adequacy for users' cognitive, motor, and sensory abilities (speed/accuracy, learning/memorization, satisfaction). Applicability concerns adequacy for users' needs across applications, devices, and user groups (see Table 3). We considered these aspects during design and for our expert evaluation questionnaire.

2.4 Influencing Factors

The interaction with menu techniques is influenced not only by their properties but also by external factors. In particular, we considered the context of use, user characteristics, user behavior during menu usage, and menu behavior during design. The menu should be designed to make the selection of items as simple as possible. This especially applies to the visual localization of the desired menu item, the selection of this item, and its activation [3]. Menu use varies by user experience and goal [3]. Novices follow roundabout paths due to a lack of

Table 3: Menu Performance Model covering usability and applicability (duplicated from [3])

Factors		Criteria	Description
Factors	Usability	Speed and accuracy	Menu efficiency for selecting commands
		Learning and memorization	The capacity of the menu to allow its users to use it in an optimal way quickly and in the long term
		Satisfaction	The capacity of the menu to provide a pleasant feeling that results from the fulfillment of what the user wants
	Applicability	Application adequacy	Capacity of the menu to become integrated into applications
		Device adequacy	Capacity of the menu to adapt different input and output devices
		User adequacy	Capacity of the menu to adapt to different user classes

mental models, gradually progressing to straighter paths as familiarity grows. Shortcut-based direct paths are unsuitable for the target user group due to user limitations. Users approach the system through exploration, function search, or command search [3]. Ideally, undirected exploration fosters learning, supported by tutorials. When users skip exploration, tutorials can highlight missing knowledge. Design goals, namely ease of use, guided exploration, visual search, navigation, and learning support, facilitate the shift from novice to advanced use [34].

The development of the Compass Menu was part of a doctoral thesis [14], focusing on the human-centered design of an assistive system for weaning patients based on a novel, context-adapted menu technique. An interactive demo application is publicly available[1].

3 Compass Menu Properties

The Compass Menu, central component of our AAC system for intensive care patients, was structured using three menu property dimensions (Menu, Menu Item, Menu System) and their sub-dimensions.

We developed the Compass Menu (see Fig. 2) specifically for the context of mechanically ventilated weaning patients in intensive care units. It comprises different assistance options, including communication support, an integrated patient bell, the display of relevant information on the current situation, control of the ambiance (exemplified by smart light control), and a media gallery for the display of personal media brought along by the patient's relatives.

The main purpose of the system is to establish communication between patients and medical staff. Thus, the menu system does not focus on providing

[1] Interactive Compass Menu Demo on https://compass-menu.eu

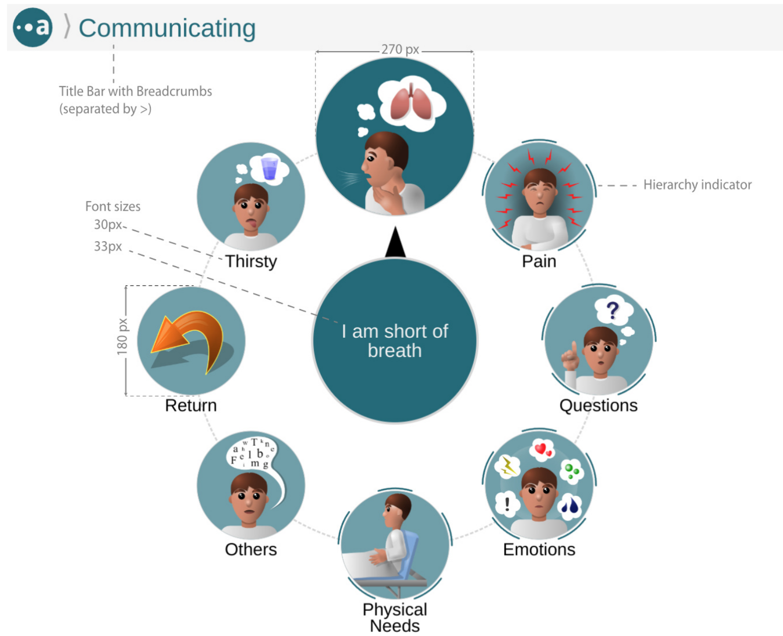


Fig. 2: Final design of the Compass Menu, enriched with information about font sizes, item dimensions, and location of breadcrumbs and hierarchy indicator.

additional functions but itself is the main object of the task by allowing navigation within a hierarchy of communication terms and selection of the desired term. This is a typical feature of interactive systems in the field of AAC.

During weaning, patients are only partially receptive due to sedation and only have limited responsiveness. Here it is particularly important to activate and inform patients about the situation. In subsequent phases, patients can interact, but have limited attention spans and fluctuating levels of consciousness. The phases in our system align with the typical weaning process (cf. approach from [7]). Initially, while patients are awakening, they passively receive information. Nurses unlock interactive system features as patients become able to interact. Tutorials help users transition from novice to inexperienced by teaching interaction basics.

A simplified version of the app unlocks first, offering a single menu level with key communication terms. Hierarchical menus unlock once users demonstrate secure interaction, expanding features and content. Users remain inexperienced at this stage, understanding interaction basics but not advanced features. Further tutorials introduce advanced functionality as users progress.

The menu is designed for input gestures using a ball-shaped device. However, other devices can be used as long as their inputs are conceptually compatible with the menu control commands (ie., using three discrete input actions).

3.1 Menu

Menu sub-dimensions (based on Table 1) include *Geometry* and *Semantics*. *Temporality*, mainly concerning animations, is covered in Subsection 3.5.

Geometry Geometry covers *Layout* and *Positioning*. Six layout variants were considered (see Fig. 3) to select the final design. The initial selection was made based on the following criteria: discrete input control and continuous display of the menu (as opposed to transient menus). Layouts included linear (horizontal/vertical), dropdown, grid, radial, and carousel (circular, with depth).

In a thorough analysis [14, p.126-130], the variants were systematically compared based on the criteria clarity, interaction, and compatibility with the intended discrete input directives (cf. Subsection 3.4). The Radial Layout was the only variant that met all of the above criteria. It allows for suitable interaction with the chosen interaction gestures. The circular shape of the layout relates to the spherical shape of the intended interaction device, as a circle is a two-dimensional representation of a sphere. Due to their geometric shape, radial layouts have no beginning or end. Therefore, the first and last items are 'naturally' positioned next to each other, which allows for a navigation in both directions at any time. Therefore, we opted for the Radial Layout.

We compared different geometrical forms for menu items (see Fig. 4). Finally, circular items were chosen for consistency and visual appeal, following the Gestalt principle of similarity [29] and prior research [33].

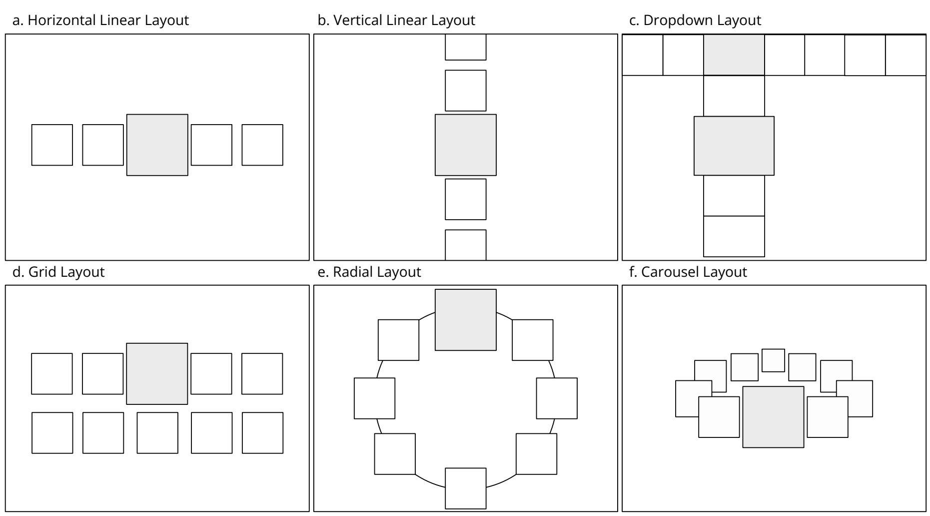


Fig. 3: Variants of suitable menu layouts include a Horizontal (a) and a Vertical (b) Linear Layout, the Dropdown Layout (c), the Grid Layout (d), the Radial Layout (e) and the Carousel Layout (f)

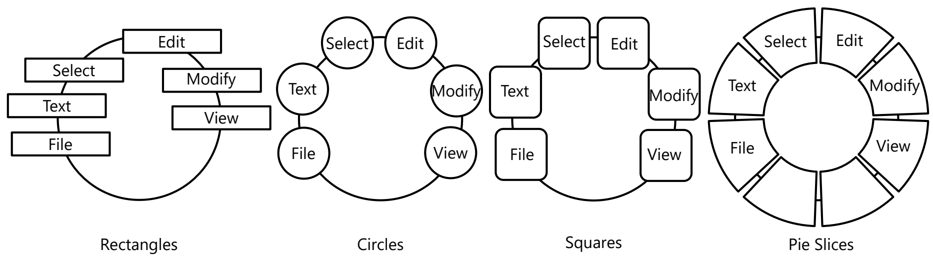


Fig. 4: A comparison of different geometrically shaped items arranged in a Radial Layout, including rectangles, circles, squares, and pie slices [33]

The final Compass Menu uses circular icons with text labels, minimizing design trade-offs (see Fig. 4). We applied the Gestalt principle of proximity [29] to visually link icons and text, enhancing aesthetics without extra elements. For gesture-based interaction, the Compass Menu is centered for visual balance, as positioning is mainly aesthetic. The focused item's position is key: Variant A rotates the menu like a clock hand, while Variant B keeps the focus fixed and rotates the items, similar to a compass (see Fig. 5).

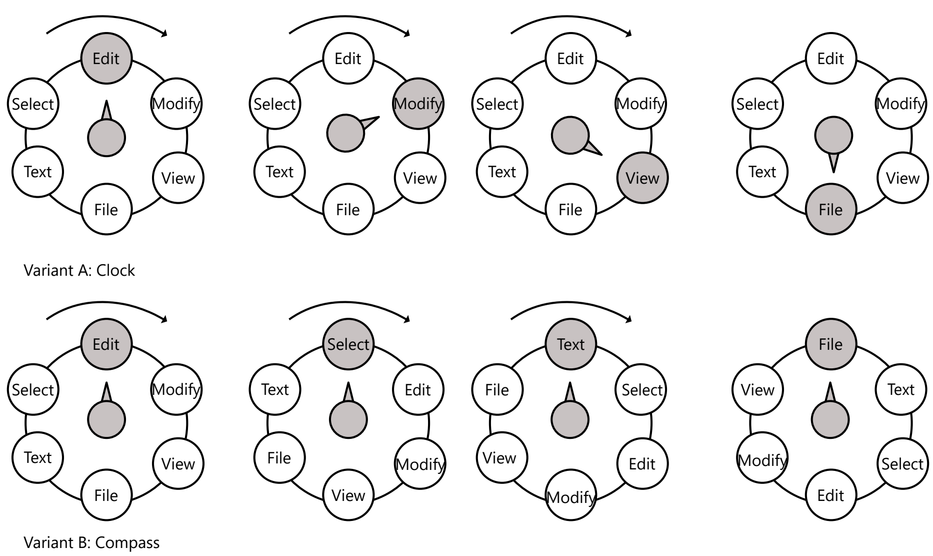


Fig. 5: A comparison of the focus shift variants: In variant A, the menu items have a fixed position, and the focus moves to the next item on the clock face, like the hand of an analog clock. Variant B is analogous to a compass; the location of the focused item remains fixed at the top of the circle, and the menu items revolve.

Variant A initially mimics linear navigation but later, the focused item moves in the opposite direction and the focus shifts to the item left. This behavior may cause confusion. In Variant B, the focus remains fixed at the top while items rotate, avoiding unexpected shifts. Animations were added to clarify state changes for users. We opted for Variant B, which is analogous to a compass.

Here, the focused icon is placed at the top of the circle, with extended text shown centrally. This design aligns with user gaze patterns and maintains visual consistency.

Semantics (Menu) The Semantics sub-dimension ensures consistent menu wording and relevant titles, reviewed iteratively during design. More details are described below in Semantics (Menu System).

3.2 Menu Item

Menu items, which represent commands or categories, are defined by three sub-dimensions: Visual Representation, Semantics, and Geometry. While the Compass Menu is not pointer-based as most of the menu techniques referenced in the original taxonomy [3], we argue that the following menu principles still apply since they are well transferable.

Visual Representation This sub-dimension covers *Conveying Information*, *Increasing Saliency* and *Increasing Visual Context*. Each item has a short label (below icon) and an extended label (centered when selected). Graphical icons and concise text enhance recognizability. A custom 50-icon set was iteratively designed for clarity and expressiveness (see a selection in Fig. 6). Based on

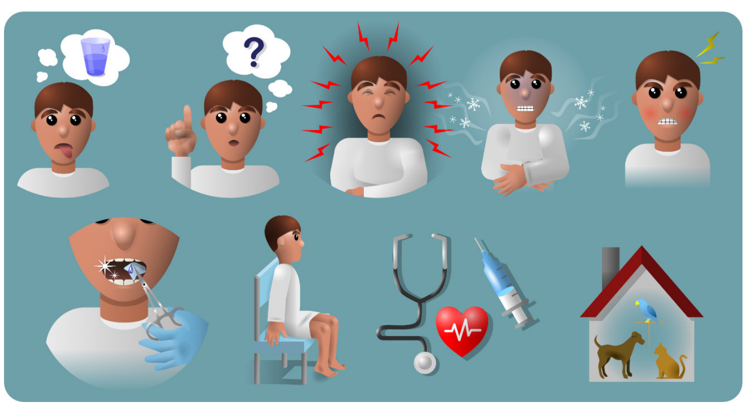


Fig. 6: Expressive icons were designed to convey the items' theme for the impaired target users. A selection of the icon set (on their original background color): Thirst, Questions, Pain, Cold, Anger (above line), Oral Care, Sitting in a Chair, Questions about Therapy, Questions about Pets.

the menu structure, the icons were explicitly not designed to be abstract, but instead as expressive as possible to further emphasize the items message and facilitate easy comprehension. Huge parts of the icon set can be seen in the demo application[1] referenced above. The focused item is 50% larger, has a stronger border, and is positioned at the top for easy identification. A visual pointer links the icon and extended label, with contrasting font for clarity. A dashed border marks parent categories, suggesting sub-menus. Various indicators were tested; the final design alludes to nested circular levels. Fig. 2 illustrates these aspects.

Semantics (Menu Item) Semantics covers *Relevant Naming* and *Character Length*. Labels must be clear, accurate, and concise for users, balancing context-specific vocabulary and readability. For ICU patients, vocabulary must be simple yet accessible, with short labels for space and extended labels for clarity. Optional text-to-speech playback reads out the extended label.

Geometry Geometry covers *Distance* and *Size*. Item order directly influences menu efficiency, particularly for beginners. According to Fitts' Law [8], placing frequently used items near the top — such as in split menus — reduces item localization time, thereby enhancing both efficiency and usability. Although efficiency is less critical in this context than usability and low complexity, reducing localization time can also help lower overall complexity. To address these priorities, the Compass Menu's structure was developed in collaboration with nursing experts, resulting in a fixed custom order that prioritizes important (and probably frequently used) topics and minimizes the number of interaction steps. Dynamic sorting was intentionally avoided to maintain consistency and orientation for users.

Larger item size improves localization and selection accuracy. Menu elements were tested to ensure visibility at typical ICU eye-display distances (120–140 cm) and for a 23.8-inch monitor. Font sizes (30–34px) were chosen for readability at this distance, with adjustments possible for users with reduced vision. They were adjusted to this distance span using a web-based font size calculator[2]. Font size and visual angle limit the number of items per menu level. Icons are round, with focused items 50% larger (270px vs. 180px). Short labels use 30px font, extended labels 34px, allowing up to 22 and 60 characters respectively.

3.3 Menu System

The Menu System dimension covers hierarchical menu structures, with interdependent sub-dimensions: *Semantics*, *Menu Breadth* and *Depth*.

[2] Font size calculator from https://www.leserlich.info/werkzeuge/schriftgroessenrechner/index-en.php based on DIN 1450, settings: visual acuity of 0.7; ratio of x-height to font size of 0.43; virtual resolution of 91 PPI; consultation text; good lighting

Semantics (Menu System) Within the menu system, semantics is primarily related to the efficiency of exploration [11]. It ensures logical hierarchy and relationships between items, balancing user expectations with functional requirements [37]. We designed a structured hierarchy for clarity and efficiency following these design guidelines. Additionally, breadcrumbs in the title bar show the user's current path in the menu hierarchy to provide better orientation (see Figure 2). Given limited verbal communication, the menu offers a predefined set of communication terms. These were developed through interdisciplinary workshops with four nurses and nursing scientists who were involved in the research project, drawing on literature and expert experience. We met several times to identify candidates and refine the choices. The terms were thematically organized into a meaningful four-level hierarchy with 80 items. A sample structure is provided in Appendix A.

Breadth and Depth Balancing breadth and depth involves trade-offs: broad menus require less decision-making but risk visual clutter, while deep menus can reduce information overload but increase navigation steps. In general, having more items increases average visual search time [27]. The Compass Menu compromises on these aspects based on domain-specific needs (cf. [23]). In our context, recognizability from a distance is key. The Compass Menu uses three to nine items per level (optimized for visibility) and a maximum depth of three levels. A Radial Layout requires at least three items. Return buttons in sub-menus avoid levels with less than two items, simplifying hierarchy. A three-level depth (exceeding typical designs) emphasizes visual cues like breadcrumbs to prevent disorientation.

3.4 Menu Behavior and Controls

Visual localization is supported by the textual and visual components of the menu items. Moreover, category items are visually distinguishable from command items by a hierarchy indicator (dashed border surrounding the icon). The menu is operated with three simple commands: two for navigation and one for selection. By default, the first item is focused. Selecting an item involves navigating left or right, then confirming with the selection command. Navigation shifts focus to adjacent items, with two possible behaviors. In Variant A, a right command rotates the circle right, focusing the item to the left. In Variant B, focus shifts in the same direction as the command—right navigates to the item on the right. Based on expert evaluations, Variant B was adopted (refer to Subsection 3.5 for an example video). Though, users could eventually choose or change their preferred variant in settings. Within a hierarchical menu structure, it is possible to switch between hierarchy levels. Menu items can be divided into category and command items. Selecting a category item navigates to the corresponding sub-menu, while selecting a command item triggers an item-specific action. Selecting the return item displayed in each menu level allows navigating to the parent menu. To streamline navigation from deeper menus, the return item triggers a

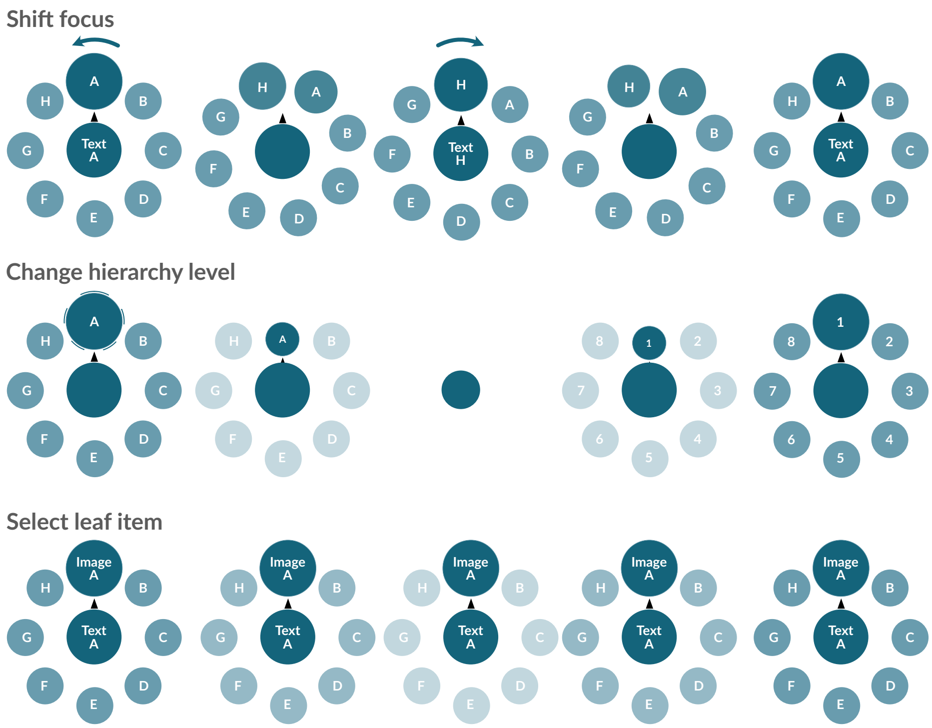


Fig. 7: Central animations: shift focus by rotation of the outer circle, change hierarchy level by contract and expand items, and select leaf item by blurring everything else

modal when the menu depth is two or more, letting users choose between the parent or main menu. This reduces interaction steps when returning to the main menu.

3.5 Animations

During the design process, it was hypothesized that carefully designed animations (in particular regarding enhancing understanding, smoothness of transitions, and visual consistency) have a positive impact on the user experience and the self-description ability of the Compass Menu.

The central animations (shift focus[3], change hierarchy level[4], and select leaf item[5]) are schematically represented in Fig. 7 and briefly described below.

[3] Animation: Shift focus by rotation of the outer circle: https://youtu.be/yeJun7ruPQg

[4] Animation: Change hierarchy level by contract and expand items: https://youtu.be/ctDyrE0cTEI

[5] Animation: Blurring everything else: https://youtu.be/AISHYEuUmME

Firstly, the focus shift initiated by a navigation command triggers an animated rotation of the outer circle clockwise or counter-clockwise around the center.

This animation avoids confusion about the changes caused by the navigation command. Specifically, the animation highlights the previously and next focused items, including their movement, color, and size transition. Another animation for hierarchy level change is used to clarify the navigation through the hierarchy levels by selecting a Category Item or Return Item. At the start of the animation, the menu circle contracts towards the center and then expands back to its original position. In the short moment, when the items are not displayed, they are replaced by the target menu items. The third important animation visualizes the successful selection of certain leaf items (ie. elements at the bottom of the hierarchy). These items do not represent another menu level or sub-application, but specific commands such as for communicating 'I need sth. to drink'. When a leaf item is selected, it is highlighted for a few seconds by blurring everything else in an animated effect.

4 Evaluation

As an initial step, we carried out a formative pre-study to evaluate the Compass Menu and our design choices in relation to the research questions.

4.1 Study Design

Our evaluation combines heuristic evaluation and expert review. To answer RQ.1, regarding the design of a menu technique that supports easy-to-use interaction with an adaptation to discrete gesture controls, participants used the menu in its intended setup to solve context-specific tasks. Then, they rated the difficulty of the interaction using the ball-shaped device.

Participants then assessed ease of use, orientation aids, and learnability (based on the design goals for menus described in Section 2), addressing whether design goals were met (RQ.2). The third research question, whether the Compass Menu fulfills established (menu) design quality criteria, was addressed by further evaluation steps, including usability and applicability (based on the menu performance model described in Section 2), animations, interaction, user experience, and aesthetics. A comprehensive questionnaire (see Appendix B) was used to collect feedback from experts. It includes a variety of non-standardized items related to the aforementioned criteria, and standardized items[6] to evaluate usability, user experience, and aesthetics.

[6] Namely System Usability Scale (SUS) [5], User Experience Questionnaire Short Scale (UEQ-S) [22], and Visual Aesthetics of Websites Inventory Short Scale (ViSAWI-S) [25]

Fig. 8: Laboratory setup of the evaluation. The central components are highlighted: the ball-shaped interaction device on the bed, its charging station on the bedside table, and the mounted display at the foot of the bed.

4.2 Setting and Procedure

Participants were informed about voluntary, confidential participation and completed a demographic questionnaire. Tasks were performed lying in bed using the ball-shaped interaction device (see Fig. 8); the display was positioned at the bed's foot.

Instructions and gesture demonstration videos were shown on a nearby large screen; participants kept their elbows on the bed during tasks. Participants were instructed to verbalize their intentions and thoughts during the task using the think-aloud method. Then, they received the interaction device into their dominant hand. During training phase, participants learned three control gestures via videos, practiced navigation tasks, and answered related questions. After that, experts familiarized themselves with the application, completed design choice questionnaires in bed, and answered closing questions after getting up; the process lasted about 90 minutes.

4.3 Instruments

Data were collected via a four-part questionnaire comprising both custom and standardized items (see Appendix B for details). Custom items were designed based on design goals introduced in Table 2, since no standardized instrument has been found. The first section gathered demographic information: age, sex, Affinity for Technology Interaction (ATI scale [36]), profession, and years since graduation. The second section (asked during training phase) addressed participants' first impressions, perceived control difficulty, and preferences for haptic feedback from the interaction device. The third and fourth sections evaluated ease of use, selection mechanism, visual structure, guidance, and menu learnability, based on design goals from Section 2. Items also addressed key animations (focus shifts, hierarchy changes, and leaf selection), with experts rating their clarity and appropriateness. Eight items covered interaction and interaction costs, including gesture-menu alignment, menu-device fit, system engagement, enjoyment, security from confirmation dialogs, and error prevention. Experts also rated whether the number of steps to reach menu items was reasonable. Additional items addressed menu performance (Table 3), usability (SUS [5]), and learnability/satisfaction (inspired by the Questionnaire for User Interface Satisfaction [6]). Applicability was evaluated for applications, devices, and users, assessing the Compass Menu's suitability for various contexts. User experience (UEQ [22]) and aesthetics (VisAWI-S [25]) were also assessed. Finally, experts answered open-ended questions on strengths, areas for improvement, and suitable or unsuitable application contexts.

4.4 Participants

Six human-computer interaction (HCI) experts participated. Inclusion criteria were a master's in media informatics or similar, ≥ 1 year professional experience, and on-site availability. Mean age was 30.2 years (SD = 3.6); four were male, two were female. Mean professional experience was 3.2 years (SD = 1.6). Five were HCI research associates, one was a software developer. Affinity for Technology Interaction was high (mean 5.0, SD = 0.6; scale 1–6).

4.5 Results

Participants rated control difficulty low (M=1.67, SD=0.82) on a 10-point Likert Scale (1=easy, 10=difficult). They evaluated haptic feedback vibration intensity for tilt and press gestures on a 10-point Likert Scale (1=weak, 10=strong), with moderate ratings (tilt M=5.83, press M=5.67). Tilt was perceived as slightly stronger.leaning slightly towards too weak. Experts also rated vibration intensity on a 7-point Likert Scale (1=too weak, 4=just right, 7=too strong), with ratings near 'just right' but slightly weak (tilt M=3.67, press M=3.83). Some experts commented on controls and vibration. One participant expected scrolling with tilt; another expected inverted controls. Tilting the device toward the body was noted as a potential interaction issue. Two participants suggested distinct

Table 4: Expert feedback (N = 6) on the menu characteristics as mean (M) values of item categories (SD = standard derivation). Each category consists of two to six items (Items column references to the complete questionnaire in Appendix B), each representing a statement to which participants indicated their level of agreement on a six-point Likert scale (1 = strongly disagree, 6 = strongly agree). We chose a six-point Likert scale to eliminate the neutral middle category and encourage respondents to express their opinions more clearly. High values correspond to a high degree of agreement.

ID	Items	Category	M	SD
1	15-16	Visual Representation	5.5	0.41
2	17-18	Selection mechanism	4.67	1.14
2.1	17	. . . is simple.	5.83	0.41
2.2	18	. . . is familiar.	3.5	1.87
3	19-21	Visual Structure	5.17	0.66
4	22-25	Guided Exploration	5.63	0.56
5	26	Effective Visual Search	4.83	0.98
6	27	Effective Navigation	5.33	1.21
7	28	Quantity	5.83	0.41
8	29	Reduced Screen Consumption	3.83	2.14
9	30	Support Learning Menu Content	5.67	0.52
10	31-34	Learnability	5.88	0.23
11	35-40	Animations	5.75	0.41
12	41-46	Interaction	5.89	0.33
13	47-48	Interaction costs	5.67	0.52
14	59-64	Applicability	5.5	0.68

vibration patterns (e.g., short pulses or duration-matched vibrations) for different gestures. Two experts felt the vibration intensity might be too weak and could cause habituation. All participants learned the functionality and completed tasks without assistance. Design decisions were assessed with 39 questionnaire items (see Appendix B). High agreement indicates positive ratings. Items were grouped into categories, and mean values calculated (Table 4). Only summary results are presented due to overall positive ratings.

Table 4 shows very positive to excellent ratings across categories, except for Selection Mechanism (ID 2) and Reduced Screen Consumption (ID 8). For Selection Mechanism, participants were neutral on familiarity (M=3.5, SD=1.87) but strongly agreed it was simple (M=5.83, SD=0.41). The SUS score averaged 85.0 (SD = 2.74), indicating excellent usability. Learning and memorization (see Fig. 3) were explicitly assessed and received near-unanimous agreement (see Table 4). Interaction items also received high agreement. Applicability (six items) also scored highly (see Table 4), indicating positive evaluation. The UEQ-S showed excellent user experience (M = 1.90, SD = 1.03), with excellent pragmatic (M = 2.25) and good hedonic quality (M = 1.56). VisAWI-S scores averaged 6.17 (SD = 0.61; scale 1–7), indicating high aesthetics. Qualitative feedback was positive, especially regarding icons, animations, and system self-description. Two participants criticized the return function: one cited logic issues, another suggested greater visual prominence. Suggested application domains included car infotainment, healthcare for impaired users, and contexts with limited interaction. They found it less suitable for emergency or safety-critical situations requiring rapid input.

5 Discussion

The results indicate that the menu technique enables easy interaction. Moreover, the participants were able to control the system using the ball-shaped interaction device as required in the above research question. However, participants considered the intensity of the haptic feedback as slightly too weak. This should be further investigated in future user tests, and probably slightly increased or even designed to be adaptable. The suggestion to use different vibration feedback patterns to distinguish the gestures could further enhance the interaction experience. The evaluation suggests that the menu design may offer sufficient ease of use for intensive care patients, considering the specific interaction device. Therefore, the first research question—how to design a suitable menu technique—has been addressed. Further studies with the target user group are needed to confirm applicability for weaning patients. As a preliminary step, a laboratory usability study with healthy older adults (N=22) evaluated the system's learnability, communication suitability, and overall user experience [17]. The next step is a clinical trial with actual weaning patients.

The results related to menu design goals were promising, with HCI experts rating most aspects positively. Even participants who found the menu unfamiliar considered it simple. Some participants found the selection mechanism familiar, likely due to experience with gaming controllers or in-game menus. The design goal of *reduced screen consumption* was intentionally not met. In the trade-off between *reduced screen consumption* and *visibility*, the latter was prioritized; the menu was designed to maximize screen space without disrupting visual representation. This is reflected in the questionnaire results (see ID 1, 3, and 8 in Table 4).

Questionnaire results indicate our menu design aligns with literature goals, addressing the research question on graphical menu design. Based on expert opinion, the Compass Menu appears to fulfill these design criteria. Both usability and applicability, as well as underlying criteria (speed/accuracy, learning/memorization, satisfaction, and application/device/user adequacy), were rated positively (RQ.2).

Additionally, UX and aesthetics ratings support our design choices. This supports the conclusion that the Compass Menu meets established design quality criteria (RQ.3) and that the design goals are suitable for this context.

Several limitations should be considered when interpreting and generalizing these results. As this study focused on interface design, we conducted an HCI expert evaluation. While this approach enables thorough assessment of interaction design, it does not allow empirical conclusions about performance with actual intensive care patients. However, HCI experts acted as proxies for the target audience, thus they considered the needs of weaning patients when assessing ease of use. Future evaluations should include intensive care domain experts and actual weaning patients. Including weaning patients would increase study complexity and require careful planning. While six HCI experts may suffice to identify common design issues, a larger sample is needed for in-depth analysis. Furthermore, all experts had similar age and level of experience. All experts had similar age and experience; future studies should validate these findings with a broader sample.

The handedness of the test subjects was not systematically recorded during the study. Most of the participants were right-handed. However, there were no indications of limitations in operation with the left hand. In future studies, a differentiated analysis of the effects of left-handedness versus right-handedness should be considered.

6 Conclusion

This paper presented the design of the Compass Menu, a radial menu technique serving as the core component of an interactive assistive system. It is specifically tailored for mechanically ventilated ICU patients and operated via simple gestures (previous, next, select) using a ball-shaped interaction device or other compatible gesture input devices.

The Compass Menu is systematically characterized through a taxonomy of menu properties, encompassing three dimensions: Menu, Menu Item, and Menu System, each with multiple sub-dimensions. Key features include the Radial Layout, which mirrors the spherical shape of the input device, the focus shift mechanism where the selected item remains fixed at the top (north pole) while the outer ring rotates upon input, and the adaptation to input gestures. The Radial Layout comes with several advantages. Based on a given item size, it can display an appropriate amount of menu items without causing risks of an information overload. Besides, it enables appropriate interaction with the selected interaction gestures. Moreover, circularly positioned items naturally arrange first and last item next to each other. A comprehensive menu structure was developed in cooperation with nursing experts to meet ICU patients' needs, featuring custom-designed icons and appropriate wording for each menu item. Furthermore, the self-description ability of the system state was improved by three carefully designed animations (shift focus, change hierarchy level, select leaf item).

Initial expert evaluations assessed the Compass Menu's compliance with menu design goals and UI quality criteria such as usability, applicability, user experience, and aesthetics. The results were encouraging, suggesting the system's suitability for its intended domain. Notably, the ease of use afforded by the interaction and the effective adaptation to the ball-shaped interaction device represent significant progress toward our objectives.

While these findings are promising, the study's limitations—including the use of expert participants and the need for clinical validation—should be acknowledged. Future work will include clinical trials with the target patient group.

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A Menu structure

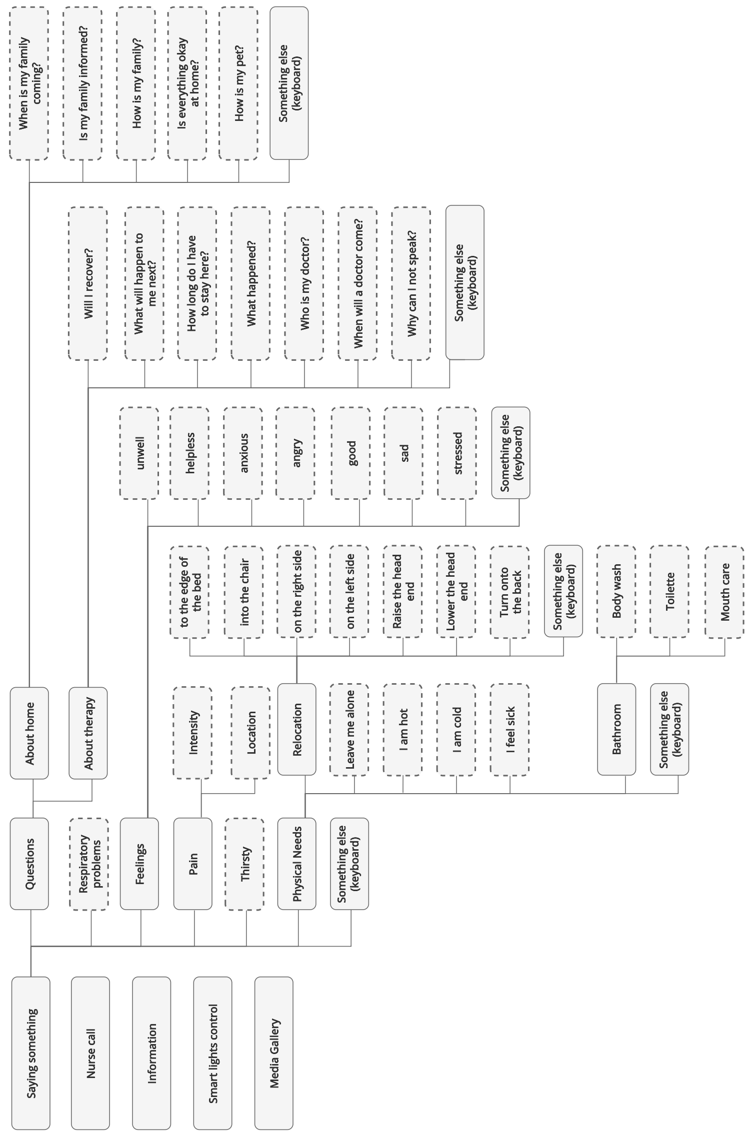

Fig. 9: Sample of the menu structure taken from the application to support mechanically ventilated weaning patients. In total, the hierarchy contains 56 elements describing typical needs of the user group. Note that the dashed items are leaf/command items. The others are category items representing another menu level or a sub-application.

B Evaluation

Section	ID	Items	Corres-ponding Scale	M	SD
1	1	**Demographic Data (Age, Sex, Field of Expertise, Professional Experience)**			
		Affinity for Technology Interaction (ATI)	A1-6	5.00	0.60
	2	I like to occupy myself in greater detail with technical systems.		5.50	0.55
	3	I like testing the functions of new technical systems.		5.33	0.52
	4	I predominantly deal with technical systems because I have to.		5.00	0.63
	5	When I have a new technical system in front of me, I try it out intensively.		4.83	0.75
	6	I enjoy spending time becoming acquainted with a new technical system.		5.00	0.63
	7	It is enough for me that a technical system works; I don't care how or why.		4.83	0.75
	8	I try to understand how a technical system exactly works.		4.67	0.82
	9	It is enough for me to know the basic functions of a technical system.		4.83	0.98
	10	I try to make full use of the capabilities of a technical system.		5.00	1.10
2		**First Impression**			
	12	What is your assessment of the difficulty of the controls via BIRDY?	C1-10	1.67	0.82
	13.1	To what extent do you perceive the vibration of BIRDY when tilting?	D1-10	5.83	2.32
	13.2	To what extent do you perceive the vibration of BIRDY when pressing?	D1-10	5.67	2.42
	14.1	What is your opinion of the vibration level selected for the gesture tilting?	E1-7	3.67	0.52
	14.2	What is your opinion of the vibration level selected for the gesture pressing?	E1-7	3.83	0.75
3		**Menu Design Goals**		**5.11**	**0.74**
		Ease of Use	A1-6		
		The visual representations of the commands are...		5.50	0.41
	15	readable		5.83	0.41
	16	meaningful		5.17	0.41
		The selection mechanism is...		4.67	1.14
	17	simple		5.83	0.41
	18	familiar		3.50	1.87
		The visual structure clearly communicates the concepts of ...		5.17	0.66
	19	menu items		5.83	0.41
	20	menu levels		5.83	0.41
	21	menu depth		3.83	1.17
		Guided Exploration	A1-6	**5.63**	**0.56**
		The menu ...			
	22	decreases the information load.		5.67	0.52
	23	enables exploration.		5.33	0.82
	24	supports the orientation.		5.67	0.52
	25	allows the exploration of all relevant locations.		5.83	0.41
	26	The menu allows to quickly search menu content (**Effective Visual Search**).		4.83	0.98
	27	The menu allows a quick and direct navigation between all menu locations and items (**Effective Navigation**).		5.33	1.21
	28	The menu hierarchy can be extended to include additional levels and items (**Quantity**).		5.83	0.41
	29	The menu has a space-saving design (**Reduced Screen Consumption**).		3.83	2.14
	30	The menu is consistent with global visual aspects such as item locations, sizes, and colors (**Support Learning**		5.67	0.52
		Learnability	A1-6	**5.88**	**0.23**
	31	It is easy to learn how to use the system.		6.00	0.00
	32	It is easy to discover new features through trial and error.		6.00	0.00
	33	It is easy to remember the names and uses of commands (or menu items).		5.83	0.41
	34	Performing tasks with the system is easy.		5.67	0.52
		Animations	A1-6	**5.75**	**0.41**
		The animation of the element change (rotation of the circle to the right/left) ...		5.92	0.20
	35	helps me to understand the system state.		5.83	0.41
	36	is appropriate.		6.00	0.00
		The animation of the hierarchy level change (collapsing to the center and expanding again) ...		5.33	1.03
	37	helps me to understand the system state.		5.33	1.03
	38	is appropriate.		5.33	1.03
		The animation of selecting a leaf node element (temporarily highlighting the element and fading out the rest)		6.00	0.00
	39	helps me to understand the system state.		6.00	0.00
	40	is appropriate.		6.00	0.00

Table 5: Questionnaire for the expert evaluation: part I (items translated from German). Refer to Table 6 for the Survey Response Scales. Please note that BIRDY is name of the Ball-shaped Interactive Rehabilitation Device used to control the system.

Section	ID	Items	Corres-ponding Scale	M	SD
3		**Interaction**	A1-6	**5.83**	**0.33**
	41	The gestures of the input device match the reactions of the menu.		6.00	0.00
	42	The circular menu layout and the ball shape of the input device fit together.		5.83	0.41
	43	The system encourages exploration.		5.83	0.41
	44	Interacting with the system is fun.		5.83	0.41
	45	The confirmation dialogs provide confidence during operation.		6.00	0.00
	46	The confirmation dialogs can prevent erroneous interactions.		5.83	0.41
		The number of necessary interaction steps to reach the menu items...	A1-6		
	47	is appropriate.		5.67	0.52
	48	cannot be reasonably reduced any further.		5.67	0.52
4		**Usability and Applicability**			
		System Usability Score (SUS)		**85**	**2.74**
	49	I think that I would like to use this system frequently (considering a ventilation situation).	SUS1-5	4.00	0.00
	50	I found the system unnecessarily complex.		1.50	0.55
	51	I thought the system was easy to use.		4.00	0.00
	52	I think that I would need the support of a technical person to be able to use this system.		1.00	0.00
	53	I found the various functions in this system were well integrated.		4.00	0.00
	54	I thought there was too much inconsistency in this system.		1.00	0.00
	55	I would imagine that most people would learn to use this system very quickly.		3.83	0.41
	56	I found the system very cumbersome to use.		1.17	0.41
	57	I felt very confident using the system.		4.00	0.00
	58	I needed to learn a lot of things before I could get going with this system.		1.17	0.41
		Applicability	A1-6	**5.50**	**0.68**
	59	The menu is adequate for the application tested in this study.		5.67	0.52
	60	The menu is adequate for other applications (with adjustments if needed).		5.33	0.52
	61	The menu is adequate for these input and output devices.		5.83	0.41
	62	The menu is adequate for other input and output devices (with adjustments if needed).		5.00	1.55
	63	The menu is adequate for the intended users.		5.67	0.52
	64	The menu is adequate for other users (with adjustments if needed).		5.50	0.55
		User Experience Questionnaire (UEQ)		**1.90**	**1.03**
	65	obstructive | supportive	UEQ1-7	6.50	0.84
	66	complicated | easy		6.33	0.52
	67	inefficient | efficient		5.83	1.17
	68	confusing | clear		6.50	0.84
	69	boring | exciting		5.17	1.17
	70	not interesting | interesting		5.50	1.38
	71	conventional | inventive		5.83	1.60
	72	usual | leading edge		6.33	1.21
		Visual Aesthetics of Websites Inventory (VisAWI)	B1-7	**6.17**	**0.79**
	73	Everything goes together on this site.		6.17	0.41
	74	The layout is pleasantly varied.		6.00	1.10
	75	The color composition is attractive.		6.00	1.10
	76	The layout appears professionally designed.		6.50	0.55
Closing questions	77	What is good about the system and should be retained?	Open questions		
	78	What could be improved in the system?			
	79	Can you think of other contexts in which the system (or parts of it) could be used?			
	80	What use cases can you think of for which the system is not suitable/usable?			

Survey Response Scales

A1-6	completely disagree / largely disagree / slightly disagree / slightly agree / largely agree / completely agree
B1-7	completely disagree / largely disagree / slightly disagree / neutral / slightly agree / largely agree / completely agree
C1-10	1 (easy) / 2 / 3 / 4 / 5 / 6 / 7 / 8 / 9 / 10 (difficult)
D1-10	1 (weak) / 2 / 3 / 4 / 5 / 6 / 7 / 8 / 9 / 10 (strong)
E1-7	1 (too weak) / 2 / 3 / 4 (just right) / 5 / 6 / 7 (too strong)
SUS1-5	strongly disagree / slightly disagree / neutral / slightly agree / strongly agree
UEQ1-7	1 / 2 / 3 / 4 / 5 / 6 / 7

Table 6: Questionnaire for the expert evaluation: part II (items translated from German), including the Survey Response Scales.